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Deer Herd Health and Production Profiling

A thesis presented in partial fulfilment of the requirements for the

degree of Doctor of Philosophy

in Veterinary Science at

Massey University

Laurent Jean Marie Audigé

1995

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This work is dedicated to my parents, my brothers and sisters-in-law, my grand-mother, the rest of my family and all my friends, especially Kathy, who encouraged and supported me in my efforts until completion and acceptance for the PhD degree.

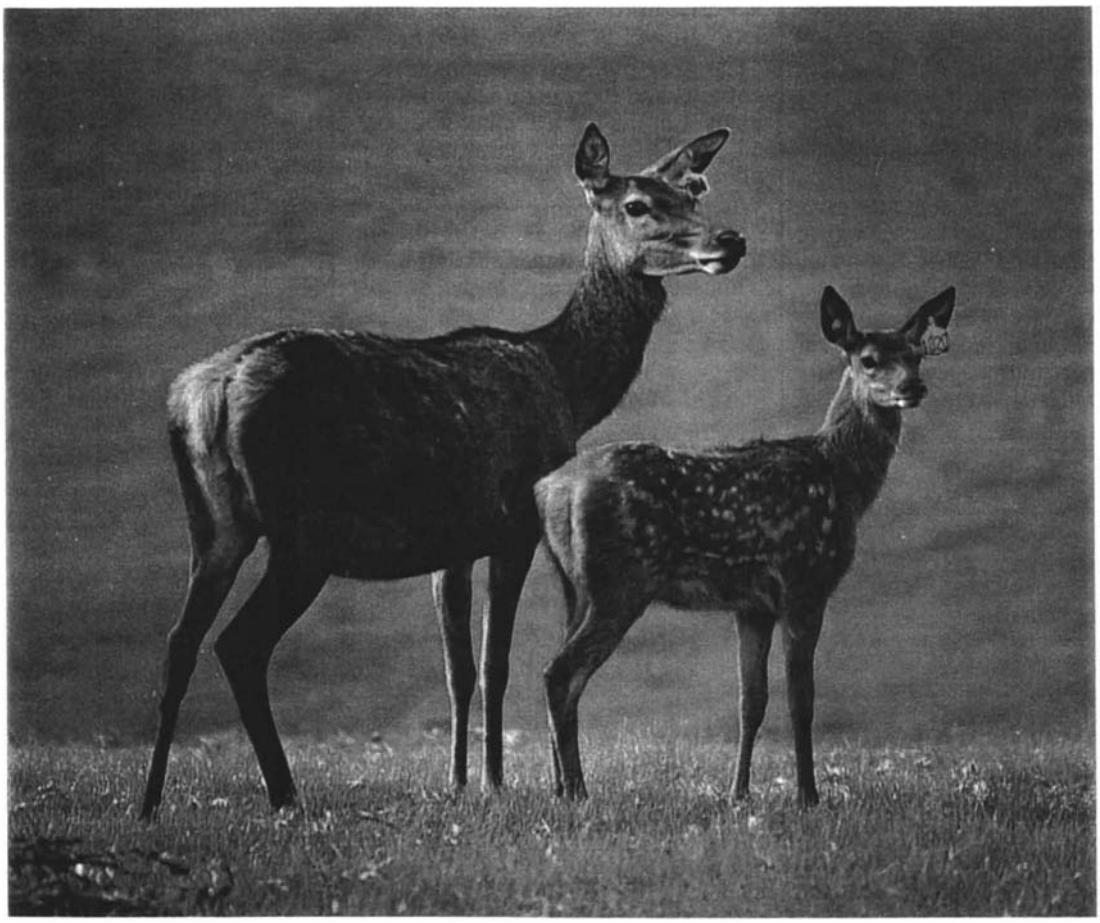


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ABSTRACT

Deer farming in New Zealand has been developed for about 25 years, with about 1.3 million deer being currently farmed. Knowledge of deer health and production has been acquired from experimentation in research stations and from field experience, but until now there has been limited research data from commercial farms. Little was known about the relative importance of a range of management practices, farm or animal characteristics, and how they related to deer health and production.

"Herd health and production profiling" is a tool for studying complex systems such as pastoral farming. This is the first time this technique has been used for the study of deer farming. It is a longitudinal observational study with an holistic epidemiological approach. It involves gathering a variety of relevant information about the whole farm which is analysed by advanced multivariable statistical techniques at farm, herd or mob, or individual animal levels.

The present study aimed to explore the health and production results from selected red deer farms; to investigate risk factors associated with the most important performance outcomes, and to identify the most relevant fields for further research.

This study involved observations from commercial red deer farms in the lower part of the North island of New Zealand, and was conducted over two years beginning in March 1992.

Potential participating farmers were solicited by mail questionnaire. Fifteen with the appropriate stock and facilities were selected after farm visits. Farm characteristics were recorded by direct measurements or by questionnaires. Farm layout was mapped. Each deer paddock was described with characteristics such as area, topography, water supply, type of fence, shelter, exposure to wind, pasture type and weeds recorded. Deer were identified by sex (hinds or stags) and age (weaners, yearlings or adults). About 2700 hinds, 2400 weaner deer and 1500 stags were individually monitored each year.

Farmers recorded daily farm management practices such as grazing management, mating and calving management, handling and disease control; individual deer data such as rearing performance of hinds, bodyweight, velvet antler grade and weight; health problems and weather data. Post-mortem investigations were conducted by researchers, local veterinarians or farmers themselves.

Farm visits were scheduled in March, June, September and November to record information and collect samples with additional visits as required. Body measurements were recorded, and blood and faeces samples were collected from 30 selected deer of both sex and three age categories per farm. Pasture and soil samples were collected and measurements were taken for each paddock. A body condition scoring (BCS) system was devised, and hinds scored in March before mating, September before calving and in March of the next year at weaning. All hinds mated were pregnancy tested by rectal ultrasound during the June visit and pregnant hinds were classified as having conceived before or after May 1.

Blood on EDTA was analysed for standard haematology. Sera were analysed for total protein, albumin, phosphorus, gamma glutamyl transferase, blood urea nitrogen, glutathione peroxidase,

pepsinogen, copper, vitamin B12, and serological evidence of yersiniosis and leptospirosis. Faeces were analysed for egg and larval counts. Pasture mineral profiles (Cu, Co, Se, Mn, Mo, Zn, Fe, and S) and soil fertility (Olsen P, K, S and pH) were investigated.

Data were entered into a relational database. Databases were corrected for erroneous and missing information by reference back to farmers, and calculations were performed for mob and farm characteristics. Data on farm and deer characteristics, management practices, deer health and productivity parameters, and biological markers were tabulated and graphed at the individual and farm level.

Some of the key health and production outcome were: 84.7% and 96.8% of yearling and adult hinds conceived at mating, respectively, and 17.0 and 9.1% of them lost their progeny by weaning; mean bodyweights of weaner standardised on April 1within farms ranged 42-59 kg and 39-51 kg in stags and hinds, respectively; the percentage of stags reaching 92 kg bodyweight by one year of age within farms ranged 0-48%; the mean yearling hinds bodyweight at mating was 81.3 (SD=8.5) and 82.8 kg (SD=9.4) in 1992 and 1993, respectively; 2-year-old stags produced on average 1.16 and 1.19 kg of velvet antler in 1992 and 1993, respectively; annual mortality rates of weaners (3-15 months), hinds and stags were 5.87, 1.77 and 2.60 per 100 deer-years, respectively; deer blood characteristics and feacal parasite egg and larval counts varied significantly between farms.

Specific production outcomes chosen for risk factors analysis were: hind early conception (ie before May 1) and conception *per se*; hind lactational status at weaning and weaning rates (as a result of progeny losses from conception to weaning); bodyweights of weaners standardised to April 1; seasonal weaner growth rates; velvet antler grade and weight (summarised as the velvet monetary value), and the most important specific health problems, ie yersiniosis, malignant catarrhal fever and dystocia.

Path analysis was the main analytical technique used in this study. Preliminary univariate analyses were carried out to identify associations between single descriptive variables and the outcome variable under investigation. Variables which showed sufficient evidence of an association in these analyses ($p<0.20$) were included in multivariable analyses such as multiple linear or logistic regression. A forward stepwise selection procedure was used for identification of risk factors associated with the outcome under investigation ($p<0.05$). Null hypothesis and final path diagrams were formulated.

Final path diagrams were consistent in most respects with the current understanding of deer health and production, and allowed a more thorough investigation of causal webs within the deer production system. This study confirmed some already identified or suspected relationships, such as the positive influence of yearling hind bodyweight on conception, that of imported blood lines, wapiti blood lines and grazing swards over 5-10 cm for weaner growth, and that of stag age on velvet production. Many other relationships between risk factors and outcomes were novel, thus identifying areas for further research to identify whether they were causal. The most striking of these findings were the significant positive relationships between hind body condition scores and reproductive performance, the apparent negative effect of sunshine on hind early conception, weaner bodyweight and weaner growth, and the overall apparent beneficial effect of the presence of trees in deer paddocks on these outcomes. The other most important observation is the lack of significant risk factors predicting the probability of yearling hinds rearing a calf up to weaning, suggesting an underlying limiting physiological process for yearling hind lactation.

A putative epidemiological model was proposed from risk factors analyses for management options that are likely to increase the performance. Potentially the most practical management tool defined in this study was the body condition score chart, and it is proposed that it should be used industry-wide. It is also believed a farm faecal lungworm larvae index, serum albumin, copper, phosphorus and vitamin B12 concentrations, and blood packed cell volume, haemoglobin and glutathione peroxidase activities may be useful for whole-farm investigation of health and productivity.

It is proposed that final models and putative management proposals should be targeted for future research.

This thesis provides the most comprehensive reference data available of farm characteristics, management practices, and health and production parameters of commercial deer farms. Data has shown a large range of productivity levels and, for the first time, potential productivity levels in a commercial farming environment have been demonstrated. These data can be used at the farm level for evaluation of performance and identification of production targets, and at the industry level for strategic planning of farm output. This study shows that there is considerable potential to improve the production efficiency and productivity on many deer farms and has identified the key factors likely to achieve that potential.

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TABLE OF ABBREVIATIONS AND UNITS

Codes	Descriptions	Units
%	Percentage	
% DM	Percentage of dry matter	
°C	Degrees Celsius	
µmol/l	Micromole per litre	
*	Statistical significance level p<0.05	
**	Statistical significance level p<0.01	
/g	Number per gram	
95% CI	95% confidence interval	
Alb	Serum albumin	g/l
ANOVA	Analysis of variance	
B12	Serum Vitamin B12	pmol/l
BCS	Body condition score	
BUN	Blood urea nitrogen	mmol/l
cm	Centimetre	
Co	Cobalt	
Cu	Serum copper	µmol/l
DSP	Deer slaughter premise	
Exch.K	Exchangeable potassium	ppm
Fe	Iron	ppm
FEC	Faecal egg count	/g
FLC	Faecal lungworm larval count	/g
g/d	Gram per day	
g/dl	Gram per decilitre	
g/l	Gram per litre	
GGT	Gamma glutamyl transferase activity	IU
GIB	Game industry board	
GSHPx	Glutathione peroxidase	kIU/l
ha	Hectare	
Hb	Haemoglobin	g/dl
IU	International unit	
kg	Kilogram	
kg DM/ha	Kilogram of dry matter per hectare	
kIU/l	Kilo international unit per litre	
l/l	Litre per litre	
MAF	Ministry of agriculture and fisheries	
Max	Maximum	
Min	Minimum	
MJME/kgDM	Mega joules of metabolizable energy per kilogram of dry matter	
mm	Millimetre	
mmol/l	Millimole per litre	
Mn	Manganese	ppm
Mo	Molybdenum	ppm
mU Tyrosine/l	Milliunit Tyrosine per litre	
NS	Not statistically significant at p<0.05	
Olsen P	Olsen phosphate measurement of soil	ppm
OR	Odds ratio	
P	Serum phosphorus	mmol/l
PCV	Packed cell volume	l/l
Peps	Serum pepsinogen	mU Tyrosine/l

Table of abbreviations and units (Cont'd)

Codes	Descriptions	Units
pmol/l	Picomole per litre	
ppm	Parts per million	
r or R	Correlation coefficient	
S	Sulphur	%
SD	Standard deviation	
Se	Selenium	ppm
TP	Serum total protein	g/l
WCC	White cell count	
Zn	Zinc	ppm

COMPUTER SOFTWARE USED

Usage	Name	Version	Company
Word processor	Word	6	Microsoft corporation, One Microsoft Way, Redmont, WA, USA
Spreadsheet	Excell	5	Microsoft corporation, One Microsoft Way, Redmont, WA , USA
Drawings	Wordperfect presentation	2	Wordperfect corporation, 1555 N. Technology Way, Orem, Utah, USA
Data management	Paradox DOS	4	Borland International Inc., Scotts Valley, CA, USA
	DBMS/COPY Plus	3	Conceptual Software Inc, Houston, Texas, USA, published by SPSS Inc, Chicago, IL, USA
Statistical software	Statistix	4	Analytical Software, StPaul, MN, USA
	NCSS	5	Jerry L. Hintze, Kaysville, Utah USA
	SAS	6.04	SAS Institute Inc., Cary, NC, USA
	Statistica	4.1	Statsoft Inc., Tulsa, OK USA
Reference manager	Procite	2.2	Personal Bibliographic Software Inc., Ann Arbor, Michigan, USA
Farm mapping	FarmTracker	3	Physical Farm Management Software, B.M. Butler Computing Ltd, Palmerston North, NZ

ANIMAL REMEDIES USED FOR DISEASE CONTROL

Drug company	Code	Drug name
Anthelmintics		
Ancare New Zealand Ltd	ARR	New Arrest
	ARH	New Arrest Hi-Mineral
	OCH	Oxfen C Hi-Mineral
	OHM	Oxfen Hi-Mineral
	OXC	Oxfen C
Cyanamid of New Zealand Ltd	CPO	Cydectin Pour On
	VES	Vetdectin Oral Sheep
Merck Sharp & Dohme New Zealand Ltd	IOC	Ivomec Oral Cattle
	IOS	Ivomec Oral Sheep
	IPO	Ivomec Pour On
Hawke's Bay Veterinary Services Ltd	RLC	Red Label Cattle
	RLS	Red Label Sheep
Pitman-Moore New Zealand Ltd†	SMD	Synanthic Mini Dose
	SMS	Synanthic Mini Dose + Selenium
	SYS	Systamex Sheep & Catle
	SYC	Systamex Low Dose Cattle
SmithKline Beecham Animal Health	VAL	Valbazen
	VMD	Valbazen Mini Dose
Copper supplements		
Pitman-Moore New Zealand Ltd†	CIN	Coprin
	CNE	Copper Needles (4 grams)
	CNL	Copper Needles Large (12 grams)
	CUP	Cuprax (10 grams)
Rhône Mérieux	C05	Copacaps (5, 10 or 20 grams)
Vaccines		
Pitman-Moore New Zealand Ltd†	LPC	Leptavoid 3
	VAC‡	5-in-1 clostridial vaccine
AgVax Developments Ltd	YER	Yersiniavax

Note : Source New Zealand Index of Veterinary Specialities Annual 1994 (IVS), Volume 9

† now Mallinckodt Veterinary New Zealand Ltd

‡ Farmers noted whether they used multi-strain clostridial vaccines without the vaccine name. There are a number of clostridial vaccines marketed in New Zealand and published in the IVS.

GLOSSARY

Risk factor codes used for analytical investigations and their descriptions

Codes	Tables	Descriptions
%AHCM	2.11	Percentage of adult hind (hinds at least 3 years old) in the calving mob
ADULT	2.18	Deer at least 2 years old in March (hind at least 3 years old at calving)
ADVC	2.18	Hind (or dam) conceived before May 1 (early conception)
AGE	2.18	Deer age at the beginning of the survey year, ie in March
AGE3	2.18	Deer over 3 years old in March (hind over 3 years old at mating or at calving)
AGE4	2.18	Deer over 4 years old in March
AH	2.10	Number of adult hinds in the mating mob
AH2	2.10	Number of adult hinds in the back-up mob at mating
ALB	2.23	Serum albumin concentration
AVMAT	2.27	Average of daily maximum temperatures during the grazing period
AVMIT	2.27	Average of daily minimum temperatures during the grazing period
AVMMT	2.27	Average of daily temperature ranges (maximum-minimum) during the grazing period
AVWIND	2.31	Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt.
B12	2.23	Serum vitamin B12 concentration
B12185	2.36	Serum vitamin B12 concentration >= 185 pmol/l
BACK	2.10	Use of at least one back-up stag before May 1 at mating
BACKD	2.10	Number of days between April 1 and the first back-up sire used before May 1
BACKM	2.10	Use of at least one back-up stag after May 1 at mating
BCS	2.18	Body condition score
BCSD	2.18	Body condition score difference between March (pre-mating) and September (post-winter)
BCSL	2.18	Body condition score change during late pregnancy and lactation (between September and weaning)
BCSM	2.18	Pre-mating body condition score (recorded in March)
BCSM25	2.18	Pre-mating body condition score below 3
BCSM4	2.18	Pre-mating body condition score over 3.5
BCSS	2.18	Post-winter body condition score (recorded in September)
BCSS2	2.18	Post-winter body condition score below 2.5
BCSS4	2.18	Post-winter body condition score over 3.5
BIRTH	2.18	Number of days between November 1 and the date of birth (BIRTHD)
BSHEEP	2.31	Time spent in paddocks on deer farm boundary adjacent to paddocks where sheep could be found all year round
BULLR	2.31	Mean paddock bull rushes score during the grazing period
BUN	2.23	Blood urea nitrogen concentration
CHD	2.10	Number of days between April 1 and the use of the first back-up sire
CHS	2.10	Use of at least one back-up stag at mating
CHS2	2.10	Use of at least one more back-up stag a second time during mating
CHW9C	2.18	Bodyweight change between September and calving (late October-November)
CHWJV	2.18	Percentage of stag bodyweight change between June and the time of velvet antler harvesting
CLAH	2.10	Presence of adult hinds in the mating group
CLAHC	2.11	Paddocks shared with adult hind(s)(hind at least 3 years old at calving) at least one day during calving and early lactation
CLOVER	2.29	Mean pasture clover score during the grazing period
COATD	2.21	Coat density of sentinel deer
COATL	2.21	Length of the upper coat of sentinel deer
COPPER	2.33	Copper supplementation prior or during winter (before early July)

Glossary (Cont'd)

Codes	Tables	Descriptions
CU	2.23	Serum copper concentration
CU8	2.36	Serum copper concentration >= 8 μmol/l
CUT	2.18	Number of days between October 1 and the date of velvet antler harvesting
DAM	2.31	Percentage of time spent in paddocks with a dam, pond or swamp
DEATH1	2.36	Mob experienced natural death other than that caused by misadventure before June 1
DEATH2	2.36	Mob experienced natural death other than that caused by misadventure after June 1
DEER	2.29	Average number of deer in the mob during the grazing period
DEER/Ha	2.29	Average number of deer per deer-fenced hectare (grazing density)
DOSEOK	2.33	Weaner receiving at any drench the recommended dosage of anthelmintic
DRENCH1	2.33	Mean time interval between two anthelmintic treatments
DRUG	2.33	Use of only ivermectin/albemycin or benzimidazole-based anthelmintics
EASES	2.21	Deer blood sampled without firm physical restraint
ENTERP	2.11	Frequency of entering calving paddocks during visits
EOP	2.23	Eosinophil percentage
EXP	2.10	Use of at least one experienced sire stag for mating
EXP2	2.10	Use of at least one experienced sire stag for back-up at mating
FAREA	2.31	Mean paddock size (deer-fenced area)
FEC	2.23	Faecal egg count
FEC>0	2.36	Positive faecal egg count
FLC	2.23	Faecal lungworm larval count
FLC>0	2.36	Positive faecal larval count
FLCI	2.36	Farm calf faecal lungworm larvae index = geometric mean lungworm larval count multiplied by the number of calves with positive count (over 10 calves)
FSUP	2.32	Food supplementation of deer during the grazing period
GGT	2.23	Serum gamma glutamyl transferase activity
GIRTH	2.21	Thoracic girth of sentinel deer
GR46	2.18	Growth rate between April 1 and June 1
GR46<0	2.18	Weaner losing bodyweight between April 1 and June 1
GR69	2.18	Growth rate between June 1 and September 1
GR912	2.18	Growth rate between September 1 and December 1
GRADE	2.18	Highest grade of the left and right velvet antler
GRJS	2.18	Bodyweight gain between June and September
GSHPx	2.23	Serum glutathione peroxidase activity
GSHPx3	2.36	Serum glutathione peroxidase activity >= 3 kIU/l
GULLY	2.31	Mean paddock gully score during the grazing period
HB	2.23	Haemoglobin concentration
HIND	2.18	Weaner hind (ie sex = female)
HIND/Ha	2.11	Number of hinds per deer-fenced hectare at calving
HINDCM	2.11	Number of hinds in the calving mob
ISWH	2.29	Mean pre-grazing pasture sward height during the grazing period
IVE	2.33	Use of ivermectin/albemycin anthelmintics only
JOIN	2.10	Number of days between February 15 and joining with stag(s)
JULYD	2.33	Anthelmintic treatment in July (mid winter drench)
JUNED	2.33	Anthelmintic treatment in June (early winter drench)
JUNEW	2.18	Pre-winter bodyweight recorded in June (same variable as WD6)
KALE	2.29	Deer grazing on a kale crop at least one day
LAME	2.36	Mob with observed lameness (including clinical osteochondrosis)
LAUGD	2.33	Anthelmintic treatment in the last 15 days of August
LP	2.23	Lymphocyte percentage
LYING	2.21	Deer lying on the floor of the pen during handling (sampling)
M%AH	2.29	Mean percentage of adult hinds in the hind mob during the grazing period
M%WS	2.29	Mean percentage of weaner stags in the weaner mob
MACRO	2.31	Hinds grazing in at least one paddock with macrocarpa tree
MALB	2.36	Mean serum albumin concentration within farms

Glossary (Cont'd)

Codes	Tables	Descriptions
MARW	2.18	Pre-mating bodyweight (recorded in March)
MAXW4	2.18	Bodyweight differences between individual bodyweights (W4) and the highest bodyweights within mobs on April 1
MAXW6	2.18	Bodyweight differences between individual bodyweights (W6) and the highest bodyweights within mobs on June 1
MAXW9	2.18	Bodyweight differences between individual bodyweights (W9) and the highest bodyweights within mobs on September 1
MAXW12	2.18	Bodyweight differences between individual bodyweights (W12) and the highest bodyweights within mobs on December 1
MB12185	2.36	Geometric mean vitamin B 12 concentration >= 185 pmol/l
MBUN	2.36	Mean blood urea nitrogen concentration within farms
MCU	2.36	Mean serum copper concentration within farms
MCU8	2.36	Mean serum copper concentration >= 8 µmol/l
MEOP	2.36	Geometric mean eosinophil percentage within farms
MGGT	2.36	Geometric mean serum gamma glutamyl transferase activity within farms
MGSHPx	2.36	Mean glutathione peroxidase activity within farms
MGSHPx3	2.36	Mean glutathione peroxidase activity >= 3 kIU/l
MHB	2.36	Mean haemoglobin concentration within farms
MINSUP	2.33	Use of mineral supplemented anthelmintics
MJME/Ha	2.29	Mean mob daily energy requirements per grazed hectare (effective paddock area)
MLP	2.36	Mean lymphocyte percentage within farms
MNP	2.36	Mean neutrophil percentage within farms
MNZ	2.29	Mean weaner percentage of New Zealand blood lines within mobs
MP	2.36	Mean serum phosphorus concentration within farms
MPCV	2.36	Mean packed cell volume within farms
MPEPS	2.36	Geometric mean serum pepsinogen activity within farms
MTP	2.36	Mean serum total protein concentration within farms
MW4	2.29	Mean weaner bodyweight on April 1within mobs.
MWCC	2.36	Geometric mean white cell count within farms
NANTH	2.33	Number of anthelmintic treatments during the studied period
NFEC>0	2.36	Number of calves with positive faecal egg count (over 10 calves)
NOVD	2.33	Anthelmintic treatment in November
NP	2.23	Neutrophil percentage
NUMFS	2.32	Number of food supplementation episode during the grazing period
NZ	2.18	Percentage of New Zealand blood lines (estimated for many weaners)
NZ100	2.18	Pure New Zealand type deer
NZC	2.18	Estimated percentage of New Zealand blood lines in the calf
NZD	2.18	Percentage of New Zealand blood lines in the dam
NZS	2.10	Presence of only New Zealand red sire stag for mating
ODEER	2.29	Weaners grazing with deer over-15-month-old during the grazing period
OTHERST	2.29	Paddocks shared with stock other than deer at least one day during the grazing period
OSHEEP	2.29	Paddocks shared with sheep at least one day during the grazing period
P	2.23	Serum phosphorus concentration
PAREA	2.4	Paddock size, eg calving paddock area
PASTT	2.31	Mean pasture type score during the grazing period
PBULLR	2.4	Paddock bull rushes score
PCV	2.23	Packed cell volume
PDAM	2.4	Presence of a dam, pond or swamp in the paddock
PEPS	2.23	Serum pepsinogen activity
PERCW12	2.18	Percentile of deer bodyweight (12 = on December 1) within mobs on December 1
PERCW4	2.18	Percentile of deer bodyweight (4 = on April 1) within mobs on April 1
PERCW6	2.18	Percentile of deer bodyweight (6 = on June 1) within mobs on July 1
PERCW9	2.18	Percentile of deer bodyweight (9 = on September 1) within mobs on September 1
PFP	2.4	Paddock fence pacing score

Glossary (Cont'd)

Codes	Tables	Descriptions
PGULLY	2.4	Paddock gully score (visual estimate of its depth)
PRAG	2.4	Paddock ragwort score
PRIVER	2.4	Presence of a river or stream all year round in the paddock
PSTUMP	2.4	Presence of stump, branches, or objects (eg. drums, rubbish) in the paddock
PSUR	2.4	Paddock proximity to road, buildings or houses (ie signs of human presence)
PTHISTLE	2.4	Paddock thistle score
PTOPO	2.4	Paddock topography score
PTREES	2.4	Presence of trees (tree score)
PWIRE%	2.4	Percentage of paddock fence being wire-and-batten fences close to the ground.
RAG	2.31	Mean paddock ragwort score during the grazing period
RAIND	2.27	Average daily rainfall during the grazing period
RATIO	2.10	Hinds to sire stag ratio for mating
RATIO2	2.10	Hinds to sire stag ratio with back-up stags
REMD	2.10	Number of days between April 1 and sire stag removal
RIVER	2.31	Percentage of time spent in paddocks with a river or stream running all year round
RSWH10	2.29	Mean residual (ie post-grazing) pasture sward height over 10 cm during the grazing period
RSWH5	2.29	Mean residual (ie post-grazing) pasture sward height below 5 cm during the grazing period
SEPTD	2.33	Anthelmintic treatment in September
SEROYERJ	2.36	Maximum seroprevalence (increase of 20 Unit OD between March and June) against *Yersinia pseudotuberculosis* type I, II or III
SEROYERS	2.36	Maximum seroprevalence (increase of 20 Unit OD between March and September) against *Yersinia pseudotuberculosis* type I, II or III
SET	2.11	Number of days between October 1 and the date when hinds were set-stocked for calving
SHELT	2.4	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
SHIFT	2.34	Number of times deer were shifted between paddocks
SIPC	2.33	Number of days between January 1 and the starting date of internal parasite control (first drench)
SIZE	2.21	Shoulder height of sentinel deer
SSIRE	2.10	Single sire mating
SSIRE2	2.10	Single sire mating with back-up sire
STAG	2.29	Paddocks shared with stag(s) over 15 months old at least one day during calving and early lactation
STARTD	2.33	Number of days between the start of the studied period (eg June 1 or September 1) and the next anthelmintic treatment (drench)
STOCK	2.34	Number of times the mob composition was changed
STRIP	2.29	Deer strip grazing at least in one paddock during the grazing period
SUMD	2.33	Anthelmintic treatment in summer (December 1 - March 1)
SUN	2.27	Average daily sunshine score during the grazing period
SUPEN	2.32	Estimated daily individual energy intake (MJME) through food supplementation during the grazing period
SUR	2.31	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence) during the grazing period
TAGB	2.11	Tagging of calves at birth
TEETH	2.21	Incisor teeth score of sentinel deer
THISTLE	2.31	Mean paddock thistle score during the grazing period
TINE	2.18	Velvet antler with a bez tine on at least one side
TOPO	2.31	Mean paddock topography score during the grazing period
TP	2.23	Serum total protein concentration
TREES	2.31	Mean paddock tree score during the grazing period
USED	2.10	Sire stag(s) already use in the first mating mob

Glossary (Cont'd)

Codes	Tables	Descriptions
VCLOST	2.33	Vaccination of young deer against clostridial diseases with two doses of vaccine 3 to 4 weeks appart (5-in-1)(injection of at least one dose before April 1 as risk factor for W4)
VICTIM	2.21	Visible hair loss (sign of victimisation) on the back of the deer
VISIT/W	2.11	Number of visits of calving hinds per week by the farmer
VISITCP	2.11	Close monitoring calving hinds by moving throughout the calving paddock
VYERS	2.33	Weaners vaccinated with the Yersiniavax vaccine
VYERS1	2.33	First dose of Yersiniavax vaccine injected into weaners before April 1
W12	2.18	Individual deer bodyweight standardised to December 1
W4	2.18	Individual deer bodyweight standardised to April 1
W40	2.18	Individual weaner bodyweight standardised to April 1 below 40 kg
W50	2.18	Individual weaner bodyweight standardised to April 1 between 40 and 50 kg
W6	2.18	Individual deer bodyweight standardised to June 1
W9	2.18	Individual deer bodyweight on September 1
WAP	2.18	Percentage of wapiti (or elk) blood lines in the deer
WAPC	2.18	Estimated percentage of wapiti (or elk) blood lines in the calf
WAPS	2.10	Presence of one or more wapiti-type sire stag
WCC	2.23	White cell count
WD6	2.18	Post-mating dam bodyweight calculated on June 1 (same variable as JUNEW)
WEAN	2.18	Date of weaning = number of days between January 1 (February 15 in the analysis of hind conception, see Table 2.10) and weaning
WEIGHT	2.18	Weight of velvet antler harvested
WET	2.18	Hind lactating at weaning
WET-1	2.18	Hind lactating at weaning the year before
WINCOP	2.33	Copper supplementation of stag in winter (June 1 - September 1)
WINTD	2.33	Anthelmintic treatment during winter (June 1 - September 1)
YARDBW	2.34	Calves handled in yards before weaning
YARDED	2.34	Number of times weaners were yarded by June 1
YERS	2.36	Mob experienced clinical yersiniosis
YERS1	2.36	Mob experienced clinical yersiniosis before June 1
YH	2.10	Number of yearling hinds in the mating mob
YH2	2.10	Number of yearling hinds in the back-up mob at mating
YS	2.10	Presence of exclusively one or more yearling sire at mating
YSMATE	2.10	Yearling hinds left with their yearling stag mates during the rut
YSPM	2.10	Yearling hinds grazing with yearling stags up to mating

L

PUBLICATIONS

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2. Audigé L. (1992) The winter weaner disease : yersiniosis - a high cost illness. *The Deer Farmer*, **96**: 49-51
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CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION - THE CURRENT STATUS OF DEER FARMING

There are 42 species of deer worldwide grouped in 17 genera which have adapted to a wide variety of environments from the Arctic circle to the tropics (Whitehead, 1993). Feral deer have been exploited by mankind in many countries for centuries, in particular through hunting for food supply or recreation. In other countries, however, deer have been domesticated to serve another form of exploitation, such as in China where domesticated sika deer have been a source of traditional medicinal products or in sub-arctic regions where semi-domesticated reindeer have been herded for food and hides.

In the early 1970's, however, "deer farming" has emerged as an additional form of exploitation of cervidae.

1.1.1 Deer farming worldwide

"Deer farming" describes the exploitation of deer in an enclosed and controlled environment. There are 21 major deer producing countries worldwide farming approximately 2.5 million deer in 1992 (Table 1.1), although very few countries have accurate population statistics (Wilson, 1993). With nearly half of the world population of farmed deer, New Zealand has been a pioneer in this area, demonstrating the sustainability of deer farming through the domestication of feral deer, implementation of adapted management practices and control of the processing and marketing of deer products.

In 1994, there was a range of temperate or tropical species of deer being farmed worldwide, with red (*Cervus elaphus*) and fallow deer (*Dama dama*) the most common temperate species. The New Zealand, Australian and British experience has shown they have a suitable temperament for farming, can be easily managed and handled in groups, reproduce well in captivity, and diseases can be effectively controlled (Alexander and Buxton eds, 1994). Other temperate species include elk or wapiti (*Cervus elaphus canadensis*), which are commonly farmed in North America. They are larger and produce bigger antlers than red deer, and in New Zealand have been increasingly cross-bred with red deer for venison production.

The main tropical species of deer farmed were Rusa (*Cervus timorensis*), Sambar (*Cervus unicolor*) and Chital (*Axis axis*). There have been attempts to exploit the potential of some other species of deer for farming such as Pere David's deer (*Elaphurus davidianus*) in the UK and New Zealand, the white-tailed deer (*Odocoileus virginianus*) in North America and the roe deer (*Capreolus capreolus*) in Europe, although their temperament or susceptibility to disease might limit exploitation (Woodhouse ed, 1993).

In some countries such as New Caledonia, deer farming has been developed in a situation where the exploitation of other introduced domestic livestock encountered difficulties due to climatic and disease conditions (Chardonnet, 1988).

Table 1.1 : Farmed deer species and estimated numbers in the major deer producing countries worldwide.

Country	Principal species farmed	Total number	Output	Sources
Argentina	Red	6000		Wilson, 1993
Australia	Fallow, Red, Wapiti, Chital, Rusa, Sambar	150-180,000	200 tonnes venison	Holder, 1993†
Canada	Fallow, Red, Elk, Reindeer, White-tailed deer	70,000		Fiedel and Hudson, 1993
P.R. China	Sika, Wapiti, Reindeer, Musk	300,000	Velvet only	Chunyi, 1993†
China-Taipei	Sambar, Sika, Red, Fallow, Wapiti	30,000	Velvet	Wilson, 1993
Denmark	Fallow, Red	?20,000		Wilson, 1993
East Europe	Red, Fallow	?>4000		Somogyvá, 1993†
France	Red, Fallow	30,000	?	Cappelle, 1993†
Germany	Fallow, Red	70,000	1000 tonnes venison	Hermann Krog, 1993†
Ireland	Red	10,000		Mulcahy, 1993†
Japan	Sika, Red	4201	Tourism	Wilson, 1993
Korea	Sika, Red, Wapiti	143,000	Velvet only	Kwon, 1993†
Malaysia	Fallow, Sambar	?4000		Wilson, 1993
Mauritius	Rusa	60,000 10,500 farmed	420 tonnes venison	De Maudave Bestel, 1993†
New Caledonia	Rusa	12,000	50	Wilson, 1993
New Zealand	Red, Wapiti, Fallow	1.33 million	12,000 tonnes venison 400 tonnes velvet	Anonymous, GIB, 1993b
Norway	Reindeer	220,000 semi-domesticated	2674 tonnes venison in 1991	Tyler and Jonasson, 1993†
Russia	Reindeer, Elk Maral, Sika	3-4 millions farmed or ranched 400,000	Velvet	Wallis, 1993†
Sweden	Fallow, Red	2000		Wilson, 1993
UK	Red, Fallow	50,000	500 tonnes venison	Fullerton-Smith, 1993†
USA	Fallow, Elk, White-tailed deer, Red, Axis, Sika	100,000	2300 tonnes venison farmed and ranched	Chase, 1993†

† Information from (Woodhouse ed, 1993)

The consumption of deer meat products is very traditional in some countries such as Germany, and the demand for such products has increased with increased population. In the meantime, the demand for other red meats has declined. Urban populations in developed countries have become more health-conscious and are consuming more healthy products. Venison from farmed deer is recognised as a lean, tender, red meat with high dietary value (Drew and Greer,

1978). The need for quality products makes farm-raised venison a food product which caters to the consumers' preference in the 1990's.

Deer farming is now a recognised part of agricultural diversification (Haigh and Hudson, 1993).

1.1.2 The New Zealand deer industry

1.1.2.1 History

Deer were introduced into New Zealand by man during the last century. Between 1851 and the early 1990s, red, fallow, wapiti, sika, rusa, white-tailed, and sambar deer were liberated and established (Wallis, 1993). These introductions disturbed the balance of nature and by the 1920s, deer herds (mainly red deer) were blamed for causing damage to the natural environment. Deer were classified as noxious animals and were heavily culled from 1930 onwards. The commercial exploitation of feral venison started in the 1950s to the USA, but Germany rapidly became New Zealand's major market. In the meantime, velvet antlers (the antlers of stags cut at a growing stage when they are still covered by a "velvet-like" skin as in Figure 1.1) and other deer products were sold to oriental communities as a source of traditional medicine, and antler buyers suggested deer could be kept in captivity for velvet antler harvesting as was practised in China.

Figure 1.1 : Farmed stag before the harvesting of its velvet antlers



Deer farming was legalised in New Zealand in 1969 by the Noxious Animals in Captivity Regulations and the Deer Farming Regulations, and the first commercial deer farm was set up in 1970. The New Zealand Deer Farmers' Association and the New Zealand Game Industry Board (GIB) were established in 1975 and in 1983, respectively (Pattison, 1993; Williams, 1993). The GIB is a joint producer, processor and exporter organisation with statutory authority to collect levies for the purpose of marketing and promotion of the deer industry.

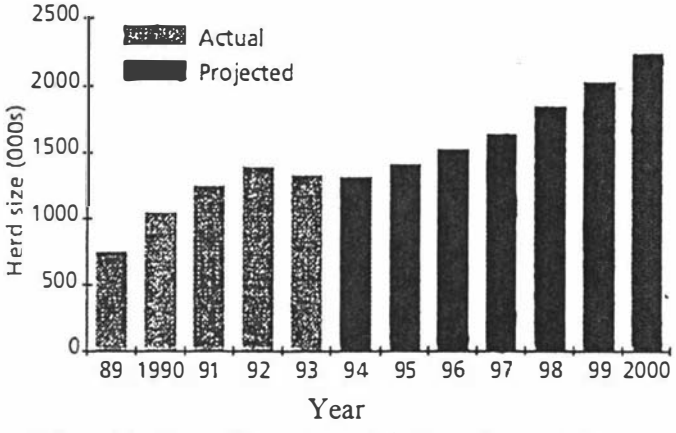
Wild deer were intensively captured and, despite initial high losses, adapted well to pastoral grasslands in captivity. For twenty years the New Zealand deer industry has worked to

improve the health and production status of its captive herd, supported by extensive development and research concerning all aspects of deer farming (Dixon, 1975; Drew, 1976; Drew and McDonald eds, 1976; Drew ed, 1978). This included farm design, animal selection and management practices (such as handling and yarding of deer), nutrition, reproduction and disease control (Yerex, 1982; Yerex and Spiers, 1991; Woodhouse ed, 1993). By 1994, a substantial pool of knowledge was available about the nutritive and reproductive biology of farmed deer as well as their susceptibility to diseases (English, 1988; Reid, 1988; Haigh and Hudson, 1993; Alexander and Buxton eds, 1994).

1.1.2.2 Industry growth and strategy

From 1970 to 1994, the New Zealand deer industry has grown steadily, although the deer population has recently fluctuated (Figure 1.2). In December 1993, there were 1.33 million deer in the New Zealand captive herd, farmed on 4100 properties (Anonymous, GIB, 1993b). About 85% of these deer were pure red deer, 10% were wapiti (elk) or wapiti-red hybrids, and 5% were fallow deer (Guild, 1993). Some sika, sambar, père David's, and rusa deer were also present, but in negligible proportions (Wilson, 1993).

Figure 1.2 : Actual and projected size of the New Zealand farmed deer herd for the years 1989-2000.



Source : New Zealand Game Industry Board strategic planning summary, September 1993

In the year to September 1993, 13,500 tonnes of venison were exported, mainly to Europe (88%), but export volumes to America and Asia were increasing. Venison export earnings reached a record of $127.9 million in 1993. The Cervena™ branding strategy was launched in 1993 in the USA and New Zealand as part of the GIB objective to "improve per animal returns and increase profitability for all sectors of the industry" (Anonymous, GIB, 1993d).

The production of velvet antler (velvet) from New Zealand increased from 80 tonnes (dried equivalent) in 1990 to over 150 tonnes in 1993, and export returns were $47.5 million to September 1993. The main markets were Korea and Hong Kong and competition was strong from Russian reindeer velvet. The GIB was investigating market diversification for deer velvet including the production of a "user friendly" velvet tonic (Anonymous, GIB, 1993c).

Meanwhile, farmers were urged to cull their stags to improve velvet grades and thus profitability.

Other returns to the industry came from by-products and skins which fetched $10.8 million to September 1993. Priority was to ensure the maximum number of skins could be used by the leather industry, through the limitation of skin damage during movement between farm and slaughter plant.

1.1.3 Main constraints to New Zealand deer farming

1.1.3.1 Biological constraints : seasonality of red deer

The biology of temperate species of deer is highly seasonal. Circannual daylight changes, influencing hormonal regulations, result in marked reproductive, nutritional and morphological cycles (Brown et al., 1979). In seasonal environments such as New Zealand, deer were naturally selected for maximum survival of their calves. This depends directly upon food availability during the peak of lactation (Loudon and Brinklow, 1992).

The year-round cycle of reproduction of red deer in New Zealand is outlined in Table 1.2. Red deer are "short-day" breeders (Fennessy et al., 1985).

Table 1.2 : Reproductive cycle of farmed red deer in New Zealand

	HINDS	STAGS
AUTUMN (March-May) 65 days	Silent oestrous cycles, oestrus, conception, early pregnancy	Rut Maximum testis size Hard antlers
WINTER (June-August) 100 days	Polyoestrus (6-8 cycles), or pregnancy	Low reproductive behaviour, but fertile Casting of hard antlers late in winter (old stags) or early spring (young stags)
SPRING (September-November) 100 days	Anoestrus or late pregnancy, early calving	Growing of velvet antlers Infertile.
SUMMER (December-February) 100 days	Late calving, lactation pre-rut weaning on farms (most often)	Progressive testis development, increased aggressive behaviour, hardening of antlers

Red deer hinds are seasonally polyoestrous. The onset of first oestrus marks the beginning of the rut, which occurs in late March or early April, depending on the influence of a multiplicity of factors. Silent ovulations can occur in red hinds prior to the first behavioural oestrus. Conception occurs usually within the first three oestrous cycles (mean duration 18.2 days) although some hinds may otherwise conceive late in winter if not pregnant early in the season and left with the stag. Calving in red deer occurs after a mean gestation period of 233 days. Most hinds give birth to a single calf between mid-November and late December, with the peak of calving occurring in late November/early December. Most farmers in New Zealand wean calves before the next breeding season, between late February and late March.

The reproductive cycle (including the antler cycle) of red stags has been extensively described elsewhere (Lincoln, 1971; Hochereau-de Reviers and Lincoln, 1978; Barrell et al., 1985; Fennessy et al., 1985; Fennessy and Suttie, 1985). Prior to the rut, testes progressively develop, testosterone secretion and spermatogenesis increase to reach optimum levels during the rut. In autumn, stags are fertile and display strong reproductive behaviour, which is directly related to their blood testosterone levels (Lincoln et al., 1972). Stags usually remain fertile during winter, but testosterone levels decrease, reducing their rutting behaviour. This drop in testosterone concentration triggers the shedding of hard antlers and the growth of the new set of velvet antlers. In spring, testosterone level is very low and stags are virtually aspermic. The rise of testosterone levels during the subsequent summer will trigger the calcification and hardening of velvet antlers and the associated change in body conformation (development of neck muscles) before the next rutting season. Antler weights and sizes increase each year to a maximum at around 8 years of age.

Red deer also have a significant seasonal change in voluntary food intake, due to the adaptation of their digestive physiology to seasonal changes in food availability in temperate natural environments (Milne et al., 1978; Kay and Staines, 1981; Barry et al., 1991). Deer have a high food intake in spring and summer, followed by a marked reduction over autumn and winter, resulting in reduced growth rates or weight loss (Fennessy, 1982). An additional influence on food intake comes from behavioural changes during the reproductive cycle, the rut being associated with low appetite and weight loss in stags. Hinds have maximum energy requirements for lactation which occurs in summer (November-March), whereas energy requirements of stags rise in winter and spring to recover body condition after the rut. Breeding stags can lose up to 15% of their pre-mating bodyweight during the mating season (Round-Turner, 1979).

1.1.3.2 New Zealand pastoral systems (seasonality of pasture growth)

New Zealand has a temperate climate dominated by a maritime influence, with marked seasonal temperature patterns but rainfall generally distributed throughout the year. Changes in moisture, temperature and light result in specific pasture growth patterns (Round-Turner et al., 1976; Korte et al., 1987) with maximum production occurring in spring (October-November), followed by a progressive reduction of pasture growth during summer and autumn. Winter pasture growth rates are generally low. "The colder the winter, the lower the winter growth rates and the greater the spring 'flush' of growth" (Korte et al., 1987).

Ryegrass/white clover pastures are the most common type grazed by deer on New Zealand farms. One major constraint is that pasture production patterns often do not fit well with feed energy requirements of breeding hinds. Maximum energy supply is needed during the lactational peak which occurs in red hinds during summer (Loudon and Brinklow, 1992), while maximum pasture growth occurs in spring when hinds are in late pregnancy and feed requirements are lower. This mismatch of pasture production with feed requirements can affect the economics and feeding efficiency of deer farming as, in some dry areas of New Zealand, farmers may need to provide feed supplements to hinds for lactation.

1.1.3.3 Market requirements

New Zealand's major venison markets require chilled venison for Northern hemisphere winter consumption. They are traditionally European countries such as Germany. These overseas

markets also require venison cuts to be processed from lean 50-to-70-kg carcasses. Thus for many years, demand for venison from importing countries has increased between August and December, and farmers were paid premium prices for the supply of deer weighing between 92 and 120 kg liveweight. During December, prices could fall 1 to 2 NZ$ per kg carcass. Until the Game Industry Board develops profitable non-seasonal markets, deer farmers would have to meet the seasonal demand for optimum returns. Therefore, for a pure venison operation, the objective was to have young deer reach at least 92 kg liveweight by late November (Fraser, 1993).

Most velvet antler from New Zealand was sold to Korea where its consumption is traditional. Koreans required large velvet sticks and pay premium prices for them. With the recent fall of the Soviet Union and the liberalisation of trade, reindeer velvet flooded Korea and competed against New Zealand velvet because of the larger size of reindeer antler. This caused prices to New Zealand producers to fall significantly between 1990 and 1993, and emphasised the need to increase the production of high-grade velvet (as defined in the GIB velvet grading chart presented in Appendix 1.1).

1.1.3.4 Production limiting factors

Maximum production is obtained when animals can express fully their genetic potential in terms of reproduction or growth. This can be achieved if animals are farmed in suitable environments, ie free of nutritional deficiencies, social or climatic stress, and diseases. Various factors may inhibit deer from achieving their potential.

1.1.3.4.1 Physical and social environment

Deer are highly socially ranked animals and, on farms as in the wild, a hierarchy establishes in any group of deer. Social interactions between deer are very common. It is believed that groups should not be reorganised too often to avoid contests for dominance, and hence induce social stress, which might be a major production limiting factor. For instance farmers are advised to sort out hinds into mating groups well before the rut to minimise social stress during the rut (Haigh and Hudson, 1993), with the expectation of better conception rates.

Wild deer may be hardy partly because of their ability to move away from stress situations (stressors) and go into shelter. For instance, subordinate deer can escape from fighting with dominant deer, or deer can move into sheltered areas under adverse climatic conditions. On farms, this may not always be possible depending on paddock characteristics.

Climatic conditions have been related to deer growth, as outdoor energy requirements for maintenance are higher than in indoor requirements (Fennessy et al., 1982), and disease outbreaks such as yersiniosis in young deer have been associated with periods of adverse weather (Mackintosh and Henderson, 1984a).

Little is known, however, of the relative influence of physical and social environmental characteristics on the health and production patterns of farmed deer.

1.1.3.4.2 Nutritional environment

Nutritional deficiencies or imbalances are major production limiting factors on farms and can affect reproductive performance, growth and health of domestic livestock species (Grace, 1983a). This is likely to be true for farmed deer, although knowledge of their nutritional requirements is limited. Nevertheless, attention was focused on mineral requirements since some mineral deficiencies have been identified or suspected in association with health problems in farmed deer (Jones, 1989; Wilson, 1992; Thompson et al., 1994). In New Zealand, copper deficiency is the most commonly diagnosed mineral deficiency in relation to health problem (Killorn and Wilson, 1990), but its importance for deer growth has not been clarified (Wilson, 1989b, Wilson et al., 1993). In other domestic livestock in New Zealand, economically important minerals are cobalt, selenium, iodine and copper (Clark and Towers, 1983).

1.1.3.4.3 Health-related problems

In the early days of deer farming, very little was known about existing or potential health problems on farms (McAllum, 1976). Apparently, most losses on farms occurred through stress-related problems such as traumatic injuries on fences or capture myopathy (McAllum, 1985). However, the enclosure of deer at high stocking densities exposed deer to a range of health problems they had not encountered before, partly because of exposure to other livestock species (Mackintosh and Beatson, 1985). Typical examples are the occurrence of the viral disease malignant catarrhal fever in deer transmitted by sheep (Reid, 1992), and lungworm infestations caused by grazing with cattle (Watson and Charleston, 1985). The major diseases relevant to farmed red deer in New Zealand and elsewhere have been reviewed (Wilson, 1984a; Fletcher, 1982; English, 1988; Mackintosh, 1992a; Mylrea and English, 1991; Wilson, 1991; Haigh and Hudson, 1993; Alexander and Buxton eds., 1994).

Deer are stress-prone animals, and chronic stress due to unsuitable farming environments may increase their susceptibility to disease (Griffin et al., 1988). Deer also have a high propensity to adopt a "fight-flight" response to sudden stressful situations, which may result in fatal injuries, commonly known as "misadventure".

Health related problems can be classified as affecting individuals or herds. While individual health problems - such as misadventure resulting in injuries, or cases of malignant catarrhal fever - are most often sporadic, herd health problems such as internal parasites (Connan, 1991), yersiniosis (Mackintosh, 1992b), and mineral deficiencies (Thompson et al., 1994) may affect the entire herd. Although they can cause the death of many animals through outbreaks, herd health problems are most often characterised by low mortality, high morbidity, variable severity and lowered herd productivity. The adverse effects of diseases on productivity of deer may induce premature death, reduced yield or value of animal products, altered food conversion efficiency, and reduced liveweight gain (Morris, 1985, 1988). Parasitism has been one of the most investigated health related problems in animal production (Sykes, 1994), and is a major issue in deer production.

It is believed that the overall mortality rate on commercial deer farms is typically around 1-2% (Wilson, 1987a), but on poorly managed properties mortality rates can significantly increase. Yet no research has been carried out to identify the key risk factors associated with health problems and mortality rates on deer farms.

1.1.4 Deer farm management practices

In this section the basic management practices applied to farm deer are briefly reviewed. More detail can be obtained from a large number of publications on the subject (Wilson, 1979; Haigh and Hudson, 1993; Alexander and Buxton eds, 1994).

1.1.4.1 Reproductive management

The reproductive success of farmed hinds has traditionally been evaluated through weaning rates, since these represent the convergence point of pregnancy rates, abortion rates, and neonatal mortality rates (Asher et al., 1981). More recently, however, better prices have been given for heavy weaners to ensure market requirements can be met, thus leading to slightly different farming objectives. Efficient breeding programmes aim at achieving both high weaning rates and high weaning weights (Scott, 1987). Little was known, however, of the relative importance of hind characteristics, mating strategies, and environmental factors on the reproductive performance of farmed red hinds.

Most studies on deer reproduction have identified individual hind characteristics, eg pre-rut bodyweights, as major factors associated with fertility in particular in yearling hinds (Adam, 1994). The importance of hind body condition has been confirmed in wild deer (Albon et al., 1986) but only suspected in farmed deer (Yerex ed, 1982). However, observations and results from farmed deer are difficult to compare between authors because mating strategies have not been investigated or even described.

On most deer farms in New Zealand, calves are weaned from hinds prior to the mating season and hinds are put with sire stags during March. Sire stags are usually left with hinds for 2-3 oestrous cycles (mean duration of the oestrous cycle is 18.2 days) commencing late March and a range of reproductive management practices are used (Moore et al, 1985; Moore, 1985). In particular, sire stags are usually replaced by "back-up" stags during mating to limit the consequences of using infertile stags. There have been few investigations of the relative effect of mating management options employed on hind reproductive performance.

With the emphasis placed on production costs, hinds that conceive early in the season take better advantage of the spring pasture growth (Yerex and Spiers, 1987). This has encouraged researchers to find ways of advancing the breeding season (Fennessy and Fisher, 1988; Wilson, 1989a). The use of the hormone melatonin was effective, but did not get support from the deer industry in New Zealand for marketing reasons. This reinforces the need to investigate less interventionist management practices.

1.1.4.2 Nutrition management

The pattern of growth and venison production results from the combination of genetic potential and external factors related to climate and management practices. For maximum production, deer should be fed to express their genetic potential for growth.

Farmed deer in New Zealand present a special challenge to the farmer as a result of their marked seasonal reproductive and nutritional pattern (see section 1.1.3.1.). Feed energy requirements have been established in red deer (Fennessy et al., 1981; Suttie et al., 1987) and wapiti (Scott, 1992; Haigh and Hudson, 1993) and grazing management practices have been

adapted accordingly (Fennessy and Milligan, 1987). Feed energy requirements form the basis for feed budgeting on farms (Milligan, 1984; Fraser and Stantial, 1988).

Most New Zealand pastoral systems are based on conventional ryegrass/white clover pasture, although evidence exists that deer prefer grazing other forages (Scott, 1989). However, despite significantly higher calf and weaner growth rates having been obtained on pasture species such as red clover or chicory (Niezen et al., 1991; Scott, 1992; Barry et al., 1993), such forages are not yet commonly used on commercial farms. Alternatively, guidelines for optimal utilisation of conventional pastures, mainly through the control of sward height, offer a further opportunity for increased performance in deer (Ataja et al., 1989).

1.1.4.2.1 Hind nutrition

Red deer are versatile and can adapt to harsh habitats, but this may be at the cost of reduced growth, bodyweight and reproductive performance (Kay and Staines, 1981). Should hind pre-mating bodyweight and body condition be key risk factors of fertility as suggested earlier, hind nutrition becomes a key issue in farm management. The nutrition of young hinds in particular is crucial for growth and achievement of optimum bodyweight for puberty (Adam, 1994), which is typically around 70% of mature bodyweight (Hamilton, 1988). Mature hinds should be fed high energy pasture during lactation (December-February) to ensure optimum calf growth (Loudon et al., 1983; Heydon et al., 1992). Moreover, feed shortage during this period may result in reduced fertility or delayed calving dates in the following season (Mitchell et al., 1976; Kelly and Moore, 1977; Hamilton and Blaxter, 1980; Moore, 1985; Hamilton, 1988).

To avoid over-fatness and consequently minimise the risk of calving difficulties (eg dystocia), it is common practice to keep pregnant hinds on short pasture during winter and allow for higher swards as calving dates approach (Moore, 1985; Moore et al., 1985). In Canada, mature cows (elk) can lose, on average, 6% of their peak autumn weights during winter (Hudson et al., 1991) without apparently affecting the pregnancy. The influence of winter nutrition on the reproductive performance of red hinds in New Zealand has not yet been investigated.

1.1.4.2.2 Stag nutrition

Bodyweight and growth rate of stags are positively associated with velvet yield (Moore et al., 1988b). Therefore, the nutrition of young stags may be critical to achieve optimum bodyweight at 15 months of age and guarantee their life-time velvet production. In mature stags, late summer weights were positively associated with antler weights (Hyvärinen et al., 1977). Stags require high feed energy during winter and early spring (Fennessy et al., 1981), as even away from hinds, they usually lose weight during the rut because of reduced appetite and increased activity (Fennessy, 1982). Many farmers supplement stags with concentrate feed at that time and this appears to increase velvet yield, although no research has been published on this matter. The management of stags around velvet harvesting dates appears to be implemented for practical rather than nutritional reasons, depending on herd size, handling facilities and techniques to remove velvet antlers.

1.1.4.3 Preventive medicine

In New Zealand, tuberculosis is a major threat to the deer industry, but it has been controlled on farms by an effective control programme based on identification and slaughter of infected deer (Carter, 1990). In 1993, the vast majority of deer herd were free of tuberculosis (Carter, 1993). Application of other disease control measures on farms, mostly by the use of animal remedies or vaccines, helped reduce the occurrence of some health problems such as lungworm (Mackintosh and Mason, 1985; Mackintosh et al., 1990b), ticks (Wilson, 1987b) some bacterial diseases (Mackintosh, 1992c) and trace elements (Familton et al., 1985; Harrison and Familton, 1992).

On commercial farms, young deer are usually regularly treated with anthelmintics from weaning (March) to early spring (September), essentially to control lungworm (*Dictyocaulus viviparus*). Weaners usually develop immune protection against lungworm by one year of age, so untreated mature deer can resist heavy lungworm infestations. Some farmers nevertheless treat these deer with anthelmintics, although there is no clear indication as whether it is economically justified (Wilson, 1984b). There has been increasing concern about the potential negative effect of abomasal parasites on deer health and production (Connan, 1991; Waldrup and Mackintosh, 1992; Wagner and Mackintosh, 1993), although its actual relevance to deer production is not yet known.

On many farms, deer are vaccinated with multi-strain clostridium vaccines and leptospirosis vaccines, but many farmers tended not to vaccinate their deer (Walker, personal communication). Clostridial diseases appear to be rare (Mulvaney, 1981), but leptospirosis outbreaks occasionally occur in weaner deer (Fairley et al., 1986). The development of the vaccine Yersiniavax to control yersiniosis in weaner deer, however, was very promising (Mackintosh et al., 1992), and many farmers appeared to use it in 1994. Weaner deer are commonly vaccinated around weaning with two doses of vaccine 3-to-4 weeks apart, and hinds and stags given booster immunisation prior to calving and at velvet harvesting, respectively (Mackintosh, 1992c).

Where appropriate, weaners, hinds or stags are given mineral supplements such as copper, selenium and cobalt to prevent deficiencies. These minerals can be given with anthelmintics or as specific formulations. Copper deficiency is the most identified mineral deficiency in deer in New Zealand (Familton et al., 1985), and, on marginally copper-deficient properties, deer are usually given oral copper oxide rods in late autumn (May-June) to prevent deficiency during winter (Harrison and Familton, 1992).

1.1.4.4 Animal selection

One widely used method for improving efficiency of deer production has been genetic improvement and selection. Wapiti (or elk) and European red deer have been imported and bred in New Zealand for years, for the production of bigger progeny (Fennessy, 1987, 1989). After the fall of stock prices in 1991, culling of adult hinds has substantially increased, but whether this has resulted in improvement of farm productivity is not known.

1.2 HERD HEALTH AND PRODUCTION PROGRAMMES

1.2.1 Objectives and components

To evaluate whole farm production and productivity, it is necessary to investigate the total farm profile. Herd health and production programmes are not restricted to diseases, but integrate strategic planning for reproduction, nutrition and animal growth in an holistic approach through a whole farm approach. Such programmes rely on farm, herd and individual animal data that are analysed with regard to industry needs, reference values for both health and production data and known production limiting factors (Campbell, 1985).

Herd health programmes have been increasingly accepted in the farming community as a way to maximise benefits to the producer (Blood, 1979). They have been developed for dairy cattle (Blood et al., 1978), beef cattle (Hugh-Jones, 1983) and pigs (Schultz, 1988). The implementation of such programmes in the deer industry came into perspective in 1987 (Scott, 1987; Wilson, 1987a) because the economic environment in the deer industry at that time led to financial fragility on farms. It was proposed that veterinarians be involved in herd health and production programmes on deer farms (Scott, 1987).

During the implementation of herd health and production programmes, data are collected at the farm level to construct a profile of health and production in the herd for comparison with defined industry targets (Edwards, 1985; Wikse et al., 1992). Calculated production parameters, along with biological markers such as blood or milk characteristics, provide indicators of herd health. Changes of these parameters beyond standard biological variability may indicate departure from optimal health or production (Barnouin et al., 1987; Schukken and Brand, 1994), and enable the implementation of immediate, tailor-made (and thus more cost-effective) health and production programmes.

Computers have been increasingly used in intensive livestock production systems (Russel and Rowlands, 1983). There are many examples of computerised health programmes to help the decision making process in solving problems on farms, such as in dairy herd reproduction (Bartlett et al., 1985; Dijkhuizen, 1988; Enevoldsen and Thysen, 1988; Nir, 1991) or pig production (van der Valk et al., 1984; Vos et al., 1990; Lloyd et al., 1994). Computerised health programmes are not available for deer farming, although various pieces of software have been developed for herd recording, management and feed budgeting (Gregson, 1994).

1.2.2 The need for reference data to set production targets and investigate management options.

Updated reference data on health and production are prerequisites of herd health programmes (Radostits and Blood, 1985). To determine if herd performance is optimal or not requires knowledge of what level of performance is reasonable to expect. It is also helpful to be able to compare a herd's performance with that of others in the region (Dohoo and Ruegg, 1993). Productivity parameters are viewed as surrogate measures for the overall health of the herd (Dohoo, 1994). This knowledge also allows individual farmers to set their own production performance goals to increase productivity of their farm.

While the concept of production targets can be applied to a number of outcomes on deer farms (eg conception rates, velvet yield, mortality rates), it is best illustrated with bodyweights or

growth rates. Although it may be argued these targets may differ between farms according to production objectives (ie whether they are mainly breeders, venison producers or velvet producers), there are, within the deer industry, some common goals for bodyweight. For instance, it is optimal to produce weaners ready for slaughter when markets give the best returns, ie when they are over 92 kg bodyweight at one year of age. Target weights for yearling hinds are those that will ensure puberty in time to maximise conception rate, but also sustain maximum lifetime productivity.

Body size and growth of red deer have been reviewed (Kay, 1985). A great deal of research has been carried out to investigate nutritional intake and growth under experimental conditions (Table 1.3), but few growth rate data for red deer on commercial farms have been published. Although very informative, the available research station data do not allow objective evaluation of commercial farm performance. The same observation could also be made with reproductive performance and mortality data.

Markusfeld (1993) suggested epidemiological evaluations of factors responsible for falls from targets should become routine. The identification of the most important risk factors (see next section) in this respect enables the creation of intervention programmes on farms (Perestrelo et al., 1988; Lepercq et al., 1989).

In deer farming, advice has been given for a range of management practices, in particular for reproduction (Moore, 1985; Moore et al., 1985), but there is very little research information about what actually happens on farms, eg control of parasites and grazing practices.

Therefore, there is a need to provide data on management practices, health problems and production parameters for the deer industry.

1.3 HEALTH AND PRODUCTION RESEARCH

1.3.1 Current status of deer research

In the early days of deer farming, very little was known on production parameters and existing or potential health problems of deer. While farmers built their experience by trial and error, researchers tried to answer the most urgent needs (Wilson, 1991). Most research on deer production has been confined to individual animal or discipline levels.

A great deal of research was done on the physiology of reproduction (Adam, 1994; Asher et al., 1994), and artificial insemination and embryo transfer (Asher et al., 1994; Fennessy et al., 1994). Concurrently, behavioural patterns of red deer during natural breeding were studied (Arman, 1974; Kelly and Drew, 1976b; Veltman, 1985) and methods to advance the calving season were investigated (Wilson, 1989a), in particular with the use of Melatonin implants (Wilson et al., 1991).

Table 1.3 : Examples of achievable mean growth rates of calves and weaners (up to 15 months of age) under various environmental and nutritional conditions

Year	Authors	Season	Male g/d	Female g/d	Environmental and nutritional conditions and remarks
	Calf growth				
1976a	Kelly and Drew	Su	318	287	Invermay research centre
1980	Blaxter and Hamilton	Su	206-313	124-290	Hill pasture - Glensaugh research station
1986	Adam and Asher	Su	387-424	338-358	Natural grazing Ruakura research station and farms
1988a	Moore et al.	Su	275-295 383-409	279-312 335-357	1973-74 data - Invermay research station 1982-83 data
	Weaner growth				
1976a	Kelly and Drew	A	83	83	Grazing trial. No growth rate differences were recorded between 0-5 and 5-10 cm pasture height.
1981	Blaxter et al. *Hamilton and Blaxter	W Sp/Su	52* 129*	25-46 76-110	Research - Hill country Scotland
1985	Moore et al.	A W Sp/Su	19-159 41-122 224-256	4-186 16-63 156-214	Invermay research station Range of individual growth rates
1986	Adam and Asher	A W Sp Su	125-170 34-93 196-230 130-159		Natural grazing on monitored farms
1987	Milne et al.	A W S	83-180 21 121-148		Calves (half of each sex) on 2.5-6 cm sward Light calves on high plane of nutrition Calves that had high and low plane of nutrition during winter, respectively.
1987	Suttie et al.	A W Sp Su		141 80 141 123	Tame hinds fed ad libitum during an indoor trial
1988b	Moore et al.	A W Sp/Su	18-161 60-102 218-239		Invermay research station Data 1978-80-82 Range of means
1988c	Moore et al.	A W Sp/Su	103±48 72±41 242±13	95±50 41±19 163±13	Invermay research station Data from 1974-79 and 1981-82 combined Mean±SD
1989	Ataja et al.	W Sp	103 184		Massey University deer research unit Perennial ryegrass/white clover pasture allowance 6.3 kg DM/hd/day
1991	Suttie and Corson	 W S 	 43-58 157-194 349-352 293-342		Invermay outdoor trial 1988-1989 Low plane of nutrition High plane of nutrition Low plane of nutrition during winter High plane of nutrition during winter
1992	Semiadi et al.	A W Sp	192 106 341	173 53 218	Massey University deer research unit Sward allowance 7-8 kg DM/hd/day in autumn and spring and residual dry matter : 100 kg DM/ha in winter
1992	Ataja et al.	W Sp	74-153 147-234		Massey University deer research unit. Perennial ryegrass/white clover maintained at 5cm-10cm sward height

A = autumn; W = winter; Sp = spring; Su = summer

Note : this table presents only data from deer grazing conventional ryegrass/white clover pastures.

To increase growth rates and carcass production, researchers have tried to unravel and control the complex mechanisms that regulate food intake (Barry et al., 1991; Suttie et al., 1994), while others specifically studied nutritional requirements (Fennessy et al., 1981; Suttie et al., 1987) and how to meet them. Whereas well managed ryegrass/white clover pasture can provide growth to meet market requirements (Ataja et al., 1992), the use of other pasture species such as chicory and red clover can offer profitable feeding alternatives for weaner production (Niezen et al., 1991; Barry et al., 1993). Concurrently, wapiti-type stags have been successfully used as terminal sires with red hinds to produce heavy weaners and higher growth rates (Yerex, 1991). More challenging but potentially rewarding have been the artificial breeding programmes for crossing of red deer with Pere David's deer (Asher et al., 1988; Fennessy and Mackintosh, 1992) and Sambar deer (Semiadi, personal communication). The composition and growth physiology of velvet antler are incompletely understood (Lincoln, 1992; Suttie, 1994), but limited research or clinical investigation on nutritional and management requirements, such as winter nutrition (Muir and Sykes, 1988), for optimal velvet growth have been carried out.

Originally, most data on deer diseases in farmed deer in New Zealand came from submissions to the Animal Health Laboratories (McAllum, 1976). Some information was available from studies on wild populations to investigate a range of diseases (Wilson, 1991).

Most research on deer health has been reactive, to overcome emerging health issues such as lungworm (Mason, 1985) or the fading elk syndrome (Conway, 1990), because primary concerns were to limit losses caused by clinical diseases to salvage economically valuable animals. This way of "coping" with health issues has been directed by the immediate needs of a new growing farming industry to acquire the basic principles for farming deer. Evidence showed disease control programmes (eg the use of anthelmintics) adapted to cattle or sheep do not necessarily apply well to deer and specific research was required (Mackintosh and Mason, 1985).

Most surveys on deer diseases in New Zealand have been carried out on one particular disease or syndrome either at slaughter houses (Mackintosh and Henderson, 1985) or in veterinary practices (Wilson and Collier, 1981; Smythe, 1986; Lawrence, 1986). Attempts have been made to estimate the relative prevalence of diseases observed on farms (Beatson, 1981, 1985; Gladden, 1981) or, more recently, at slaughter houses (Selwyn and Hathaway, 1990). None of these surveys could accurately measure the prevalence of diseases on farms. Provision of baseline data on animal health and productivity is necessary to establish norms for a region (Dohoo, 1994), and this was not available in a coherent form for deer farms in New Zealand.

1.3.2 The holistic approach : herd health and production profiling

1.3.2.1 Definitions and concepts

Epidemiology can be defined as the study of the frequency, distribution, and determinants of health and disease in populations (Martin et al., 1987). From a science aiming formerly at studying epidemic disease of man, epidemiology has evolved towards the study of interactions between populations and numerous factors that may be associated, in addition to specific agents, with the occurrence of disease. In veterinary medicine, there has been increased acceptance of a holistic and epidemiological understanding of disease causality (Schwabe, 1982), and methods have been developed over about twenty years to investigate the potential

causative role of determinants of diseases, also called "risk factors". Consequently, there has been increased monitoring of animal health and production on farms for epidemiological investigations. Although health monitoring has been used for regulatory functions (Morris, 1991) and increasingly for service to producers, many specific short term projects have been carried out to provide baseline data (descriptive epidemiology) and for research investigations (analytical epidemiology)(Dohoo, 1994).

"Health and production profiling" (Morris, 1991) combines health and production studies in a holistic epidemiological approach and is a tool for studying complex inter-relationships between factors which influence herd performance, not just disease occurrence. It is based on an exploratory observational longitudinal study of a small but appropriate sample of herds which involves gathering a variety of categories of relevant information about the whole farm, including physical and climatic characteristics, farmer characteristics, management practices, animal health, production outcomes, and individual sentinel animal parameters (Morris, 1982). The data is primarily useful in identifying the most important health problems (Martin et al., 1987) and obtaining indices and targets for comparison with individual herds (McDermott et al., 1991b). Secondly, data are analysed by advanced multivariable statistical techniques at the levels of whole farm, herd or mob, or individual animals to identify important risk factors for health or production outcomes, eg reproduction of beef cows in Ontario (McDermott et al., 1994a).

Morris (1991) gave examples of the development of "health and production profiles" in many developing countries such as in Asia, in Africa and in the Americas where there is an apparent need for such information, but such studies have also been carried out in developed countries (McDermott et al., 1991a; Van Til et al., 1991). Similar information have been obtained through nation-wide large-scale monitoring programmes (Dohoo, 1988, 1992; Heinrichs, 1994) but it is beyond the scope of this chapter to review them intensively. Prior to this study, "Herd health and production profiling" has never been applied for the study of deer farming in any part of the world.

1.3.2.2 Benefits

1.3.2.2.1 Multivariable approach

Epidemiological methods have been developed to investigate diseases, known as multifactorial diseases, resulting from an imbalance between multiple environmental factors and the ability of the host (eg animals) to cope with them. Each factor may contribute very little in isolation to the occurrence of diseases, but may act in synergy with others (Ganière et al., 1991). Consequently, study of these diseases may be inherently misleading since the interactions inherent in this "causal web" cannot be replicated in the laboratory situation. In deer research for instance, difficulties were encountered in experimentally reproducing diseases such as enzootic ataxia (McTaggart et al., 1981) or yersiniosis (Mackintosh et al., 1990a). One way to overcome this problem is the multivariable approach. All potential risk factors can be studied together in a way which allows their individual effects on the occurrence of health problems (or production parameters) to be distinguished. There are few examples of the use of multivariable techniques in deer research (Guinness et al., 1978a, 1978b; Albon et al., 1986; Moore et al., 1988a; Hudson et al., 1991; Friedel and Hudson, 1994), and the number of factors analysed in such cases were limited.

1.3.2.2.2 On farm investigations

Results of epidemiological studies can provide reference data to be used directly on farms to investigate a specific herd's health and productivity profile and compare it with those of other herds kept under the same conditions (McDermott et al., 1991b). Furthermore, because commercial farms are used as the field of study, it is also possible to identify risk factors for various production outcomes that can be subsequently modified even if the physiological mechanism of effect is not known (Ganière et al., 1991). There are examples of such intervention programmes in the pig industry (Perestrelo et al., 1988; Lepercq et al., 1989).

On-farm investigation also has a significant educational effect on farmers participating in the project, by ranking their farm on various criteria among their peers. Other farmers may more readily evaluate their own performance and be more motivated by results coming from commercial farms, rather than from controlled experimental units (Ganière et al., 1991).

Responding to the concern of Meek (1993) about the "under-utilisation of research results which may result from poor identification of priorities and inadequacy of investigative methods", health and production profiling is a tool which can be applied to development of farming practices to improve animal health and productivity.

1.3.2.2.3 Broad investigations

Veterinary epidemiology has emerged from the study of animal diseases (Martin et al., 1987), and its methods have been applied for the study of other outcomes including production parameters. In France, a science called "ecopathology" has evolved somewhat independently (Ganière et al., 1991; Fourichon, 1991; Landais, 1991). Diseases have even been investigated as risk factors for animal production levels or specific management decisions on farms (Luquet et al., 1992; Beaudeau et al., 1993). Conversely, production levels such as milk yield in cattle were evaluated as risk factors for the occurrence of diseases (Barnouin and Karaman, 1986; Distl et al., 1989).

Depending on research objectives and study design, risk factors may be related to individual animal characteristics (Faye et al., 1986; Gröhn et al., 1990; Joosten et al., 1991; Green and Morgan, 1994; Wittum et al., 1994), mob or group characteristics (Faye et al., 1988), management strategies (Joosten et al., 1991; Dargent-Molinat et al., 1988; Schumann et al., 1990; Tarabla and Dodd, 1990; Ollis et al., 1991; Hurnik et al., 1994a) or farm characteristics (Faye and Brochart, 1986; Mohammed, 1990).

Furthermore, biological markers (eg blood metabolic profiles or milk cell counts) have been studied in relation to health problems (Barnouin and Paccard, 1988), management practices and production outcomes, eg infertility in cattle (Forshell et al., 1991). Subsequently, factors that may influence important biological markers were investigated to determine optimum sampling periods (Fayet et al., 1986), but also as a way to minimise risks of subclinical and clinical disease (Roepstorff and Jorsal, 1990).

Longitudinal studies are appropriate to describe a production system and explore possible risk factors for various outcomes in a broad approach and are very cost-effective. From such studies, part of data may be subsequently selected for specific follow-up investigations (Faye and Brochart, 1986; Schukken and Lohuis, 1990).

1.3.2.2.4 Generation of hypotheses and identification of research priorities

Boland and Morris (1988) warned about research being based on inappropriate assumptions held by the researcher in the absence of convincing evidence, referring to earlier work carried out in sociology (Glaser and Strauss, 1967). Establishment of a theory from data was believed to be an important step to generate hypotheses that are relevant for the area that one wishes to research. This process is called "grounded theory" (Glaser and Strauss, 1967).

The identification of the most common production-limiting factors on farms and newly generated hypotheses allow the researcher and the industry to prioritise and target further investigation for cost-effective research. Case-control or cohort studies are often used consequent to longitudinal studies and there are numerous examples of such investigations in the literature (Chesterton et al., 1989; Ferns et al., 1991; Ollis et al., 1991).

1.3.2.2.5 Accuracy of data

The scope of the study (number of farms, herds and animals studied, geographic locations, intensity of recording) depends on the target population and other factors such as costs and practicality. A quick way to collate data is to do so retrospectively, because there is no need to follow up animals and the information is readily available (Erb and Martin, 1980). Often, retrospective studies have been carried out through questionnaires (le Du et al., 1985; Charles et al., 1991), but surveys are known to be susceptible to bias and, according to Edwards (1985) many surveys are poorly carried out. The repeatability of questionnaires is a matter for concern (Schukken et al., 1989; Scholl et al., 1994). In deer, health and productivity data have been collated through mail (Asher and Adam, 1985) and by on-farm interview surveys (Friedel and Hudson, 1994). In the latter survey, however, only existing accurate records were used.

In longitudinal studies, sampling units (eg animals) need to be observed over a period of time to monitor changes in exposure to potential risk factors and the outcomes being studied. Because data is collected at the time of event, it does not rely on peoples' memories, and therefore misinformation is thought to be limited (Rumeau-Rouquette et al., 1993; Martin et al., 1987).

1.3.2.3 Limitations

Edwards (1985) warned about problems that may occur with the analysis of data collected during health and production studies because of the limited number of farms monitored and the possibility of setting unrealistic goals for the use of the data. He concluded such studies are "very powerful in exploring animal production systems in real-world terms, but because they are observational, there are limitations as to the interpretation of results". This view must be fully appreciated by those employing whole herd health and production epidemiological methods, or interpretation of results.

Because it is only feasible to conduct such studies on a relatively small number of farms due to the workload involved, considerable caution is needed in deciding which findings can reasonably be extrapolated to the general population. Selection of farms which are "typical" rather than unusual in the industry is important (for example, commercial farms, not research farms), but it is not possible with this approach to select farms which are truly statistically representative. Nevertheless, provided that care is taken in selecting the farms, information about the dynamics of the production process, epidemiology of prevalent endemic diseases, and the relationship between health factors and production can be assessed. The focus has to be on issues which do not vary enormously between farms, so the technique is, for example, unsuitable for examining diseases which vary greatly in incidence between farms or between years.

Care also is required when interpreting the results because of the observational nature of the study. Traditionally in scientific research, objectives are often to find out why an event has occurred, or to investigate the causal effect of one particular factor or treatment. This requires the investigator to have control of the distribution of this factor or treatment and to randomize statistical units (eg individual animals or herds) to treatment and control groups. In contrast to experimental research, in longitudinal observational studies, the investigator has no control on the factors under study. Despite the use of statistical techniques to control for confounding factors, these studies do not allow causal interpretation of results because the identification of statistically significant associations between explanatory and outcome variables is not sufficient to prove that they have cause-and-effect relationships (Pedhazur, 1982). Such limitation has been further discussed by Chesterton et al. (1989)

In veterinary science, it is quite important to characterise key risk factors both for the prevention and control of disease, and therefore identify the most likely causative factors (if not the causative factors *per se*). A series of criteria can be used to assess the likelihood that these factors are causal (Susser, 1977; Evans, 1978a). Therefore an early step in identifying causes (or component causes) of diseases (or production performance) is to investigate factors associated with these outcomes. It is believed that results from multiple observational studies and observational approaches using different sample selection methods can be used to estimate the probability of an association to be a cause-and-effect relationship (Morris, personal communication), because the most important associations - those which are causal - are likely to be repeatedly identified. Field studies are based on the principle that truth is ultimately inescapable (Meek, 1993).

The use of sophisticated statistical techniques such as path analysis (see next section), along with results from other experimental or observational studies are taken into account for interpretation of results. Therefore conclusions about causality based on epidemiological techniques become a matter of risk assessment. The risk of drawing erroneous conclusions is reduced considerably if existing scientific information supports statistical associations.

1.3.2.4 Statistical analysis of observational data

1.3.2.4.1 Multivariable statistical techniques

Difficulties in analysing data from observational studies result from the fact that various factors are physically or biologically linked in one or more ways, and cannot be regarded as statistically independent. By analysing associations between variables one by one and the

outcome, we may find apparent differences that are in fact due to the effect of a positively linked (correlated) variable rather than the direct effect of the variables actually being measured. Genuinely important variables may be hidden in a screening analysis by negatively linked variables.

Multivariable statistical methods allow the examination of inter-relationships between a group of potential risk factors and outcome variables. Veterinary epidemiologists have adapted these methods for the study of animal diseases, although there have been different statistical approaches. In France, epidemiologists initially developed descriptive techniques, such as correspondence analysis and hierarchical classification, for the study of "systems", characterised by multiple correlated variables. These techniques are valuable to study associations between risk factors and identify "profiles" such as farm profiles or pathological associations (Faye and brochart, 1986; Faye et al., 1991). Elsewhere, the preference was for modeling techniques such as multiple linear regression or multiple logistic regression, which allow the study and quantification of the role of each risk factor while controlling for the effect of other important factors (Kleinbaum et al., 1988; Hosmer and Lemeshow, 1989). Modeling techniques, however, can also be used to identify associations between multiple variables such as between health disorders in dairy cattle (Bigras-Poulin, 1990; Correa et al., 1990; Gröhn et al.,1990), but do not identify pathological profiles in the same way as the French approach.

These two approaches are complementary (Baccini et al., 1987; Daudin, 1987; Ducrot, 1993). For instance, correspondence analysis has been seen more as an intermediate research tool which enables graphical representation of relationships in complex sets of variables. This general view of the data helps understanding of the structure of the data and may suggest hypotheses to be tested in more precise analytic methods (Leclerc et al., 1988).

1.3.2.4.2 Path analysis

Path analysis is a method for the decomposition and interpretation of relationships among variables in causal models using multiple regression procedures (Turner and Stevens, 1960; Wright, 1960; Burridge et al., 1977; Pedhazur, 1982). It was first developed in the early 20's in the field of bovine genetics, but was subsequently used more widely and many of its early applications have been in sociology (Schwabe, 1982). Since the early 1970's, path analysis has been developed for the analysis of veterinary epidemiological data (Goldsmith, 1977).

Path analysis allows epidemiologists to investigate possible causal pathways between variables by sequentially ordering variables in an hypothesised linear causal model. This explanatory model is built on the basis of knowledge, theoretical formulations, and observation of the data (Pedhazur, 1982). It allows both direct and indirect causal pathways to be hypothesised and adjusts for confounding factors. Therefore, path analysis permits the study of complex multivariate systems through manipulation of data in a biologically, as well as statistically sound manner, enabling quantification of hypothesised causal relationships between variables.

In veterinary science, early work in path analysis was done using ordinary least squares regression methods (Curtis et al., 1988c). Multiple linear regression has been used in path analysis of continuous dependent variables, while multiple logistic regression has been progressively adopted for use in path analysis to investigate dichotomous dependent variables. Examples of the use of path analysis in veterinary science are presented in Table 1.4.

Use of path analysis relies on the building of a biologically reasonable null hypothesis causal model. The method depends on the same statistical assumptions as for multiple regression (ie linearity, additivity and uncorrelated residuals), which are difficult to check due to the complexity of the system. Therefore results of path analysis should be regarded as exploratory and indicative (Burridge et al., 1977). "Consistency of the model with the data does not constitute proof of a theory; at best it only lends support to it" (Pedhazur, 1982). This view was shared by Wootton (1994).

Table 0.1 : Examples of veterinary epidemiological studies using path analysis

Year	Country	Outcome under study	Authors
1977	USA	Echinococcosis in New Zealand	Burridge et al., 1977
1981	USA	Production and reproductive diseases in Holstein cows	Erb et al., 1981
1984	Mexico	Bovine brucellosis	Salman et al., 1984a, 1984b
1985	Canada	Postpartum events and reproduction in dairy cows	Etherington et al., 1985a
1985	Canada	Therapy and reproductive performance in dairy cows	Etherington et al., 1985b
1985	Canada	Health and nutrition in Holstein cows	Curtis et al., 1985
1985	USA	Reproduction, milk production and culling in cows	Erb et al., 1985
1986	Canada	Morbidity and mortality in feedlot calves	Martin and Meek, 1986
1987	USA	Bovine brucellosis	Salman and Meyer, 1987
1988	Canada	Calfhood mortality in Holstein cows	Curtis et al., 1988c
1989	New Zealand	Lameness in Dairy cows	Chesterton et al., 1989
1990	Sweden	Health, production and culling in Swedish cattle	Oltenacu et al., 1990
1990	Spain	Bovine leukemia virus transmission	Casal et al., 1990
1990	USA	Postpartum disorders of Holstein-Friesian cows	Correa et al., 1990
1992	USA	Repeat breeder syndrome in Michigan dairy cattle	Lafi and Kaneene, 1992
1993	France	Infertility in breeding cattle	Ducrot, 1993
1993	USA	Calfhood morbidity and mortality in New York Holstein herds	Curtis et al., 1993a
1994	Mexico	Periparturient disorders and reproduction in Holstein cows	Mellado and Reyes, 1994
1994	New Zealand	Weight gain and calving rate in cattle in Indonesia	Hutabarat et al., 1994

Observational studies, along with the use of path analysis, are very useful to formulate hypotheses, and thus build the first links in the causality chain proposed by Evans (1976 cited by Martin et al., 1987). Results from observational analytical studies should be treated as predictions that point to the most important experiments and further observational studies to be conducted next. Those experiments should be deliberately designed to test the potential causal relationship between variables and outcomes. Meek (1993) suggested a more integrated approach using both experiments and field investigations should be carried out to allow better interpretation (ie causality) and use of research results. Wootton (1994), in ecological sciences, showed that combining experimental manipulations with observational studies and path analysis to be an efficient means to uncover important causal pathways.

1.4 OBJECTIVES OF THIS DEER HERD HEALTH AND PRODUCTION STUDY

It was believed that farmed deer "do well" under management practices which enhance their health and well-being, resulting in good production and profitability. However, because of the rapid growth of the deer industry in New Zealand, health and production data may have changed, so there was a need for updated information. Moreover, although information was available on farm management practices (Haigh and Hudson, 1993), little was actually known

about achievable production targets in the commercial farming environment given a range of environmental farm, management or animal characteristics. Most estimates of potential growth or target bodyweights in the literature were based on data from research farms or from specific research projects rather than appropriately sampled farm populations. Little was known also on the relative importance of these characteristics on animal health or how, through the occurrence of diseases, they affect production and profitability.

This deer herd health and productivity pilot study was set up to meet the following objectives :

- To explore the basic health problems and production results for red deer from selected farms in the lower part of the North Island of New Zealand and describe the mean values and variability of key herd production and health parameters.

- To identify and quantify the risk factors (individual deer characteristics, environmental factors, farm characteristics, management practices, etc) that are associated with the most important health and production outcomes including (see conclusion of chapter 3) :
  - health problems, diseases and mortality,
  - reproductive performance,
  - weaner bodyweight and growth,
  - antler production.

- To investigate a range of deer biological characteristics as markers, or risk factors, for sub-optimal production levels and potential health problems.

Ultimately, this research project will have :

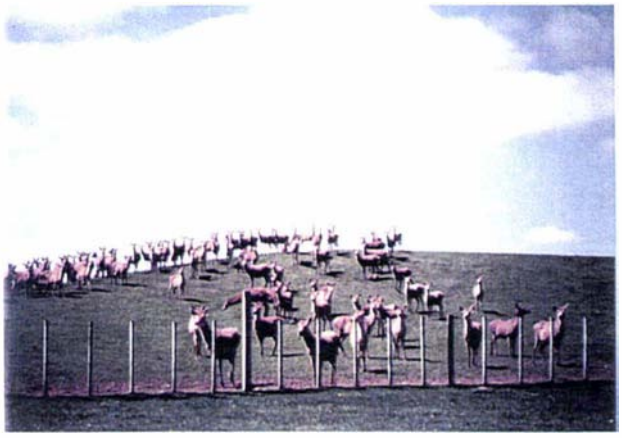
- Generated hypotheses on management strategies for deer farmers that enable cost-effective prevention of diseases, enhancement of performance and productivity.

- Identified the most relevant fields for further research.

- Identified problems that were unknown at the start of the study.

Although only exploratory, this study is a further step for the establishment of a computer model for deer production, as an aid to decision making on deer farms.

This study represents the first application of "herd health and production profiling" to commercial deer production. Its originality is to consider the farms themselves as fields of study, and thus it provides valuable information of the production system. It is a longitudinal observational study based on intensive data collection on farms and analysis of data using advanced multivariable statistical techniques. Path analysis is a very powerful statistical technique to explore complex interrelationships among sets of risk factors, and generate hypothesis on plausible causal pathways and was chosen as the most appropriate statistical technique for this study. Herd health and production profiling is a very cost- and time-efficient method for identifying the likely cause and effect relationships which can then be targeted for research, thus avoiding potential wastage of resources.









CHAPTER 2

STUDY DESIGN AND METHODS

A two-year observational study was carried out on 15 selected commercial red deer farms in the North Island of New Zealand from March 1992 to March 1994.

Codes were established for each variable for computer tabulation. Continuous variables are in normal type, categorical variables are described in italics. Calculated variables are presented with their arithmetic expression in italics (see section 2.6.2).

2.1 SURVEY FARM AND ANIMAL SELECTION

2.1.1 Farm selection - the mail questionnaire

A mail questionnaire (Appendix 2.1) inquiring about possible participation was sent to 370 deer farmers, members of the New Zealand Deer Farmer Association, in the districts within a radius of approximately 150 kilometres of Palmerston North [Manawatu, Wanganui, Taihape, Bush, Hawkes Bay (Table 2.1). Fifteen farms were required. From the 83 responses, a number of farms were considered potentially suitable based on the following criteria :

- They farmed red deer
- They farmed breeding hinds
- No use of wapiti type deer as a terminal sire in 1991
- Adequate handling facilities for collection of blood and faecal samples and the recording of data from individual deer (a weighing machine was required)
- Farm free of tuberculosis
- Selected farms ranged from 150 to almost 2000 deer (Table 2.2).

Table 2.1 : Location and number of deer farms selected for participation in the mail questionnaire

District	Deer farms targeted	Responses Number	%	Farms short-listed
Manawatu	85	22	26	3
Wanganui	43	8	19	1
Taihape	40	7	18	2
Bush	40	9	23	4
Hawkes Bay	162	37	23	7
Total	370	83	22	17

After their local veterinarians were approached for an opinion on suitability, 17 farms as detailed in Table 2.1 were short-listed for personal visits by the researcher and the supervisor. A number of farms were designated as "reserves" should 15 of the initial 17 not be suitable.

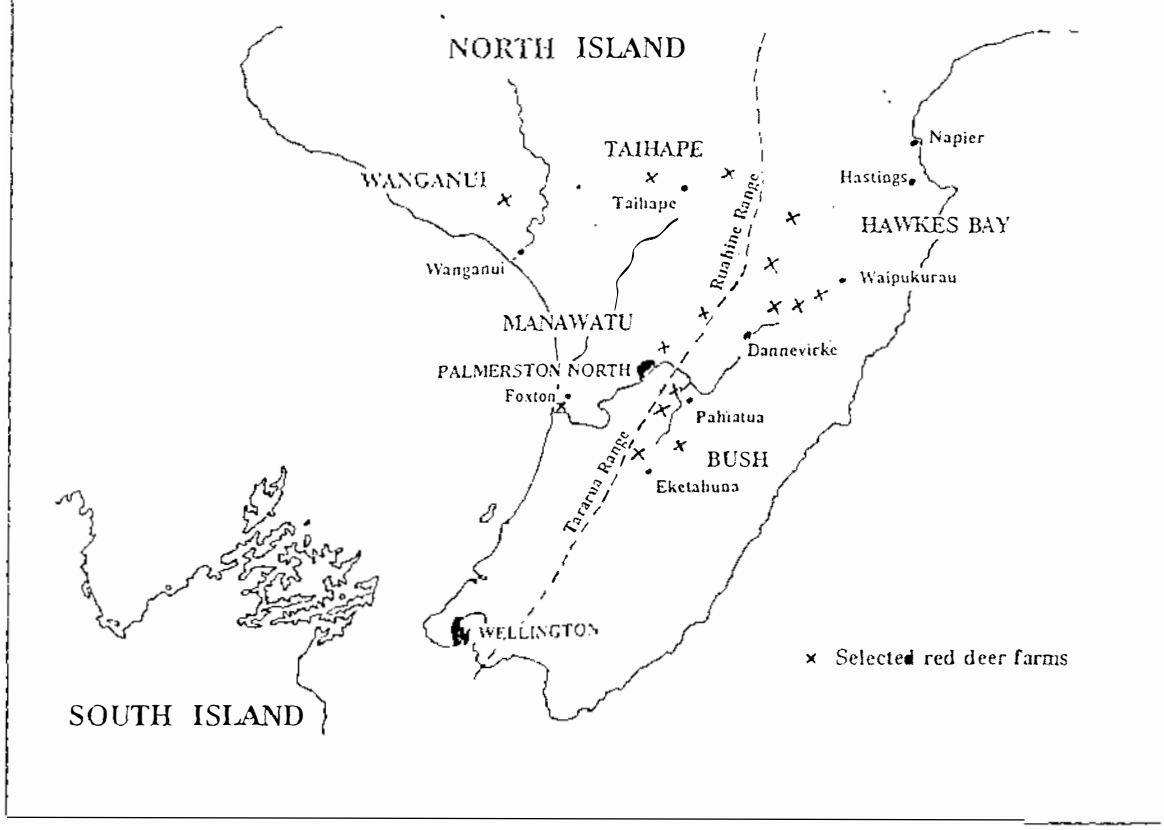
After individual visit in October-December 1991, final selection was made based on the following assessment :

- Current recording system or willingness for improvement
- Farmer personality and enthusiasm
- Farmer reliability and capability

Extensive explanation of the project was given directly during visits prior to the start of the survey. Because the study was observational and not interventionist, it was stressed that information could not be disclosed until its completion. Some data, however, could be disclosed to the farmer's veterinarian, if requested, as part of their usual veterinary service to the property.

Fifteen farms containing 7117 deer were finally selected. Their locations and characteristics are presented in Figure 2.1 and Table 2.2, respectively. The veterinary practice servicing each property was visited and the protocol explained.

Figure 2.1 : Location of selected farms in the Southern part of the North Island



A meeting was held of all participating farmers and appropriate staff at Massey University late February 1992 to enable personal contact between farmers and give some more details on the recording protocol. A folder containing all recording sheets that were needed (see section 2.3), along with an explanatory note, was provided at that meeting. The folder contained the initial set of recording sheets. Some sheets worked well, while others were modified or discontinued based on experience. Recording sheets presented in this thesis are the final or modified versions.

Farmer data collection started in March 1 1992. Two farms withdrew from the survey in late April. One farmer experienced a tuberculosis outbreak on his farm which led to the destruction of almost every deer on the farm. The other farmer stopped recording after being seriously injured and hospitalised. Two other farms were immediately selected as replacements (Table 2.2).

Farm 14 was dropped from the project in March 1993 because complete records could not be obtained according to the protocol. This farm was not replaced.

Table 2.2 : Total and deer-fenced areas and stock numbers of selected farms in each district.

District and designated farm number[1]	Total Farm Area (ha)	Deer fenced Area (ha)	Deer Stock[2]			
			Weaners	Hinds	Stags	Total
BUSH						
1	61	61	90	115	84	289
2	360	55	100	215	10	325
3	516	45	40	160	50	250
4	180	20	62	81	3	146
MANAWATU						
5	57	42	60	90	90	240
6	445	48	100	142	75	317
7	24	24	45	80	34	159
TAIHAPE						
8	230	62	100	235	15	350
9	450	53	71	87	31	189
HAWKES BAY						
10[3]		47	120	183	50	353
10[4]	39	38	47	205	38	290
11	404	55	75	182	112	369
12[3]		57	105	174	72	351
13	611	70	58	157	75	290
14	274	274	250	1140	570	1960
15	791	453	324	1155	201	1680
WANGANUI						
16[4]	168	79	89	124	50	263
Total[5]		1379	1511	4168	1438	7177

[1] This farm numbering system is used throughout this thesis
[2] Figures returned on the participation questionnaire mailed in Sept 1991
[3] Farms that with withdrew early late April 1992
[4] Farms selected in May 1992 to replace early withdrawals
[5] Totals do not include the two farms that withdrew early in the study

2.1.2 Animal selection

All deer on each property were designated to categories :

- Weaner : deer from 3 to 15 months of age (February 28)
  WS = Weaner Stags WH = Weaner Hinds
- Yearling : deer from 15 months (March 1) to 27 months (February 28)
  YS = Yearling Stags YH = Yearling Hinds
- Adult : Deer older than 27 months
  AS = Adult Stags AH = Adult Hinds

During the first farm visits (see section 2.2.2), 5 deer of each category were selected on each farm and identified as "sentinel deer" with a second ear-tag[1] or a plastic collar[2]. Sentinel deer were progressively selected as deer were pushed through the yards and separated into groups of 5 to 10 deer in small pens. If deer were quiet enough, the researcher entered each pen and, after closing his eyes, selected a deer. During subsequent farm visits, other deer were selected in replacement if any sentinel deer had left the farm or could not be handled.

In March 1992, new sentinel weaners were similarly selected except on farm No13 where the farmer did it himself prior to the arrival of the researcher and released the rest of the mob onto paddocks away from the yard. Sentinel weaners that were selected in 1992 were kept as sentinel yearlings in 1993. On each farm, two YH and three AH that were selected in 1992 were kept as AH in 1993 and AS were similarly selected: ie, data for 10 deer were collected over both years.

Table 2.3 : Total number of deer surveyed and deer individually monitored

	WEANERS		HINDS		STAGS	
Date	Total	% stags	Total	% yearling	Total	% yearling
Deer surveyed [1]						
Year 1992						
1-Apr	2572	49.4	3609	17.5	1233	35.6
1-Jun	2219	47.6	3077	18.8	1177	33.4
Year 1993						
1-Apr	1634	50.2	2430	20.3	1367	31.7
1-Jun	1385	50.6	2243	21.3	1385	33.3
Deer individually monitored [2]						
March 1992	2013	50.4	2752	16.6	1168	37.1
March 1993	1786	49.9	2579	20.9	1482	38.2

[1] Figures from farmers' grazing records
[2] Figures from listings of tag identifications

[1] Ear-tag provided by Allflex New Zealand Ltd, Palmerston North, New Zealand
[2] Collar provided by Te Pari product Ltd, Asshurst, New Zealand

The number of surveyed deer in each category after weaning (April 1) and before winter (June 1) are presented in Table 2.3. The tag identifications of all deer on each property were listed, except on farm 14 and 15 where recording of deer was performed only from mobs including "sentinel deer".

A "mob" was defined as any group of animals (deer, cattle, sheep or goats) that was managed as a single entity. Any mob grazed within the deer farm was recorded, except on farm 14 where only mobs including sentinel deer were surveyed.

2.2 INDIVIDUAL FARM CHARACTERISTICS

2.2.1 Farmer and farm profile

Farmers responded to a closed questionnaire (Appendix 2.2) about their family, their education and training, their involvement and commitment in deer farming, some farm characteristics (altitude, size, stock wintered) and the disease history of the deer farm (Appendix 2.3).

2.2.2 Farm layout

Farm layouts were described using maps (Appendix 2.4). When necessary, the total deer-fenced area was estimated from a scaled aerial photograph of the farm. Paddock areas were calculated using the computer package "Farmtracker". Each deer fenced paddock was described after physical inspection with characteristics and scores where appropriate as described in Table 2.4. Lane characteristics and yard designs were also described by inspection, and where appropriate, measurement with a standard tape-measure (Table 2.5)

Figure 2.2 : Examples of paddock descriptive variables

1.



Steep paddock (TOPO=3) with no trees (TREES=0) and a dam (DAM=1).

2.



Paddock steep and rolling (TOPO=2.5) with no trees (TREES=0), a deep gully (GULLY=3), some thistles (THISTLES=2) and no shelter beltt (BELT=0)

3.



Steep paddock (TOPO=3) with a stream (STREAM=1) and no shelter belt (BELT=0)

4.



Rolling paddock (TOPO=2) with a trough (TROUGH=1), a gully between 2 and 10 m deep (GULLY=2) and no trees (TREES=0)

5.



Flat paddock (TOPO=1) with a river (RIVER=1), a tree (TREES=1) and dense bull rushes (BULLR=3)

6.



Rolling and flat paddock (TOPO=1.5) with a high shelter belt (BELT=3) and medium density of bull rushes (BULLR=2).

Table 2.4 : List of variables used to describe each deer-fenced paddock.

Code	Unit	Range	Description
General characteristics			
PAREA	ha		Paddock size (deer fenced area)
EPAREA	ha		Effective deer fenced area
PSUR			Paddock proximity to road, buildings or houses (ie signs of human presence) *1 = Yes; 0 = No*
Topography variables (Figure 2.2)			
PFLAT	%		Visual estimate of the percentage of flat area in the paddock
PSTEEP	%		Visual estimate of the percentage of steep area in the paddock (Area identified by tracks made by deer while grazing)
PTOPO		1-3	Paddock topography score *(PFLAT + 2*(100-PFLAT-PSTEEP) + 3*PSTEEP)/100*
Shelter variables			
PHILL			Presence of a hill in the middle of the paddock and visual estimate of its height *0 = no hill 1 = small hill less than 5 meters high 2 = hill between 5 and 10 m high 3 = hill over 10 m high*
PGULLY (see Figure 2.2)			Presence of depression or gully and visual estimate of their depth *0 = no holes or gully in the paddock 1 = small hole, depression or gully no deeper than 1 m 2 = gully or depression between 1 and 5 m deep 3 = big gully over 5 m deep*
PTREES			Presence of trees (see Figure 2.2) *0 = no trees 1 = one or more disseminated isolated trees 2 = one or more bunch of trees (5-10 trees) 3 = one or more big group of trees, or part of a forest*
PMACRO			Presence of at least one macrocarpa tree *1 = Yes; 0 = No*
PSTUMP			Presence of stump, branches, or objects (eg. drums, rubbish) in the paddock *1 = Yes; 0 = No*
PBULLR			Presence of bull rushes (see Figure 2.2) *0 = no bull rushes 1 = a few plants (from 1 to about 10) 2 = bunches of bull rushes in some area 3 = large numbers of bull rushes widely scattered*
PBELT (see Figure 2.2)			Presence of shelter belt (line of scrub or trees along the fence or in the paddock which may protect deer from the wind) *0 = no shelter belt or belt less than 0.5 m high 1 = small shelter belt between 0.5 m and 2 m high or made of sparse trees or scrub 2 = shelter belt between 2 m and 5 m high 3 = shelter belt over 5 m high (usually made of trees)*

Cont'd

Table 2.4 (Cont'd)

Code	Unit	Range	Description
Shelter variables			
PWESTB			Potential protection by shelter belt, hill and gully,
PWESTH			against westerly winds.
PWESTG			(Scores were used as defined for PBELT, PHILL and PGULLY)
Similar scores were also recorded for easterly, southerly and northerly winds (see Figure 2.2)			
PSHELT		0-39	Overall paddock shelter score
(TREES + PWESTB + PWESTH + PWESTG + PEASTB + PEASTH + PEASTG + PSOUTHB + SOUTHH + PSOUTHG + PNORTHB + PNORTHH + PNORTHG)			
Pasture variables (recorded in 1992 and 1993)			
PPAST			Type of pasture (visual appraisal) *1 = Ryegrass-white clover pasture* *2 = Ryegrass-white clover pasture mixed with some other pasture species such as browntop or cocksfoot* *3 = Pasture predominantly browntop or cocksfoot*
PCHIC			Presence of chicory in the paddock *1 = Yes; 0 = No*
PTHISTLE		0-3	Presence of thistles *Average of thistle scores recorded during farm visits as described in Table 2.21 (calculated separately for 1992 and 1993)*
PRAG		0-3	Presence of ragwort (similar score as PTHIS)
Other variables			
PWIRE%	%		Percentage of paddock fence being wire-and-batten close to the ground as opposed to netting fences (estimation from paddock visits and farm computerised maps)
PDAM			Presence of a dam, pond or swamp (see Figure 2.2) *1 = Yes; 0 = No*
PSTREAM			Presence of a stream that dries in summer *1 = Yes; 0 = No* (see Figure 2.2)
PRIVER			Presence of a river or stream all year round *1 = Yes; 0 = No*
PTROUGH			Presence of a water trough (see Figure 2.2) *1 = Yes; 0 = No*
PSHEEP			Possibility of sheep grazing in paddocks adjacent to the deer farm (for boundary deer paddock only) *1 = Yes; 0 = No*
PCATTLE			Possibility of cattle grazing in paddocks adjacent to the deer farm (for boundary deer paddock only) *1 = Yes; 0 = No*
PFP		0-3	Fence pacing score *Average of fence pacing scores recorded during farm visits as described in Table 2.22 (calculated separately for 1992 and 1993)*

Table 2.5 : List of variables used to describe lanes and deer-yards

Code	Unit	Description
General handling equipment (recorded as dummy variables, eg 1=Yes, 0=No)		
HOPAD		Use of a holding paddock to keep deer mobs before yarding
HOPEN		Use of at least one holding pen to keep deer mobs before yarding.
A holding pen was defined as an area surrounded by solid wooden walls or horticultural shade cloth, rather than wire fences, designed only for holding deer before yarding and for splitting mobs into smaller groups.		
SHADE		Shade cloth(or wood) on the fence at the end of the lane at the approach to holding pens or the yard.
The yard is defined as the main building (usually covered) where deer are individually handled		
LANEHPY		Presence of small lane conducting to the yard door from the holding pens or the main lane.
The yard door is defined as the door by which deer enter into the yard.		
ENTRYW		Wire fence up to the yard door
CIRCP		Circular central pen
CIRCD		Rotating doors in circular pen
PEN		Small pen to handle deer (pen less than 4 m^2)
CRUSHF		Drop-floor crush
CRUSH		Crush system without dropping floor
WEIGHB		Weigh scale in box
WEIGHC		Weigh scale in open crush
WEIGHP		Weigh scale in a small to medium size pen
YLIGHT		Electric light inside the deer-yard
COVER		Yard completely closed by walls and roof
WALLS		Solid walls and doors inside the deer-yard
FLOOR		Solid flooring (bricks or concrete) in the yard
Lane and holding pen measurements		
LANEWP	m	Width of lane between paddocks
LANEWY	m	Width of the lane conducting to the yard
HPENS	m^2	Size of the holding pen
SLW	m	Width of the lane or pen conducting to the yard
SLL	m	Length of the lane or pen conducting to the yard
Yard measurements (continuous variables)		
SIZEY	m^2	Total area of the covered deer-yard
WENTRY	m	Width of the yard door
INSPEN		Number of pens inside the yard usually used to sort and hold deer
SIZEBP	m^2	Size of the biggest inside pen
SIZEMP	m^2	Size of the smallest inside pens
WINSD	m	Mean width of the doors between inside-pens
DCIRCP	m	Diameter of the circular pen
WLRAMP	m	Width of the loading ramp
LLRAMP	m	Length of the loading ramp

2.3 FARMER RECORDING

Farmers recorded their management practices and events using specific recording sheets provided as outlined in Table 2.6. The actual recording sheets are presented in Appendices 2.5 to 2.20.

Table 2.6 : Summary of recording sheets (reports) completed by the farmer

Recording of farm management practices		
Deer mobs	* Pasture height and stock report	* Deer work in yard report
	* Food supplementation report	
Paddocks	* Paddock management report	
Questionnaires	* Mating management report	* Calving management report
	* Deer handling report	* Stock reconciliation report
Individual deer	* Deer listings	* Velvetting diary
Recording of deer health problems		
Diseases	* Health problem report	* Disease occurrence reports
	* Calving problem report	* Slaughter information report
Deaths	* Post-mortem examination report	
	* Calf mortality report	
Other recording	* Farm maps	
	* Weather data report	

* represents an individual recording sheet

2.3.1 Recording of farm management practices

2.3.1.1 Grazing management and sward height

Grazing variables recorded are presented in Table 2.7. and illustrated in Figure 2.3.

Using "Pasture height and stock" recording sheets (Appendix 2.5), farmers reported the movement of mobs within the deer fenced area. A new line was filled in each time there was a change of paddock, a change in composition of the mob, or at least every 7 to 10 days if mobs were to be set stocked for more than two weeks. Farmers could fill these sheets on a mob or paddock basis as they preferred.

Each line in this report defined a "grazing interval" and identified mobs or paddocks; the start and end dates of the grazing interval; initial and final sward heights, estimation of clover content, seed head height and seed head density, deer mob composition, and the presence of other livestock species. Start and end dates of grazing intervals are coded "ENTRY" and "LEAVE" dates, respectively, for data calculations (see section 2.6.2.2.1).

The tag identifications of deer were recorded for each mob to identify deer that had been under the same grazing management.

Figure 2.3 : Examples of pasture measurements recorded by the farmer

1. Pasture sward height (GISWH or GRSWH)



Pasture sward height = 9 cm



Pasture sward height = 18 cm

2. Pasture clover score (GCLOVER)



Grass dominant pasture (G = 1)

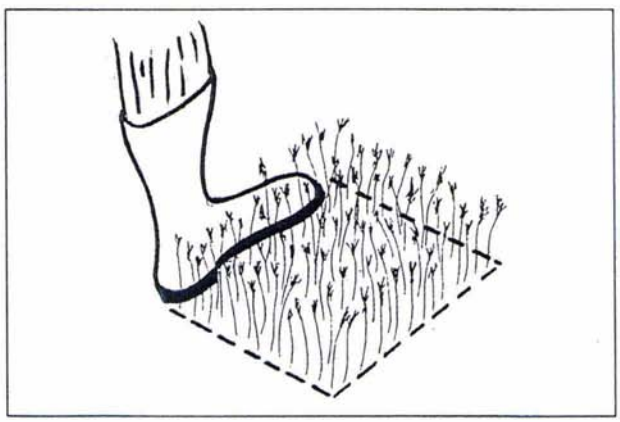


Clover dominant pasture (C = 3)

3. Seed head density score (GSHD)



Low seed head density (L = 1)



High seed head density (H = 3)

The sward height was defined as the length from the ground to the tip of the green leaves of the grass and was estimated after taking a few random measurements with a simple ruler as described in Figure 2.3. During the first visit (see section 2.4), farmers learned the technique by measuring the sward on each deer-fenced paddock with the researcher. It was advised to avoid clumps of long grasses and to measure the sward every 3-4 steps in an area representative of the paddock. If the pasture cover was even, 5 to 6 measurements were sufficient to obtain the sward height estimate, otherwise, up to 10 measurements should be made for a more accurate estimation.

Table 2.7 : List of grazing variables recorded by the farmer

Code	Unit	Description	
Pasture variables			
GISWH	cm	Pasture sward height at the start of grazing interval[1]	
GFSWH	cm	Pasture sward height at the end of the grazing interval[1]	
GCLOV		Pasture clover score estimated by a visual assessment (Figure 2.3)	
		1 = G = Grass dominant	
		2 = M = Mixed	
		3 = C = Clover dominant	
GSHD		Pasture seed head density score (Figure 2.3)	
		1 = L = Low density = less than 5 seed heads per square area of the length of the farmer's foot	
		2 = M = Medium density = between 5 and 50 seed heads	
		3 = H = High density = more than 50 seed heads	
Deer stock variables			
GWH		Number of weaner hinds in the mob during the grazing interval	
GWS		Number of weaner stags	
GYH		Number of yearling hinds	
GAH		Number of adult hinds	
GYS		Number of yearling stags	
GAS		Number of adult stags	
Other stock variables[2]			
GCATTLE		Number of cattle	
GSHEEP		Number of sheep	
GGOAT		Number of goats	
These variables were subsequently categorised as :			
CLCATTLE		Presence of cattle	*1 = Yes; 0 = No*
CLSHEEP		Presence of sheep	*1 = Yes; 0 = No*
CLGOAT		Presence of goats	*1 = Yes; 0 = No*
OTHERST		Presence of cattle, sheep or goats	*1 = Yes; 0 = No*

[1] Definition of "grazing interval" in the text, sward height measurement method described in the text and in Figure 2.3.
[2] Farmers recorded the number of each class of stock as described in Appendix 2.14 and data were recoded as described in this table for analysis.

The code given to deer mobs was left to the farmer as long as numbers were not used twice. If farmers split one deer mob in two or more sub-groups run separately from other previously defined

mobs, they renumbered each sub-group and recorded their management. However, if a sub-group was shifted to another identified mob, no numbering was necessary. When two mobs were mixed, the identification number kept was that of the biggest of the two mobs.

The location of electric fences to subdivide paddocks or to have deer strip graze, were reported on farm maps. Alternatively, when the electric fence was moved, the percentage of the grazed paddock area was estimated. An initial sward height was measured for each new paddock strip, and a final sward height measurement was made before deer left the whole paddocks.

2.3.1.2 Food supplementation

For each mob of deer, food supplements (pasture hay, silage, maize, etc), the daily quantity given to each mob and an estimate of waste were recorded (Appendix 2.6). Two types of sheet were used depending on whether farmers preferred to record on a day-to-day basis or indicate supplementation periods and supplementation frequencies on a less regular basis.

Food supplement quantities could be recorded as the number of small bales, big round bales, buckets or kilograms given per deer or to the entire mob. Whenever possible, an average weight of these units of food supplement was recorded by the farmer to convert quantities to kilograms. Codes were used as described in Table 2.8 to facilitate the computer data entry.

Table 2.8 : Food supplement variables recorded by the farmer

Code	Unit	Description	
FDATE		Date of food supplementation	
FOOD1		Type of food supplement	
		SH = Sward hay	*PH = Peavine hay*
		CH = Clover hay	*BA = Balage*
		LH = Luzerne hay	*SI = Silage*
		MA = Maize	*BY = Barley*
FORM1		Food supplement unit	
		BA = Small bale	*RB = Big round bale*
		KG = Kg	*BU = Bucket*
QUANT1		Quantity of food supplement unit given to the mob	
QD1		Quantity of food supplement unit given per deer	
WASTE1	%	Estimation of waste	

Similar codes ending with "2" were created for the recording of a second food supplement type

2.3.1.3 Deer work in the yard

Farmers reported on the "Deer work in yard" report all other deer management practices. Most related to work that was carried out in the deer yard such as sorting mobs and weighing, disease prevention such as vaccination, parasite control, trace element supplementation, tuberculosis testing, disease treatment, and velvet harvesting.

Table 2.9 : Variables used to record the work with deer in yards

Code	Unit	Description	
YDWD		Date of the work with deer	
YMOB		Identification of the deer mob	
YEVENT		Type of work *YA = Yarding for weighing, pregnancy testing or sorting* *VE = Velvet harvesting* *HE = Health control TT = Disease treatment*	
YWEIGH		Weighing all deer during yarding	*1 = Yes; 0 = No*
YIPC		Internal parasites control (drenching)	*1 = Yes; 0 = No*
YVAC		Vaccination against clostridial diseases	*1 = Yes; 0 = No*
YYERS		Vaccination with "Yersiniavax"	*1 = Yes; 0 = No*
YTES		Trace element supplementation (mainly copper)	*1 = Yes; 0 = No*
YPRE		Pregnancy testing hinds	*1 = Yes; 0 = No*
YBCS		Body condition scoring hinds	*1 = Yes; 0 = No*
YDRUG		Animal remedy used for disease treatment or prevention (See Table 3.12)	
YIVE		Use of an Ivermectin/Albemycin type based anthelmintic	*1 = Yes; 0 = No*
YDOSE	ml[1]	Dose of anthelmintic or cupric oxide rods administered to each deer	
YLU		Number of people working with deer	
YTIME		Time spent	
YCOSTD	NZ$	Total cost of drug used (drug prices are discussed in section 2.6.2.5.)	
YCLU	NZ$	Total cost labour unit (calculated at NZ$ 12 /hour).	

[1] Doses of cupric oxide rods were given in grams

Farmers reported the date, mob, type of work, type of drug and dosage if used, number of people who worked and time spent.

2.3.1.4 Reproductive management

Management of hind mobs and their composition during the mating season were recorded along with the date when sire stags were introduced to hind mobs, back-up stags were used, withdrawal of sire stags, and individual characteristics of each sire. The recording sheet is presented in Appendix 2.8, mating mob variables are presented in Table 2.10.

Calving mobs were identified before set stocking for calving. A short questionnaire was completed to investigate human presence around hinds during calving (Appendix 2.8). Weaning management practices were recorded indirectly and coded from grazing and deer work records. Variable codes are presented in Table 2.11.

2.3.1.5 Deer handling

Questions were asked about the way farmers handled deer in paddocks and yards, and how farmers perceived the behaviour of their deer (Table 2.12) The questionnaire is presented in Appendix 2.9.

Table 2.10 : Mating management variables

Code	Description	
Overall mating management		
WEAN	Number of days between February 15 and weaning	
JOIN	Number of days between February 15 and joining with stag(s)	
YSPM	Yearling stags grazing with yearling hinds up to the mating period	
	1 = Yes; 0 = No	
REM	Number of days between March 15 and sire stag removal	
Characteristics of mating mobs.		
Specific to first mating mob (when hinds joined with first sire stag(s))		
YS	Presence of only one or more yearling sires	*1 = Yes; 0 = No*
WAPS	Presence of one or more wapiti stag	*1 = Yes; 0 = No*
NZS	Presence of only pure New Zealand sire stag	*1 = Yes; 0 = No*
AGES	Sire age (or highest age of sires if multiple sire mating is used)	
WSIRE	Sire pre-rut weight (or highest weight of sires)	
YSMATE	Yearling hinds left with their yearling stag mates during the rut	
		1 = Yes; 0 = No
Variables common to first mating mobs and back-up mobs[†]		
AH	Number of adult hinds	
CLAH	Presence of adult hinds with yearling hinds	*1 = Yes; 0 = No*
YH	Number of yearling hinds	
SIRE	Number of sires	
SSIRE	Single sire mating	*1 = Yes; 0 = No*
RATIO	Hinds to sire stag ratio calculated as *(AH+YH)/SIRE*	
EXP	Use of at least an experienced sire stag	*1 = Yes; 0 = No*
CHS	Use of one or more back-up stags	*1 = Yes; 0 = No*
BACK	Use of one or more back-up stags before May 1	*1 = Yes; 0 = No*
Specific to back-up mob (after first sire stags were replace by back-up stag(s))		
BACKD	Number of days between April 1 and first back-up before May 1	
BACKM	Use of a back-up sire after May 1	
CHD	Number of days between March 1 and the first changing date	
USED	Back-up stag(s) already used as sire from joining	*1 = Yes; 0 = No*

[†] Similar variables were recorded for subsequent mating mobs if back-up stags were used, codes ending with "2" for back-up mob (second mating mobs, ie when back-up sire stags are used).

2.3.1.6 Other recording

Management practices were recorded for deer paddocks included fertilising, spraying for weeds, making hay or silage, and fencing.

Weather data were recorded daily from farmer's houses as described in Table 2.13 with the Beaufort wind scale in Table 2.14. They were collected monthly using the weather report presented in Appendix 2.11.

The cloud cover, as opposed to sunshine, was recorded with checks (√) on the weather report (Appendix 2.11.). Columns "Sun" or "Cloud" were checked if the day was mainly sunny or cloudy, respectively. If the day was sunny about half of the time, both columns were checked. Instead, some farmers reported the daily percentages of cloud, so their data was transformed before analysis for consistency. Arbitrarily, when SUN was recorded below 40%, between 40 and 60% inclusive, and over 60%, it was entered as scores 0, 0.5 and 1, respectively. Although this cannot be verified, it was assumed that farmers would have checked both cases in the recording sheet instead of recording SUN between 40 and 60%.

When farmers did not record part of the weather data, it was obtained from the nearest survey farm. Farmer 6 did not record wind and sun data, so it was obtained from farm 7 located about 14 kilometres from farm 6. Similarly, all weather data but rainfall for farm 2 were obtained from farm 1 located about 8 kilometres from farm 2.

Table 2.11 : Calving and weaning management variables

Code	Unit	Description
Calving management variables		
Overall farm management (the questionnaire is presented in Appendix 2.8)		
SET	days	Number of days between October 1 and the date when hinds were set-stocked for calving
VISIT/W		Number of visits of calving hinds per week by the farmer
ENTERP		Frequency of entering inside calving paddocks during visits *0 = Never* *1 = <50 % of the time* *2 = >50% of the time* *3 = Always*
VISITCP		Close monitoring calving hinds by moving throughout the calving paddock *1 = Yes; 0 = No*
TAGB		Tagging of calves at birth *1 = Yes; 0 = No*
Characteristics of calving mobs (data from grazing records and individual hind dataset)		
HINDCM		Number of hinds in the calving mob
%AHCM	%	Percentage of adult hind (hinds at least 3 years old) in the calving mob
CLAHC		Paddocks shared with adult hind(s) at least one day during calving and early lactation *1 = Yes; 0 = No*
HIND/Ha	hind/ha	Number of calving hinds per deer-fenced hectare (grazing density)
Weaning variables*		
WEAN		Number of days between January 1 and weaning
YARDBW		Calves yarded at least once in yards before weaning *1 = Yes; 0 = No*

* Disease prevention variables at or just after weaning are presented in Table 2.33.

Table 2.12 : Handling management variables

Code	Unit	Description	
Work with deer in paddocks			
HMOT	%	Percentage use of motorbikes, car or small 4-wheel-drive to shift mobs between paddocks (as opposed to shifting mobs by foot)	
HLUP		Number of people to shift deer between paddocks	
HLUY		Number of people to shift deer to the yard	
HDOG	%	Percentage of use of at least one dog to shift deer mobs	
HBDOG		Barking dog	*1 = Yes, 0 = No*
HTDOG		Dog responding well to the farmer's commands	*1 = Yes, 0 = No*
HCALMF		Farmer very calm and patient when shifting mobs	*1 = Yes, 0 = No*
HNOISE		Farmers making noise when shifting deer mobs	*1 = Yes, 0 = No*
HBMOB		Behaviour of deer mobs when shifting to the yard *1 = Very calm (deer almost follow the farmer through paddock gates).* *2 = Deer calm, but need to be pushed through paddock gates.* *3 = Deer restless, running around the paddock before getting through paddock gates.*	
Work with deer in the yards			
HPHAND		Number of people to handle deer in the yard	
HNOISE		Farmer speaking loudly or shouting when handling deer in yards *1 = Yes; 0 = No*	
HENTY		Manner of deer entering the deer-yard in general *1 = They enter quickly* *2 = They enter easily without rush* *3 = They don't enter easily even when pushed*	
HMOVY		Manner of deer moving inside the deer-yard in general *1 = They move quickly as soon as you open a gate* *2 = They move easily after slight push* *3 = They don't move easily even when pushed*	
AGGRES		Presence of aggressive deer	*1 = Yes, 0 = No*
CAGGRES		Culling of aggressive animals	*1 = Yes, 0 = No*

Table 2.13 : Daily weather variables recorded by the farmer

Code	Unit	Description
MINTP	°C	Minimum temperature
MAXTP	°C	Maximum temperature
RAIN	mm	Rainfall
WIND		Wind score using the Beaufort scale (see Table 2.14)
WINDD		Estimated dominant wind direction *W = Westerly wind* *SW = Southwesterly wind* *E = Easterly wind* *SE = Southeasterly wind* *S = Southerly wind* *NE = Northeasterly wind* *N = Northerly wind* *NW = Northwesterly wind*
DWW[1]		Westerly wind score > 2 Wind Beaufort score if WINDD = W, NW or SW and WIND>2
DEW[1]		Easterly wind score >2 Wind Beaufort score if WINDD = E, NE or SE and WIND>2
DSW[1]		Southerly wind score >2 Wind Beaufort score if WINDD = S, SW or SE and WIND>2
DNW[1]		Northerly wind score>2 Wind Beaufort score if WINDD = N, NW or NE and WIND>2
DSUN[2]	%	Percentage of daily sunshine transformed as : *0 = < 40% = only the column "SUN" was checked* *0.5 = > 39%,<61% = both columns "SUN" and "CLOUD" were checked* *1 = > 60% = only the column "CLOUD" was checked*
DCLOUD[2]	%	Percentage of daily cloud cover

[1] Variables created from the farmer's records for the calculation of the paddock wind exposure index (see Table 2.31)
[2] Variables alternatively recorded with checks as described in the text.

Table 2.14 : Beaufort wind scale[†]

Score	Titles	Specification of Beaufort scale for use on land
00	Calm	Calm; smoke rises vertically
01	Light air	Direction of wind indicated by smoke drift, but not by wind vanes
02	Slight breeze	Wind felt on face; leaves rustle; ordinary vane moved by wind
03	Gentle breeze	Leaves and small twigs in constant motion; wind extends light flag
04	Moderate breeze	Raises dust and loose paper; small branches moved
05	Fresh breeze	Small trees in leaf begin to sway; wavelets form on inland waters
06	Strong breeze	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty
07	Near gale	Whole trees in motion; inconvenience felt when walking against wind
08	Gale	Breaks twigs off trees; generally impedes progress
09	Strong gale	Slight structural damage (chimney pots and slates removed)
10	Storm	Seldom experienced inland; trees uprooted; considerable structural damage occurs
11	Violent Storm	Very rarely experienced; accompanied by widespread damage
12	Hurricane	Wind above 118 kilometres per hour

[†] from National Institute of Water & Atmospheric Research Ltd, Wellington

2.3.2 Health problems

Recording sheets for health problems are presented from Appendix 2.13 to Appendix 2.18

All health problems noticed by farmers were reported on the "Health problems" sheet (Appendix 2.13), giving date, deer and mob identification and brief description of the problem. Health problems were any observations that should not be seen on an apparently healthy deer, such as injuries, abscesses, lameness, scouring, fading, and death.

It was preferred that post-mortem examinations be carried out by the researchers or local veterinarians and data recorded. However where that was not possible, an attempt to record the cause of each disease or death, clinical signs, treatments or post-mortem observations was made on specific sheets (Appendix 2.14). A post-mortem form (Appendix 2.15) was provided to farmers to guide them through any autopsy they would perform themselves, in particular for the collection of organ samples. Some pots filled with 10% formalin were provided to take and store organ samples if an autopsy was carried out on a farm.

Health problem variables are presented in Table 2.15.

Table 2.15 : Health problem variables

Code	Unit	Description	
OBS		Date of observation	
OUT		Known or estimated date of outcome	
CLASS		Deer category	
MOB		Mob identification	
DEERID		Deer tag identification	
HPB		Type of health problem	
		DI = Disease	
		DE = Death	
DIAG		Diagnosis or main clinical or lesion (see codification in Table 2.17)	
VET		Intervention of the veterinarian	*1 = Yes; 0 = No*
PM		Post-mortem examination	*1 = Yes; 0 = No*
LAB		Laboratory confirmation	*1 = Yes; 0 = No*
TREAT		Treatment of the disease	*1 = Yes; 0 = No*
DRUGT		Drug used for treatment	
DOSE	ml	Drug dosage	
DAYS		Number of days of drug administration	
CDRUG	NZ$	Total cost of drugs	
CLU	NZ$	Total cost of labour at NZ$ 12 per hour	
COSTT	NZ$	Total cost of treatment (Drugs + Labour + Vet fees)	

Table 2.16 : Dystocia and calf mortality variables

Code	Unit	Description	
Dystocia variables			
DOBS		Date of observation	
DCM		Calving mob identification	
CLASS		Deer category	
CMOB		Calving mob identification	
PAD		Paddock identification	
DEERID		Deer tag identification	
SEXC		Sex of the calf	*1 = M = Male ; 0 = F = Female*
CALFW	kg	Calf weight	
DYS1		Calf survival during dystocia	*1 = Yes; 0 = No*
DYS2		Calf position	
		BAL = Back legs first	*FRL = Front legs first*
		BFL = Back and front legs first	
		BLH = Back legs and head first	*HEB = Head back*
VETI		Veterinary intervention	*1 = Yes; 0 = No*
FARMI		Farmer intervention	*1 = Yes; 0 = No*
DDRUGR		Use of drug for restraint	*1 = Yes; 0 = No*
DCRUSH		Use of crush for restraint	*1 = Yes; 0 = No*
DTT		Treatment after intervention	*1 = Yes; 0 = No*
DSURVH		Hind survival after dystocia	*1 = Yes; 0 = No*
DSURVC		Calf survival	*1 = Yes; 0 = No*
DMOTH		Calf mothered after dystocia	*1 = Yes; 0 = No*
Calf mortality variables			
COBS		Date of observation	
CMOB		Calving mob identification	
CPAD		Calving paddock identification	
SEXC		Sex of the calf	*1 = M = Male 0 = F = Female*
CALFW	kg	Calf weight (if fresh carcass)	
CFENCE		Calf found through fence	*1 = Yes; 0 = No*
CTRAU		Signs of trauma on the calf	*1 = Yes; 0 = No*
CLUNG		Lungs of the calf inflated	*1 = Yes; 0 = No*
CHOO		Hoof pads worn	*1 = Yes; 0 = No*
CMILK		Presence of milk in the stomach of the calf	*1 = Yes; 0 = No*
CDIAR		Presence of liquid faeces	*1 = Yes; 0 = No*
CALFM		Reason for the calf mortality	
		DEA = Calf found dead (unconfirmed cause of death)	
		STB = Stillbirth; SWF = Small weak calf; MAL = Malformation	
		CRI = Cryptosporidiosis; LBH = Calf left behind when shifted	
		LOF = Calf lost through the fence	
		MIM = Mismothering (hind rejecting her calf from suckling)	
		OMO = Overmothering (hind licking her calf excessively)	
		RST = Ruptured stomach	
		VIC = Fawn victimised (from visible lesions on the skin)	

Table 2.17 : Diagnoses, clinical signs and lesions recorded by farmers or veterinarians.

Code	Description
DI	**Disease or health problem not associated with spontaneous death**
Diagnosis	
ABS	Abscess
FAB	Foot abscess
BAP	Balanoposthitis
BLI	Blind deer (deer hitting obstacles when mustered in paddock or yards)
BRL	Broken leg
ENZ	Enzootic ataxia
OST	Osteochondrosis
MDI	Miscellaneous misadventure not causing death
	INJ : Injury *HAE : Haematoma*
UNE	Unconfirmed diagnosis
Observed clinical sign (when unconfirmed diagnosis)	
	FAD : Fading (syndrome associated with weight loss)
	LAM : Lameness (SWJ=Lameness associated with swollen joints)
	SCO : Scouring with no significant loss of weight
DE	**Spontaneous death of deer**
Cause of death	
BRN	Broken neck
SEP	Septicaemia
VOL	Volvulus
YER	Yersiniosis
MCF	Malignant catarrhal fever (confirmed histologically)
	AMC: Acute malignant catarrhal fever
	CMC: Chronic malignant catarrhal fever
MIS	Miscellaneous misadventure causing death
	DRA;Drowned; GUN: Gun shot; FIGHT: Stag fight
	VEL:Death occurring shortly after velvet antler removal
	STR: Stress related (death occurring during or shortly after handling)
UNE	Unconfirmed cause of death
Observed lesions at post-mortem examination when unconfirmed cause of death (same codes were used for observed lesions at inspection during slaughter)	
	CAC:Cachexia; BRU: Bruising; RUM : Rumenitis
	FRA: Fracture (FLC = Fracture leg chronic; FRC = Fracture rib chronic)
	ENT: Enteritis (AEN = Acute enteritis; CEN = Chronic enteritis)
	PER: Peritonitis (PEC = Peritonitis chronic)
	PYL: Pyogenic lesion in liver; HEP : Hepatitis
	PLE: Pleurisy (PLC = Chronic pleurisy)
	FL: Fibrosed Liver; PL : Parasitic Liver; LIC : Liver cancer
	CYL: Cyst in liver; PNE :Pneumonia (LUN = Occurrence of lungworms)
	NEP:Interstitial nephritis; CYK :Cyst in kidneys

Mortalities were classified according to their likely causal factor as dystocia, malignant catarrhal fever (MCF), yersiniosis, osteochondrosis, misadventure (including injuries and broken bones), miscellaneous (rare mortalities with identified causal factor) and unconfirmed (mortalities with causal factor unknown or only suspected, either because post-mortem and laboratory examinations could not be done in time or did not lead to a definitive diagnosis). Codes and descriptions of diagnoses, clinical signs and lesions recorded by farmers and veterinarians are presented in Table 2.17. Total number of deer at risk were obtained from grazing records to compute seasonal and annual mortality rates.

During the calving season, farmers reported problems such as dystocia (Appendix 2.16) and perinatal mortality (Appendix 2.17). A simple post-mortem examination of dead calves was carried out by answering a short list of questions. When possible, freshly dead calves were frozen until the end of the season, so all post-mortem examinations could be performed by the researcher. Dystocia and calf mortality variables are presented in Table 2.16.

At deer slaughter premises at Feilding, Hastings or Wairoa, MAF veterinarians examined slaughtered deer and recorded the gross lesions they observed on the slaughter sheet sent by farmers with their deer (Appendix 2.18).

2.3.3 Individual deer

Individual deer recording sheets are presented in Appendix 2.19 and Appendix 2.20.

Listings of deer were regularly updated with individual characteristics such as ear-tag identification, class of stock, year of birth, sex and blood line category (Table 2.18). Computer listings of deer were regularly printed and sent to farmers on which they recorded bodyweights or other types of individual data such as mob identification, velvet weights and grades (Appendix 2.19). This technique minimised tag reading and transcription errors.

2.3.3.1 Bodyweights and velvet yields

Individual deer bodyweights were monitored according to the schedule in Table 2.19. All weighing machines were checked once using a 20-litre plastic container of water weighing 21.5 or 22 kg.

Individual first cut velvet antler yields were recorded. Regrowth antler was not recorded. Farmers recorded date of velvet antler harvesting, total velvet weight and velvet grades for each side for each stag. The velvet industry standard grading guidelines defined by the Game Industry Board of New Zealand were used (Appendix 1.1). When available, dates of shedding of remaining hard antlers (called also the button drop) and stag bodyweights, close to or at the time of velvet antler harvesting, were also recorded. During the second harvesting season of the study, a "velvetting diary" was used to report the movements of stags between mobs during the velvetting season, thus identifying individual grazing management (Appendix 2.20).

Farmers also recorded dates of spike removal of weaner stags (<15 months).

Table 2.18 : Description of datasets for raw and calculated individual deer variables

Code	Unit	Description
Deer identification		
DEER		Deer tag identification
YEAR		Year of birth
AGE	year	Age at the beginning of the survey year (March)
ADULT		Deer over-2-year-old in March (hind over-2-year-old at calving)
CLASS		Deer category (see section 2.1.2)
BLOOD	%	Percentage of blood of the breed of deer defined below (Appendix 2.19)
BREED		Breed of deer
(AU = Austrian; DA = Danish; EN = English; GE = German; HU = Hungarian;		
NZ = New Zealand; SW = Swedish; WA = Wapiti type; YU = Yugoslav)		
BT		Blood line category
		NZ or "New Zealand" = 100% New Zealand
		EN or "English" = 100% English or English-NZ cross-breeds
		EUR or "European" = Some European blood other than English
		WA or "Wapiti" = 100% wapiti or wapiti-red hybrids
NZ†	%	Percentage of New Zealand blood lines
NZ100		Pure New Zealand type deer *1 = Yes; 0 = No*
WAP†	%	Percentage of Wapiti (or Elk) blood lines
(NZC = NZ of the calf; WAPC = WAP of the calf; NZD = NZ of the dam)		
Weight records		
		Each weight record was entered in two fields as for example :
MARW	kg	Bodyweight recorded in March
DWMAR		Date of weighing in March
*Fields were created to contain bodyweights recorded according to annual schedule (*Table 2.19*) in dataset "Hind" and "Stag" :*		
JUNEW (and WD6), SEPTW, VELVW are bodyweight recorded in June (date DJUNEW), September (date DSEPTW) and at the time of velvet antler removal, respectively		
Fields were created for every month of the year in dataset "Weaner".		
W4	kg	Calculated bodyweight on April 1 (as the 4th month of the year)
Fields were created to contain bodyweights calculated as described in section 2.6.2.3.1		
GR46	g/day	Growth rate between April 1 and June 1
Fields were created to contain growth rates calculated as described in section 2.6.2.3.1		

† Although already used above, these variables and codes were used for risk factor analysis in chapter 4.

Table 2.18 (cont'd)

Code	Unit	Description	
Mob history			
ARRIVAL		Date of arrival on the farm (Data entered as March 1 if on farm at that time)	
MOB4		Identification of mob where deer were on April 1	
Similar fields were created to contain mob identifications on June 1, September 1, December 1, and March 1 as MOB6, MOB9, MOB12 and MOB3, respectively. Mob and date fields were created to contain dates and mob identifications for each individual deer.			
Individual outcome			
LEAVE		Date when deer leave the farm	
CAUSE		Cause of deer leaving the farm	
LS = Live sell; DE = Deer died spontaneously; ES = Deer escaped outside the deer farm boundary; ED = Diseased deer euthanased on the farm; EI = Injured deer euthanased on the farm; SV = Deer slaughtered on the farm for home consumption; TO = Taken away by share farmer; WO = Deer send to the works; MIS = Deer missing from unconfirmed cause			
BW	kg	Bodyweight before deer left the farm	
CW	kg	Carcass weight at slaughter	
GR	mm	GR measurement as defined in section 2.3.3.4	
PATH		Gross pathology recorded at Deer Slaughter Premises	
Fields specific to dataset "Hind"			
Body condition score variable (see Appendix 2.21 for scoring chart)			
BCSM		Pre-mating body condition score (first March visit)	
BCSS		Post-winter body condition score (September visit)	
BCSW		Body condition score at weaning (second March visit)	
BCSD		Body condition score difference between March and September *BCSS-BCSM*	
BCSL		Body condition score change during late pregnancy and lactation *BCSW-BCSS* (change between September and weaning)	
BCSM25		Pre-mating body condition score below 3	*1 = Yes; 0 = No*
BCSM4		Pre-mating body condition score over 3.5	*1 = Yes; 0 = No*
BCSS2		Post-winter body condition score below 2.5	*1 = Yes; 0 = No*
BCSS4		Post-winter body condition score over 3.5	*1 = Yes; 0 = No*
Other hind variables			
PREG		Pregnancy status in June (see section 2.4.1.3) *A = Advanced (Conception before May 1)* *L = Late (Conception after May 1)* *MT = Empty or Not pregnant*	
ADVC		Hind conceiving before May 1	*1 = Yes; 0 = No*
CONC		Hind conceiving	*1 = Yes; 0 = No*
CHW9C	kg	Bodyweight change between September and calving (November)	
MM1		Identification of the first mating mob *MM2 and MM3 identified second and third mating mobs (back-up mob), respectively*	
CMOB		Identification of calving mob	

Table 2.18 (cont'd)

Code	Unit	Description
Fields specific to dataset "Weaner"		
BIRTH		Date of birth = number of days between November 1 and the date of birth
WEAN		Date of weaning = number of days between January 1 and weaning
HIND		Weaner hind (ie female sex) *1 = Yes; 0 = No*
DAMID		Identification of the dam
W40		Bodyweight standardised to April 1 below 40 kg *1 = Yes; 0 = No*
W50		Bodyweight standardised to April 1 between 40 and 50 kg *1 = Yes; 0 = No*
MAXW4†	kg	Bodyweight differences between individual bodyweight (W4) and the highest bodyweight in the mob at the start of the studied period (4 = on April 1)
PERCW4†	%	Percentile of deer bodyweight (4 = on April 1) within the mob on April 1
MAXW6, PERCW6, MAXW9, PERCW9, MAXW12 and PERCW12 were also calculated from bodyweights W6, W9 and W12, respectively, within mobs on June 1, Sept 1 and December 1, respectively. (Percentiles were computed with the statistical package Statistix).		
GR46<0		Weaner losing bodyweight between April 1 and June 1 *1 = Yes; 0 = No*
SPIKE		Date of spike removal
Fields specific to dataset "Stag"		
CHWJV	%	Percentage of stag liveweight change between June and the time of velvet harvesting *(VELVW-JUNEW)*100/JUNEW*
GRJS	g/d	Bodyweight gain between June and September *(SEPTW-JUNEW)*1000/(SEPTW-DJUNEW)*
Velvet production variables for each of the years 1990, 1991 and 1992‡		
CAST		Date of casting hard antlers
CUT		Date of velvet harvesting
DVGR	day	Number of days between antler casting and velvet antler harvesting *CUT-CAST*
WEIGHT	kg	Weight of velvet
GLV		Grade of the left velvet§
GRV		Grade of the right velvet
GRADE		The highest of GLV and GRV
TINE		Velvet antler with a bez tine on at least one side *1 = Yes; 0 = No* (see Appendix 1.1)
PVM		Identification of the mob prior to velvet harvesting
VM		Identification of the mob after velvet harvesting

† These variables were calculated using the computer software Statistix

‡ The second year of study were entered data from 1991, 1992 and 1993

§ Grade of velvet as defined in the Guidelines for the removal of velvet antler (Appendix 1.1), which was revised in 1993 (Anonymous, 1993a)

2.3.3.2 Reproduction

Depending on farm management practices, status of the udder at weaning, sex and weight of calves at weaning, and calving dates were recorded for each hind. Hinds were pregnancy tested in June (see section 2.4.1.3.). Their pregnancy status was checked before calving by direct palpation of the udder or bodyweight changes between June or September and late October/early November.

2.3.3.3 Mob history

Wherever possible, the mob identification was recorded for each deer so deer under similar grazing management could be traced. Arrival and departure date of deer from the farm, and the reason for leaving the farm were recorded. Reasons for deer leaving farms were recorded as described in Table 2.18. Rarely, deer could not be identified during successive handling in yards, so they were reported "missing" on the mid-date between the date when they were seen last (usually in yards) and the date when they were noticed missing for the first time.

Table 2.19 : Annual schedule of deer mob recording and paddock sampling

Month	Deer Paddock (number of samples)	Class of deer		
		Weaner deer	Yearling & adult hinds	Yearling & adult stags
March	Pasture (3 paddocks)	Weight	Weight Body condition score	Weight of yearling stags
June	Soil (4-5 paddocks)	Weight	Weight Pregnancy test	Weight
September	Pasture (3 paddocks)	Weight	Weight	
November		Weight	Weight close to calving period	Weight Velvet

2.3.3.4 Slaughter

Tag numbers, carcass weights and standard GR measurements (tissue depth over the 12th rib 160 mm from the dorsal midline, as a measure of fatness) were provided by slaughter companies[3] with the observations of MAF veterinarians.

[3] Venison New Zealand Ltd at Feilding (Manawatu) and Hastings (Hawkes' Bay)
Venex at Waiora (Hawkes' Bay)

2.4 FARM VISITS

In addition to periodic visits to collect and collate data, each farm was visited in March, June, September and November 1992, and March, June and September 1993 specifically to collect samples and make measurements and observations on animals, pastures and soils. All these observations and samples were made directly by the researcher. One farm was visited per day during sampling periods. Because samples were processed the day after collection, farms were visited from Monday to Thursday each week. Thus sampling visits occurred within about 4 weeks.

2.4.1 Individual deer recording and sample collection

2.4.1.1 Sampling of selected sentinel deer

Selection of sentinel deer is described in section 2.1.2. The annual schedule of deer sampling is presented in Table 2.20. On each sampling visit, sentinel deer were sorted and retained in the yards. Depending on the class of the deer and time of year, measurements and observations were recorded as detailed in Table 2.21.

Table 2.20 : Schedule of measurements and sample collection from selected sentinel deer

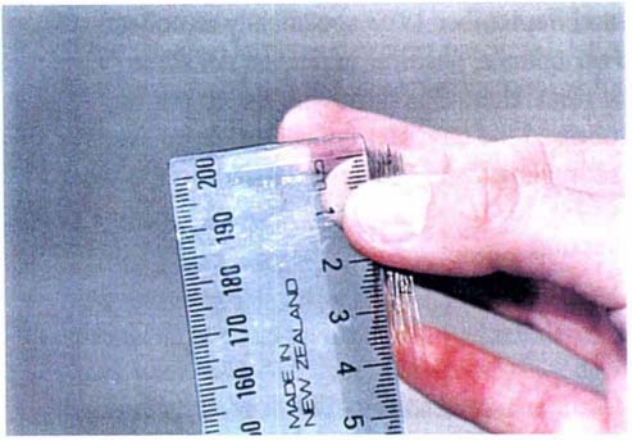
	Class of deer		
Month	Weaner deer (3-15 months)	Yearling & Adult hinds	Yearling & Adult stags
At each visit	Thoracic girth †, Weight Blood † & faeces samples	Weight, Size, Thoracic girth Condition score Coat length Blood samples	Weight, Size, Thoracic girth Condition score Coat length Blood samples
March	Faeces samples before the first anthelmintic treatment	Teeth† Faeces samples	Teeth
June	Coat length† Coat density‡		Faeces samples
September	Coat length Size†	Faeces samples	
November‡	Coat length Size		faeces samples

† See Figure 2.4 and Table 2.21

‡ Only during the first year of survey

Figure 2.4 : Examples of measurements and observations made on sentinel deer during farm visits (see Table 2.21 for further details).

1. Coat length (COATL)



Coat length measured with a ruler (38 mm)

2. Deer thoracic girth (GIRTH)



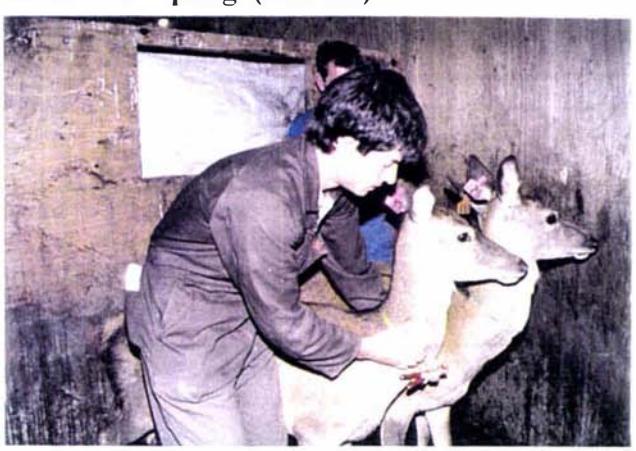
Measure of the thoracic girth of a weaner with a measuring tape

3. Adult deer teeth score (TEETH)



Teeth score of an adult hind (TEETH=1)

4. Blood sampling (EASES)



Blood samples were taken by venipuncture of the jugular vein of deer standing quiet in the pen (EASES=1)

5. Deer body height at shoulder (SIZE)



Measurement of body height at shoulder with an altitude stick

Table 2.21 : Description and method for measurements and observations made on individual sentinel deer during farm visits

Code	Unit	Description
SAMPL (see Figure 2.4)		Ease of blood sampling and method of restraint used *1 = sampling in a pen without firm physical restraint: deer quiet during sampling with or without light physical restraint* *2 = sampling in a pen with firm physical restraint of the head of the deer, if the deer struggled with only light physical restraint* *3 = sampling in a crush system, which may be after first attempts in a pen*
EASES		Deer blood sampled without firm physical restraint *1 = Yes; 0 = No*
LYING		Deer lying on the floor of the pen during sampling *1 = Yes; 0 = No*
STRESS		Deer restless during sampling needing to be released *1 = Yes; 0 = No*
AGGR		Deer biting or kicking other deer or handlers during sampling *1 = Yes; 0 = No*
VBW	kg	Bodyweight (if weighing machine available in the yard at the time).
GIRTH	cm	Thoracic girth (see Figure 2.4) *A weighband marketed for use in cattle and pig[1] was put vertically around the thorax just behind the forelegs, then it was pulled slightly tight before measurements were read.*
SIZE	cm	Deer shoulder height (see Figure 2.4) *The height of deer was recorded at the shoulder level using an altitude stick[2] with deer quietly standing in the pen with head up and forelegs vertical.*
BCS		Body condition score as defined in Appendix 2.21.
VICTIM		Visible hair loss (signs of victimisation) on the back of the deer *1 = Yes; 0 = No*
COATD	g	Coat density *Estimated by the weight of a sample of hair clipped on the mid lateral aspect over the caudal ribs (approximately the 8th to 10th rib). The clipped area was delineated by a metal frame 5-cm width and 6-cm long. Hair samples were kept in plastic bags until weighing.*
COATL	mm	Coat length (see Figure 2.4) *A few hairs were pulled from the same lateral site as defined above, grouped together, and their average length measured with a ruler.*
TEETH		Incisor teeth score as described by Orr and Moore (1989) (see Figure 2.4) *3 = Functional incisors* *2 = Moderately worn incisors* *1 = Severely worn incisors*

[1] Weighband, cattle and pig weighing tape, Dalton supplies Ltd, Nettlebed, Henley-on-Thames, Oxon, England
[2] Altitude stick, Adrian J.Paul Compagny of Duncan, Oklahoma.

Blood samples were collected and the behaviour of the deer during collection recorded. Three 15 ml plain and one 5 ml EDTA blood sample were collected into vacuum glass tubes by jugular venipuncture using 20x1" needles and processed as in section 2.5.1. Deer were sampled in small pens during gentle physical restraint in most cases (Figure 2.4). On rare occasions, they required firm physical restraint in the pen by a second person, or in a crush. Faeces samples were collected per rectum for parasite egg and larvae counts. When necessary, farmers collected faeces samples from 10 randomly selected calves before their first anthelmintic treatment.

2.4.1.2 Body condition score

A body condition scoring system has been developed for this study, scores ranging from 1 (very lean deer) to 5 (very fat deer) with half-unit increments as described in Appendix 2.21. A body condition score was assigned to all hinds in March before mating, in September before calving and in March of the next year at weaning.

In March 1994, 49 yearling hinds and 114 adult hinds on 4 properties were independently scored twice by two assessors to investigate assessor bias and inconsistency (Evans, 1978b; Nicholson and Sayers, 1987)(see section 3.3.1.2.1.).

2.4.1.3 Pregnancy testing

All hinds were pregnancy tested by ultrasound using a 5 MHz rectal linear probe, 15 to 70 days after sire stags were withdrawn from hinds (June visit). Hinds were classified as having conceived before May 1, or after May 1 based on foetal and placental measurements (Revol and Wilson, 1991), or as being not pregnant.

2.4.1.4 Deer behaviour

Attempts were made to define a scoring system of the farmer-deer relationships at handling, based on subjective observations of deer in the yard during farm visits. The scoring chart is presented in Appendix 2.22

2.4.2 Recording of paddock data

From each deer-fenced paddock, pasture characteristics were recorded including sward height, clover content score, seed head density score, ragwort and thistle density score, pasture cover and fence pacing score, as described in Table 2.7 and Table 2.22.

Pasture samples were collected in March and September from 3 paddocks that were reserved for grazing mobs of weaners, hinds and stags, respectively. Whenever it was possible, pastures were sampled prior to grazing by deer. Three to five handfuls of pasture were hand-plucked on an area that had not been grazed, and kept in plastic bags. Grasses close to faeces, thistles, ragwort, and clumps of long stalky grasses were avoided.

Soil samples were taken in June from 4 or 5 paddocks to assess soil fertility. Fifteen soil cores of minimum 7 cm deep were collected with a metal tube in each paddock as described by Cornforth (1980) and kept in one plastic bag per paddock.

Table 2.22 : Definition and method of measurements and observations made on paddocks during farm visits

Code	Description
VSWH	Pasture sward height (see Table 2.7 and Figure 2.3)
VCLOV	Pasture clover score estimated by a visual assessment (see Table 2.7 and Figure 2.3)
VSHD	Pasture seed head density score (see Table 2.7 and Figure 2.3)
VCOVER	Pasture cover (Unit = kgDM/Ha)
Measurement made using a pasture rising plate[1]. Readings were recorded before and after 50 random measurements across the paddock; the formula used to calculate the pasture cover was that already defined for each plate after calibration on ryegrass-clover pasture.	
VTHIS	Presence of thistles (visual assessment) *0 = no thistle* *1 = a few plants of thistle* *2 = many plants of thistle scattered in some area* *3 = numerous plants of thistle in most parts*
VRAG	Presence of ragwort (as described for thistles)
VFP	Signs of fence pacing by deer as the defoliation of pasture (or bare soil) caused along fences *0 = No sign of fence pacing, there was no visible track along the fence, the grass was growing up to the fence* *1 = Slight sign of fence pacing, there was a small walking track along the fence, no more than 30 cm wide and no more than 5 cm deep* *2 = Moderate sign of fence pacing (observation between 1 and 3)* *3 = Substantial sign of fence pacing, there was severe damage of the pasture along the fence on an area at least 1 m wide or at least 20 cm deep.*

[1] Pasture rising plate, Ashgrove Pastoral Products, Palmerston North, New Zealand

2.5 PROCESSING AND ANALYSIS OF SAMPLES

2.5.1 On farms

Blood samples that were collected on EDTA were immediately cooled on ice, and a glass slide smear was prepared on farms. Other blood samples were clotted for 2 to 4 hours at environmental temperature, then were centrifuged to extract the serum. Serum samples were cooled on ice for 4 to 5 hours before being frozen at -20°C. Faeces samples were cooled on ice immediately after collection until analysis the day after collection.

Samples from post-mortem examinations performed by the farmer were put in formalin diluted at 10% according to instructions in Appendix 2.15 and kept until the next visit. Fresh dead newborn calves were stored frozen in plastic bags in domestic freezers.

2.5.2 Laboratory analyses

A range of blood and faecal analyses were performed for each sampling period as described in Table 2.23.

2.5.2.1 Haematology

Analysis of haematological characteristics were carried out from fresh EDTA blood samples within 24 hours after collection.

White cell counts (WCC), and haemoglobin concentration (HB) were performed using a haematology analyzer[4]. Packed cell volumes were determined after centrifugation of capillary tubes.

Sera were analysed for biochemical, mineral and serological characteristics within 3 months after being frozen.

Blood smears were stained, covered and stored to be read later. Differential leucocyte counts were performed by counting 100 cells under magnification (x40). Leucocytes were classified as lymphocytes and polymorphonuclear neutrophils, eosinophils, basophils, band cells (immature polymorphonuclear neutrophils), and monocytes and "unusual lymphocytes".

"Unusual lymphocytes" were white cells not strictly conforming to the normal morphology of lymphocytes as their nuclei were severely indented. However, they were classified as lymphocytes for subsequent analyses as in other studies (Cross, personal communication).

2.5.2.2 Serum biochemistry

After analysis of haematological characteristics, 6 blood samples collected on EDTA (3 from weaner deer and 3 from hinds or stags depending on the visit) were analysed for glutathione peroxidase activity (GSHPx) at the MAF Bachelar Animal Health Laboratory. Other biochemical characteristics were analysed from thawed frozen sera within three months of blood collection.

Total protein (TP), albumin (ALB), phosphorus (P) and blood urea nitrogen (BUN) concentrations, and gamma glutamyl transferases (GGT) activities were measured from the sera using an automatic analyser[5].

Serum copper and vitamin B12 concentrations were analysed from frozen sera at the MAF Ruakura Animal Health Laboratory.

Serum copper (CU) was determined by acid digestion of the sample followed by atomic absorption analysis from 1 ml of serum. At the level of 12.5 µmol/l, the confidence variation was 3.5% (the 2-standard-deviation (2SD) range was 11.8-13.2 µmol/l). As the sensitivity of the assay was limited to 2 µmol/l when using only 1 ml of serum, tests were carried out again with 2-ml samples when this threshold level was reported.

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[4] CELL-DYN 900 Haematology Analyzer , Sequoia-Turner Corporation, Montain View, California 94043
[5] COBAS MIRA, F. Hoffmann-La Roche & Co Ltd, Diagnostica, Basle, Switzerland.

Serum vitamin B12 (B12) concentrations were investigated using a competitive protein-binding assay with a range of measurements 70-3000 pmol/l. At the level of 225 pmol/l, the confidence variation was 7% (the 2SD range was 190-258 pmol/l).

Serum pepsinogen levels (PEPS) were assayed at the Physiology and Anatomy Department of Massey University by a method described by Pomroy and Charleston (1989). Two batches of deer serum samples that gave "high" (>400 mU Tyrosine/l) and "low" (<400 mU Tyrosine/l) pepsinogen levels were pooled and analysed 30 times for quality control of the assay. Mean values (±SD) were 594 (±65) and 206 (±80) for the "high" and "low" samples, with coefficients of variation of 11% and 39%, respectively.

2.5.2.3 Serology

Antibody titres against leptospirosis were investigated using the microscopic agglutination test (Faine, 1982). Antigens used were live leptospires of the three major serovars of *Leptospira interrogans* affecting deer in New Zealand, namely *pomona, hardjo* and *copenhageni*.

Antibody titres against yersiniosis (*Yersinia pseudotuberculosis*) were investigated at the Deer Research Laboratory of Otago University from the sera of weaner deer using an ELISA test that was developed originally for the diagnosis of tuberculosis in red deer (Griffin et al., 1994). The antigens used were specific proteins of the three serotypes of *Y.pseudotuberculosis* identified in New Zealand farmed deer, namely serotype I, II and III. All weaners were assumed to be seronegative at the March sampling and results from that visit were taken as an individual baseline for interpretation. Arbitrarily, any increase in optical density over 20 units between March and June within the same animal was considered as a sign of seroconversion (Griffin, personal communication).

2.5.2.4 Parasitology

Faeces samples were analysed the day after collection. Faecal egg counts (FEC) were performed using a technique that involved mixing 2 g of faeces in 28 ml of saturated salt water, the count of one egg was equivalent to 50 eggs per g of faeces (modified Master technique). Faecal lungworm larvae counts (FLC) were performed using a modified Baermann technique (Henriksen, 1965).

2.5.2.5 Soil, pasture and food supplements

Pasture samples were washed and oven dried for 2-3 days before being sent to the Ruakura Animal Health Laboratory for analysis of the macronutrient profile. Soil samples were submitted directly to the Fertiliser and Lime Research Centre laboratory at Massey University for analysis. Details of sampling of pasture and soil samples are presented in Table 2.23.

Table 2.23 : Schedule of sample collection and the range of analyses undertaken.

Month	Sentinel deer	Samples	Laboratory analyses carried out
March and September	Weaners and Hinds	EDTA blood Serum Faeces	WCC, Diff., HB, PCV, GSHPx TP, ALB, P, GGT, BUN, CU, B12, PEPS FEC, FLC
	All deer	Serum	Serology leptospirosis
	Weaners	Serum	Serology yersiniosis
		Pasture	Micronutrient profile : Cu, Co, Se, Mn, Mo, Zn, Fe, S
June	Weaners and Stags	EDTA blood Serum Faeces	WCC, Diff., HB, PCV, GSHPx TP, ALB, P, GGT, BUN, CU, B12, PEPS FEC, FLC
	All deer	Serum	Serology leptospirosis
	Weaners	Serum	Serology yersiniosis
		Soil	Olsen P, Exch. K, S, pH
November (in 1992 only)	Weaner deer and Stags	EDTA blood Serum Serum Faeces	WCC, Diff., HB, PCV, GSHPx TP, ALB, P, GGT, BUN, CU, B12, PEPS Serology leptospirosis FEC, FLC
	Weaners	Serum	Serology yersiniosis

Blood WCC: White Cell Count; Diff: Differential leucocyte count†;
HB: Haemoglobin; PCV: Packed Cell Volume; GSHPx: Glutathione peroxidase
Serum TP: Total Protein; ALB: Albumin; P: Phosphorus;
GGT: Gamma Glutamyl Transferase; BUN: Blood urea nitrogen;
CU: Copper; B12: Vitamin B12; PEPS: Pepsinogen
Faeces FEC: Faecal Egg Count; FLC: Faecal Larval Count;
Pasture Cu: Copper; Co: Cobalt; Se: Selenium; Mn: Manganese; Mo: Molybdenum;
Zn: Zinc; Fe: Iron; S: Sulphur
Soil Olsen P: Olsen phosphate; Exch.K: Exchangeable potassium; S: Sulphur

† Differential leucocyte count :
LP : Lymphocyte percentage (including "unusual" lymphocytes);
NP : Neutrophil percentage; BANDS : Band percentage;
EOP : Eosinophil percentage; BP : Basophil percentage; MOP : Monocyte percentage

Samples of hay and silage were freeze-dried and grounded before being analysed by *in vitro* digestibility at the nutrition laboratory of the Animal Science Department at Massey University to estimate their nutritive value (MJME /kgDM).

2.6 COMPUTER DATABASE AND DATA CALCULATIONS

2.6.1 Primary, secondary and master datasets

Data were entered into the relational database Paradox. Multiple datasets, called "primary datasets", were used to enter raw data that were recorded on farms or from the laboratory (Table 2.24).

Table 2.24 : List of primary datasets containing raw data

Dataset name	Information recorded	Cross reference
Farm characteristics		
"Paddock"	Paddock individual characteristics	Table 2.4
"Farms"	Farm location, lane, deer-yards	Table 2.5
"Farmer"	Farmer direct questionnaire	Appendix 2.2
Management practices		
"Graze"*	Grazing management (pasture and stock variables)	Table 2.7
"Foodsup"	Food supplementation	Table 2.8
"Deerwork"	Work with deer in the deer-yards	Table 2.9
"Mating"	Mating mobs, sires and dates	Table 2.10
"Calving"	Calving mob and management	Table 2.11
"Handling"	Handling management	Table 2.12
"Stock"	Farm animal stock wintered	Appendix 2.12
Individual deer data (Individual characteristics, performance and mob history)		
"Weaner"*	Weaner stags and hinds data	Table 2.18
"Hind"*	Yearling and adult hinds data	Table 2.18
"Stag"*	Yearling and adult stags data	Table 2.18
Other farmer recording		
"Climate"*	Climate data	Table 2.13
"Health"	Disease and death of deer	Table 2.15
"CalfM"	Calf mortality	Table 2.16
"Dysto"	Dystocia records	Table 2.16
Visit recording		
"Blood"**	Sentinel deer data including lab results	Table 2.20 and Table 2.21
"Padwalk"**	Paddock measurements	Table 2.22
"Pasture"	Pasture micronutrient profile	Table 2.23
"Soil"	Soil fertility data	Table 2.23

* Datasets were created for each farm for data entry before being merged in master datasets
** Datasets were created for each farm visits for data entry before being merged in master datasets

After verification, raw data specific to each analysis were isolated from primary datasets and stored in "secondary datasets" from which calculations were subsequently performed for mob and farm

characteristics. Results of these calculations were entered into "master datasets" which were used for multivariable analyses. Many calculated individual deer variables, however, were kept in primary datasets as described in Table 2.18.

As an example, the growth rates of weaner deer during a given grazing period (eg from June 1 to September 1, defined in this thesis as GR69) were calculated (see section 2.6.2.3) and analysed as an outcome variable. Potential risk factors that may be causally associated with GR69, such as weather variables (from dataset "climate"), average paddock characteristics, mean pasture measurements, grazing densities, average mob composition and food supplementation levels (from raw data in datasets "graze", "paddock" and "foodsup"), were also calculated. These calculated management factors were included with individual weaner characteristics for multivariable analyses of risk factors for GR69 (see section 4.4).

2.6.2 Description of calculated variables

Calculated variables are presented with their arithmetic expression in italics. Arithmetic symbols used throughout this thesis are those used for calculation in queries undertaken using the relational database Paradox :

+	Addition :	A+B is the sum of A and B
-	Subtraction :	A-B is B subtracted from A
*	Multiplication :	A*B is the product of A and B
/	Division :	A/B is A divided by B

Variable codes used in arithmetic expressions have been described in previous tables in this chapter (Table 2.24).

2.6.2.1 Farm variables

2.6.2.1.1 Mean paddock variables within farms

Farm mean paddock variables were calculated for combined 1992 and 1993 data, as described in Table 2.25. Individual paddock variables (see Table 2.4) were corrected by the percentage of time paddock were available for grazing deer during the study (%TIME).

2.6.2.1.2 Pasture cover measured at farm visits

Farm pasture cover variables were calculated as described in Table 2.26 from paddock observations and measurements recorded during visits by the researcher (Table 2.22)

Table 2.25 : Calculated farm mean paddock variables†

Code	Unit	Range	Description
Farm areas			
FTAREA	ha		Farm total deer fenced paddock area *Sum of (TPAREA * %TIME/100)*
NPAD			Number of deer fenced paddocks *Sum of (%TIME/100)*
MPFAREA	ha		Mean deer fenced paddock area *FTAREA/NPAD*
Calculations using paddock variables corrected for paddock size			
FTOPO		1-3	Farm topography score *Sum of ((PTOPO*TPAREA*%TIME /100)/ FTAREA)*
The following farm variables‡ were calculated using a similar arithmetic expression :			
FPAST		1-3	Farm pasture quality score
FTHIS		0-3	Farm thistle score
FRAG		0-3	Farm ragwort score
Calculations using paddock variables without correction for paddock size			
FSUR	%		Percentage of paddocks close to road, buildings or houses *Sum of ((PSUR*%TIME)/NPAD)*
The percentage of paddocks with dam, pond or swamps (FDAM) and the percentage of paddocks with rivers or streams all year round (FRIVER) were calculated using a similar arithmetic expression			
FHILL		0-3	Farm hill score *Sum of ((PHILL*%TIME/100)/NPAD)*
Farm gully scores (FGULLY), farm tree score (FTREES), farm bull rushes score (FBULLR), farm wind shelter score (FSHELT), farm fence pacing score‡ (FFP) and farm potential protection by shelter belt, hill and gully, against westerly winds (FWESTH, FWESTB and FWESTG) (similar scores were created for easterly, southerly and northerly wind protection) were calculated using a similar arithmetic expression			

† Calculations were made from individual paddock variables described in Table 2.4.

‡ Means of PPAST, PTHIS, PRAG and PFP over the two years was used for calculations

Table 2.26 : Calculated farm pasture cover variables from each farm visit

Code	Unit	Range	Description
FVCOVER	kgDM/ha		Mean farm pasture cover at the time of the visit *Sum of ((VCOVER*EPAREA) / EFPAD* †
FVSWH	cm		Mean farm sward height at the time of the visit *Sum of ((VSWH*EPAREA) / EFPAD*
FVSHD		0-3	Mean farm pasture seed head density score at the time of the visit *Sum of ((VSHD*EPAREA]/ EFPAD*
FVCLOV		0-3	Mean farm clover score at the time of the visit *Sum of (VCLOV*EPAREA)/ EFPAD*
FVFP		0-3	Mean farm fence pacing score at the time of the visit *Average of VFP*

† EFPAD is the sum of effective deer fenced area of measured paddocks

2.6.2.1.3 Calculated weather variables

Weather variables were calculated from daily records (Table 2.13) as described in Table 2.27 Calculations were made for various grazing periods as described in section 2.6.2.2.1.

Table 2.27 : Calculated weather variables

Code	Unit	Range	Description
AVMIT	°C		Average of daily minimum temperatures (*MINTP*)
AVMAT	°C		Average of daily maximum temperatures (*MAXTP*)
AVMMT	°C		Average of daily temperature ranges (*MAXTP-MINTP*)
RAIND	mm/d		Average daily rainfall (*RAIN*)
SUN		0-1	Average daily sunshine score (*DSUN* as scores)

2.6.2.2 Calculated mob variables

2.6.2.2.1 Calculated grazing management variables

Grazing management variables were calculated from grazing records (Table 2.7) for each grazing period under study. A "grazing period" was defined as a time period for which the grazing management of deer was studied which could include one or more "grazing intervals" described in section 2.3.1.1. Grazing periods for which grazing mob variables were calculated are presented in Table 2.28.

From individual deer datasets, groups of deer with similar grazing history during the defined grazing periods were given a grazing mob identification and grazing records corresponding to their grazing history were selected from the dataset "Graze". These selected grazing data were entered in specific datasets from which calculations were made.

Table 2.28 : Grazing periods for which grazing mob variables were calculated

Class of deer	Grazing period Starting date (START) - End date (END)	Corresponding farm management period
Weaners	Weaning - April 1	Post-weaning
	April 1 - June 1	Autumn growth
	June 1 - September 1	Winter growth
	September 1 - December 1	Spring growth
	December 1 - March 1	Summer growth
Hinds	March 15 - May 1	"Early mating" period
	March 15 - June 1	"Mating" period
	June 1 - September 1	Winter
	September 1 - December 1	Pre-calving
	November 1 - January 1	Calving
	December 1 - Weaning	Lactation
Stags	June 1 - September 1	Winter
	September 1 - Velvet harvesting	Pre-velvetting

2.6.2.2.1.1 Calculated pasture and stock variables

If more than one paddock was grazed simultaneously during grazing intervals, values for pasture sward heights, clover and seed head scores were first calculated from each paddock records in proportion to their effective area. Results were then used in final calculations for grazing periods as described in Table 2.29 along with the other calculated pasture and stock variables.

Total metabolisable energy requirements were calculated from seasonal requirements of red deer in New Zealand (Fennessy et al., 1981; Suttie et al., 1987) as summarised in Table 2.30.

Table 2.29 : Calculated grazing management variables†

Code	Unit	Range	Description
Pasture management variables			
ISWH	cm		Mean pre-grazing pasture sward height *Average of GISWH measured prior the entry to a new paddock*
RSWH	cm		Mean residual (ie post-grazing) pasture sward height *Average of GFSWH measured after deer left a paddock*
RSWH5			Mean residual pasture sward height below 5 cm *1 = Yes ; 0 = No*
RSWH10			Mean residual pasture sward height over 10 cm *1 = Yes ; 0 = No*
CLOVER		1-3	Mean pasture clover score *Sum of GCLOV*(ENTRY-LEAVE)/(END-START)*
SHD		0-3	Mean seed head density score *Sum of GSHD*(ENTRY-LEAVE)/(END-START)*
KALE			Deer grazing on a kale crop at least one day *1 = Yes ; 0 = No*
STRIP			Deer strip grazing at least in one paddock *1 = Yes ; 0 = No*
Stock variables			
MNZ	%		Mean weaner percentage of New Zealand blood lines within mobs
MW4	kg		Mean weaner bodyweight on April 1within mobs
DEER			Average number of deer in the mob *(Sum of(GWS+GWH+GYS+GYH+GAS+GAH) *(ENTRY-LEAVE))/(END-START)*
MWS			Average number of weaner stags in the mob *Sum of GWS*(ENTRY-LEAVE)/(END-START)* Similar calculations were made for MWH, MYS, MYH, MAS, and MAH
ODEER			Weaners grazing with deer over 15 months old *1 = Yes; 0 = No*
STAG			A least one stag over 15 months grazed with hinds *1 = Yes; 0 = No*
M%WS	%		Mean percentage of weaner stags in the weaner mob *WS*100/(WS+WH)*
M%AH	%		Mean percentage of adult hinds in the hind mob *AH*100/(AH+YH)*
MJME/Ha	MJME/ha		Total mob daily energy requirement per grazed hectare (effective area)‡ *(MWS*EDWS + MWH*EDWH + MYS*EDYS + MYH*EDYH + MAH*EDAH + MAS*EDAS)/MEAREA*
DEER/Ha	deer/ha		Average number of deer per deer-fenced hectare *DEER/FAREA*
OSHEEP			Deer grazing with sheep at least one day during the studied period *1 = Yes; 0 = No*
OTHERST			Deer grazing with stock other than deer (ie sheep, cattle, goat) *1 = Yes; 0 = No*

† See Table 2.7 for description of codes used in the formulations; MEARE and FAREA are described in Table 2.31
START and END describe start and end dates of grazing periods, respectively (see Table 2.28)
ENTRY and LEAVE describe start and end dates of grazing intervals, respectively (see section 2.3.1.1.)
‡ Reference values of MJME/Day (Energy demand) used are presented in Table 2.32
EDWS, EDWH, EDYS, EDYH, EDAH and EDAS are daily energy requirement of weaner stags, weaner hinds, yearling stags, yearling hinds, adult hinds and adult stags, respectively (see Table 2.30)

Table 2.30 : Seasonal metabolisable energy requirements of red deer used for calculations of the total daily energy demand per hectare (MJME/Ha)†

	Codes†	Age Months	Autumn April 1-June 1	Winter June 1-Sept 1	Spring Sept 1-Dec 1	Summer Dec 1-April 1
Stags						
Weaner	EDWS	3-15	16.0	20.9	27.0	26.5
Yearling	EDYS	15-27	24.5	28.0	31.5	30.0
Adult‡	EDAS	> 27	19.0	35.0	42.0	38.0
Hinds						
Weaner	EDWH	3-15	15.0	17.5	22.0	21.0
Yearling	EDYH	15-27	20.5	23.5	23.5	45.0
Adult‡	EDAH	> 27	23.0	22.0	24.0	47.0

†see Table 2.29
Source Fennessy et al. (1981) and Suttie et al. (1987).
‡Values for adults were published by Haigh and Hudson (1993).

2.6.2.2.1.2 Calculated paddock variables

During any grazing interval, deer mobs could graze up to three paddocks at a time, so before calculation of mean paddock variables (as described in Table 2.31), these individual paddocks were joined as a "master paddock" which were described as in Table 2.4. The codes of variables to describe these "master paddocks" are similar to those found in Table 2.4, although these variables were calculated from variables describing each individual paddock. The calculation of master paddock variables are described below :

- Variables PTOPO, PPAST, PTHIS, PRAG and PWIRE% were calculated from corresponding individual paddock variables corrected for their size (TPAREA).

- Variables PSUR, PSTUMP, PCATTLE, PSHEEP, PTROUGH, PDAM, PRIVER and PCHIC were given the value 1 if at least one of individual paddocks had value 1 for these variables.

- Variables PBULLR, PHILL, PGULLY, PTREES, and wind protection scores such as PWESTB, PWESTH and PWESTG were given the maximum score recorded for any individual paddock.

- The fence pacing score (PFP) was calculated as the mean value of fence pacing scores of individual paddocks.

The final calculations of mean paddock variables for studied grazing periods (Table 2.28) were then performed from individual paddock characteristics (when a single paddock was grazed at a time) and master paddock characteristics (if 2 or 3 individual paddocks were grazed at a time)(Table 2.31).

Table 2.31 : Calculated paddock variables during grazing periods

Code	Unit	Range	Description
FAREA	ha		Mean paddock size (fenced area)
MEAREA	ha		Mean paddock effective area
SUR	%		Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence) *PSUR*100*(ENTRY-LEAVE)/(END-START)*[†]
Similar calculations were made for variables STUMP, BSHEEP, BCATTLE, TROUGH, DAM, RIVER and CHIC as the percentage of time spent in paddocks described with values of variables PSTUMP, PSHEEP, PCATTLE, PTROUGH, PDAM, PRIVER and PCHIC, respectively, equal to 1 as presented in Table 2.4.			
MACRO			Deer grazing on at least one paddock with macrocarpa tree *1 = Yes; 0 = No*
TOPO		1-3	Mean topography score *PTOPO*(ENTRY-LEAVE)/(END-START)*
Similar calculations were made for the following shelter variables HILL, GULLY, TREES, BULLR, and BELT (scores from 0 to 3), wind protection variables (WESTB, WESTH, WESTG, and similar scores were recorded for easterly, southerly and northerly winds), and pasture variables PASTT (score from 1 to 3), THISTLE and RAG (scores from 0 to 3), the fence pacing score FP (from 0 to 3) and the shelter score SHELT (score from 0 to 39) from respective paddock variable described in Table 2.4.			
Note : HILL, BELT and wind protection variables (WESTB, WESTH, WESTG, and similar scores recorded for easterly, southerly and northerly winds) were calculated although not included in risk factors analyses (Chapter 4)			

AVWIND Paddock average wind exposure index

When wind Beaufort scores were reported over 2 (see Table 2.13 and Table 2.14), a daily index of wind exposure was calculated for the paddock where deer grazed. This wind index was calculated according to the dominant wind direction. For example, if the wind was recorded from the West :

West Wind Index = DWW / (PTREES+PWESTB+PWESTH+PWESTG)

When the wind was recorded from two dominant wind directions, two daily indices of paddock wind exposure were calculated, then averaged to give a mean daily index.

The paddock average wind exposure index, noted AVWIND, was calculated as the average of daily wind indices calculated during the grazing period for each grazing interval.

[†] START and END describe start and end dates of grazing periods, respectively (see Table 2.28)
ENTRY and LEAVE describe start and end dates of grazing intervals, respectively (see section 2.3.1.1.)

2.6.2.2.1.3 Food supplementation variables

Food supplementation variables were calculated for any grazing periods from the dataset "Foodsup" as described in Table 2.32. Among these variables, the average daily individual intake of metabolisable energy through food supplementation (SUPEN) was estimated for any studied grazing period. Percentages of dry matter (%DM) and metabolisable energy contents (MJME/kg DM) of given food supplements used for calculations are presented in Table 3.15 with descriptive results.

Table 2.32 : Food supplement variables and calculated supplementary food energy intakes.

Code	Unit	Description	
FSUP		Food supplementation of deer	*1 = Yes; 0 = No*
HAY		Supplementation of deer with hay	*1 = Yes; 0 = No*
SILAGE		Supplementation of deer with silage or balage	*1 = Yes; 0 = No*
CONC		Supplementation of deer with concentrate	*1 = Yes; 0 = No*
NUMFS		Number of times deer were given food supplements	
SUPEN	MJME/Deer Days		

Estimated daily individual energy intake (MJME) through food supplementation

Daily energy intakes (X) by individual deer were initially calculated for any food supplement

$$X = (QUANT1*(1- WASTE1/100)*MJME/kgDM*\%DM)/GDEER\dagger$$

Then final calculations were made for any studied grazing period :

$$SUPEN = (Sum\ of\ (X1+X2))/(END-START)\ \ddagger$$

† Energy values of food supplements are presented in Table 3.15.
GDEER is the mob size at supplementation obtained from grazing records

‡ (END-START) is the duration in days of the studied grazing period

Note : These calculations were carried out for any grazing period under study as defined in Table 2.28, codes used are presented in Table 2.8.

2.6.2.2.1.4 Disease control variables

Disease control variables were created as described in Table 2.33 from the dataset "Deerwork" (Table 2.9). Anthelmintics, trace element supplements and vaccines used by farmers during the study are listed in the next chapter (Table 3.12).

2.6.2.2.2 Handling management variables

Some handling management variables were recorded at the farm level through a questionnaire (Appendix 2.3) and presented in Table 2.12. Others were calculated from grazing and deer work in yards records as described in Table 2.34. These latter variables were calculated where appropriate for any class of stock and any time period such as grazing periods.

Table 2.33 : Disease control variables

Code	Unit	Description
Vaccination variables		
VCLOST		Vaccination of young deer around weaning against clostridial diseases, with two doses of 5-in-1 vaccine 3 to 4 weeks apart
HCLOST		Booster vaccination of hinds against clostridial diseases before calving
VYERS1		First dose of the vaccine Yersiniavax injected to weaners before April 1. *1 = Yes; 0 = No*
VYERS		Weaners vaccinated with two doses of the vaccine Yersiniavax *1 = Yes; 0 = No*
Internal parasite control and trace element supplementation		
GUN		Did the farmer check the accuracy of the delivering system (drenching gun) before each drench by squirting a number of doses into a measuring container ? *1 = Yes; 0 = No*
JUNED, JULYD, WINTD, SEPTD, NOVD, SUMD were codes describing anthelmintic treatment in June, July, winter, September, November and summer, respectively *(1 = Yes; 0 = No)*. These variables were created for weaners and stags where appropriate for multivariable analyses.		
Yearling and adult hinds, and yearling and adult stags *(1 = Yes; 0 = No)*		
IVEA		Use of an ivermectin/albemycin anthelmintic
WINCOP		Copper supplementation of stags in winter (June 1 - September 1)
Weaner deer (variables recorded for the period between weaning and June 1)		
SIPC		Number of days between January 1 and the first anthelmintic treatment
STARTD		Number of days between the start of the studied period (eg June 1 or September 1) and the next anthelmintic treatment (drench)
NANTH		Number of anthelmintic treatments
DRUG		Use of only ivermectin/albemycin or benzimidazole-based anthelmintics *1 = Yes; 0 = No*
IVE		Use of ivermectin/albemycin anthelmintics only *1 = Yes; 0 = No*
DRENCHI		Mean number of days between two anthelmintic treatments *(Date last Drench-Date first drench) / (NANTH-1)*
PRECD	%	Average percentage of the recommended anthelmintic dose by drug companies that was actually given to the deer† *Average of (DOSE/BW)*100/RECD calculated for each treatment*
DOSEOK		Weaner received the recommended dose of anthelmintic† *1 = Yes; 0 = No*
MINSUP		Use of mineral (Cu, Co, Se) supplemented anthelmintics *1 = Yes; 0 = No*
COPPER		Copper supplementation prior or during winter (before early July) *1 = Yes; 0 = No*
CUD	g	Dose of cupric oxide rods given to the deer Possible doses were 0, 4, 5, 8, 10, 12 and 20 g

†Variable recorded for each deer, DOSE is the anthelmintic dose given, RECD is the dose recommended in deer (or cattle or sheep) by drug compagnies as listed in table 3.12. BW is the individual bodyweight calculated at the time of treatment as described in section 2.6.2.3.

Table 2.34 : Handling management variables

Code	Description	
From grazing records		
STOCK	Number of times the mob composition was changed	
SHIFT	Number of times deer were shifted between paddocks	
From Deer work records		
YARDED	Number of times deer were yarded	
YARDBW	Calves handled in yards before weaning	*1 = Yes; 0 = No*

2.6.2.3 Calculation of individual animal variables

2.6.2.3.1 Calculation of bodyweights and growth rates

Calculations of individual bodyweights and growth rates were performed directly in datasets "Weaner", "Hind" and "Stag" (Table 2.18). From bodyweights recorded by farmers, bodyweights were calculated at defined dates. For instance, W4 was calculated as the bodyweight on April 1 as follows :

Given BW1 and BW2 as individual bodyweights recorded on dates D1 and D2, respectively (April 1 being between D1 and D2), the growth rate (GR) between D1 and D2 was calculated as (BW2 - BW1)/(D2 - D1), and W4 as :

$$W4 = BW1 + (April\ 1 - D1) * GR \quad (kg)$$

Similar calculations were performed where possible to obtain bodyweights on the first day of each month of the year such as on June 1, September 1, December 1 and March 1, coded as variables W6, W9, W12 and W15, respectively.

Individual growth rates were calculated from these calculated bodyweights such as the growth rate between April 1 and June 1 noted GR46 :

$$GR46 = (W6-W4) * 1000/(June\ 1 - April\ 1) \quad (g/d)$$

Weaner growth rates GR69, GR912 and GR123 were similarly calculated in the same way as winter, spring and summer growth rates (periods are described in Table 2.28). Growth rates or bodyweight changes of hinds and stags during winter (GR69) were also calculated.

2.6.2.3.2 Calculation of velvet antler monetary value

Monetary value of velvet antlers was directly calculated from its weight and grade described in the Game Industry Board guidelines for velvet harvesting (Appendix 1.1). Prices used for this calculation were averages from the last 4 harvesting seasons commencing in 1990/1991 as detailed in Table 2.35 (Isaacs, GIB, personal communication).

Table 2.35 : Prices of velvet antler (NZ$/kg) used for calculation of velvet antler monetary values

		Velvet antler harvesting seasons				
Grade	Score	90/91	91/92	92/93	93/94	Average price
E	1	81	120	44	60	76.25
D	2	100	145	59	82	96.50
C	3	126	163	73	100	115.50
B	4	149	181	108	127	141.25
A	5	163	190	127	136	154.00
SA	6	163	190	127	136	154.00

Note : calculations were based on the highest grade of the left and right velvet antler.
Source New Zealand Game Industry Board (Isaacs, personal communication)

2.6.2.4 Calculated health variables and biological markers

Health problem variables and calculated biological markers are presented in Table 2.36

2.6.2.5 Measures of health and productivity parameters

Health problems and productivity results were calculated for each farm as described in Table 2.37. Results and discussion of these calculations are presented in Chapter 3.

Table 2.36 : Health problem variables and calculated biological markers.

Codes	Unit	Description	
Health problem variables recorded at the mob level (specific to weaner mobs)			
		(1 = Yes; 0 = No)	
LAME		Mob with observed lameness (including clinical osteochondrosis)	
DEATH1		Mob experienced natural death other than that caused by misadventure before June 1	
DEATH2		Mob experienced natural death other than that caused by misadventure after June 1	
YERS		Mob experienced clinical yersiniosis	
YERS1		Mob experienced clinical yersiniosis before June 1	
Individual biological markers			
Blood markers			
CU8		Serum copper >= 8 µmol/l	*1 = Yes; 0 = No*
B12185		Serum vitamin B12 >= 185 pmol/l	*1 = Yes; 0 = No*
GSHPx3		Glutathione peroxidase >= 3 kIU/l	*1 = Yes; 0 = No*
Parasite markers			
FLC>0		Positive faecal larval count	*1 = Yes; 0 = No*
FEC>0		Positive faecal egg count	*1 = Yes; 0 = No*
Farm-level biological markers			
Blood markers			
MWCC, MHB, MPCV, MNP, MEOP, MLP, MTP, MALB, MP, MGGT, MBUN, MCU, MB12, MGSHPx and MPEPS were calculated as the mean or geometric mean (where appropriate) of WCC, HB, PCV, NP, EOP, LP, TP, ALB, P, GGT, BUN, CU, B12, GSHPx and PEPS from sentinel deer separately for weaners (< months), hinds and stags (and separately between age or sex group where where there was statistically significant difference as described in chapter 3 (Appendix 3.70 and Appendix 3.71)			
MCU8		Mean serum copper >= 8 µmol/l	*1 = Yes; 0 = No*
MB12185		Mean serum vitamin B12 >= 185 pmol/l	*1 = Yes; 0 = No*
MGSHPx3		Mean glutathione peroxidase >= 3 kIU/l	*1 = Yes; 0 = No*
Parasite markers (specific to calves before commencement of anthelmintic treatment)			
FLCI		Farm calf faecal lungworm larvae index = geometric mean lungworm larvae count multiplied by the number of calves with positive count (over 10 calves)	
NFEC>0		Number of calves with positive faecal egg count (over 10 calves)	
Yersiniosis serology (specific to weaners)[†]			
SEROYERJ		Maximum seroprevalence (increase of 20 Unit OD between March and June) against *Yersinia pseudotuberculosis* type I, II or III	
SEROYERS		Maximum seroprevalence (increase of 20 Unit OD between March and September) against *Yersinia pseudotuberculosis* type I, II or III	

[†] see section 3.4.1.4.1 for further detail.

Table 2.37 : Measures of health and productivity of deer farms

Codes	Unit	Description
***Reproduction*†**		
CONCR	%	Conception rate *Number of hinds pregnant in June*100 / Number of hinds mated* *estimated by : Number of hinds diagnosed pregnant in June*100 / Number of hinds scanned*
ADVCR	%	Early conception rate (conception before May 1) *Number of hinds conceiving early *100 / Number of hinds mated* *estimated by : Number of hinds diagnosed conceiving early *100 / Number of hinds scanned*
WEANR	%	Weaning rate *Number of calves weaned*100 / Number of hinds pregnant at calving*
REPEFF	%	Reproductive efficiency *Number of calves weaned*100 / Number of hinds mated*‡
WW/HC		Mean calculated bodyweight of weaners on April 1 per hind at calving. *Total weaner weight on April 1 / Number of hinds pregnant at calving*
WW/HM		Mean calculated liveweight of weaners on April 1 per hind mated *Total weaner weight on April 1 / Number of hinds mated*
MW4	kg	Mean bodyweight of weaners standardised to April 1 *(separately for weaner hinds and stags)*
Venison		
MW6§	kg	Mean bodyweight of weaners standardised to June 1 *Similar calculation were performed for each month, eg MW9, MW12 and MW3 were calculated as mean bodyweights standardised to September 1, December 1 and March 1, respectively.*
MGR46§	g/d	Mean growth rate of weaner stags between April 1 and June 1 *MGR69, MGR912, MGR123 were calculated as mean growth rates of weanes between June 1 and September 1, between September 1 and December 1, and between December 1 and March 1, respectively.*
WS92	%	Percentage of weaner stags reaching 92 kg bodyweight before December 1
Velvet antler		
VGRSA	%	Percentage of velvet antler grading SA# *VGRB, VGRC, VGRD and VGRE are defined as percentages of velvet antler grading A, B, D, C and E, respectively*
MWEIGHT	kg	Mean velvet antler weight per stag *Mean of WEIGHT*
MGRADE		Mean velvet antler grade per stag *Mean of GRADE*
MCVEL$	NZ$	Mean velvet antler monetary value per stag corrected for the mean age of the velvetting herd (adult stag only) *Mean of VELV$ / Mean of AGE*
MCVW	kg	Mean velvet antler weight corrected for age per adult stag *Mean of (WEIGHT - 0.281*AGEV)* *Given 0.281 the slope of the regression line between WEIGHT and AGEV, the age of the stag at the time of velvet antler removal (see section 3.3.3.3)*

† Calculations were made separately for yearling and adult hinds where appropriate.
‡ Includes all breeding hinds except those leaving the farm for reasons not related to pregnancy test results.
§ Calculations were separately made for weaner hinds and stags
# Velvet antler grades are described in Appendix 1.1

Table 2.37 (Cont'd)

Codes	Unit	Description
Mortality rates		
PROLOSS	%	Progeny loss rate *(Number of hinds pregnant in June - number of calves weaned)*100* *Number of hinds pregnant in June*
ABORTR	%	Abortion rate *Number of hinds pregnant in June*100* *Number of hinds pregnant at calving*
CALFMR	%	Calf mortality rate (progeny loss rate - abortion rate) *(Number of hinds pregnant at calving - number of calves weaned)*100* *Number of hinds pregnant at calving*
WMR		Mortality rate of weaners from 3 to 15 months of age (Year period beginning on March 1) *Number of weaner losses (death or deer euthanised due to health problem)* *Number of weaner-years*
Mortality rates were similarly calculated, all farms combined, for each class of deer and for the following periods: - Autumn : from March 1 to June 1 - Winter : from June 1 to September 1 - Spring : from September 1 to December 1 - Summer : from December 1 to March 1		
Culling		
CULLH	%	Culling rate of mature hinds (YH and AH) between mating seasons

† Velvet antler grades are described in the game industry board guide line for the removal of velvet antler (see Appendix 1.1).

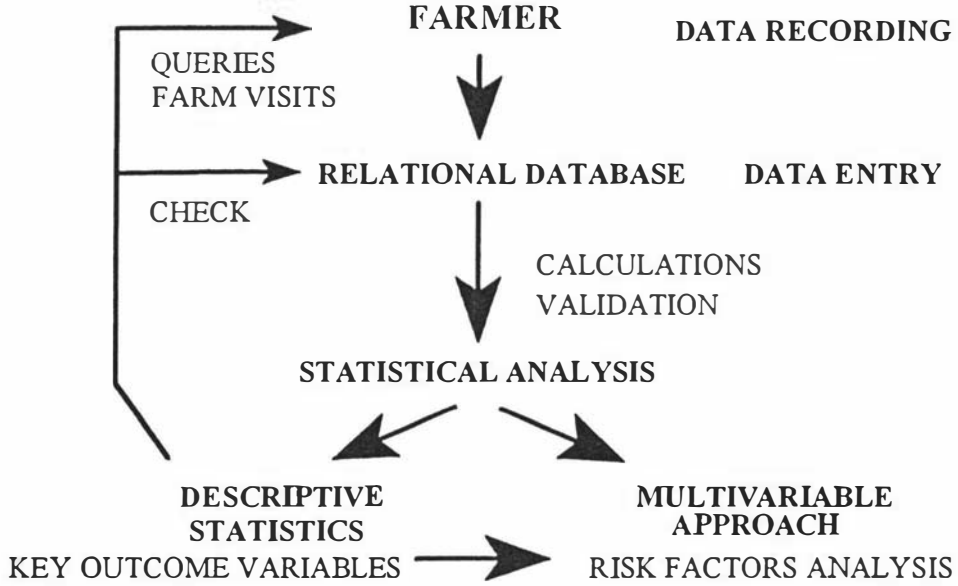
Note : these are the main health and production parameters that were calculated. Other parameters are presented in Chapter 3 with descriptive results where appropriate.

2.6.3 Data validation

The circulation of information relating to data entry, checking and validation is described in Figure 2.5.

Data were entered into primary datasets as soon as possible after collection on farms or at the laboratory. The computer data was then checked for each dataset by printouts, basic calculations and basic statistical analyses. Databases were corrected where possible for erroneous and missing information by reference back to farmers. Computer listings of deer tag identifications, when used by farmers, were very useful both to avoid the misreading of tag identifications on the deer at recording, and to simplify the computer data entry, thus minimising mistakes. Once raw and calculated data were validated, final statistical analyses were carried out. Descriptive statistics were carried out to validate the data and identify key performance outcomes (Chapter 3) which required further investigations, ie multivariable analysis of risk factors (Chapter 4).

Figure 2.5 : Data entry and validation before statistical analyses



Validation of data was also performed through cross checking of information from successive farm records and between computer datasets. For instance, the sex of some weaners recorded at weaning appeared to be wrong, eg about 5-6 weaner "hinds" grew antlers and weaner "stags" did not, indicating farmer error at weaning.

As pasture sward height and hind body condition score appeared to be important risk factors for many performance outcomes, repeated measures were carried out during the last farm visit to investigate potential measurement bias. On each farm, 9-10 swards heights were measured by both the farmer and the researcher on the same paddock areas to evaluate consistency of measurement between farmers. The investigation of body condition scoring is presented in section 3.3.1.2.1.

2.7 STATISTICAL DATA ANALYSES

While descriptive epidemiological investigations and univariate statistical analyses are presented in Chapter 3 where appropriate, this section gives an overview of statistical techniques used for multivariable risk factor analyses. Specific considerations are presented and discussed in Chapter 4 where appropriate along with each analysis.

2.7.1 Selection and rejection of variables

In this study, a large number of variables relevant to deer production were recorded but only a proportion of them were analysed. During data collection and univariate analyses (see section 0), data were checked carefully for completeness and accuracy. Those likely to be subject to important recording bias (eg pasture seed head height, time of labour and costs) were rejected from further investigation. The remaining variables were tabulated and are presented in Chapter 3.

Production or health outcome variables that were further subject to multivariable statistical analyses are presented in chapter 4 and are listed in Table 2.38. These variables were considered as important

in the deer production process and discussion of the criteria used in chosing them is presented in section 5.2.2. Because of the limited number of farms monitored, most multivariable analyses were carried out on individual deer variables.

For multivariable analyses, potential risk factors for each outcome variable were identified based on their known or suspected causal relationship with the outcome from the literature, or from logical thought (biologically sound) inferring their plausible causal relationship with the outcome. Because only the most important production and health outcomes were investigated in this thesis, not all recorded or calculated variables were included in risk factor analyses. Variables selected as potential risk factor are listed in the glossary and within each section in Chapter 4.

2.7.2 Handling of missing values

Missing values were frequent in this study as in any observational study. Variables with a high frequency of missing values were excluded from analyses, as were variables deemed too subjectively or inaccurately recorded.

Multivariable analyses were carried out where possible depending on the number of "valid" records in the dataset. In many instances, analyses were carried out on data subsets and a limited number of variables, eg the investigation of individual dam characteristics as risk factors for weaner bodyweight on April 1 (see section 4.2) involved only the eight farms which recorded dam-offspring pairing.

To avoid the exclusion of records during multivariable analyses, missing data were replaced by the appropriate mean of the respective variables in accordance with standard procedures for handling missing observations. For the analysis of dichotomous outcomes, missing values of potential risk factors were replaced using NCSS, while missing values of potential risk factors for continuous outcomes were replaced using Statistica.

2.7.3 Pooling of data

In most analyses in this thesis, data from both years were pooled and analysed together, thus increasing the number of statistical units. However, when a production outcome in one year (eg the lactational status of a hind at weaning) was investigated as a risk factor for the same production outcome the next year, data from both years were analysed separately.

2.7.4 Path analysis

Risk factors were investigated using path analysis (Pedhazur, 1982). This statistical technique was used to decompose and interpret relationships within sets of correlated variables, and identify those most significantly associated with each outcome under study. The analytical steps followed in this process are described in general terms below. The detail of each risk factor analysis is presented in Chapter 4.

2.7.4.1 Step 1 : Data screening

In a preliminary analysis, potential risk factors for each outcome variable were screened using univariate statistical methods for association with the outcome under investigation. When the outcome variable was dichotomous, continuous and ordinal variables were analysed without

Table 2.38 : Summary of outcome variables under investigation in this thesis

Codes	Unit	Range	Description
INDIVIDUAL DEER OUTCOME			
Reproduction *(Yearling and adult hinds separately)*			
CONC		D	Hind conceiving (pregnancy diagnosed in June)
ADVC		D	Hind conceiving before May 1
WET		D	Hind rearing a calf at weaning (as an indicator of progeny loss)
Venison production *(Weaner hinds and stags separately)*			
W4	kg		Bodyweight on April 1
GR46	g/d		Growth rate between April 1 and June 1 (autumn growth)
GR69, GR912 and GR123 as winter, spring and summer growth rates, respectively			
Velvet *(Yearling and adult stags separately)*			
VELV$	NZ$		Velvet antler monetary value
CVELV$	NZ$		Velvet antler monetary value corrected for age (adult stag only) *VELV$ / AGE*
WEIGHT	kg		Weight of velvet antler
GRADE			Grade of velvet antler[†]
7 = Grade SA ; 6 = Grade A ; 5 = Grade B ; 4 = Grade C ; 3 = Grade D ; 2 = Grade E ; 1 = Other grade			
Health			
All hinds >15 months together			
DYS		D	Hind experiencing dystocia
MCF		D	Hind dying from malignant catarrhal fever (MCF) in winter.
All stags >15 months together			
MCF		D	Stag dying from MCF from winter to summer
Weaners			
YERS		D	Weaner dying from suspected or confirmed yersiniosis
MOB OR FARM OUTCOMES			
ADVCR	%		Early conception rate (conception before May 1) *(Yearling hinds)*
CONCR	%		Conception rate *(Yearling hinds)*
WEANR	%		Weaning rate *(Yearling and adult hinds separately)*
MW4	kg		Mean weaner weight on April 1.
MGR46	g/d		Mean weaner growth rate between April 1 and June 1
MGR69, MGR912 and MGR123 as mean weaner winter, spring and summer growth rates, respectively (g/d)			
MMCF		D	Stag or hind mob experiencing malignant catarrhal fever
MYERS		D	Weaner mob experiencing suspected or confirmed yersiniosis
MCVELV$	NZ$		Mean velvet antler monetary value corrected for age (adult stag only) *MVELV$ / MAGE*
MWEIGHT	kg		Mean weight of velvet antler (*WEIGHT*)
MGRADE		1-7	Mean grade of velvet antler[†] (*GRADE*)

[†] as defined in the New Zealand guidelines for the removal of velvet antler (Appendix 1.1).
D = dichotomous outcome (1 = Yes; 0 = No)
Note : this list of outcomes was not exhaustive and more investigations will be carried out as the analyses progress further (see Table 5.4), but it was not in the scope of this PhD thesis. A summary of analyses carried out is presented in Table 4.1 and Table 4.2.

transformation by the t-test or rank sum test (t-test carried out on the ranks for datasets with limited number of records for one outcome category), while categorical variables were analysed by the Chi-square test of independence, using the computer package SAS. When the outcome variable was continuous, continuous and discrete (eg body condition score) independent variables were analysed without transformation using the Spearman rank correlation test using Stastistica and categorical variables were analysed by the t-test or rank sum test using SAS. Variables not showing statistically significant association with the outcome variable at a screening level ($p>0.20$) were rejected from subsequent multivariable analyses unless they were recognised as potentially important factors on external biological grounds. This step enabled deletion of variables that appear not important on statistical grounds at an early stage, and simplified the process of building null hypothesis path diagrams.

2.7.4.2 Step 2 : Building of null hypothesis path diagrams

Because of the high number of potential risk factors often selected for one investigation, these factors were grouped according to their area of data collection, eg individual deer characteristics or grazing management variables. In any of these blocks of variables could be found variables that were recorded or calculated at the individual, mob or farm level. These clusters or blocks (Salman and Meyer, 1987) were analysed together or separately, depending on the outcome variable. Significant individual deer characteristics were included in the analyses of management practices and environmental factors, since they may otherwise be important confounding factors.

For each block of variables potentially associated with a given outcome, a null hypothesis path diagram was drawn from factors that were selected after univariate screening as in 2.7.2.1. Variables were ordered in logical sequence, and biologically plausible pathways were drawn between them with unidirectional arrows (Goldsmith, 1977) to investigate the pathways of association between important risk factors. Paths could be justified on scientific grounds by previous published studies, or hypothesised from previous observations or experience (Curtis et al., 1988c). No reciprocal effects or feedback loops were allowed in the diagram, as all relationships in a path model were assumed to be linear and recursive (Burridge et al., 1977).

Some potential risk factors were identified as endogenous variables, ie they were considered to be determined by some linear combination of other variables under consideration (eg with arrows leading to them). The other variables, called exogenous variables, have no arrows leading to them, eg their variability was considered to be caused by variables not recorded or not included in the analysis. Potentially important confounding factors (such as variables found significant within the block of individual deer risk factors) were included in the path diagram.

2.7.4.3 Step 3 : Multivariable analysis and estimation of path coefficients

Within each null hypothesis diagram, the outcome variable and each endogenous variable was regressed on all endogenous or exogenous variables (independent variables) with arrows leading to it. Continuous and categorical variables were analysed using multivariable linear (Kleinbaum et al., 1982) and logistic regression analysis (Hosmer and Lemeshow, 1989), respectively, using a forward stepwise procedure.

The computer package SAS was used for logistic path analysis of dichotomous outcomes. In stepwise logistic regressions analyses, variables that improved the goodness of fit statistic (deviance) of the model significantly ($p<0.05$) were selected by the model building procedure, while in the

linear regression procedure, the 5% significance level of the partial F statistic was used as a thresold for inclusion or exclusion from the model.

The computer package Stastistica was used for path analysis of continuous outcomes. Independent variables with a partial F statistic over 4.00 in multivariable stepwise linear regression analyses were allowed to remain in respective models. The limited number of logistic regression analyses within these path diagrams were carried out using Statistica using a backward stepwise procedure based on the significance of regression coefficient at the 5% confidence level.

2.7.4.4 Step 4 : Final path diagram and interpretation

Unstandardised multivariable linear regression coefficient estimates are presented on significant paths of association between continuous or categorical independent variables and continuous dependent variables (outcome or endogenous variables).

In logistic regression, the exponential of beta coefficients presented on significant paths between dichotomous variables are interpreted as odds ratios (Curtis et al., 1988b). The interpretation of regression coefficients when independent variables are continuous is not straightforward, unless there is a linear relationship between the continuous variable and the probability of occurrence of the outcome under investigation. The sign of these coefficients, however, is informative, eg independent continuous variables are negatively or positively associated with the outcome (Chesterton et al., 1989). Thus only signs of these coefficients are presented in final path diagrams.

The goodness of fit of each final model was estimated through the deviance statistic in logistic regression (Hosmer and Lemeshow, 1989) and the overall F test in linear regression (Kleinbaum et al., 1982). A p value over 5% was considered as good fit. In multivariable linear regression, the square of the multiple correlation coefficient (r^2) was recorded and interpreted as the proportion of variability in the outcome variable "explained" by the variables included in the model (Kleinbaum et al., 1982). Using logistic regression, the equivalent of the model r^2 was obtained by calculating the proportional reduction in deviance when significant variables were included in the model (Frome and Checkoway, 1985).

Logistic (or linear) beta coefficient estimates of the final models, standard error of beta coefficients and their significance level (p value), the deviance of the model and the percentage of reduction in deviance caused by the variables in the model (or r^2, where appropriate) are presented. When using logistic regression, odds ratios and their 95% confidence interval were calculated for each dichotomous risk factor.

2.8 DISCUSSION.

2.8.1 Sample size.

Contact with farmers and farm visits were primarily performed by one investigator, thus limiting the number of farms to fifteen. Cost was also a major factor. This was in contrast with many other longitudinal epidemiological studies in other domestic species, in which much larger numbers of farms have been surveyed (Barnouin and Brochart, 1986). These required many observers for data collection and less detailed data collection. Those studies investigated one disease or syndrome at a time, targeting specific potential risk factors. As disease outcomes may be relatively rare, these studies require a large number of farms (in particular if the outcome is recorded at the mob or farm

level). In holistic herd health and production profile studies, the number of farms can be small because diseases of interest occur almost universally (Morris, 1991). In this study, 15 farms provided significant numbers of mobs and animals to enable appropriate statistical analysis of both mob and individual risk factors.

2.8.2 Farm selection

To optimise the quality and quantity of observations that were made, farm selection was primarily based on the farmer's willingness and motivation to participate and record a large amount of data in a form suitable for scientific investigations. Farmer members of the New Zealand Deer Farmers' Association were chosen because of access to a suitable mailing list. The proportion of participating questionnaires that were answered (22%) in this study was deemed large considering response rates usually obtained with conventional mail surveys (Rumeau-Rouquette et al., 1993).

Red deer farms were selected as red deer represented 80% of the farmed deer population in New Zealand (Guild, 1993). Herds had to include hinds for study of reproduction, and also had to have appropriate yards. Wapiti-type adult hinds and stags were avoided, but it was difficult to reject wapiti-type weaners because wapiti cross-bred terminal sires are being used increasingly for venison production.

Farm sizes were selected to be representative of the deer industry. It was expected, however, that data recording would not be as intensive and complete on the two biggest farms (Farm 14 and 15 in Table 2.2) as on the other farms.

Personal contact with farmers through initial visits and the meeting with all participant at Massey University was critical to ensure farmers' preparedness for the project, evaluate the level of recording that could be achieved on farms, and obtain farmers' commitment for two years. Two farms unfortunately withdrew early in the study because of circumstances unrelated to the project. Farm 14 was deleted after the first year as limited information was recorded. Information from the remaining 14 farms was considered sufficient to complete the study.

Deer age categories were chosen to help data collection in that no deer changed category during each year of the study. This also enabled recording of management practices and performance of yearling and adult hinds from mating (March-April) to weaning (February-March), ie during a full management cycle. Terminology used was at slight variance from common usage.

2.8.3 Sentinel animal selection

In selection of sentinel deer, those likely to leave farms were excluded because of the requirement for repeated sampling over time. Although care was taken not to select the heaviest or biggest deer (more likely to stay on farms), it was difficult to estimate the bias which may have arisen through this selection procedure. Comparison of bodyweights of weaners at the time of selection was made for hinds and stags between the sentinel deer and the rest of the mob using the Mann-Whitney U test. There were 3 of 56 groups in which the main mob showed significant mean bodyweight differences from selected deer (5.35%). On this basis, the selection procedure was considered adequate. In 1993, mean bodyweights were highly significantly different between groups on farm 13 because the farmer clearly selected weaner deer, so the selection on that farm was biased.

2.8.4 Deer identification

When the farmer did not have good farm records, it was extremely difficult, or in some instances impossible, to obtain accurate lists of all deer identification. Figures presented in Table 2.3 give the best estimate of the number of deer of each category that were reported to be on farms or recorded by their tag identification. Discrepancies occurred as not all deer were ear-tagged or individually known by every farmer, and accurate figures of deer numbers (mostly hinds) were difficult to obtain on 3 farms. During visits, deer could escape handling and therefore be reported missing. In yards, muddy ear-tags could be misread or one number reported twice in the listing. Computer print-outs were used to limit these problems, but the number of deer actually individually monitored could only be the best estimate. Deer numbers recorded in grazing sheets were consistently checked against individual data and were deemed the most accurate estimates. However, the minor inevitable inaccuracies in recording were not considered sufficient to influence the analyses.

2.8.5 Farm and farmer familiarisation and recording

In many ecopathological studies, data collection periods are preceded by a period of designing and experimenting protocols on farms at each phase of data recording, processing and analysis (Ganière et al., 1991). In this study, emphasis has been put on farm visits and planning meetings prior to data collection. This helped familiarisation between farmers and researchers. Shortly after the start of data collection, the protocol along with recording sheets were modified slightly to facilitate farmers' recording and meet the farmers' needs. The recording sheets presented in appendices were those used at the time of thesis writing. In some instances, other specific sheets were created for one or two farmers. Farmers were encouraged to record events at the time of occurrence to improve accuracy. Frequent and regular visits of the study farms were necessary to ensure motivation and to continually keep farmers abreast of progress.

2.8.6 Information access and availability

This study was observational, allowing no interference with farm management. Therefore information could not be directly disclosed to participating farmers during the study unless it was unavoidable (eg pregnancy testing observations) or when specifically requested by the farmer's veterinary practitioner as part of normal investigations on the property, or where witholding information would result in duplication of expense to the farmer for routine management practices (eg soil test results).The bias that responses to that information may contribute is unavoidable in this type of study, but is likely to be small.

2.8.7 Farm visit calendar

Farm visits were planned for animal sampling at times when deer could be handled easily in the yards according to deer circannual biological cycles (see section 1.1.3.1.) and farm management practices. The first visit was scheduled in March because, on most commercial red deer farms, calves are weaned and this was the earliest period when calves could be handled. March also marks the onset of the mating season and farmers would handle hinds at that time. Unfortunately, most adult stags could not be safely mustered and handled during this visit. The second farm visit was scheduled in June as the onset of winter. Hinds could also be tested for pregnancy after sire stags were isolated from hinds (Revol and Wilson, 1991). The third farm visit was carried out in September, as the end of the winter season, when stags could be handled before velvet antler

growth, and hinds before pregnancy became too advanced. In November, hinds could not be handled as they were set stocked for calving. As only weaners and, a limited number of stags could be handled at that time because of velvet antler growth, it was decided that the November farm visits would not be carried out during the second year of study.

2.8.8 Farm management recording

2.8.8.1 Recording sheet utilisation and accuracy of data collection

Some recording sheets were not used by all farmers during this study because they were designed to gather a lot of information some farmers may not have. For instance, only three farmers carried out post-mortem examinations themselves, thus making post-mortem reports obsolete for other farms. Management practices related to deer work in yards were often recorded in grazing sheets in the column "info". Regular farm visits were necessary to check, transcribe and complete the information in a suitable form before computer data entry.

In general, where farmers already kept records and deer were frequently handled during the study, data was more accurately and intensively recorded. On 4 farms, farmers had no complete previous written records and figures were not as accurate. However, these farmers were more often visited or contacted by phone to ensure data were valid and erroneous information was minimised before calculations and analyses (see section 2.6.3.). Cross-checking of data was performed wherever possible. For instance, individual tag identifications during visits enabled a check of recorded mob sizes, and before calculation of mob grazing variables, all grazing records were printed and manually checked for erroneous and missing information.

Not all farmers recorded every handling of deer mobs in the yard. Cross-checks were performed with individual deer data and grazing records to ensure corresponding mobs were recorded as being handled. It was suspected missing data would be more likely from yarding for sorting deer as management practices such as weaning, anthelmintic treatments, vaccinations, mating and calving strategies were checked from print-outs directly with farmers at the end of the data collection phase.

2.8.8.2 Grazing management and nutrition

Possibly the most demanding records were grazing management records. Pasture height was chosen to monitor pasture availability for deer during this study as it is a cheap and effective method for estimating pasture dry matter (Piggot, 1986; Webby and Pengelly, 1986). Sward height is also recognised as a measure that condenses many sward variables into one assessment which can be used to assist grazing management (Stakelum and Dillon, 1990; Hayllor and Seal, 1990). Pasture sward height up to 10-15 cm is positively associated with increased liveweight gain in sheep (Chestnutt, 1992), cattle (Moore et al., 1992; Wright et al., 1990), and deer (Ataja et al., 1989). Other methods of pasture dry matter assessment include the use of weighted disc (pasture plate), and electronic pasture probe, but it was not practical and too expensive to be used by farmers. However, a pasture plate was used by the researcher to estimate and compare overall farm pasture covers during farm visits.

Sward height is best estimated by taking at least 30 measurements within a paddock, although it is not practical on commercial farms (Webby and Pengelly, 1986). In this study, the mean of 6-10 measurements taken in areas typical of the paddock, which could be corrected after visual appraisal, was accepted. The training of farmers during the first farm visit gave the researcher the confidence

that most farmers did record sward height according to the technique explained, although there may be variations between farmers. Occasionally, some farmers did not use the ruler but their hand to estimate sward heights, or forgot to report their measurements. Rarely, farmers gave their best guess to complete a set of data. The reliability of this estimation was evaluated by the researcher during regular visits. When there were a lot of missing measurements on recording sheets, however, no attempts were made to complete the data. The validation exercise carried out at the end of the project showed farmers' recordings overall were consistent with the researcher's measurements.

Clover and seed head density score were recorded to estimate pasture quality (Butler, personal communication), although it is related to sward height. For instance, as the sward gets longer, the proportion of white-clover diminishes and that of stems and dead material increases (Stakelum and Dillon, 1990). Seed head density scores were introduced to farmers in spring 1992 (see Figure 2.3 and 2.4), but this recording was not completely satisfactory because many farmers regularly forgot to report it and there was no way to check whether the information was missing or whether paddocks had no seed heads. This extra variable showed the limit of what could be recorded as one farmer stopped recording his grazing management for the whole summer in 1992-1993. Considering this, it was believed a score of pasture quality indicating the amount of stem and dead material should have been devised and introduced at the start of the study. Introducing an extra variable after a few months of data collection when farmers were in their routine was not successful.

2.8.9 Monitoring health and disease

2.8.9.1 Health problems and mortalities

Monitoring health problems was possibly the most challenging recording in this study. It is commonly believed that disease is uncommon on well managed properties, although deer are susceptible to a range of disease conditions (Haigh and Hudson, 1993). By nature deer are able to conceal or resist outward manifestation of these conditions so it may take some time before any sign of disease can be noticed by the farmer, in particular in extensive properties. Often, when clinical signs develop the disease process is already advanced to an irreversible stage, thus leading to death. In this study, it was therefore not expected that all clinical health problems would be identified. However, mortalities could be closely monitored, in particular for deer that were tagged and individually recorded in the database. Post-mortem reports, sampling procedures and the local veterinarians' involvement were enlisted to maximise the number of diagnoses. Post-mortems carried out on farms were valuable in teaching farmers the technique for examination and organ sampling, and this was successfully repeated by 4 farmers. A number of farmers delivered carcasses to the Massey University post-mortem room for autopsy.

2.8.9.2 Influence of other domestic species on health problems

Other domestic species are often integrated with deer for grazing management (Cowie, 1991). Sheep, for instance, are used on deer farms to control ragwort, a weed that is very toxic to deer (Haigh and Hudson, 1993). The recording of domestic species was to investigate their influence on deer production and the occurrence of health problems such as malignant catarrhal fever or leptospirosis.

2.8.9.3 Inspection at deer slaughter premises

Carcasses of all deer sent for slaughter were inspected at deer slaughter premises (DSP). Reports were collected to evaluate sub-clinical disease such as facial eczema, or further assess the effects of known disease.

Unfortunately, some farmers sending their deer for slaughter did not forward the "MAF veterinarian slaughter sheet" (Appendix 2.18) so inspectors could recognise trial farms and specifically record gross lesions for this study. Moreover, DSPs involved were those of Venison New Zealand Ltd which went into receivership before the end of the project during the main slaughter period in spring 1993. Consequently, deer were sent to other slaughter plants where MAF veterinarians did not record gross lesions for this project. Therefore, these data were not complete. Further, because of time limitations, no attempts could be made to standardise observations between slaughter plants and meat inspectors, so recordings could vary. Thus, this data was of limited validity.

2.8.10 Recording during farm visits

2.8.10.1 Sentinel deer

Sentinel deer were monitored three-monthly to investigate individual biological characteristics as markers for individual performance, subclinical diseases and potential clinical health problems. These markers were also investigated as farm variables in relation to farm performance levels.

It was important to describe the sampling technique and the behaviour of deer during sampling, as it can have a major impact on blood profiles (Audigé, 1992; Cross, personal communication). Because deer can become stressed when handled in the yards, sampling and measurements were as quickly done as possible. Deer were sampled in a pen unless it was deemed unsafe.

The range and type of individual measurements and observations made on sentinel deer were limited by the time involved in recording them. For instance, the investigation of coat density (Table 2.21) was not continued after June 1992 because it was difficult to carry out, thus reducing its accuracy.

The thoracic girth and deer height at shoulder were measured to investigate their relationships with bodyweights and various production outcomes. Body measurements have been related to growth in cattle (Gilbert et al., 1993) thus indicating possible selection criteria. The use of a weighband appeared easy in deer, but the height stick was not straightforward to use when deer were not quiet or bent their forelegs (frequent), or when the floor was uneven. Deer height was recorded only as described in Table 2.21 to ensure accuracy.

The recording of hair loss on the back of deer indicated "victimisation". Subordinate or diseased deer can be bitten or kicked by dominant deer (Moore et al., 1985) resulting in visible loss of hair. These deer are thought to be under social stress which may impair their productivity. On occasions, however, signs suggestive of victimisation were suspected to come from deer climbing over each other during yarding, and thus were not recorded.

Red deer have a double coat (Ryder and Kay, 1973; Ryder, 1977). The outer coat, made of coarse bristly hairs, covers a shorter and finer under coat of wool. Moulting occurs twice a year. According to Ryder (1977), the change of coat of deer is not related to their body condition, but the plane of

nutrition during moulting may influence the density and length of the coat. It was believed the thicker the coat, the better their protection against adverse weather conditions, lowering energy requirements for maintenance. Deer with thicker coats may grow better or be less susceptible to diseases. The site to clip hair and measure the coat length (Table 2.21) has been used previously for investigation of coat (Ryder, 1977) and was also chosen as being easily accessible, clean and free of damage caused by other deer during handling or through victimisation. Statistical analysis showed significant correlations ($p<0.05$) between coat density and coat length recorded in March 1992 (summer coat) and June 1992 (winter coat) from both weaners (WS and WH) and hinds (YH and AH) groups. Thus coat length was considered as an indirect estimate of coat density and therefore measurement of coat density was stopped after June 1992 to improve recording and sampling efficiency.

It was not uncommon to find adult deer with heavily worn incisors on farms (Orr and Moore, 1989). There was a common belief by farmers that "no teeth" was associated with "old age" and "poor condition" in deer, although deer with severely worn incisors do not always lose their body condition, as it depends on grazing management (Orr and Moore, 1989). It may also be that the incisors alone are a poor indicator of cheek tooth condition (Richardson et al., 1979). However, such deer may have lowered feed intake and reduced productivity, as observed in sheep (Coop and Abrahamson, 1974). Teeth wear was therefore considered to be an important potential risk factor in deer.

2.8.10.2 Body condition score

Condition scoring has been used to study the effect of nutritional status (which reflects on BCS) on the health and production level in cattle (Treacher et al., 1986; Edmonson et al., 1989; Garnsworthy and Haresign, 1989; Gearhart et al., 1990; Rasby et al., 1990) and sheep (Cumming et al., 1975; Pollott and Kilkenny, 1976; Thomas, 1990). In sheep, the BCS has been found to be highly significantly correlated with a direct measurement of backfat depth or the proportion of fat in the animal body, and it provided a better estimate of the proportion of fat than body weight did (Russel et al., 1969; Guerra et al., 1972).

The importance of body condition of deer has been essentially demonstrated in the wild habitat (Mitchel and Lincoln, 1973; Albon et al.,1986), and only suspected in farmed deer (Yerex ed, 1982; Heydon et al., 1992). This may be due to the lack of objective methods to assess the body condition of live deer, whereas that of wild deer has been commonly assessed by the amount of fat enveloping kidneys (Wegge, 1975; Finger et al., 1981; Albon et al., 1986; Audigé, 1992). The body condition of live deer has been assessed visually in the wild environment (Riney, 1955; Watson, 1971) but it appeared difficult to carry out from long distances. The technique required close proximity to the deer, and even then only large variation in BCS could be assessed.

The body condition scoring chart presented in Appendix 2.21 has been adapted from that described by Russel et al. (1969) to provide a management support tool for commercial deer farms and for deer research. While primarily studied in relation to health and reproduction outcomes on farms, it was anticipated that BCS in deer could be used to predict the GR measurement of the deer before slaughter and then avoid the downgrading of carcass for over-fatness. This was not investigated in this study.

2.8.10.3 Pregnancy diagnosis

The ultrasound technique was the most practical and reliable technique for determining the pregnancy status. Pregnancy tests were carried out between 15 and 70 days after sire stags were removed but most hinds were scanned 30 and 40 days after stag removal to maximise the accuracy of foetal ageing (Revol and Wilson, 1991). Because of the large number of hinds tested, it was not possible to estimate conception dates for every hind. For practical reasons, hinds were categorised as conceiving early (before May 1), conceiving late (after May 1) or not pregnant. Non-pregnant hinds were carefully examined and re-scanned to ensure accuracy of diagnosis. Those sent for slaughter by September and checked for sign of pregnancy (foetus) were confirmed "non-pregnant", thus validating the ultrasound technique used.

2.8.11 Laboratory investigations

As health and production of livestock are closely related (Blood et al., 1978), monitoring herd health is a management tool to diagnose production-limiting problems. One prerequisite to deer health programmes was to identify the most relevant biological markers which can be used to monitor sub-optimal production levels or subclinical health problems.

2.8.11.1 Blood profiles

Blood biochemical profiles (or metabolic profiles) were developed in the late 70's to investigate health-related problems in groups of animals, eg in intensive farming units (eg dairy cattle, pig) and also in more extensive grazing systems (eg beef cattle, sheep). Although blood characteristics have been evaluated in farmed red deer in New Zealand (Wilson and Pauli, 1983 a, 1983b), so far, rare attempts have been made to relate them to health and production parameters.

Barnouin et al. (1987) described the use of blood markers in metabolic profiles. The principles described in that paper were applied to this study. The blood characteristics investigated in this study were chosen for their known inclusion in blood profiles in other livestock species (Adams et al., 1978; Barnouin et al., 1987). Cost was a major limiting factor, therefore the sampling protocol presented in Table 2.23 was a compromise. For instance, it was unfortunate that iodine could not be investigated, as it is recognised as a significant production limiting factor in sheep in New Zealand (Barry, 1983).

The variations of chosen blood markers are not specific to any health or production outcome in deer, but may highlight departure from optimal health and/or adequate nutritional supply for optimal production. For instance, serum GGT activity is a good indicator of liver damage in deer, in particular in relation to facial eczema (Mortimer, 1984), and it may also be a relevant index of liver metabolism as it is in cattle (Barnouin et al., 1987). Serum copper is commonly tested in deer because copper deficiency has been associated with enzootic ataxia and osteochondrosis (Wilson et al., 1979; Familton et al., 1985; Mackintosh et al., 1986b; Thompson, 1993; Thompson et al., 1994; Audigé et al., 1995).

The number of samples per class of deer was chosen for optimal interpretation of test results. Mineral characteristics such as serum copper and vitamin B12 required the sampling of 10 deer for interpretation of adequacy of supply at the farm level (Mackintosh et al., 1986b; Clark and Ellison,

1993). In contrast, three blood samples were sufficient for assessment of glutathione peroxidase and thus selenium status (Clark and Ellison, 1993).

2.8.11.2 Parasitology

The faecal egg (FEC) and larvae counts (FLC) have been chosen in this study because they are standard techniques to investigate internal parasites in farmed deer, although their relevance to investigate parasitism in deer has been debated (Presidente, 1984; Watson and Charleston, 1985). Limited data suggested there may be a relationship between faecal lungworm larvae counts and actual worm burden in lungs (Mason and Gladden, 1983; Mackintosh et al., 1984), while this was not identified for faecal eggs (Johnston, 1982; Anderson, 1985; Waldrup et al., 1994). However, until better tests are available, it was believed FEC and FLC may be useful to highlight overall mob and farm parasite infestations.

Serum pepsinogen activity has been explored in red deer (Wilson and Pauli, 1983b) but its relevance for deer production was unknown. However, it is an indicator of abomasal damage due to parasites in other domestic species (Armour et al., 1979; Pitt et al., 1988) and high pepsinogen activities have been associated with poor condition and growth in red deer (Connan, 1991).

2.8.12 Data management

2.8.12.1 Data validation

The amount of information collected during this study was substantial. It was not anticipated that all data could be analysed in this thesis. Investigations in this thesis are limited to the most important health or production outcomes. However, all variables that were recorded were described to highlight the wide range of information that was investigated.

For instance, the recording of behavioural characteristics of deer (as described in Appendix 2.22) was not straighforward. It was anticipated to record these observations during each visit separately for all classes of deer handled, and later calculate a farm score. However, they were not properly recorded for the duration of the study, because data collection was already intensive during visits. It was believed, however, that this chart could be useful in designing and evaluating a more adequate technique to assess deer behavioural characteristics.

As the intensity and accuracy of recording varied between farms, some calculations and statistical analyses were carried out using the data that were collected on less than 15 farms, providing the number of sample units was satisfactory. The prevention of erroneous data collection during collection and computer entry in this study was essential as far as possible to ensure that calculations and conclusions were valid. It was expected, however, that despite preventive measures a proportion of data could be incorrect, as found in other observational studies (Barnouin, 1980). That fact contributes to the error of interpretation but is not sufficient to invalidate this technique of data analysis.

In this thesis, some variables have been described, but recording was deemed too incomplete (eg the sead head density score in Table 2.7), subjective (eg variable GUN in Table 2.33) or inaccurate (eg cost variables in Table 2.33) to ensure validity of information. These variables were not further analysed.

2.8.12.2 Missing values

Missing values are also frequent in observational studies. The large number of individual deer included in this study enabled the selection of deer with minimum missing values for analysis. However, in some instances, missing values were replaced by means (continuous variables) or estimates (discrete variables). This replacement procedure allowed the analysis of all records, thus taking into account the maximum variability of the data in multivariable analyses. With more animals (statistical units) and fewer independent variables in the analysis, it is possible to select records with no missing data (Curtis et al., 1985; Dargent-Molinat et al., 1988), thus allowing a more accurate estimation of regression coefficients. In the context of this study, however, it was not deemed necessary.

2.8.12.3 Transformation of variables

For risk factor investigations presented in Chapter 4, a limited number of continuous risk factors were categorised, as hypothesised relationships between them and outcomes under study were suspected to be non-linear. While some risk factors (eg the use of single sire at mating (SSIRE) instead of the actual number of sires used (SIRE)) were analysed solely as dichotomous variables, others were analysed twice, ie as continuous and later as categorical variables. Both forms of the same risk factor were analysed separately. This approach was chosen because the cut-off point(s) for categories was not known *a priori*, such as for weaner bodyweight variables W40 and W50, the weaner growth rate variable GR46<0 and hind body condition score variables BCSM25 and BCSM4 (see Table 2.18). For these latter variables, cut-off points were chosen arbitrarily (W40, W50 and GR46<0) or after investigation of the data distribution (BCSM25 and BCSM4).

In this thesis, however, continuous variables were not transformed unless there was a justification for it on biological grounds or from the scientific literature. The choice of categories may have a pronounced impact on the results (Farver and Gonzalez, 1989). For instance, three blood markers were categorised, ie serum copper (CU), vitamin B12 (B12) and glutathione peroxidase (GSHPx)(see Table 2.36), from available data from deer and other domestic species. All three markers have a recognised minimum threshold level under which health problems may occur and production levels may be reduced. The minimum required blood level for CU in deer is thought to be 8 µmol/l (Clark and Hepburn, 1986; Mackintosh et al., 1986), whereas that for GSHPx in sheep were reported as 3 kIU/l (MAF Optigrowth Animal Health profile). Although critical values of serum vitamin B12 in cattle can be around 38-76 pmol/l (Suttle, 1991), concentrations below 185 pmol/l are regarded as deficient in sheep (Clark and Millar, 1983). This latter threshold has been chosen because of the sensitivity of the assay (not below 70 pmol/l) and the distribution of the data. There was a need, however, to investigate these blood markers as continuous variables because these cut-off points may not be adequate for deer (even the proposed 8 µmol/l for serum copper concentrations).

For many other variables, the investigation of the actual nature of their relationship with health and production outcomes was beyond the scope of this thesis and is a matter for further research in the future.

2.8.13 Statistical analysis

2.8.13.1 Multivariable analyses and the use of path analysis

In regression analyses, statistical units are assumed to be independent, ie data have been independently collected for each unit (Kleinbaum et al., 1988). It is recognised, in this study, that this assumption has been violated, since most outcomes under investigation were individual outcomes and deer were clustered within herds or farms (see section 2.8.13.3). Further, data from both years were combined and thus some deer (adult hinds and stags) were represented twice in the "master dataset". This technique, however, allowed the investigation of individual deer characteristics along with management and environmental factors for which, otherwise, the number of observations may have been limited.

For selection of potential risk factors during the screening process in preliminary univariate analysis, the liberal level of significance ($p<0.20$) was chosen because of the exploratory nature of the study. In other epidemiological studies, authors used a 10% (Curtis et al., 1988c; Gröhn et al., 1990; Gröhn and Bruss, 1990) or 15% (Ferns et al., 1991) significance level, which was more selective, but also increased the risk of excluding possible associations that might be significant when adjusted for other variables in the multivariable model (Dargent-Molinat et al., 1988). In this study, a few biologically very important variables which failed to reach the required significance level were forced back into the null hypothesis model to ensure they were given adequate consideration in the definitive analysis. Their exclusion in the screening phase may have been an artifact of considering only univariate relationships, and the multivariable analysis offered a more objective assessment of their significance.

Because the number of variables being collected was large, variable scores were created where possible to summarise a set of variables describing closely related characteristics (eg variable SHELT in Table 2.4 summarises paddock shelter variables). However, in some analyses (eg the analysis of conception status) many potential risk factors were selected after the univariate screening process (step 1), thus making it difficult to fit all variables in a single null hypothesis path diagram with all plausible causal pathways. It was therefore more appropriate to group variables per area of data collection (called block throughout this thesis) and analyse them separately so important variables within each block could be identified. Simplified diagrams have been produced with blocks of variables in the same diagram (Salman et al., 1984a; Salman and Meyer, 1987), but in such diagrams all pathways are not clearly visualised. Often the analysis per block was necessary because of the nature of the data, as was carried out in other multiple regression studies (Bigras-Poulin et al., 1990; Schukken et al., 1990). In analysing all blocks together, most or part of the variation in the data will be "absorbed" by some major factors, thus "hiding" the effect of other potentially important factors. Separate path models were very informative because they enabled better observation and interpretation of plausible causal pathways. Significant individual deer characteristics, however, were considered potentially important confounding factors in many analyses, and therefore were included in null hypothesis path diagrams of management and environmental factors. Specific considerations for each risk factors analysis are presented in Chapter 4 and discussed in Chapter 5.

It was believed in this project that there were many ways to analyse the data. The general approach was to choose the method thought to be the most appropriate at the time of analysis. Through the multiplicity of analyses that were carried out, it was anticipated a number of "statistically significant" results would occur just by chance. However, associations that are causal (but not proven here)

would be identified in analyses of a range of outcomes. When building null hypothesis path diagrams, only plausible direct causal pathways were represented and analysed. Two-headed arrows could have been drawn between exogenous variables to imply non-causal or exogenous relationship (Erb et al., 1981; Curtis et al., 1988c), but they have been omitted for clarity in the diagram (Burridge et al., 1977).

The 5% significance level was chosen for inclusion of associations in final path diagrams as in many studies (Erb et al., 1981; Etherington et al., 1985a; Correa et al., 1990; Oltenacu et al., 1990). This was in contrast to other studies (Curtis et al., 1985, 1988c; Erb et al., 1985; Martin and Meek, 1986), for which authors adopted a significance level of 10%, but it was deemed this was too liberal and would have increased the likelihood of identifying spurious associations.

Logistic regression analysis models the log odds of categorical outcomes such as conception status or disease, as a linear function of explanatory variables. Logistic regression is based on the binomial distribution, and therefore suited for the analysis of categorical outcomes (Hosmer and Lemeshow, 1989). In logistic path analysis, regression coefficients associated with categorical variables can be interpreted as odds ratios (OR), which are a multiplicative measure of risk that range from 0 to infinity (Fleiss, 1981). The null value is 1. An OR over 1 is predisposing and implies a positive association between independent and dependent variables, while an OR below 1 is preventive and implies an inverse association. Path coefficients associated with continuous variables however, are not ORs. There is no easy interpretation of these coefficients, because the assumption of linearity in the model may not be valid. Their sign however, gives important information as whether risk factors are positively or negatively associated with the outcome.

In linear multivariable models, the total effect of risk factors were not decomposed to examine the direct, indirect and spurious effects on the outcome. This can be done by calculation from standardised path coefficients in the linear regression path model (Erb et al., 1981) or by carrying out a hierarchical entry sequence of variables in a regression equation (Martin and Meek, 1986), but it was beyond the scope of this thesis.

Path analysis is a valuable epidemiological tool used to investigate the multiple interrelationships that exist among a set of correlated variables. It enables an insight into associations and helps understanding the structure of the data. By conducting separate analyses for each block of explanatory variables, the most important risk factors within each block can be identified, even if they do not remain in the overall final model because of marginal significance. Further discussion of the technique used in this thesis is presented in Chapter 5.

2.8.13.2 The problem of herd effect

In veterinary epidemiology, there is a special challenge in analysing individual animal outcomes (eg occurrence of disease or performance) that have been recorded from clusters such as herds or farms, because individual observations within clusters are not independent (Schwabe et al., 1977). This dependence is known to be caused by "herd effects". Herd effects result from differences in factors such as genetics, climate and management practices, known statistically as "random effects" because they are often unmeasured or unmeasurable. Herd effects may also result from intraherd correlation, ie when the performance of one individual animal depends on that of others in the herd (eg this is suspected in this thesis for hind conception, see section 4.1). A good introduction on herd effect is presented by Curtis et al. (1993b).

The problem of herd effect is further discussed here using the example of hind conception (CONC in Table 2.38), ie a dichotomous outcome. When using the standard logistic regression model (LR) to model individual probabilities of hinds conceiving, it was assumed that each hind exposed to the same set of risk factors has the same probability of conceiving. This assumption is invalid. In this case, there is a herd effect (or cluster effect) which leads to extra variability in the data (called "extra binomial variation" or EBV) and the use of LR in such cases, will produce lower parameter variances and therefore overestimated statistical significance. This may lead to incorrect inference of the significance of risk factors and potentially invalid results (Goelema et al., 1991; McDermott and Schukken et al., 1994). In such investigations, it is argued that appropriate statistical methods should be used to adjust for herd effect. Recently, McDermott et al. (1994b) reviewed the various methods available to control for the problem of herd effect which may be through appropriate study design or statistical control. For categorical outcome, for instance, random-effect logistic regression may be used to test for the significance of path coefficients and the presence of extrabinomial variation (Curtis et al., 1988a). Conditional logistic regression can also be used for evaluation of risk factors while correcting for herd effect (study design in which cases are matched to non-case herdmates)(Laporte et al., 1994), but since conditional logistic regression does not have an intercept, it cannot be used to model prediction of outcome.

In the context of this study, the statistical adjustment of herd effect, eg through random-effect logistic regression, was carefully considered, and was not deemed a critical issue. Since the objective of this study was to explore the relative importance of risk factors for various outcomes in relation to a sample of the general population of New zealand farmed deer, and to note whether risk factors and outcome were positively or negatively associated, rather than accurately estimating the actual magnitude of regression coefficients, the above problem (ie not adjusting for herd effects) should not present major difficulties. Several papers have presented inferences that resulted from analyses with and without statistical adjustment (estimation of the significance of EBV)(Curtis et al., 1993b). It is the researcher's view-point that there is not a dramatic change in the magnitude of regression coefficients and that risk factors significant below the 1% confidence level, without adjustment, would remain significant below the conventional 5% confidence level after adjustment for herd effects. Therefore, although the 5% confidence level has been used for variable selection in final models, one may consider risk factors associated with respective outcomes below the 1% confidence level as the most important factors to discuss, which may overcome the lack of statistical control of herd effect.

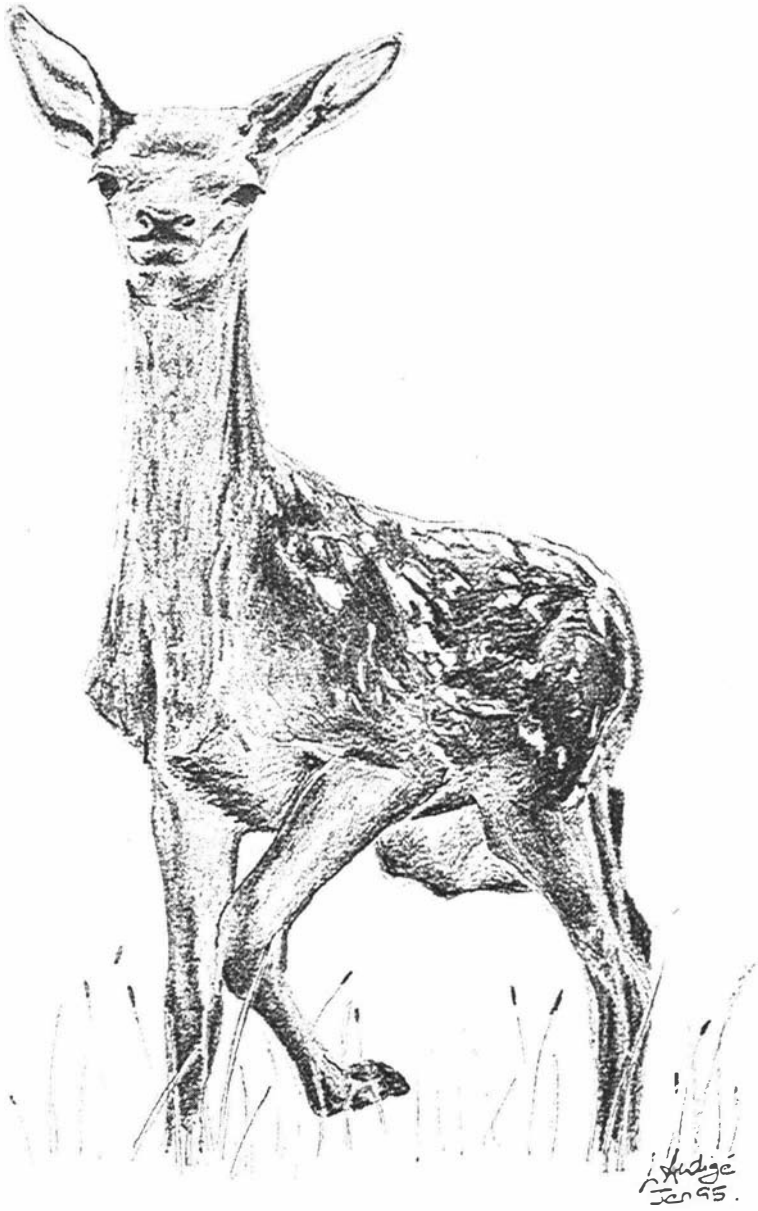
The preferred approach of Curtis et al.(1993b) is first to model the data using standard regression methods, and then to account for the presence of EBV in a follow-up analysis, unless the presence of EBV is *a priori* suspected. Post-hoc adjustment of variance estimates using a variance inflation factor (from the mean herd size and the intraherd correlation coefficient) can be used to investigate the possibility of incorrect inferrence when herd effects were not accounted for in the analyses (McDermott and Schukken, 1994; McDermott et al., 1994b). In the context of this study, such investigations will be considered as follow-up analyses which could be carried out subsequently.

2.9 Conclusion

"Deer herd health and production profiling" had broad objectives (Chapter 1) and therefore required the recording of a wide range of relevant information. Farmers were the main source of information and their recruitment was critical to ensure the success of the project. The design of recording sheets was fine-tuned to enhance the quality of the information recorded and enable cross-checks, and thus validation of data. In many respects, some important production and health

problem outcomes (eg growth or malignant catarrhal fever) and some associated risk factors were known or suspected from previous research, or experience, and thus were investigated. However, other information or recording techniques collected in this study were not previously studied and needed to be thought through prior to or during data collection (eg body condition scoring). Recording sheets were not perfect, nor the list of variables exhaustive, but in view of the technical and financial support, and the amount of extra-work asked of participating farmers the optimum was achieved.

Statistical analyses were innovative as path analysis has not been used as extensively in any research project of this sort. The statistical approach used has limitations, but it is a time-effective way of screening a large amount of data.These limitations have been recognised, discussed and accounted for in analyses and conclusions in this study. Results and conclusions are therefore considered to be valid.


Jan 95.

CHAPTER 3
DESCRIPTIVE EPIDEMIOLOGY

INTRODUCTION

This chapter presents raw data and calculated statistics to describe deer farming as it was on 15 randomly selected farms in the lower part of the North Island of New Zealand. It is the result of the most extensive longitudinal study carried out on farmed deer worldwide. Multivariable statistical analyses are presented in Chapter 4.

Data is presented so the reader can at first appreciate the profile of farmers involved and the environmental conditions under which the study was carried out. Farms, deer paddocks, type of stock farmed and climatic conditions are described under the broad category of "farm characteristics". Management practices are presented to allow comparison between farms. Farm performance results are then presented. This is the health and production profile of farmed red deer studied, which provides reference data for numerous outcome parameters.

Finally, sentinel deer are described, including individual physical measurements and behaviour during blood sampling, and a preliminary analysis of blood biological characteristics, faecal parasite markers and serological investigations.

3.1 FARM CHARACTERISTICS

3.1.1 Farmer profile

Responses to direct questionnaires are presented in detail in Appendix 3.1. Farmers were on average 44.5 years old, with one farmer under 30 years and 4 over 50 years. They had worked on a farming operation for 24.6 years and farmed deer for 8.4 years on average. The youngest farmer had farmed deer for 3 years only, but was brought up on a deer farm. The next youngest farmer was in partnership with his father. All other farmers had children who were not necessarily working on the farm. The manpower on most farms was from the family, and half of the farms, in particular large operations, had an employee at least part time. The two biggest deer farms had a manager.

All farmers but two (including one manager) came from a farming environment, mostly sheep and beef farms. Two farmers were brought up on dairy and another two were brought up on deer farms. Five farmers have had formal training in agriculture and two in other areas. Six farmers had interests in other businesses and 7 had other commitments in the deer industry other than just farming. Eleven claimed to enjoy the lifestyle of farming more than the income. All farmers but one took at least one week of holidays each year. The main reason for farming deer was diversification or because they just enjoyed working with deer. Half of the farmers were also farming deer for the income generated. On average, 25% of farmers' income came from the deer, with only one farm living solely from them.

Achieving one-year venison production was the objective of 5 farmers, while 9 farmers were focused on velvet production with a selection of the stags at two years of age. Thus, most deer were planned to be sold over one year of age, either alive or killed for venison. One of the biggest farms was a stud breeder, another had a good reputation as a velvet producer. A few others developed a stud herd with or without the help of artificial breeding techniques.

3.1.2 Farm characteristics

A detailed description of farm physical characteristics (including yards and lane measurements) are presented in Appendix 3.2 and Appendix 3.3. Total farm areas ranged from 57 to 791.6 ha, with deer farm fenced area ranging from 20 to 453.3 ha. Farm altitude ranged from sea level in the Manawatu to 700 m north of Taihape (Figure 2.1).

The number of deer-fenced paddocks per farm ranged from 10 to 44 (Appendix 3.4). Some farms built new deer fences during the study thus either creating new paddocks for deer or splitting already existing deer paddocks.

3.1.2.1 Paddock characteristics

3.1.2.1.1 Individual paddock profile and farm paddock profile

In total, 292 deer paddocks were described during the study, although some were available to deer only part of the time because of new fencing (addition of new paddocks or splitting of already existing paddocks). Paddock characteristics on each survey farm are presented in detail in Appendix 3.4 and summarised in Table 3.1. Mean paddock characteristics on each survey farm over 1992 and

1993 are presented in Appendix 3.5 and summarised in Table 3.2. The mean paddock size was 4.85 ha. A majority of paddocks were almost flat (64%), while 8.6% were rather steep.

The amount of shelter in each paddock was variable. The overall shelter score ranged from 0 to 36, with a mean of 12.2. Deep gullies were found in 18% of paddocks, while 25% had medium gullies, often associated with the presence of a stream or a river. Few paddocks had a hill in the middle (16.8%). Shelter belts were found in little more than half of the paddocks. Most belts were trees which could be groups or part of a forest along side the paddock. There were trees in fewer than half of the paddocks (4.1% had at least one macrocarpa tree) and very few had part of a forest (17.8%). Stumps or branches were found in 38.3% of the paddocks, and about a quarter of paddocks had bull rushes to some extent, with only 1.4% having large quantities of them. Five farms had no or very limited amounts of bull rushes.The distribution of potential protection scores by gully, shelter belt or hill from westerly, easterly, southerly or northerly wind are summarised in Table 3.1. There was ryegrass/clover and very little low quality pasture (eg browntop) in a third of the paddocks both years. Fifteen to 20% had poor quality pasture. Large quantities of thistles and ragwort were found in 23.3% and 26.4% of the paddocks in 1992, respectively, and less in 1993. Four and one farm had no or very limited amount of ragwort and thistles, respectively. Chicory was found on only one farm in 1992 and 2 farms in 1993.

Table 3.2 shows mean paddock characteristics were variable between farms, such as the overall topography score (ranging from all flat to almost all steep and rolling paddocks) or the the overall amount of shelter (gully, hill, belt and trees combined). Macrocarpa trees were found in 5 farms. The water supply was mainly through the use of troughs although some farms largely exploited dams and rivers for that purpose. Over each farm, the percentage of use of wire-and-batten fence (as opposed to netting fence) ranged from 0 to 100, with most farms using a combination of both netting and wire-and-batten fences. Eight to 62 % of paddocks were located close to a road, buildings or houses. Only one farm was not adjacent to sheep paddocks, and all deer farms had cattle grazing outside to some extent during the survey.

3.1.2.1.2 Interrelationships between paddock variables

Because it was suspected that individual paddock variables were correlated, regression analyses were used to identify statistically significant associations between them. Each variable was regressed on all other variables using a forward stepwise selection procedure with a 5% significance level for inclusion and removal from the models. Logistic and linear regression analyses were used when the dependent variable was categorical and continuous, respectively. The statistical package used was SAS. As variables STUMP and MACRO were not recorded on farm 14, missing values were replaced from other paddock data using NCSS so paddocks from this farm can be included in the analysis. The mean of pasture, thistle and ragwort scores over two years were used, and variables describing potential wind protection were not included as they were combined in one overall shelter variable (SHELT).

From these analyses, a paddock profile have been identified :

- Large paddocks were more likely to be rolling to steep with a deep gully, a hill and trees; a river, a stream or a dam; with low quality pasture including thistles and low quantities of bull rushes.
- Smaller paddocks tended to have the opposite characteristics.

Table 3.1 : Summary of paddock characteristics over all farms in 1992 and 1993.

Paddock characteristics		Unit/Score	number	%
Number of paddocks				
Year 1992		All time	261	
		New*	12	
Year 1993		All time	223	
		New*	9	
Mean paddock total area		ha	4.85	
Mean effective area		ha	4.81	
Total number of paddock described (Including paddock open part of the year)			292	
Topography and shelter				
Topography		<1.5	187	64.0
		>2.5	25	8.6
Gully		1	35	12.0
		2	74	25.3
		3	52	17.8
Hill		1	49	16.8
Shelter Belt		1	22	7.5
		2	52	17.8
		3	106	36.3
Trees		1	49	16.8
		2	16	5.5
		3	52	17.8
Macrocarpa tree		1	12	4.1
Stump		1	95	38.3
Bull rushes		1	25	8.6
		2	47	16.1
		3	4	1.4
Pasture characteristics				
Pasture type	1992	1	81	27.7
		3	44	15.1
	1993	1	92	31.5
		3	58	19.9
	Overall mean score (SD)		1.85 (0.64)	
Thistle score	1992	0	127	43.5
		>1.5	68	23.3
	1993	0	139	47.6
		>1.5	47	16.1
	Overall mean score (SD)		0.91 (0.90)	
Ragwort score	1992	0	64	21.9
		>1.5	77	26.4
	1993	0	124	42.5
		>1.5	42	14.4
	Overall mean score (SD)		0.59 (0.84)	
Fence pacing score				
Fence pacing 1992		<1	54	18.5
		>2	51	17.5
Fence pacing 1993		<1	60	20.5
		>2	26	8.9
	Overall mean score (SD)		1.35 (0.70)	
Water supply				
Dam		1	61	20.9
River		1	89	30.5
Stream		1	29	9.9
Trough		1	166	56.8

Paddock characteristics	Unit/Score	number	%
Potential wind protection			
Potential protection from westerly wind			
Shelter belt	1	18	6.2
	2	37	12.7
	3	78	26.7
Hill	1	23	7.9
	2	23	7.9
	3	66	22.6
Gully	1	22	7.5
	2	54	18.5
	3	44	15.1
Potential protection from easterly wind			
Shelter belt	1	11	3.8
	2	44	15.1
	3	58	19.9
Hill	1	18	6.2
	2	25	8.6
	3	76	26.0
Gully	1	21	7.2
	2	54	18.5
	3	47	16.1
Potential protection from southerly wind			
Shelter belt	1	13	4.5
	2	43	14.7
	3	67	22.9
Hill	1	31	10.6
	2	22	7.5
	3	71	24.3
Gully	1	14	4.8
	2	31	10.6
	3	78	26.7
Potential protection from northerly wind			
Shelter belt	1	20	6.8
	2	22	7.5
	3	68	23.3
Hill	1	20	6.8
	2	22	7.5
	3	68	23.3
Gully	1	20	6.8
	2	56	19.2
	3	41	14.0
Overall shelter score	Mean (SD)	12.2 (9.0)	
	Range	0.0 36.0	
Miscellaneous			
Fence			
Wire%	0	124	42.5
	100	159	54.5
Potential contact with other domestic livestock outside deer farm boundaries			
Sheep	1	135	46.2
Cattle	1	124	42.5
Paddock location			
Close to road, houses or buildings	1	95	32.5

* Newly fenced or subdivided paddock available during the year.

Year 1992 : Farm 1 used electric fences to split 2 paddocks during winter; Farm 3, 7 and 13 split 1, 2 and 1 paddock during 1992, respectively; Farm 8 reduced the size of one paddock

Year 1993 : Farm 15 sold part of the deer-fenced area; Farm 7 split one paddock in two.

Note : pasture, thistle, ragwort and fence pacing in 1993 and stumps and were not recorded on farm 14.

The description of paddock characteristics is presented in Table 2.4.

There was no tendency for large paddocks to be more sheltered than small ones, although the nature of this shelter tended to be different. In small paddocks, shelter mainly came from tree belts, whereas in large paddocks, it came from gullies and hills. There was also no clear tendency as to where ragwort occurred the most as far as paddock characteristics are concerned. The mean ragwort scores on each farm (Table 3.2) suggest it was a farm-specific problem.

Table 3.2 : Range, mean, median and standard deviation of mean paddock characteristics on each survey farm during the study

Paddock characteristics	Codes*	Min	Max	Mean	Median	SD
Paddock areas						
Number of paddocks	NPAD	10.50	44.00	18.00	14.13	8.89
Mean paddock area	PFAREA	0.92	16.74	4.42	3.62	3.82
Paddock mean topographical characteristics						
Mean topography score	FTOPO	1.00	2.58	1.66	1.56	0.54
Mean gully score	FGULLY	0.00	2.00	1.12	1.19	0.62
Mean hill score	FHILL	0.00	0.54	0.17	0.12	0.16
Paddock water supply						
Percentage with a dam	FDAM	0.00	64.29	20.15	18.52	16.27
Percentage with a stream	FSTREAM	0.00	36.13	6.50	0.00	11.16
Percentage with a river	FRIVER	0.00	69.00	30.94	28.57	22.09
Percentage with a trough	FTROUGH	8.33	84.21	49.14	59.26	25.50
Mean paddock shelter scores						
Mean shelter belt score	FBELT	0.38	2.55	1.40	1.38	0.62
Mean tree score	FTREES	0.16	1.66	0.73	0.70	0.46
Mean overall shelter score	FSHELTW	4.18	21.08	12.44	11.81	5.61
Percentage with stumps,...	FSTUMP	0.00	66.67	33.99	36.84	19.70
Mean paddock pasture characteristics						
Mean bull rushes score	FBULLR	0.00	1.62	0.51	0.55	0.51
Percentage with chicory	FCHICO	0.00	14.29	0.95	0.00	3.69
Mean pasture score	FPAST	1.15	2.76	1.93	1.92	0.39
Mean thistle score	FTHIS	0.00	2.15	1.13	1.07	0.60
Mean ragwort score	FRAG	0.00	2.24	0.69	0.51	0.76
Miscellaneous						
Percentage of wire-and-batten fence	FWIRE	0.00	100.00	63.06	68.00	34.17
Percentage with macrocarpa tree	FMACRO	0.00	26.32	3.98	0.00	7.66
Percentage close to road, buildings,...	FSUR	8.33	62.50	30.80	33.33	16.25
Mean fence pacing score	FFP	0.74	1.68	1.21	1.25	0.31
Mean contact with sheep paddocks	FSHEEP	0.00	0.79	0.44	0.48	0.25
Mean contact with cattle paddocks	FCATTLE	0.09	0.65	0.39	0.43	0.20

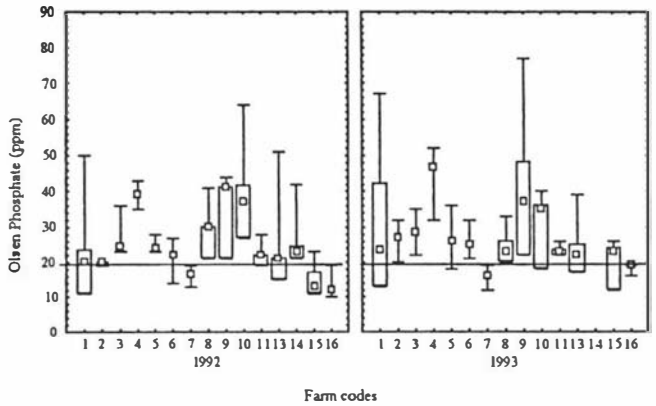
* Codes and calculations are described in Table 2.25
Min = minimum; Max = maximum; SD = standard deviation

3.1.2.2 Soil fertility levels

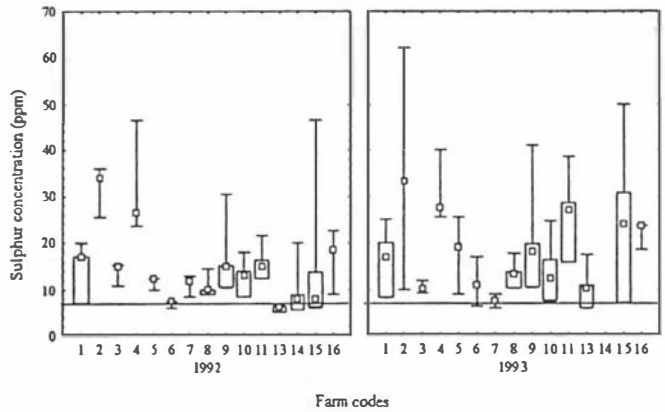
Minimum, maximum and quartiles of soil Olsen P, potassium, sulphur and magnesium concentrations on each survey farm data are presented in Figure 3.1, while soil pH data are presented in Figure 3.2.

Figure 3.1 : Median ▫ , 25th and 75th percentile ☐ ,and range ⊥ of soil Olsen phosphate , sulphur, exchangeable potassium and magnesium concentrations on each survey farm in 1992 and 1993 (n = 4-5 paddocks per farm).

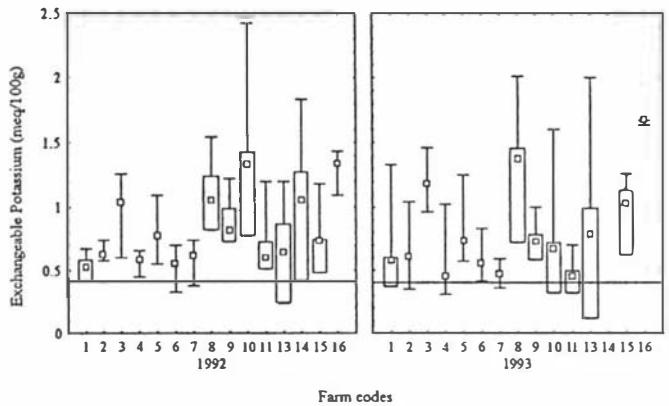
1. Olsen phosphate (ppm)



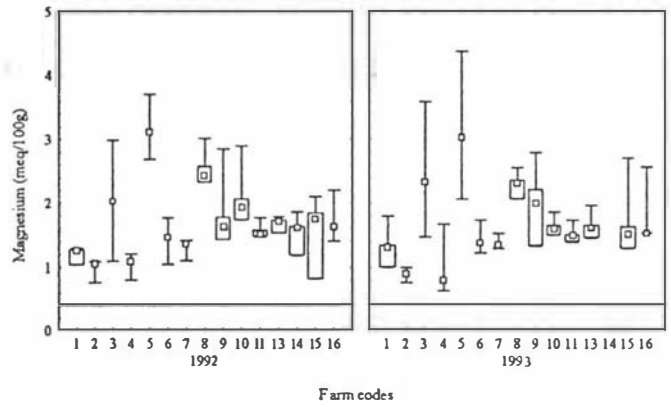
2. Sulphur (ppm)



3. Exchangeable Potassium (meq/100g)



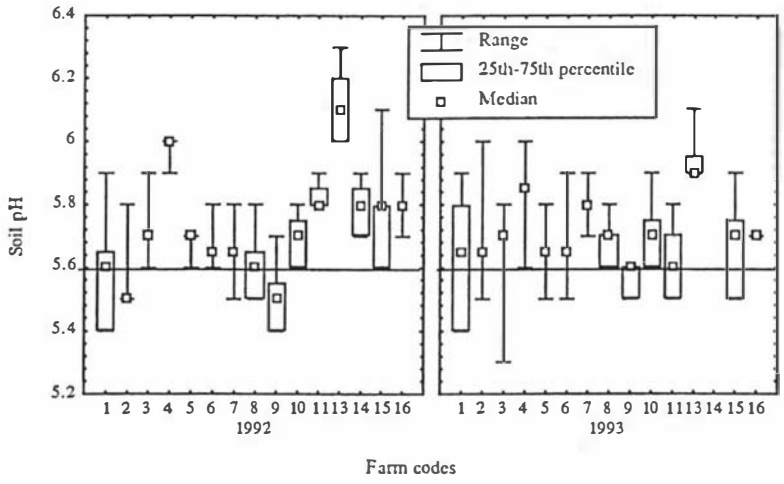
4. Magnesium (meq/100g)



Note : Horizontal lines represent the optimum (Olsen P) or minimum required element concentration (K^+, S^-, Mg^{++})

Although one or two paddocks on some farms had low soil pH, the median soil pH was adequate on most farms in 1992 and 1993. The median soil Olsen phosphate was marginally low on farms 1, 2 and 13 in 1992 and on farm 16 in 1993, whereas it was below the limit of 20 ppm on farms 7, 15 and 16 in 1992, and again on farm 7 in 1993. Median sulphur concentrations were adequate on all but farm 13 in 1992. Median soil exchangeable potassium and magnesium concentrations were adequate on all farms in 1992 and 1993.

Figure 3.2 : Quartiles and range of soil pH on each survey farm in 1992 and 1993.



Note : The horizontal line represents the minimum required soil pH, while the maximum is 6.4

The history of fertiliser application on each farm in 1992 and 1993 is presented in section 3.2.1.

3.1.2.3 Pasture mineral profile

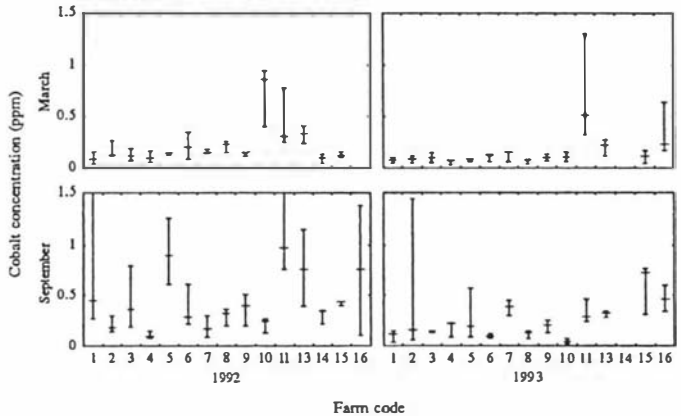
Minimum, maximum and median of pasture mineral concentrations on each survey farm are presented in Figure 3.3 and Figure 3.4. Minimum requirements and toxic levels are shown on each graph by horizontal lines.

Pasture cobalt concentrations were adequate on all farms, but low on farm 10 in September 1993. Median copper, manganese and zinc concentrations were within the normal range on all farms at any sampling visit. Median iron concentrations were below the toxic level of 500 ppm in March but higher in September on most farms. On farms 11 and 16, however, it was consistently close or above 500 ppm. The median molybdenum concentration of farm 9 was above the toxic limit in September 1992. Median selenium concentrations were adequate on most farms.

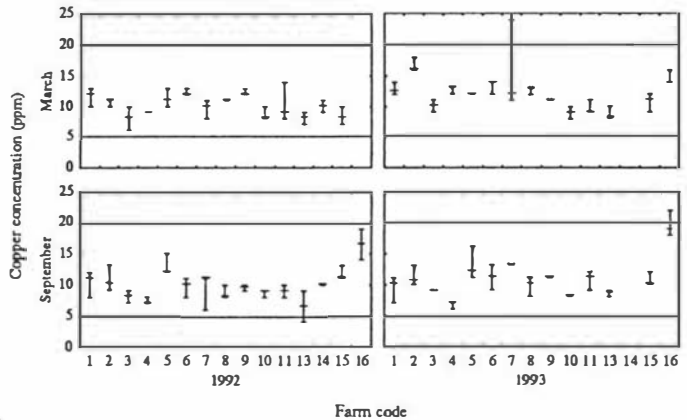
Because soil contamination can affect the mineral profile of pasture samples, multiple ANOVA were carried out using SAS to investigate the effect of sward height at the time of sampling on mineral concentrations. Factors year, farm, month of sampling (March or September), pasture type and clover score at sampling (as described in Table 2.7 and Figure 2.3) were included in the model as potential confounding factors. The significance of these factors with regard to each mineral are presented in Table 3.3.

Figure 3.3 : Minimum, maximum and median of pasture cobalt, copper, iron and manganese concentrations (ppm) on each survey farm in March 1992 and 1993 and in September 1992 and 1993[1] (n = 3-4 pastures were sampled per farm)

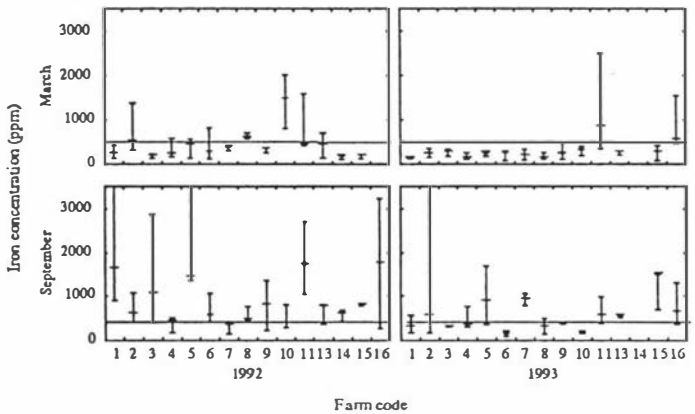
1. Cobalt



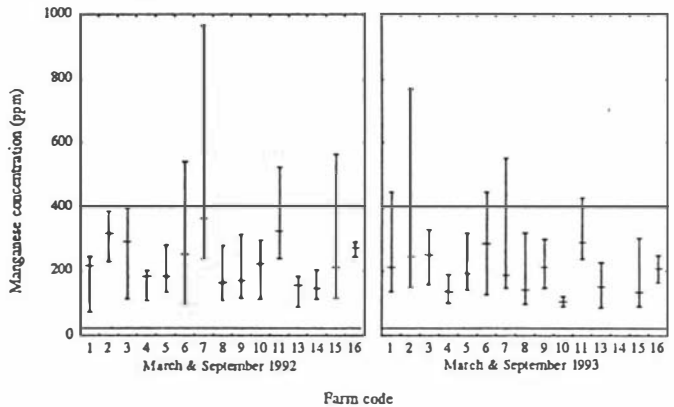
2. Copper



3. Iron



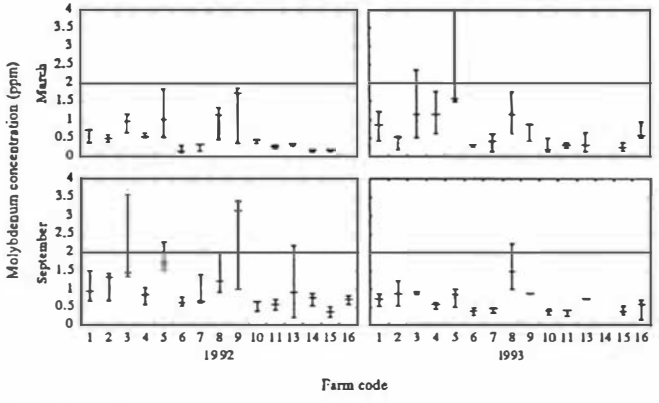
4 . Manganese



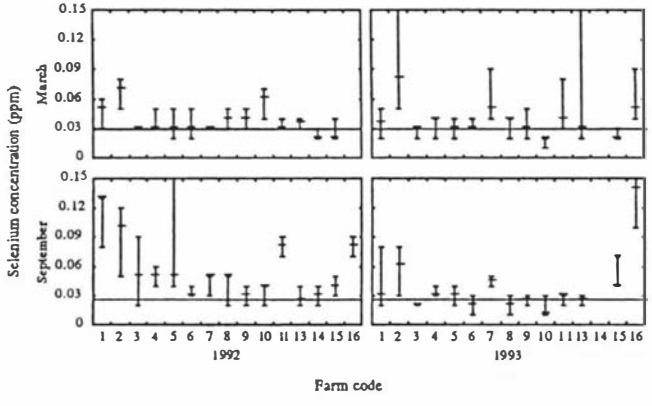
[1] Where possible, horizontal lines represent toxic levels (Iron, copper and manganese) and minimum levels (copper and manganese). Manganese concentrations were not significantly different between March and September, so data were combined.

Figure 3.4 : Minimum, maximum and median of pasture molybdenum, selenium, sulphur and zinc concentrations (ppm) on each survey farm in March 1992 and 1993 and in September 1992 and 1993[1] (n = 3-4 pastures were sampled per farm).

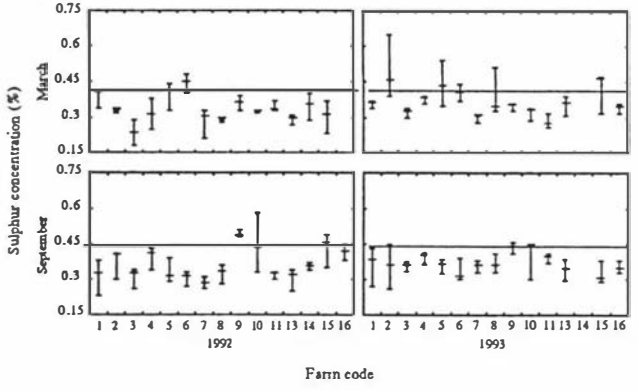
1. Molybdenum



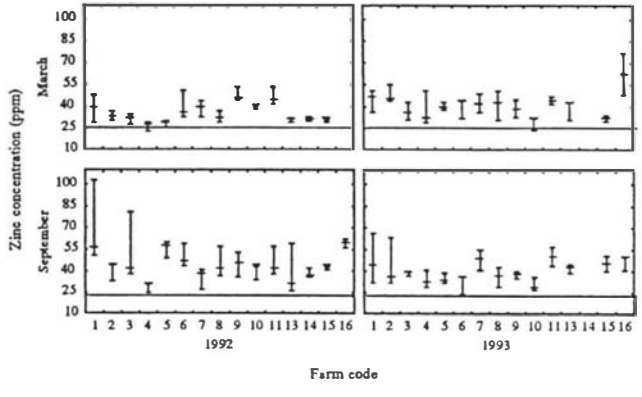
2. Selenium



3. Sulphur



4. Zinc



[1] Where possible, horizontal lines represent toxic levels (molybdenum and sulphur) and minimum levels (selenium and zinc).

Pasture zinc, iron and cobalt concentrations were significantly higher as the sward was short at sampling. Pasture with high clover content had significantly high copper concentrations and low manganese concentration.

Table 3.3 : Statistical significance of factors: year; farm; visit; pasture type; clover score, and sward height in explaining pasture mineral profile variability.

	Type III sum of square p value							
Model factors	S	Mn	Zn	Cu	Fe	Co	Mo	Se
Year	*	*	NS	**	*	**	NS	NS
Farm	NS	**	**	**	*	**	**	NS
Visit†	NS	NS	NS	**	NS	NS	NS	NS
Pasture type	NS	NS	NS	NS	NS	NS	NS	NS
Clover score	NS	*	NS	**	NS	NS	NS	NS
Sward height	NS	NS	**	NS	**	**	NS	NS

S = Sulphur; Mn = Manganese; Zn = Zinc; Cu = Copper; Fe = Iron; Co = Cobalt; Mo = Molybdenum; Se = Selenium. ** $p<0.01$ * $p<0.05$ NS = Not significant
Sward height was transformed into categories as: 1: <5cm, 2: >4 and <10cm, and 3: >9cm.
† Pastures were sampled during farm visits in March and in September

3.1.3 Stock

Farm stock reconciliations in June 1992 and June 1993 are presented in Appendix 3.6. A summary is presented in Table 3.4.

Table 3.4 : Summary of farm stock reconciliation in June 1992 and 1993

	FARM CODE															
Type of stock	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	All farms
Year 1992																
Deer	416	396	129	151	245	338	167	413	225	258	439	249	C	2225	227	5878
Cattle	-	260	106	73	50	602	6	183	401	-	206	403	372	637	42	3341
Sheep	7	3150	7207	525	-	7580	15	1662	3950	-	2760	6360	98	6960	2080	42354
Goats	2	-	-	-	-	185	19	-	-	-	1	-	-	1000	-	1207
Horses	-	-	-	-	-	8	5	-	1	-	2	-	-	-	1	17
Year 1993																
Deer	412	382	300	146	273	306	173	421	346	335	422	396		632	469	5013
Cattle	-	247	174	34	-	629	11	196	382	-	191	436		954	12	3266
Sheep	-	2410	6702	438	-	8146	-	460	3101	-	2965	4838		3515	1255	32075
Goats	-		-	-	-	200	17	-	-	-	-			210	-	427
Horses	-		-	-	-	4	4	-	-	-	-			-	1	9

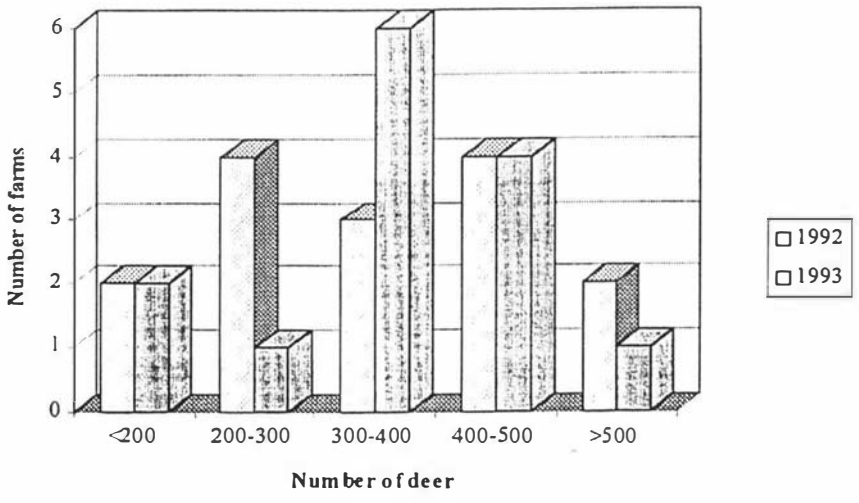
Note : Farm 14 was not monitored in 1993, the number of deer in 1992 remained confidential (C)

3.1.3.1 Deer

3.1.3.1.1 Herd size

The number of deer on each farm in June 1992 and 1993 ranged from 146 to 2225. Its distribution between farm is presented in Figure 3.5.

Figure 3.5 : Deer farm size distribution in June 1992 and 1993



For reasons of confidentiality, the actual number of deer on one farm was not disclosed by the farmer, but it was known to be over 500, so it was included in the graph. In June 1993, the largest deer farm in the study had 632 deer.

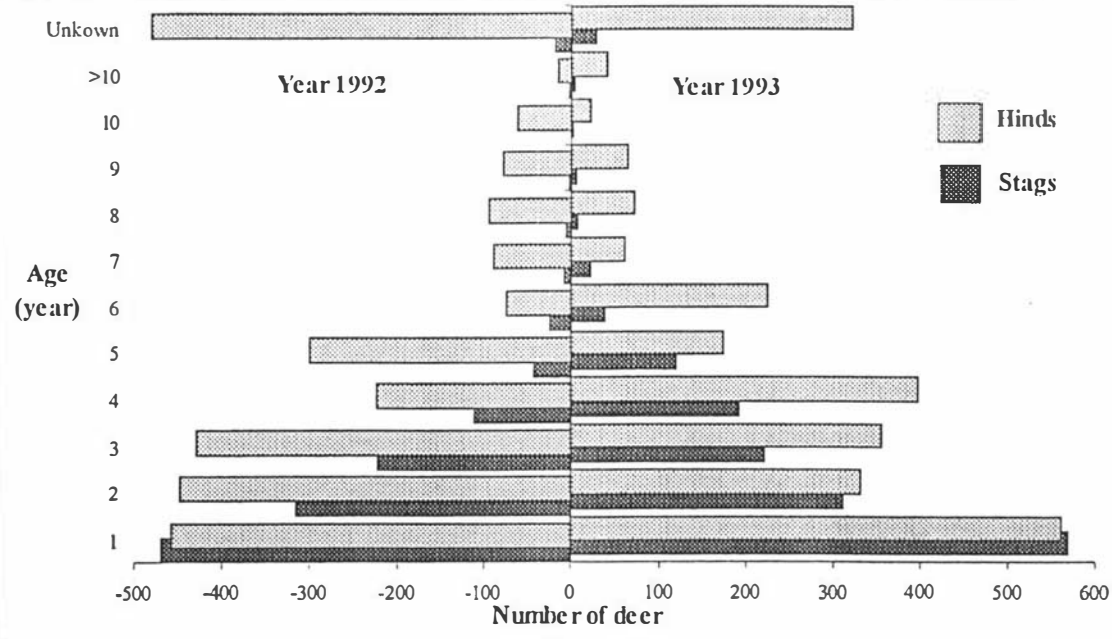
3.1.3.1.2 Sex and blood line distributions

The distribution of deer individually monitored on each farm, by age and sex, and by blood line categories (as described in Table 2.18) in 1992 and 1993 are presented in detail in Appendix 3.7 and Appendix 3.8. The overall age pyramids of hinds and stags in 1992 and 1993 are presented in Figure 3.6.

Means of known ages of adult hinds and stags (1992-1993) were 4.4-4.5 and 3.1-3.5 years, respectively. Hinds and stags over 6 years of age represented only a small proportion of total herd numbers, while the age of almost all monitored stags was known, many hinds were of unknown age. However, most of these latter hinds were suspected by farmers to be over 4-5 years old.

The percentages of hinds within each blood line category show that there were almost no wapiti types within the study group. Despite the intensive use of foreign blood lines on some farms, the mean percentage of New Zealand blood within the study herd remained over 90%. A very large proportion of hinds were 100% New Zealand and imported blood lines were more prevalent in hinds below 3 years of age as presented in Table 3.5.

Figure 3.6 : Age pyramids of hinds and stags individually monitored in 1992 and 1993



The blood line percentages of weaner herds changed from 1992 to 1993 (see Appendix 3.8 and Figure 3.7). Whereas wapiti blood lines were very limited in 1992 due to the selection of farms, two farmers were using wapiti hybrids as sires in 1993, thus introducing wapiti blood in their weaner herds. One farm had both years a small herd of hinds mated with a half cross wapiti sire and managed separately from the main mob of hinds. The amount of English and European blood also increased in 1993 as all farms had used sires with foreign blood lines for mating in 1992.

Figure 3.7 : Distribution of blood line categories within hinds, stags and weaners in 1992 (left) and 1993 (right).

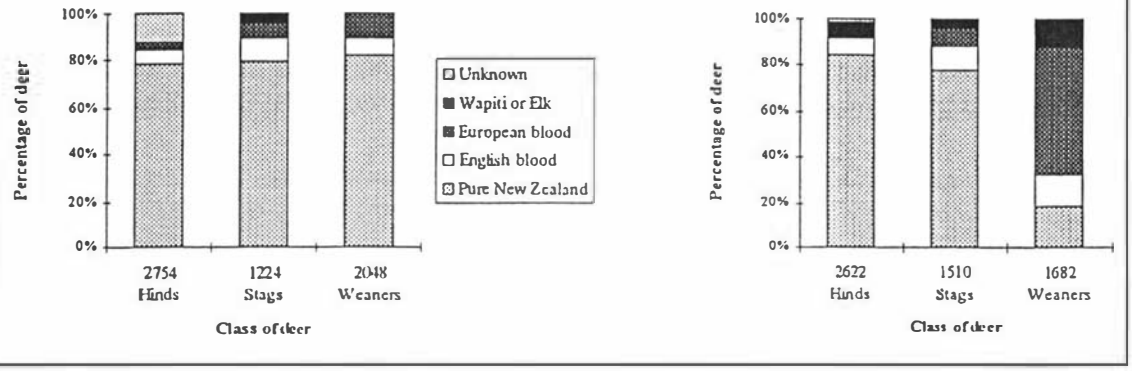


Table 3.5 : Percentage of hinds and stags within different New Zealand blood lines and age categories in 1992 and 1993 and mean percentage of New Zealand blood lines of hinds and stags within each age category in 1992 and 1993.

Age category*	Number of deer	Percentage of New Zealand blood lines						NZ%	
		<25	25 to 49.9	50 to 74.9	75 to 99.9	100	Unknown	Mean	SD
HINDS									
Year 1992									
1	457	0.2	3.5	5.7	13.6	75.9	1.1	90.8	19.0
2	448	0.0	2.2	12.7	4.7	79.9	0.4	90.8	19.7
3-5	928	0.1	1.8	4.8	0.0	90.6	2.6	96.0	15.0
>5	443	0.0	0.0	0.0	0.2	96.4	3.4	99.9	1.2
Unknown	478	0.4	0.0	0.0	0.0	96.2	3.3	99.6	6.6
All age	2754	0.1	1.6	4.6	3.1	88.3	2.3	95.5	14.9
Mean age of adult hinds (>=2 years)								4.4	2.4
Year 1993									
1	562	0.7	4.1	16.0	11.7	67.1	0.4	86.1	22.6
2	334	0.3	3.0	5.7	16.5	74.6	0.0	90.5	18.6
3-5	927	0.0	2.7	10.1	2.0	85.1	0.0	92.4	19.0
>5	479	0.0	0.0	0.0	0.0	100.0	0.0	100.0	0.0
Unknown	320	0.6	0.0	0.0	0.0	97.5	1.9	99.4	8.0
All age	2622	0.3	2.2	7.7	5.3	84.1	0.3	93.0	17.7
Mean age of adult hinds (>=2 years)								4.5	2.2
STAGS									
Year 1992									
1	468	5.6	3.2	9.8	13.0	68.4		88.8	20.4
2	315	0.6	1.0	6.7	4.4	87.3		94.2	16.7
3-5	385	0.5	0.5	8.1	5.5	85.5		93.9	16.0
>5	45	2.2	0.0	8.9	0.0	88.9		93.3	20.0
Unknown	11	0.0	0.0	0.0	0.0	100.0		100.0	0.0
All age	1224	2.5	1.6	8.3	7.8	79.7		92.1	18.2
Mean age of adult stags (>=2 years)								3.1	1.4
Year 1993									
1	568	0.7	2.6	8.6	10.2	77.8		90.9	19.3
2	312	7.7	1.6	8.0	16.7	66.0		89.3	19.4
3-5	532	1.1	0.6	8.3	6.0	84.0		93.5	16.6
>5	80	3.8	1.3	12.5	1.3	81.3		90.1	22.9
Unknown	18	11.1	0.0	0.0	0.0	88.9		100.0	0.0
All age	1510	2.6	1.6	8.5	9.5	77.9		91.6	18.6
Mean age of adult stags (>=2 years)								3.5	1.5

* Age in March at the start of the survey year

3.1.3.2 Other domestic livestock

Stock reconciliations from all farms in 1992 and 1993 are presented in Appendix 3.6. Most farms were farming sheep and cattle to some extent. Sheep flocks varied from 15 to almost 7000 head, while cattle herds varied from 6 to about 870 head between the two years. Two farms in 1992 and 4 farms in 1993 did not have any sheep in June. Another farm which was a pure deer operation had 7 pet sheep in 1992 which grazed outside the deer farm boundary.

3.1.4 Deer health problems and disease control in 1991.

Deer stock, disease control programme and health problems on each survey farms in 1991 are presented in Appendix 3.9.

3.1.5 Weather conditions

Monthly mean minimum and maximum temperatures, total rainfall and mean daily sunshine score on each survey farm from March 1 1992 to March 31 1994 are presented in Appendix 3.10 and Appendix 3.11.

Data from survey farms were combined and monthly mean daily maximum and minimum temperature, rainfall and sunshine score were calculated within each district, ie the Manawatu/Wanganui (farms 5, 6, 7 and 16), Taihape (farms 8 and 9), Bush (farms 1,2,3 and 4) and Hawkes' Bay districts (farms 10, 11, 13, 14 and 15). The monthly variations of these weather characteristics are presented in Figure 3.8 to Figure 3.11.

The variability of these weather data due to year, month and district difference were analysed by three-way ANOVA using SAS. The statistical significance of model factors are presented in Table 3.6.

Table 3.6 : Summary results of variability of maximum and minimum temperatures, rainfall and sunshine scores due to year, month and districts[1].

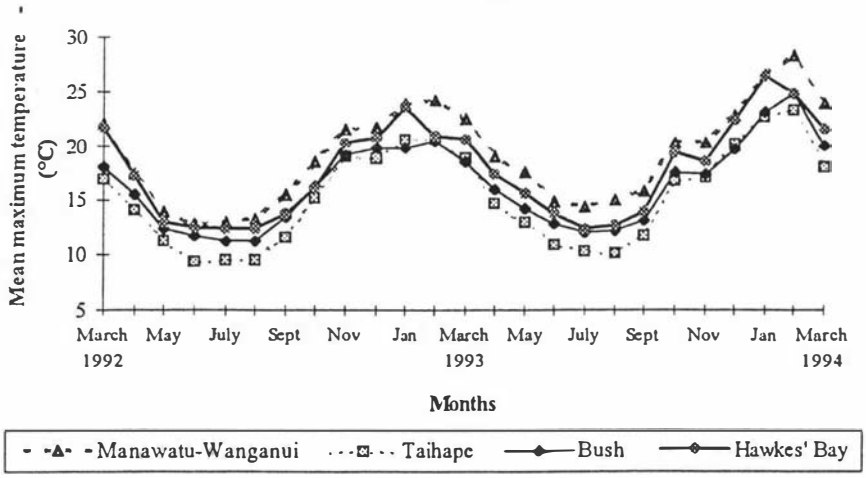
Model factors	Maximum Tp	Minimum Tp	Daily rainfall	Sunshine
Year	**	NS	NS	**
Month	**	NS	NS	**
District	NS	NS	NS	*
Year x Month	**	NS	NS	**
Year x District	NS	NS	NS	*
Month x District	NS	NS	NS	*

* $p<0.05$; ** $p<0.01$; NS = Not Significant; Tp = Temperature
[1] Data from all farms within each district were combined for analyses as described in the text.

There were significant variations of daily maximum temperature and sunshine score between years and between month, and the year to month interaction term was highly significant, indicating year differences varied between months. No significant differences of minimum temperature and daily rainfall between years, months and districts were shown in this model. However, minimum

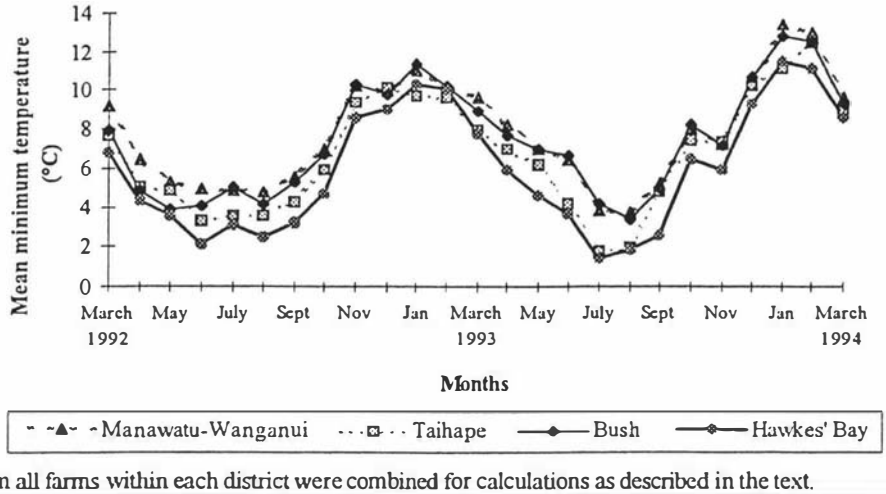
temperatures in Hawkes' Bay tended to be lower than in other districts (Figure 3.9), probably due to the greater number of frosts associated with clear skies, as demonstrated by higher sunshine hours (Figure 3.11).

Figure 3.8 : Mean maximum temperatures (°C) in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts* from March 1992 to March 1994.



* Data from all farms within each district were combined for calculations as described in the text.

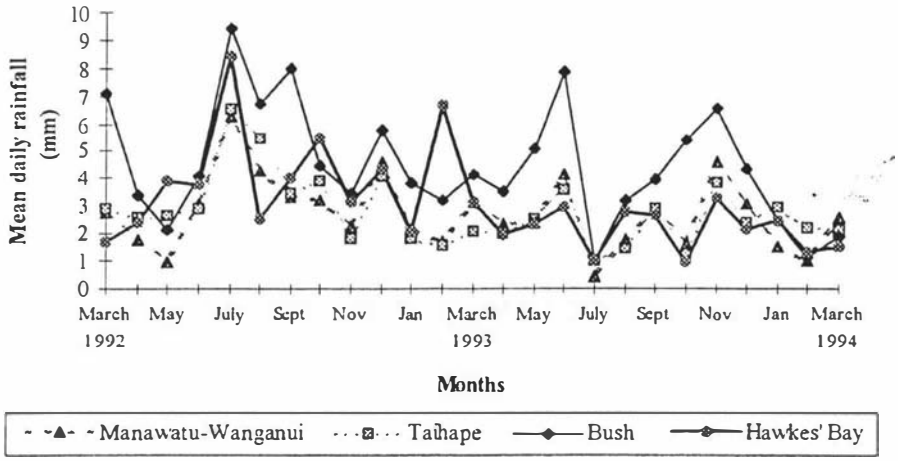
Figure 3.9 : Mean minimum temperatures (°C) in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts* from March 1992 to March 1994.



* Data from all farms within each district were combined for calculations as described in the text.

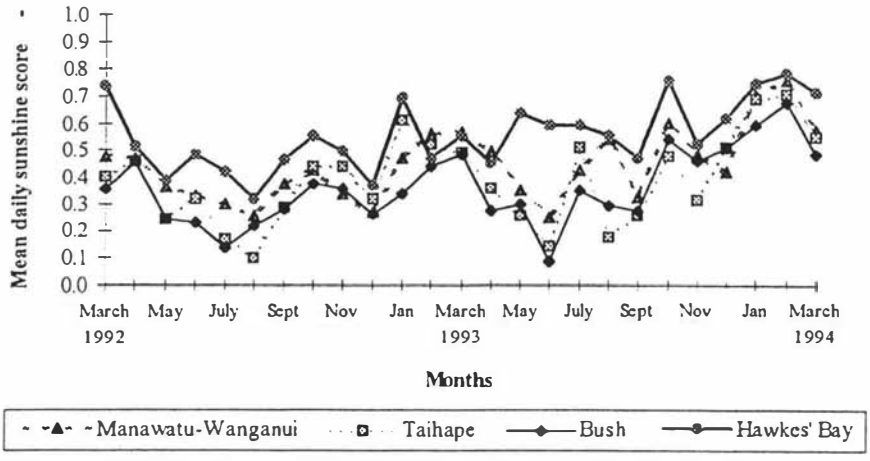
The rainfall tended to be higher in the Bush district in autumn and winter (Figure 3.10) which had the lowest sunshine score at that time of the year (Figure 3.11). Maximum temperatures tended to be lower in the Taihape district possibly due to the higher altitude. These farms had limited amount of snow during winter but it did not last more than a few days. Frosts were occasionally recorded on all farms but mean monthly minimum temperatures always remained positive.

Figure 3.10 : Mean daily rainfall (mm) in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts* from March 1992 to March 1994.



* Data from all farms within each district were combined for calculations as described in the text.

Figure 3.11 : Mean daily sunshine score in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts* from March 1992 to March 1994.



* Data from all farms within each district were combined for calculations as described in the text.
Note : The mean sunshine score is described in Table 2.13 and Table 2.27.

3.2 FARM MANAGEMENT PRACTICES

3.2.1 Paddock fertiliser application and weed control

The history of fertiliser application and weed control on survey farms during the study is presented in Table 3.7.

Table 3.7 : History of fertiliser application on survey farms during the study.

Farm code	Year	Date	Number of paddocks	Description or Drug
1	1993	15-Mar	1	Weed control
		30-Jun	12	2 tonnes DAP + 4 tonnes 15% Potassic Super / 20 ha
		30-Jun	9	4 tonnes 15% Potassic Super / 20 ha
2	1992	20-Aug	3	DAP
		20-Aug	1	DAP 135 at 125 kg/ha
	1993	02-Feb	1	Superphosphate at 375 kg/ha
		19-Apr	7	Superphosphate at 300 kg/ha
3	1993	07-Aug	11	DAP 123.5 kg/ha
4	1994	15-Feb	1	5 tonnes of sulfur super
7	1992	06-Oct	6	Cropmaster 15.10.10 at 154 kg/ha
	1993	01-Oct	6	Clop 15 at 150 kg/ha
8	1993	24-Apr	18	DAP 13 S at 100 kg/ha
10	1992	23-Mar	2	Urea
		26-Mar	4	Urea
		12-Aug	3	Cropmaster 20
	1993	02-Feb	16	Dicalcic super at 333.7 kg/ha
		11-Aug	8	Cropmaster
		03-Sep	7	Cropmaster
11			0	DAP 135 at 135 kg/ha
	1993	07-May	14	Superphosphate at 250 kg/ha
16	1992	01-Sep	12	DAP at 26.7 kg/ha by plane
	1993	20-Jul	16	DAP at 26.7 kg/ha by plane

DAP = Di-amonium phosphate
Note : This information may not be exhaustive, as the researcher did not check whether all farmers provided it or not.

3.2.2 Farmers' deer handling practices

Farmers' deer handling practices in paddocks and in the yards are presented in detail in Appendix 3.12. Usually 1 or 2 people at a time were used for shifting deer between paddocks. On 4 farms, an extra labour was used to shift deer to the yard for handling. Nine farmers used a motorbike (or small 4 wheel drive) all the time for shifting deer around the farm, while 4 farmers used one part of the time and one farmer always shifted deer by foot. Dogs were used on 7 farms, although the frequency of utilisation and the dog's behaviour varied between farms and class of stock. While 12 farmers shouted at their deer or to command the dog while working in paddocks, 4 farmers intimated they stayed silent. During handling in paddocks, only weaners were perceived as restless

on 6 farms, while the rest of the deer were reported calm and easy to work. On one farm, however, all classes of deer were reported difficult to work in paddocks and this was confirmed during successive farm visits. In contrast, on that farm all deer were very quiet to handle when inside the yards.

On 10 farms, there were usually 2 people to handle deer in the yards, while other farmers worked alone. This handling was carried out silently on half of the farms, although on other farms workers would occasionally speak loudly to each other. There was a range of difficulty in moving deer from handling paddocks or pens to yards (covered working area) and inside the yards. Two farmers perceived all class of deer as difficult to move around yards and this was confirmed at each visit, while on other farms, this did not appear to be a major constraint. Twelve farmers qualified all or part of their deer as calm to handle individually, and none qualified their deer as easily stressed during handling. While most farmers agreed they had aggressive hinds or stags on their farms, some farmers usually culled them. On 4 farms, however, these aggressive deer were not culled. However, it was the author's perception, from a tentative recording of farmer and deer behavioural observations, that where aggressive deer were not culled and farmers were occasionally observed hitting or kicking their deer, deer appeared the most difficult to handle.

3.2.3 Reproductive management

3.2.3.1 Mating strategies

Mating management strategies implemented on each survey farm are presented in Appendix 3.13 and Appendix 3.14. The summary description of mating mobs is presented in Table 3.8.

Over two years, 104 mating mobs were recorded, excluding 4 mobs of hinds artificially inseminated. Adult hinds were weaned from February 25 to April 30 with an overall median date on March 11, and they were joined with sire stag(s) between February 1 and March 26, with a overall median date on March 18. Yearling hinds were joined with sire stags later than adult hinds unless they were left with their yearling mates for mating. Sire stags were withdrawn from hinds between April 28 and June 30 with an overall median date on May 11.

There were between 4 and 150 adult hinds and between 1 and 196 yearling hinds in mating mobs. Median hind:stag ratios were lower for mobs including yearling hinds (median = 29.3) than adult hinds (median = 37.5), although mobs of yearling hinds left with yearling stags for mating were not included for this comparison (3 mobs or 6.7% of mobs including yearling hinds). Single-sire mating was the most used mating strategy. The largest mob using single-sire mating was 83 hinds. Experienced sires were more often used with adult hinds (84.5%) than with yearling hinds (64.5%).

Back-up sires were used for 56.5% and 42.2% of adult and yearling mating mobs, respectively. Dates of change of sire stags ranged from April 2 to May 26, and this was often carried out by mixing initial mating mobs together.

Table 3.8 : Summary of mating management strategies implemented in 1992 and 1993.

		Year 1992				Year 1993			
		Total	AH	YH		Total	AH	YH	
Number of natural mating mobs*		58	52	24		56	47	21	
		min	max	mean	median	min	max	mean	median
Weaning dates		29-Feb	30-Apr	15-Mar	10-Mar	25-Feb	06-Apr	14-Mar	15-Mar
Joining hinds with sire stag(s)		01-Feb	27-Mar	18-Mar	23-Mar	01-Feb	26-Mar	09-Mar	15-Mar
Removal of sire stag(s)		28-Apr	30-Jun	17-May	16-May	30-Apr	11-Jun	17-May	13-May
Hinds									
Number of hinds/mob	AH	4	150	40	38	8	118	37	31
	YH	2	196	27	12	1	52	21	21
Hind : sire ratio	AH	8	82	40	42	14	71	36	36
	YH	1	51	27	25	2	71	34	33
Sire stags									
Percentage (%) of mobs mated with :			AH	YH			AH	YH	
single sire			90.4	62.5			85.1	90.5	
experienced sire			90.4	66.7			78.7	61.9	
their yearling mates				8.3				4.8	
only sire(s) of pure NZ origin			46.1	62.5			31.9	23.8	
use of wapiti cross sire(s)			9.6	0			8.5	4.7	
Use of back-up sire(s)			55.7	45.8			57.4	38.1	
Mixing mating mobs for back-up			26.9	16.7			36.2	9.5	
Second change of back-up mobs			5.7	4.2			15.7	4.7	
Back-up sire mobs		min	max	mean	median	min	max	mean	median
Dates of first back-up sire		02-Apr	15-May	26-Apr	23-Apr	22-Apr	26-May	05-May	05-May
Dates of second back-up sire**		03-May	14-May			05-May	29-May		26-May
Number of hinds/mob	AH	25	148	72	56	8	182	65	54
	YH	5	41	18	15	5	35	17	12
Hind : sire ratio	AH	20	174	63	53	23	99	51	42
	YH	20	174	62	47	8	75	40	30

Note : - Mating mobs were groups of hinds and sire stag(s) that were set up for mating at the beginning of the rut
- Back-up mobs were mating mobs once back-up stags were joint with hinds.
- One mob of adult hinds in 1992 and 3 mobs in 1993 were artificially inseminated before being joined with the back-up sire. These mobs are not included in this summary

* One mob with one yearling hind was mated with wapiti sire

** This occurred on 2 farms in 1992 and 1993 (see Appendices 3.13 and 3.14)

AH = Adult hinds; YH = Yearling hinds

The composition of some back-up mobs was changed once more before sire stag removal. Hind:stag ratios used for back-up ranged from 8 to 174, which were higher than ratios used for first mating groups.

3.2.3.2 Selection and culling of breeding hinds

Data is presented in Appendix 3.16 and in Table 3.9.

The percentage of yearling hinds within the breeding herd ranged between farms from 0.8% to 35.8%. The proportion of yearling hinds kept for breeding each year depended on the culling percentage of adult hinds and whether farmers wished to increase or decrease the size of the hind mob.

Table 3.9 : Percentage of yearling hinds in the breeding herd and culling percentage (%) of yearling and adult hinds from mating to after weaning. Minimum and maximum farm and overall values in 1992, 1993 and both years combined.

Year			Farm data Minimum	Farm data Maximum	All farm combined
1992	% yearling hinds[a]		0.8	28.6	16.4
	Culling[b]	Yearling	0.0	100.0	23.0
		Adult	0.0	33.9	17.2
1993	% yearling hinds		0.9	35.8	18.8
	Culling	Yearling	0.0	66.7	18.0
		Adult	0.0	25.8	11.3
Both years combined	% yearling hinds				17.4
	Culling	Yearling			20.5
		Adult			14.5

a Percentage of yearling hinds in the breeding herd
b Percentage of mated yearling or adult hinds culled after weaning

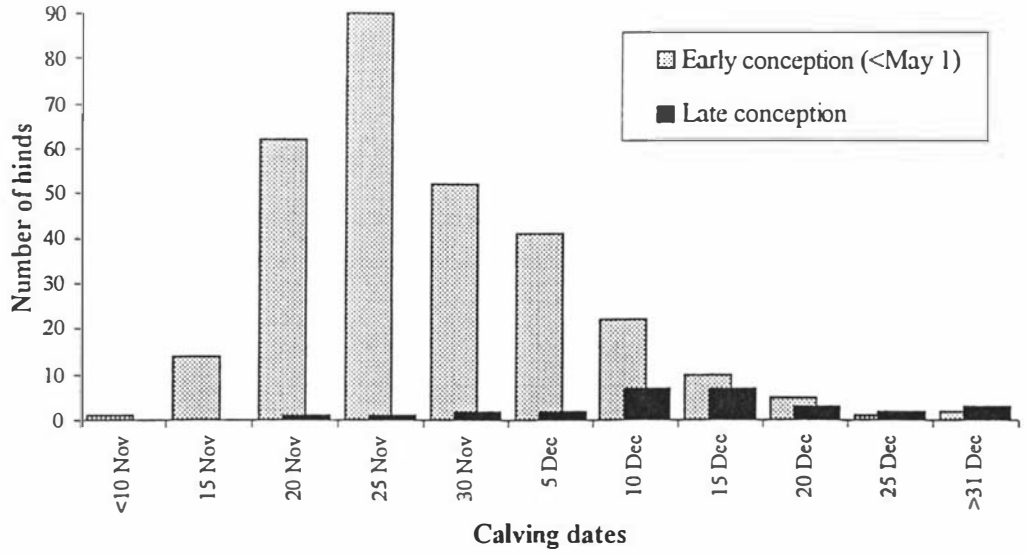
3.2.3.3 Pregnancy diagnosis

Early pregnancy diagnosis by ultrasound was not commonly used on survey farms prior to this survey. Scanning was performed between June 4 and July 8 and between May 30 and June 21 in 1992 and 1993, respectively.

The validity of the scanning technique used to classify pregnant hinds as conceiving before or after May 1 was investigated from calf birth dates that were recorded on 3 farms in 1992 and 1 farm in 1994. Hinds categorised as conceiving before May 1 calved statistically significantly earlier than hinds categorised as conceiving after May 1 ($p<0.01$), although dates overlapped as shown in Figure 3.12, as expected due to natural variation in gestation length and error of measurements used to predict foetal age.

Given a mean gestation length of 233 days in red deer (Fisher and Fennessy, 1985), hinds diagnosed as conceiving before and after May 1 should have calved before and after December 20, respectively. Thus errors of diagnosis of late conceptions were evident, particularly when scanning was late (eg July 8 1992) and only placentomes were measurable. Those errors are predictable (Revol and Wilson, 1991) and were largely avoided in 1993 when scanning was undertaken earlier.

Figure 3.12 : Calving date distributions of hinds that conceived early (before May 1) and conceived late as diagnosed by ultrasound. Data from 4 survey farms which recorded calving dates, combined.



Note : The mean calving date of hinds conceiving late (> May 1) was statistically significantly later than than of hinds conceiving early (before May 1)($p<0.01$).

3.2.3.4 Calving

Calving management practices varied between farms (see Appendix 3.16, summarised in Table 3.10).

Over two years, the size of calving mobs ranged from 2 to 169 hinds, the size of calving paddocks was between 0.5 and 24.3 ha. While the stocking rate used for calving was on average 10 hinds per ha, it ranged from 0.5 to 33.5 hinds per ha. Hinds were shifted to their calving paddock between September 24 to November 26, although one mob in 1992 stayed on the same paddock from winter through to summer. On one farm both years, pregnant hinds were individually examined in the yards in November and those showing signs of imminent calving (eg udder development) were shifted into calving paddocks, so set-stocking for calving was spread over time on that farm.

Four farmers in 1992 and 5 in 1993 did not monitor hinds during calving at least once a week and most of them never did for the duration of calving. Five farmers both years visited calving mobs once or twice a week, and the rest visited their hinds every day. On two farms, hinds artificially inseminated were more often visited than the rest of the breeding herd. Three farmers in 1992 and 2 in 1993 always visited hinds by foot, while the others used a motorbike. However, 10 farmers in 1992 and 11 in 1993 went around calving paddocks to closely check for calving problems. Three farmers in 1992 and two in 1993 tagged their calves shortly after birth.

Table 3.10 : Summary of calving management practices in 1992 and 1993.

	Year	
	1992	1993
Number of calving mobs	67	57
with only yearling hinds	4 (6.0 %)	7 (12.3%)
with both YH and AH	21 (31.3 %)	15 (26.3%)
Date of set-stocking		
the earliest	24-Sep	11-Nov
the latest	25-Nov	26-Nov
Number of hinds per mob		
Minimum	2	9
Maximum	169	138
Mean	32.6	36.4
Caving paddock size (ha)		
Minimum	0.5	0.7
Maximum	24.3	24.3
Mean	4.2	4.8
Number of hinds per hectare		
Minimum	0.5	4.0
Maximum	33.3	32.8
Mean	9.8	10.0

YH = yearling hinds; AH = adult hinds

3.2.3.5 Weaning

Data is summarised in Table 3.11. Weaning occured between February 25 and April 30 (mean, March 15) and was associated with a range of handling procedures. Although the timing of events differed between farms, some procedures such as tagging, weighing, and anthelmintic treatment were carried out on every farm. Two thirds of the time dams and calves were handled in yards (eg for tagging, drenching and/or weighing) at least once prior to weaning, so all procedures were not carried out the same day. Farmers tried to wean their calves within a given week each year, but the final date was chosen depending on weather forecasts and other commitments. Fine days were preferred for weaning.

3.2.4 Disease monitoring and control

There was almost no monitoring of health problems on study farms prior to this survey. Only farm 1 monitored the egg and larvae output in the faeces of weaners late autumn and early spring before treatment with anthelmintics. Farm 3 did ask for serum copper data in the face of clinical health problem.

Table 3.11 : Summary of weaning management practices on each farm in 1992, 1993 and 1994.

Farm code	Year	Nov-Dec**	January			February			March			April		
			1-10	11-20	21-31	1-10	11-20	21-28	1-10	11-20	21-31	1-10	11-20	21-30
1	1992	TBirth						W-T	A V-Wean	S	A W		V	W
	1993	TBirth				T		W	Wean-A V		S-H-A		Y	A V
	1994					T M		W-T	Wean Y		V Y	W		
2	1992								S	W T M	A W Wean			A
	1993								W T M-A Wean		S		A	
	1994								W A T M Wean			A		
3	1992					T			W Wean-A S			A W		
	1993				C				T W-A S Wean			A W		
	1994						T A			A W Wean		W		
4	1992					T A		A W Wean			A W		A W	
	1993	TBirth			A W			A W T Wean		S-A W			A W V	
	1994	TBirth					T W	A Wean			A W - Y		A W	
5	1992									S-A W T Wean				
	1993								W T Wean		A Y		A W Y	
	1994									A W T V Y Wean				
6	1992									S	A W Wean			A W
	1993										A-S	W T Wean		A
	1994											A W Wean		
7	1992								A W T Wean	W	S	A	W	
	1993										A T W V Wean	A W		
	1994										A T W Y Wean		A W	
8	1992									A T Wean-S	W	H-W		A
	1993								A T-W S Wean			A W		
	1994								A W T Y - Wean		W A Y			
9	1992			T A					Wean	A W		A		W
	1993					A W T		W	W-S Wean		W	A W		
	1994				T W				A Wean	Y	H			
10	1992	T							A V Wean-W				A W V	
	1993	T							A W V Wean		A W V Y			A W Y-H
	1994							A V W Wean						
11	1992								S	A T Wean		A		H
	1993						T W		S	A W Wean			A	
	1994								T A W Wean			A W Y		
13	1992								A W T	Wean-S				A-W
	1993						T			A W Wean		S	Y	YT
	1994								T V		W A C Y Wean			
14	1992			A VL					S		A W-Wean		A	
15	1992										S			A W T Wean
	1993											A W T Wean		
	1994								T A W Wean			A W		
16	1992	TBirth									A T Wean			A
	1993	TBirth									A W Wean-S			
	1994								T W		T M - H - A W Wean			

A : Anthelmintic treatment; C : Copper supplementation; M : Matching mother-offspring; S : Sampling visit; T : Tagging; TBirth : Tagging calves at birth; H : Handling calves in yards for sorting
V : Vaccination against clostridial diseases (5-in-1); VL : Vaccination against leptospirosis; W : Weighing; Wean : Weaning;
Y : Vaccination against yersiniosis ("Yersiniavax"); YT : Treatment of clinical yersiniosis
- hyphen : Management practices separated by an hyphen have been carried out on different days
* Recording ended on April 1 1994, so data may be missing after that date from some farms
** Calving period (November-December) the previous year

The list and composition of anthelmintics, vaccines and trace element supplements used by farmers during this study is presented in Table 3.12.

Table 3.12 : Animal remedies used by farmers during the study for disease control

		Anthelmintic		Mineral supplement[2]		
Code	Drug name or description		RECD[1] ml/kg	Cu	Se	Co
Anthelmintics						
ARR	New Arrest**	Ben	0.2	0	0	0
ARH	New Arrest Hi-Mineral*	Ben	0.2	1	1	1
CPO	Cydectin Pour On	Ive	0.1	0	0	0
IOC	Ivomec Oral Cattle*	Ive	0.05	0	0	0
IOS	Ivomec Oral Sheep**	Ive	0.25	0	0	0
IPO	Ivomec Pour On*	Ive	0.2	0	0	0
OCH	Oxfen C Hi-Mineral	Ben	2	1	1	1
OHM	Oxfen Hi-Mineral	Ben	0.2	1	1	1
OXC	Oxfen C	Ben	2	0	0	1
RLC	Red Label Cattle*[3]	Ben	2	1	1	1
RLS	Red Label Sheep**[3]	Ben	0.05	1	1	1
SMD	Synanthic Mini Dose	Ben	0.05	0	0	0
SMS	Synanthic Mini Dose + Se	Ben	0.05	0	1	0
SYS	Systamex Sheep & Catle**	Ben	0.2	0	0	0
SYC	Systamex Low Dose Cattle*	Ben	0.05	0	0	0
VAL	Valbazen**	Ben	0.2	0	0	0
VMD	Valbazen Mini Dose	Ben	0.07	0	0	0
VES	Vetdectin Oral Sheep**	Ive	0.2	0	0	0
Copper supplements						
CIN	Coprin		0.02			
CNE	Copper Needles		4			
CNL	Copper Needles Large		12			
C05	Copacaps 5g		5			
C10	Copacaps 10g		10			
C20	Copacaps 20g		20			
CUP	Cuprax 10g		10			
Vaccines						
LPC	Leptavoid 3	Leptospirosis vaccine				
VAC	5-in-1	Multistrain clostridial vaccine				
YER	Yersiniavax	Yersiniosis vaccine				

(Source New Zealand Index of Veterinary Specialities Annual 1994, Volume 9)
Note : company names are presented at the beginning of this thesis
[1] CONC = drug concentration (Copper supplements except Coprin are given in g/bolus)
RECD = Dosage recommended for use in deer, or for use in cattle (*) or sheep (**) if the anthelmintic was not licensed for use in deer
[2] Mineral supplements : Cu = Copper; Se = Selenium; Co = Cobalt; 1 = Yes; 0 = No
Farm 6 added Selenium in all anthelmintics (Ivomec Oral Cattle) before use.
[3] Anthelmintic marketed by Hawke's Bay Veterinary Services Ltd

3.2.4.1 Weaners

The chronological sequence of anthelmintic treatments to weaners along with handling practices around weaning has been presented earlier (Table 3.11). Detailed descriptions of anthelmintic treatments, trace element supplementations and vaccination programmes of weaners are presented in Appendix 3.22, Appendix 3.23 and Appendix 3.24.

While on all farms every weaner was treated with anthelmintics during autumn and early winter (June), treatment regimes varied between farms. Some weaners were treated with anthelmintics as early as January 15, others were not treated until April 30, and the mean starting date was March 9. The number of treatments ranged from 1 to 5 in autumn, from 0 to 3 during winter, from 0 to 2 in spring, and from 3 to 9 all seasons combined. Three farmers in 1992 and one in 1993 stopped internal parasite control on weaners after mid-June. Drenching intervals during autumn ranged from 20.6 to 89 days (mean, 36.3 days). Seven farmers in 1992 and 9 farmers in 1993 used ivermectin/albemycin-based anthelmintics, systematically or occasionally, while the others used benzimidazole-based anthelmintics exclusively. In Hawkes' Bay, farmers used a locally prepared mineral supplemented benzimidazole anthelmintic supplied by their local veterinarian. Dosages given are reported in the above appendices.

Copper, selenium and cobalt were supplemented to weaners on 7 farms as they were mixed with anthelmintics (Table 3.11). In the Manawatu, one farmer mixed selenium with the ivermectin-based anthelmintic used before treatment. Preventive copper supplementation was carried out on properties known to be copper deficient. Four to 10 g of copper oxide rods were given orally to weaners in May or June to control a potential depletion of liver reserves during winter. On one farm, copper supplementation was administered in December-January in response to clinical problems.

Vaccinations against clostridial diseases (5-in-1) were carried out around weaning on 2 farms in 1992 and 2 in 1993, and on one farm in May 1993. The Yersiniavax vaccine was used in 1993 only. It was used preventively on 4 farms and used in response to clinical problems (eg weaner mortality) on 3 other farms.

3.2.4.2 Hinds and stags

The detailed chronological sequence of disease control measures implemented on hinds and stags is presented in Table 3.13.

Ivermectin/Albemycin-based anthelmintics were most often used for hinds and stags, although farmers from Hawkes' Bay used the benzimidazole drench supplied by their local veterinarian. There was no consistency of treatment between the two years on most farms. Yearling hinds were treated before mating on 2 farms in 1992 or 1993, while on another 3 farms yearling and/or adult hinds were treated during winter, although this happened only one year. On yet another two farms, however, hinds were systematically treated with anthelmintics prior to calving early November. Yearling and/or adult stags were treated with anthelmintics sometime between June and September on 10 farms, and between February and May on 5 farms, but again this was not repeated during the two years of study.

Table 3.13 : Summary of disease control practices on hinds and stags (> 15 months) on each farm in 1992, and 1993

Farm	Year	MONTH											
		March	April	May	June	July	August	September	October	November	December	January (The following year)	February
1	1992							6th : YH Drench (IOS 20ml)					
	1993						28th : YS Drench (IOS 30ml) 9th : YS Drench (IOS 30ml)						
2	1992			23th : YS/AS Drench (IPO 12.5/20ml)									
	1993												
3	1992				20th : YS/AS Copper 20g						4-18th : AS Copper 20g	21th/30th : AH Copper 20g/AS Drench (IPO 20ml)	
	1993	16th : YH-YS Drench (IPO 10ml)				3th : YH/AH Copper 20g		10th : YS-AS Drench (IPO 10/20 ml)					
4	1992									15th : YH/AH Drench (OHM 20ml) & Vac 5-in-1			
	1993				1st : YH/AH Copper 12g					1st : YH/AH Drench (OHM 25ml) & Vac 5-in-1			
5	1992						28th YH/AH : Copper 10g				At velvetting : YS/AS Copper 20g		
	1993							4th : YS/AS Drench (IPO 15ml)			At velvetting : YS/AS Copper 10g		
6	1992									9th : AH Drench (VMD 7ml)			
	1993						15th : YS-AS Drench (IPO 12ml)			15th : YH Drench (Arrest 16ml)			
7	1992	29th : YS Drench (IOC 5ml)					9th : AH Copper (Inj "Coprin" 2ml)		8-14th : YH/AH Vac 5-in-1				
	1993		4th : YS Drench (OHM 5ml)		7th : AH Copper 10g 6th : YS Copper 10g		2nd/22th : YS Drench (IOC 5ml)/Copper 4g 16th : AH Drench (OXC 5ml) 16th : AS Copper 10g Drench (OXC 7ml)						
8	1992				16th : AS Drench (IPO 50ml)								
	1993				15th : YH-AH Copper 10g		8th : AS Copper 20g						
9	1992				25th June/9th July : YH/AH Copper 10g 24-29th : YS/AS Copper 10g								
	1993					16-20th: YS/AS Copper (10g/20g)							
10	1992						25th : AS Drench (RLC 12ml)						
	1993												
11	1992						14th : AS Drench (RLS 15ml)						
	1993												
13	1992	10th : YH-YS-AS Drench (RLS 20ml)											
	1993									4-17th : YH/AH Vac 5-in-1			
14	1992												
15	1992				4th/15th/26th : AS/YS/AH Drench (IPO 20/12.5/20ml)								
	1993												28th : YS Drench (VPO 12.5ml)
16	1992							13th/14th : YS-AS/YH-AH Drench (IOC 10ml)					
	1993				28th/29th/1st Aug : YS/AS/AH Drench (IPO 10/20/12.5ml)								

Drench : Anthelmintic treatment; Copper : Copper supplementation with copper oxyde rods; Inj : injection

Vac 5-in-1 : Vaccination against clostridial diseases (5-in-1);

YH = yearling hinds ; AH = adult hinds (>26 months); YS = yearling stags; AS = adult stags (>26 months)

Codes used for anthelmintics :

IOS = Ivomec Oral Sheep; IOC = Ivomec Oral Cattle; IPO = Ivomec Pour On; OXC = Oxfen Conc; OHM = Oxfen High Mineral

RLC = Red Label Cattle; RLS = Red Label Sheep; VMD = Valbazen Mini Dose; VPO = Vetdectin Pour On

Note on table interpretation :

"4th/15th : YS/AS Drench (IPO 15/20 ml)" should be read "Yearling stags were drenched on the 4th with 15 ml of Ivomec Pour On and Adult stags on the 15th with 20ml"

Copper was the main mineral supplemented to hinds and stags, although selenium and cobalt were found in mineralised "Red label" anthelmintics (Table 3.12). Although injectable copper was used once on adult hinds, 10 to 20 g of copper oxide rods were given orally. Treatment of hinds or stags occurred in June or July on 6 farms, while one farmer supplemented some deer in August and another supplemented stags at the time of velvet antler removal. The timing of this latter supplementation was because handling facilities did not allow treatment of stags other than after chemical restraint.

Stags did not receive any vaccine on any farm during the study. Hinds were given a booster 5-in-1 vaccine prior to calving on 3 farms, although this was carried out both years on just one farm.

3.2.5 Entries and removals

Entries and removals describe the movement of stock in and out of the deer farm, respectively.

3.2.5.1 Weaners

The timing of removal of weaners (weaner leaving the farm) varied between farms in 1992 and 1993. Except from farm 15 in 1992 and farm 13 in 1993 where significant weaner mortalities occurred, most removals were from culling either sold alive or killed at DSPs. Overall, weaners were either sold early before winter (from breeding units) or after at least one year of age. One farm achieved a one-year weaner stag venison production as almost all weaner stags were sold by December 1 each year. On other farms, young stags were culled during their second autumn or were kept in the velvet herd. Young hinds were mostly culled prior to mating and those culled were sent to DSPs before their second winter. The calendars of culling, carcass characteristics (or bodyweights) of weaner deer are presented in Appendix 3.17.

3.2.5.2 Hinds and stags

Calendars of entries and removal of hinds and stags and carcass characteristics of deer slaughtered on each survey farms are presented in detailed from Appendix 3.18 to Appendix 3.21.

Very few yearling or adult hinds entered survey farms during the years of study. Hinds left the properties mainly because of culling due to poor reproductive performance (see Appendix 3.15) or poor temperament, and because many hinds were taken away to other properties by their respective owners. The other hinds died or were killed by the farmer for home consumption or because of health problems.

The entries of yearling and adult stags were also limited. These stags were leased or purchased to increase the velvet herd, such as on farm 5 in August 1992 and on farm 9 in June 1992, or for mating (many single stags entered prior to the rut). Removals were mainly due to death or culling because of health problems or relatively poor velvet antler records.

3.2.6 Nutrition management

3.2.6.1 Grazing management

3.2.6.1.1 Grazing records

Over the duration of the study, there were over all farms 7357 grazing intervals recorded. This information was mainly used for calculation of environmental and grazing management variables that were analysed in the next Chapter. The results of these calculations are included in univariate statistics presented for each analysis of risk factors.

3.2.6.1.2 Mean farm pasture characteristics recorded during visits.

Calculated pasture cover variables for each farm after each visit in 1992 and 1993 are presented in detail in Appendix 3.25 and Appendix 3.26, respectively. Range and quartiles of mean pasture sward height, pasture cover, clover score, and ragwort and thistle score are presented in Figure 3.13.

On most farms each year, mean pasture covers were over 1400 kgDM/ha in March and November, dropped below this level by June and decreased further by September. In September 1992, mean pasture covers ranged from 604 to 910 kgDM/ha. Similarly, mean pasture sward heights were over 10 cm in spring and summer, but dropped during autumn and winter. In September 1992 and 1993, there was 5 and 4 farms, respectively, with a mean pasture sward height below 5 cm.

There was a highly statistically significant correlation ($r = 0.89$) between mean pasture covers and mean sward heights all visits and farms combined. The regression equation was defined as :

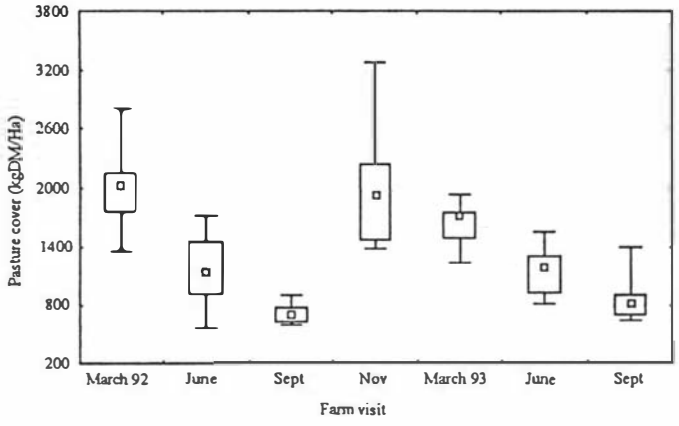
$$\text{Mean pasture cover} = 27.7 + 143.5 \times \text{mean pasture sward height}$$
$$(r^2 = 0.80, p<0.001)$$

Mean clover scores were minimum in June 1992 with a median score of 1 (the lowest score) and remained close to 1 on a few farms, while on others this score rose significantly during spring. The mean ragwort and thistle scores show wide variation between farms. Whereas thistles were found on each farm, ragwort was not observed on 4 farms, and were only occasionally found on three other farms (possibly due to regular manual removal of plants as observed during the study).

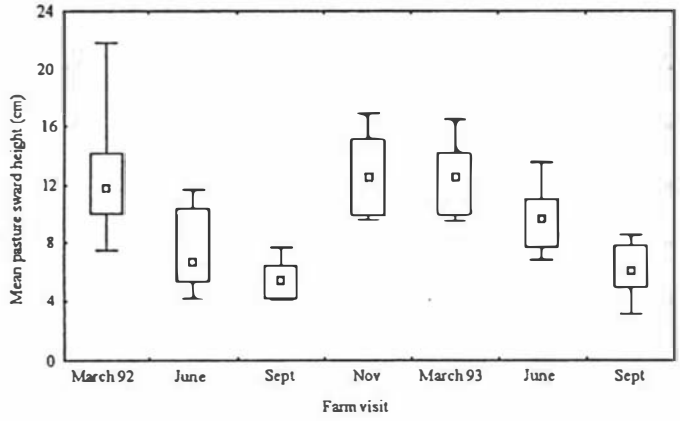
The variability of mean pasture covers, mean sward heights and mean clover scores due to year, farm and visit difference were explored by three-way ANOVA using SAS. The statistical significance of model factors are presented in Table 3.6.

Figure 3.13 : Median ▫ , 25th and 75th percentiles ▯ ,and range ⊥ of mean farm pasture cover, sward height, clover score, and weed score at each farm visit in 1992 and 1993.

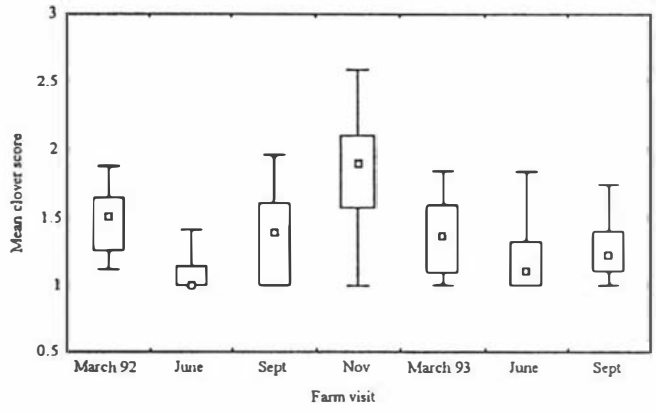
1. Pasture cover (kgDM/Ha)



2. Mean pasture sward height (cm)



3. Mean clover score (range from 1 to 3)



4. Mean ragwort and thistle score (range from 0 to 3)

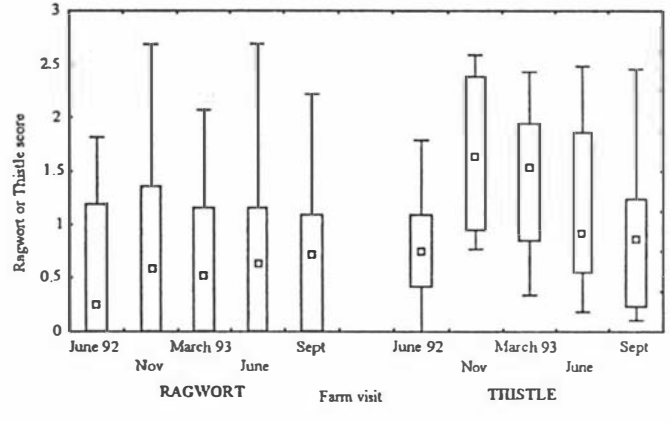


Table 3.14 : Summary results of three-way ANOVA to test the variability of mean pasture cover, mean sward height and mean clover score due to year, farm and visit[1].

Model factors	Mean pasture cover kgDM/ha	Mean sward height cm	Mean clover score 1 to 3
Year	NS	**	NS
Farm	**	**	*
Visit[1]	**	**	**
Year x Farm	**	*	NS
Year x Visit	**	*	NS
Farm x Visit	**	**	NS

* p<0.05; ** p<0.01; NS = Not Significant
[1] Visits were in March, June and September 1992 and 1993, and November 1992.

There were significant variations of all three mean farm characteristics between visits and between farms. Only mean sward heights showed overall between year variation. Interaction terms were significant in the analyses of mean pasture covers and mean sward heights, thus indicating that the variability of these characteristics differed depending on the farm, visit and year. It was not in the scope of this project to investigate these differences further.

3.2.6.2 Food supplementation

The chronological sequence of food supplementation to weaners is presented in detail in Appendix 3.27. Supplementation to hinds is presented in Appendix 3.28 and Appendix 3.29, while that to stags is presented in Appendix 3.30 and Appendix 3.31.

Weaners were given food supplements (maize) post-weaning every year on just one farm, while on another 4 farms weaners were supplemented after weaning in 1992, 1993 or 1994. On 9 farms in 1992 and 8 farms in 1993, weaners were given food supplements from May or June onwards. On many of these farms, supplementation was carried out until late August or September. Most often maize, but also barley, peavine hay, balage and sward hay was the principal component of this supplementation. The list of food supplements used and their nutritive value (MJME/kgDM) is presented in Table 3.15.

On 6 farms in 1992 and 4 farms in 1993, hinds were given sward hay, silage, balage or maize in May (on two occasions in April) after mating. On all survey farms in 1992 and 10 farms in 1993, food supplementation was implemented during winter, starting often in June and finishing in September. The types of food given were balage, silage, hay (from ryegrass/clover sward, clover or peavine) and concentrates (maize and barley). On one farm in 1992 and two farms in 1993, a kale crop was strip-grazed daily or every second day by hinds in winter. Three farmers supplemented lactating hinds late summer in 1993 (one also did it in 1992) with maize, balage or hay.

There was little food supplement given to stags during the rut. Supplementation during winter was implemented on 14 farms in 1992 and 11 farms in 1993, with similar practices as described for hinds. In spring, however, stags were supplemented up to October or November on 5 farms in 1992 and one farm in 1993 to support the growth of velvet antlers. Kale was strip-grazed by stags both years on only one farm.

Feeding episodes are reported in appendices for each mob that was identified by farmers, so supplementation history of individual deer is not presented here. These data were used to calculate food supplementation variables for each group of deer with the same grazing and food supplementation history. This information is presented along with univariate statistics of risk factor analyses in the next chapter.

Table 3.15 : List of food supplements used by farmers

		Year 1992		Year 1993	
Farm code	Type of food	Dry Matter %	Nutritive value MJME/kgDM	Dry Matter %	Nutritive value MJME/kgDM
1	Balage	53.9	8.04	70.4	7.66
	Peavine hay[1]	90.0	10.25		
3	Peavine hay[1]	89.9	10.33	90.0	10.25
	Sward hay	88.7	7.32		
4	Sward hay	94.6	7.76	87.9	7.75
	Balage	51.7	8.21		
5	Sward hay	90.6	9.23	87.9	8.61
6	Sward hay	90.3	8.07	89.6	6.92
	Sward hay(Poor)	90.4	6.92		
	Balage	40.1	8.32		
7	Sward hay	85.2	8.01	87.9	8.18
	Red clover hay[2]	85.0	8.50	85.0	8.50
8	Sward hay	89.1	8.95	89.4	7.74
9	Sward hay	91.3	8.17		
	Silage	67.0	9.23		
10	Peavine Hay	90.2	10.23	88.9	10.20
	Silage	18.2	9.29	15.4	7.34
11	Sward hay	91.9	8.59	89.3	8.58
13	Sward hay	95.3	8.85	85.5	8.30
14	Silage	7.9	9.30		
15	Sward hay	92.6	7.91		
16	Sward hay	92.8	7.91	88.6	8.33
All but[3]	Maize[2]	85.0	14.0		
5 and 16	Barley[2]	85.0	12.5		
7 and 8	Kale[3]	15.0	12.5		
6	Pellets[4]	89.0	11.5		

Note : Nutritive values were analysed by the Massey University Nutrition Laboratory unless stated otherwise

[1] Values taken as the averages of %DM and MJME/kgDM from the three analysis of Peavine Hay samples in this study (Farm 10 in 1992 and 1992, and Farm 3 in 1992)

[2] Source Ulyatt et al., 1980

[3] All farms but farms 2, 6 and 14

[4] High Energy Dairy pellets, Harvey Farms Pty Ltd, Mt Mauganui, New Zealand

3.2.7 Velvet antler harvesting

Six farmers were accredited to harvest the velvet antlers of their own stags. Two farmers used chemical tranquilisation, while the other 4 used a crush device to immobilise the stags to allow injection of local anesthetic and cutting. The rest of the farmers asked their local veterinarian to do the job, which most often was carried out using chemical restraint. The velvet spikes of weaner

The grazing management of stags prior to velvet antler removal was adapted to the size of mobs, the adequacy of handling facilities, the harvesting technique used and the stage of velvet antler growth within each velvet herd. Often farmers separated stags in small groups according to the stage of velvet antler growth. These mobs were frequently changed as the harvesting season progressed to allow the handling of only small numbers of stags in the yards, thus limiting the risk of causing injuries to the stags (and their antler).

The grazing history of each stag up to velvet antler harvesting was recorded for the calculation of pre-harvesting environmental and grazing management variables. Results of these calculations are presented with univariate statistics in the analysis of risk factors for velvet antler production in the next chapter.

3.3 DEER AND FARM PERFORMANCE

3.3.1 Hind performance

3.3.1.1 Hind weights

Detailed descriptive statistics of three-monthly bodyweights of yearling and adult hinds per farm are presented in Appendix 3.32 and Appendix 3.33, and while a descriptive summary of these hind bodyweights over all farms in 1992 and in 1993 is presented in Table 3.16.

The distribution histogram of yearling and adult hind pre-mating bodyweights is presented in Figure 3.14. Both years, the mean bodyweight of yearling and adult hinds was in the range 75-80 kg and 95-100 kg, respectively.

Table 3.16 : Descriptive summary of yearling and adult hind bodyweights (kg) in 1992 and 1993

	Yearling hinds					Adult hinds				
Year	Number of hinds	Mean	Min	Max	SD	Number of hinds	Mean	Min	Max	SD
MARCH (Pre-mating)										
1992	311	82.8	52.0	107.0	9.4	1158	98.0	65.0	133.5	10.6
1993	442	81.3	44.0	113.0	8.5	1422	98.7	56.0	144.5	10.7
JUNE										
1992	325	84.8	53.5	114.0	10.2	1167	97.1	66.5	130.0	10.1
1993	417	85.1	59.5	118.0	8.6	1408	99.5	66.0	140.0	9.6
SEPTEMBER										
1992	177	80.5	58.0	109.5	10.4	637	94.2	57.5	136.5	10.7
1993	323	85.3	58.5	115.0	9.1	1403	98.4	68.5	135.5	9.3
NOVEMBER (Pre-calving)										
1992	258	91.0	52.0	119.0	11.5	925	102.9	67.0	139.0	11.6
1993	139	96.8	75.0	124.0	8.8	564	109.9	78.0	156.5	10.7

Min = minimum; Max = maximum; SD = standard deviation

Differences in pre-mating bodyweights of hinds due to year, farm, age (2, 3 or 4 years) and blood line category (Pure New Zealand or not) were investigated by multiple-way ANOVA using SAS. Only hinds below 5 years were included because very few older hinds had imported blood lines. There were significant differences ($p<0.01$) between farms, age and blood line category, but no difference between years. Consequently, only the 1992 hind pre-mating bodyweights are presented on Figure 3.15.

Figure 3.14 : Pre-mating bodyweight distribution of yearling and adult (>2 years) hind in 1992 and 1993.

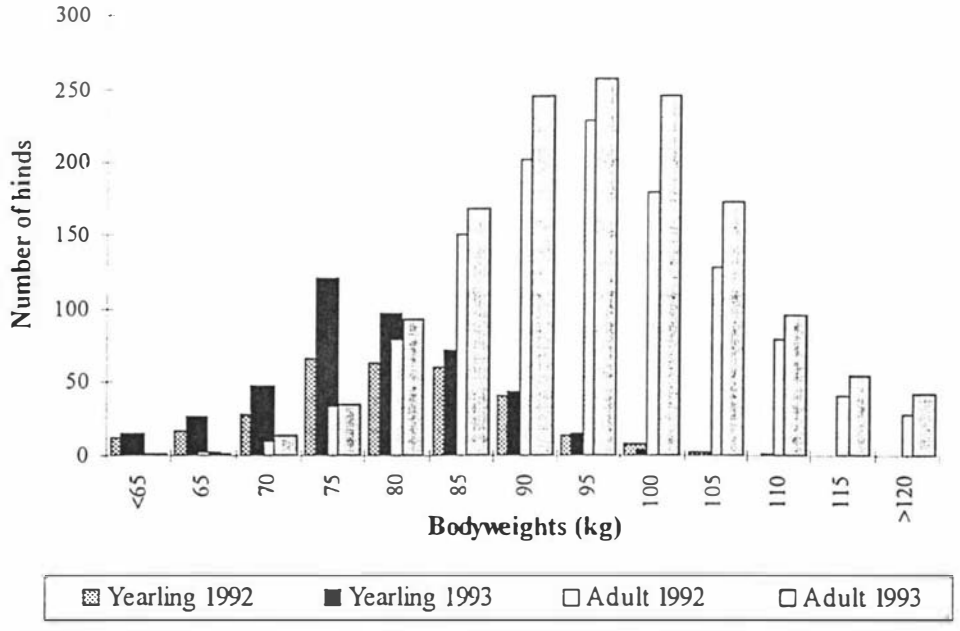
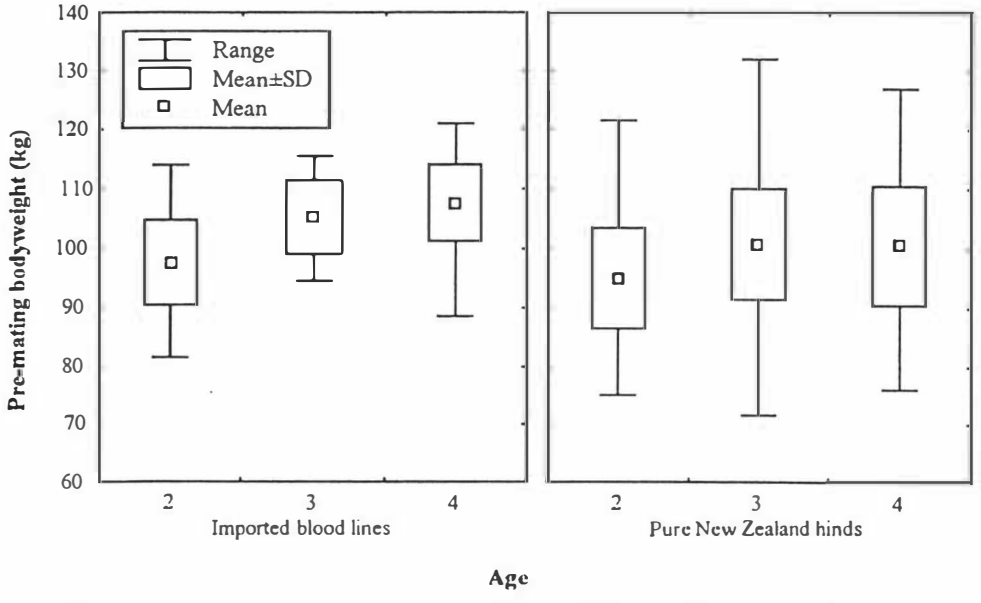


Figure 3.15 : Mean, standard deviation (SD) and range of pre-mating bodyweights of 2-, 3- and 4-year-old hinds with imported blood lines or pure from New Zealand, respectively in 1992.



Note : There were significant bodyweight differences between age group and between blood line group ($p<0.01$).

3.3.1.2 Hind condition scores

3.3.1.2.1 Validation of the scoring technique

The body condition chart used in this study was assessed for repeatability and reproducibility using the method described by Jansen et al. (1985). The repeatability is the proportion of the score variance due to scoring variation by the same assessor, while the reproducibility is the score variance due to hind difference.

During the last visit in March 1994, yearling and adult hinds were scored independently twice on the same day by two separate assessors. Assessors were the researcher and a second assessor trained on the first visited farm. On four farms, 20-30 adult hinds and 10-15 yearling hinds were scored by the two assessors at the beginning of the visit and scored again after all hinds in the mob were scored as it was usually done once by the researcher.

Analyses were carried out separately for yearling and adult hinds. The variability of hind scores due to assessor, score and hind was investigated by a three-way ANOVA using SAS. Preliminary analyses were carried out to determine if interaction terms were significant, and only statistically significant terms were included in the final model for calculation of repeatability and reproducibility. Variance components were calculated using SAS. The final model and formulations are presented in Table 3.17, while calculated variance components, repeatability and reproducibility are presented in Table 3.18.

Table 3.17 : Model components and calculation formula of the repeatability and reproducibility of hind body condition scoring[†].

Model	$y_{ijk} = \mu + h_i + a_j + s_k + (ha)_{ij} + e_{ijk}$
were : y_{ijk} = body condition score on the i^{th} hind by the j^{th} assessor for the k^{th} score μ = overall mean body condition score h_i = effect of the i^{th} hind (i = 1...n) all yearling hinds : n = 49 all adult hinds : n = 60 a_j = effect of the j^{th} assessor (j = 1,m with m=2) s_k= effect of the k^{th} score (k = 1,p with p = 2) $(ha)_{ij}$ = interaction of the i^{th} hind with the j^{th} assessor e_{ijk} = error term	
Repeatability	$r_1 = (v_{Total} - v_s - v_e) / v_{Total}$
Reproducibility	$r_2 = v_h / v_{Total}$
where : v_h, v_a, v_s, v_{ha} and v_e are the variance components of h_i, a_j, s_k, $(ha)_{ij}$ and e_{ijk}, respectively. and the total variance	$v_{Total} = v_h + v_a + v_s + v_{ha} + v_e$

[†] Method from Jansen et al. (1985)

Table 3.18 : Analyses of variance, estimates of variance components, repeatability (r_1) and reproducibility (r_2) of body condition scoring in yearling and adult hinds.

Effects	d.f.	Mean type III squares	Estimates of variance components	r_1	r_2
Yearling hinds					
Hinds	38	2.3505 **	0.5598	0.91	0.81
Assessors	1	3.3910 **	0.0420		
Scores	1	0.1603 NS	0.0012		
Hinds x Assessors	38	0.1114 *	0.0243		
Error	77	0.0629	0.0629		
Adult hinds					
Hinds	89	2.8923 **	0.6612	0.89	0.79
Assessors	1	1.4694 **	0.0068		
Scores	1	0.3361 *	0.0014		
Hinds x Assessors	89	0.2475 **	0.0793		
Error	179	0.0889	0.0889		

d.f. : degrees of freedom; * $p<0.05$; ** $p<0.01$; NS = Not significant
Note : formula for calculation of r_1 and r_2 are presented in Table 3.17.

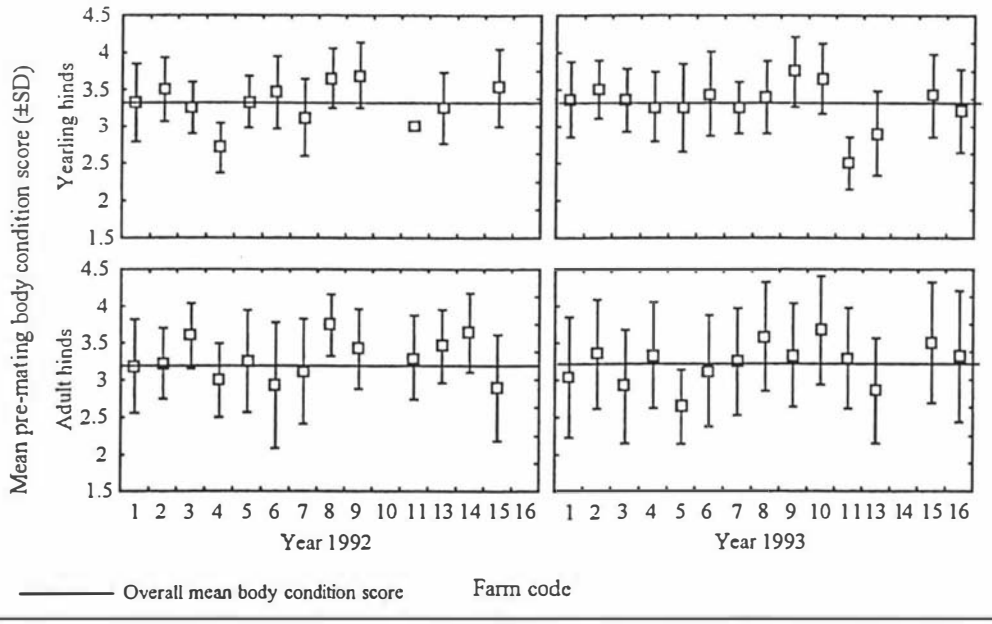
Hind body condition scores were composed of a fixed mean value plus variables components due to hinds, assessors and score assessments, respectively. There was a significant interaction between hind and assessor, which means that assessor differences varied according to the level of hind body condition scores (eg between fat and thin hinds).

3.3.1.2.2 Body condition score distribution

The distributions of pre-mating, pre-calving and weaning body condition scores of yearling and adult hinds in 1992 and 1993 on each farm are presented from Appendix 3.34 to Appendix 3.37. Mean body condition scores of yearling and adult hinds (±Standard deviation) between farms are presented in Figure 3.16.

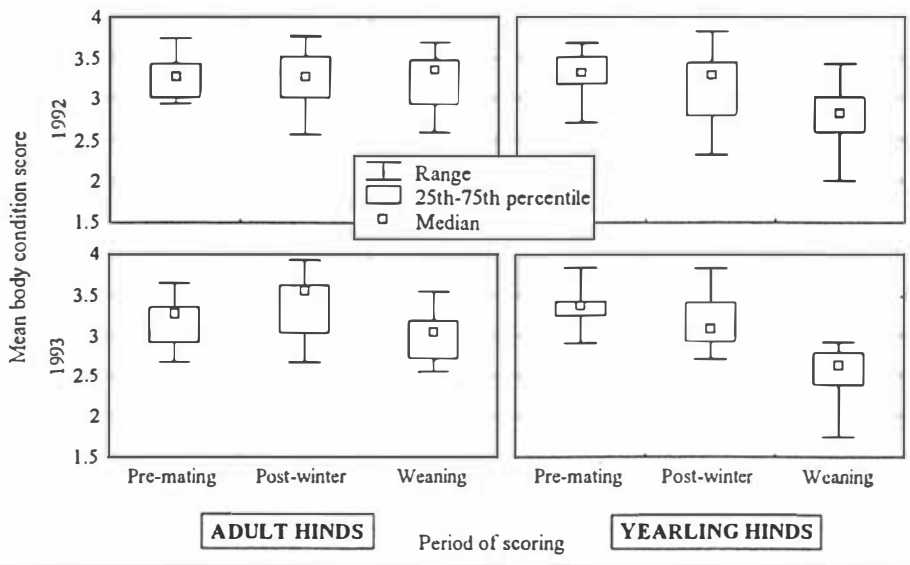
The variability of hind body condition scores due to year, farm, age (yearling or adult) and period (pre-mating, post-winter and weaning) differences was investigated by a multiple-way ANOVA using SAS. Second order interaction terms were included in the model. There was highly statistically significant variation due to farm, age and period. There was no significant variation between year, although the interaction terms "Year x Farm" and "Year x Period" were statistically significant, which means that difference between years varied between farms and periods. The interaction term "Age x Period" was highly significant, as the variation of body condition score differed between yearling and adult hinds.

Figure 3.16 : Mean yearling and adult hind body condition score (±SD) between farms in 1992 and 1993.



Consequently, data from both years were kept separate for presentation. The ranges and quartiles of farm mean yearling and adult hind body condition scores recorded pre-mating, post-winter and at weaning are presented in Figure 3.17.

Figure 3.17 : Range and quartiles of farm mean yearling and adult hind body condition score recorded pre-mating, post-winter and at weaning in 1992 and 1993.



Further three-way ANOVA with year, farm and period as main effects carried out within each class of age showed there was a significant period effect only in yearling hinds, and confirmed there was no significant main year effects. The mean body condition score of yearling hinds significantly decreased from mating to weaning. The "Year x Period" interaction term however, was significant in the analysis of adult hinds mean score, as period variation occurred in 1993 as shown in Figure 3.17.

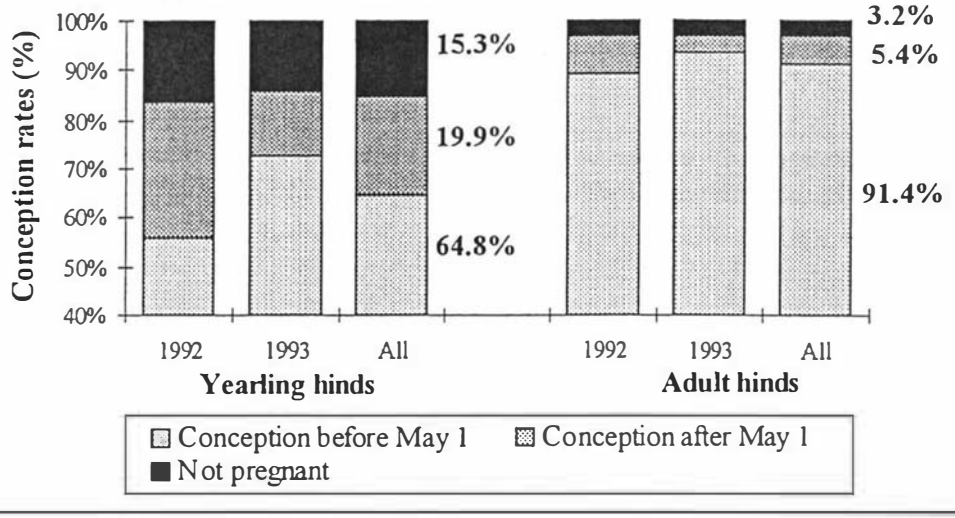
3.3.1.3 Reproductive performance

The reproductive performance of yearling and adult hinds from mating to weaning on each farm over two years is presented in Appendix 3.38 and Appendix 3.39.

3.3.1.3.1 Hind conception

The percentages of yearling and adult hinds conceiving before May 1, conceiving after May 1 and not pregnant over all farms in 1992 and 1993 and both years combined are presented in Figure 3.18. The same performance parameters calculated beetween farms in 1992 and 1993 are presented in Figure 3.19. Summary statistics of farm-level reproductive performance of yearling and adult hinds in 1992, 1993 and both years combined are presented in Table 3.19.

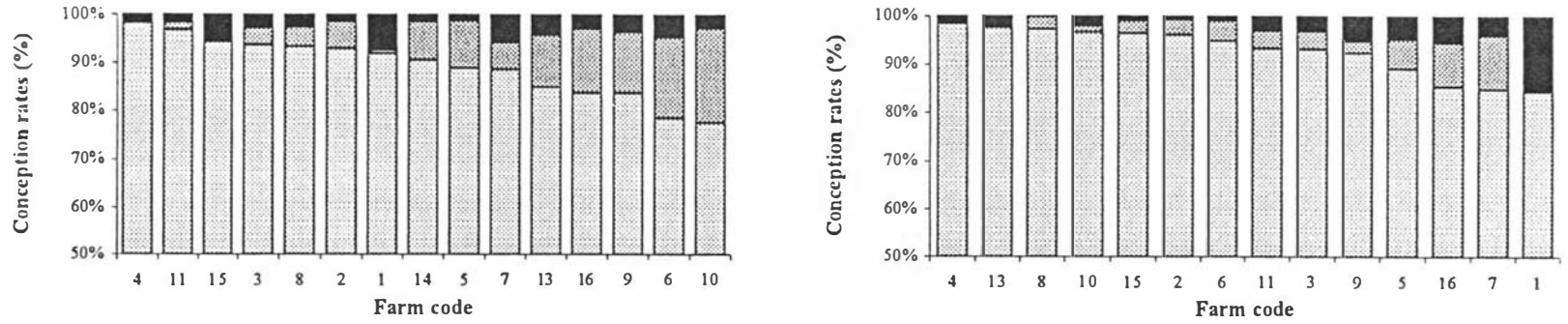
Figure 3.18 : Percentage of yearling and adult hinds conceiving before May 1, conceiving after May 1 and not pregnant over all farms in 1992, 1993 and both years combined.



Conception results presented in Figure 3.19 show there were wide variations between farms in 1992 and 1993 in both age groups. The percentage of yearling and adult hinds conceiving before May 1 on each farm ranged from 8.3 to 95.0% and from 77.6 to 98.4%, respectively. While the overall conception rates between the two years of study did not differ significantly, in both age groups there was a highly statistically significant (using Chi square test) increase of the proportion of hinds conceiving before May 1 from 1992 to 1993. Overall, the proportion of yearling and adult hinds not conceiving was 15.3% and 3.2%, respectively.

Figure 3.19 : Percentages of yearling and adult hinds conceiving before May 1, conceiving after May 1 and not pregnant on each survey farm in 1992 and 1993.

1. Adult hinds **YEAR 1992** **YEAR 1993**



2. Yearling hinds

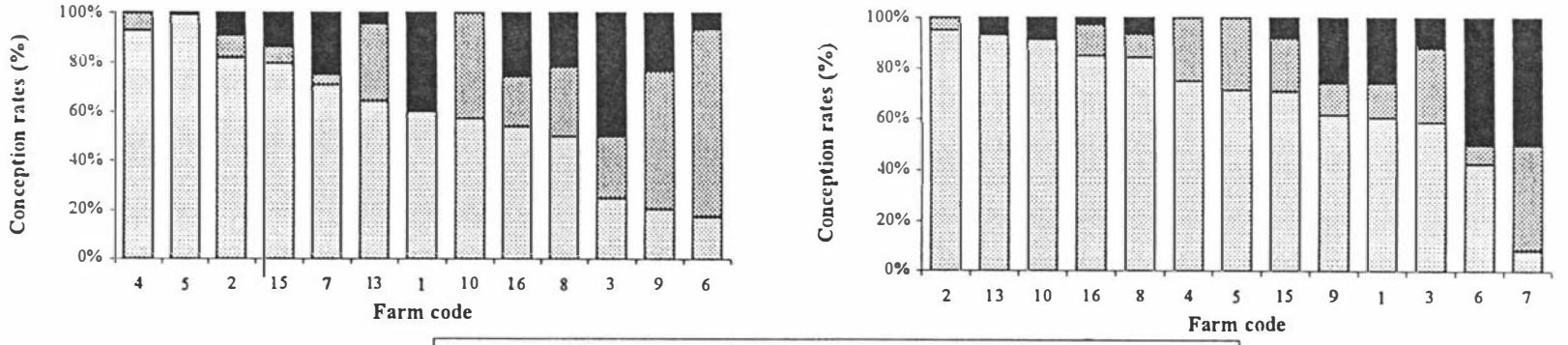


Table 3.19 : Summary statistics of farm-level reproductive performance of yearling and adult hinds in 1992, 1993 and both years combined.

			Yearling hinds							Adult hinds						
Year		Unit	Number of farm-year*	Min	25th percentile	Mean	75th percentile	Max	SD	Number of farm-year	Min	25th percentile	Mean	75th percentile	Max	SD
1992	Number of hind mated		12	12	19	33	47	48	14	15	40	87	137	166	226	54
	Early conception rate (before May 1)	%	12	17.4	51.9	61.5	80.7	92.9	24.2	15	77.6	83.8	89.2	93.8	98.3	6.3
	Conception rate	%	12	60.0	75.7	85.0	94.5	100.0	12.3	15	92.7	95.4	96.7	98.4	98.8	1.8
	Number of hind calving		12	11	18	26	35	42	11	15	33	76	122	156	205	48
	Weaning rate	%	12	64.3	76.9	83.2	87.1	100.0	9.9	15	84.1	87.7	91.8	95.4	98.3	4.3
	Reproductive efficiency	%	12	43.5	58.1	66.4	73.2	87.5	13.0	15	68.8	77.5	81.3	85.6	93.5	6.4
1993	Number of hind mated		13	7	12	31	38	76	19	14	53	66	121	146	194	44
	Early conception rate (before May 1)	%	13	8.3	58.8	69.1	84.7	95.0	24.0	14	84.6	85.6	92.9	96.6	98.4	4.9
	Conception rate	%	13	50.0	74.4	85.0	95.6	100.0	17.7	14	84.6	94.9	96.6	98.8	100.0	3.9
	Number of hind calving		13	4	12	28	32	92	22	14	51	60	119	136	188	44
	Weaning rate	%	13	73.3	77.1	84.7	89.2	92.3	6.3	14	81.4	86.3	91.7	96.3	99.3	5.4
	Reproductive efficiency	%	13	25.0	57.4	70.6	83.7	91.7	19.8	14	72.7	81.6	86.0	90.0	93.3	5.8
Both years	Number of hind mated		25	7	16	32	43	76	16	29	40	82	129	155	226	49
	Early conception rate (before May 1)	%	25	8.3	53.8	65.5	83.1	95.0	23.9	29	77.6	84.9	91.0	95.5	98.4	5.9
	Conception rate	%	25	50.0	74.5	85.0	94.7	100.0	15.0	29	84.6	95.4	96.7	98.4	100.0	2.9
	Number of hind calving		25	4	13	27	32	92	17	29	33	76	121	145	205	45
	Weaning rate	%	25	64.3	76.9	84.0	87.8	100.0	8.1	29	81.4	87.7	91.8	95.7	99.3	4.8
	Reproductive efficiency	%	25	25.0	57.4	68.6	81.2	91.7	16.6	29	68.8	78.0	83.6	87.3	93.5	6.5

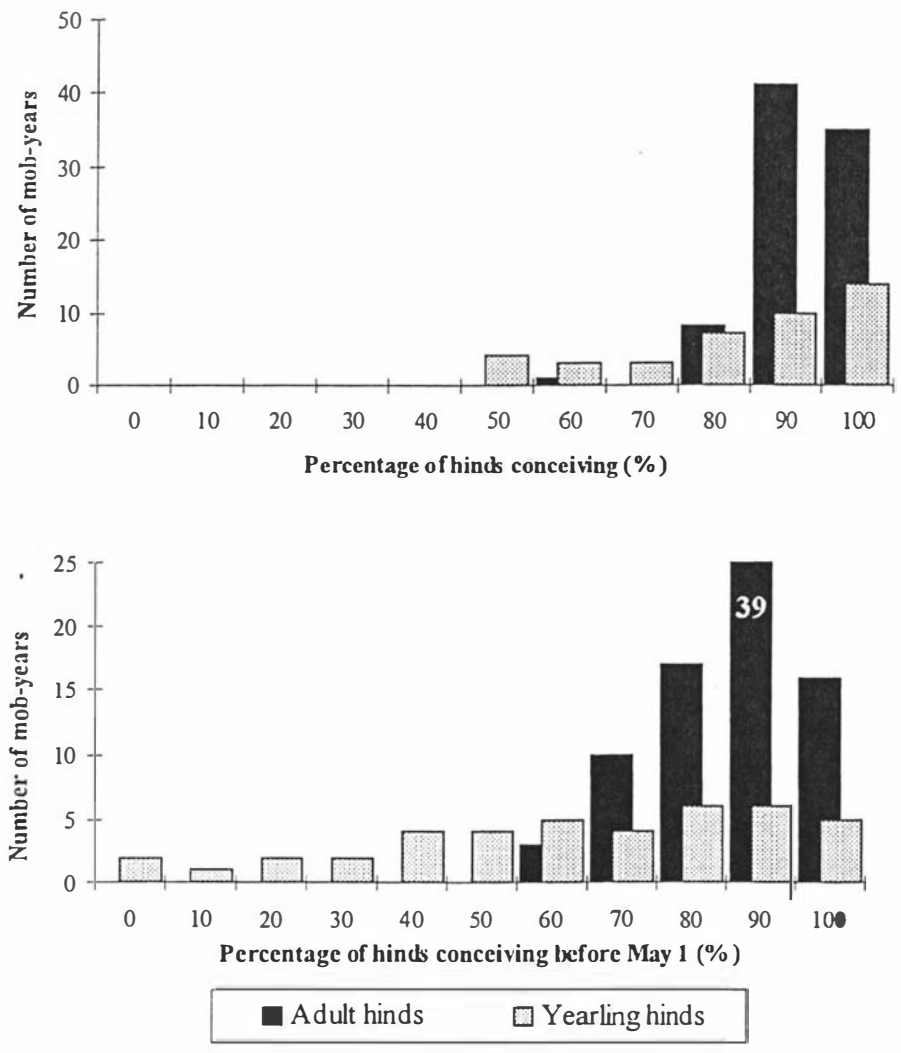
Min = minimum, Max = maximum, SD = standard deviation

* Farm-year with less than 5 yearling hinds at mating were not included (see Appendix 3.38)

Note : descriptive statistics of yearling and adult hind reproductive performance on each farm are presented in Appendix 3.38 and Appendix 3.39, respectively.

The distribution histograms of percentages of conception, and of early conception within mating mobs are presented in Figure 3.20. In this study 85 and 41 mating mobs with adult and yearling hinds, respectively, were scanned for conception status. Conception rates of adult hinds within mating mobs were generally over 90%, while 41.7% of mating mobs had 100% conception rate. One mating mob of adult hinds had only a 62% conception rate, due to the failure of a newly introduced sire stag combined with a short mating period and the lack of back-up sire. In contrast, the conception rates of yearling hind mobs were more variable (5 mobs were below 50%), although 34.1% of mating mobs reached the 100% conception mark. There was an even greater variability of early conception rates of yearling hinds within mating mobs as they ranged from 0 to 100%. Early conception rates of adult hinds within mating mobs, however, were all above 50% and 64.7% of mating mobs were above 90%.

Figure 3.20 : Distribution histogram of yearling and adult hind conception rates and early conception (before May 1) rates within mating mobs. Data from 1992 and 1993 combined.



3.3.1.3.2 Calving dates

As discussed in section 3.2.2.3, calving dates were recorded on four farms in 1992 and one farm in 1993. The range, median, mean and standard deviation of calving dates within each of these farms, and overall, in yearling and adult hinds are presented in Table 3.20.

Table 3.20 : Mean, standard deviation (SD), median, range of calving dates of yearling and adult hinds on farm recording birth dates in 1992 and 1993.

Year	Farm code	Number of hinds	Start	End	Median	Mean	SD
Yearling hinds							
1992	1	3	21-Nov	28-Nov	26-Nov	25-Nov	2.9
	4	11	27-Nov	3-Jan	14-Dec	14-Dec	9.6
	9	10	13-Dec	24-Dec	15-Dec	16-Dec	3.5
	16	19	28-Nov	25-Jan	8-Dec	13-Dec	13.2
1993	4	10	30-Nov	28-Dec	10-Dec	10-Dec	8.9
	All farms	53	21-Nov	25-Jan	13-Dec	12-Dec	11.1
Adult hinds							
1992	1	74	4-Nov	22-Jan	29-Nov	30-Nov	10.2
	4	57	19-Nov	23-Dec	2-Dec	1-Dec	6.6
	9	10	22-Nov	13-Dec	6-Dec	5-Dec	5.9
	16	102	18-Nov	31-Dec	30-Nov	3-Dec	10.0
1993	4	58	16-Nov	21-Dec	26-Nov	27-Nov	7.0
	All farms	301	4-Nov	22-Jan	30-Nov	1-Dec	9.2

The distribution of calving dates between class of hind, calf sex and farms (within year) was assessed by a three-way ANOVA using SAS. Whereas yearling hinds calved significantly later than did adult hinds, there was no statistically significant calving date difference between stag and hind calves. The distribution histograms of calving dates (or birth dates) between stag and hind calves and between yearling and adult hinds are presented in Figure 3.21 and Figure 3.22, respectively.

The possibility that calf sex may be a confounding factor for the age class difference observed here was further rejected by the analysis of farmers' records of dam-offspring pairs (213 yearling hinds and 968 adult hinds). There was no statistically significant difference of calf sex distribution between yearling and adult hinds using the Chi-square test ($p=0.34$).

3.3.1.3.3 Weaning rates and reproductive efficiency

The weaning rate is defined for this thesis as the percentage of hinds diagnosed pregnant in June, for which there was no evidence of progeny loss at calving (ie which were considered to have carried a calf to full term), that reared a calf up to weaning.

Reproductive efficiency is defined as the percentage of hinds mated that reared a calf up to weaning. Hinds mated and culled on the basis of pregnancy results were included in the calculation of

Figure 3.21 : Birth date distributions of hind and stag calves in 1992 and 1993. Data from 4 survey farms combined.

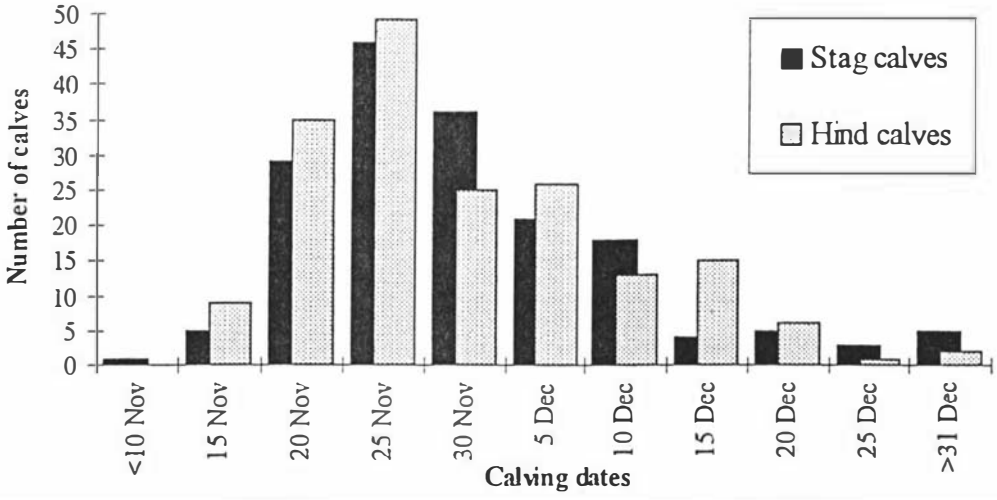
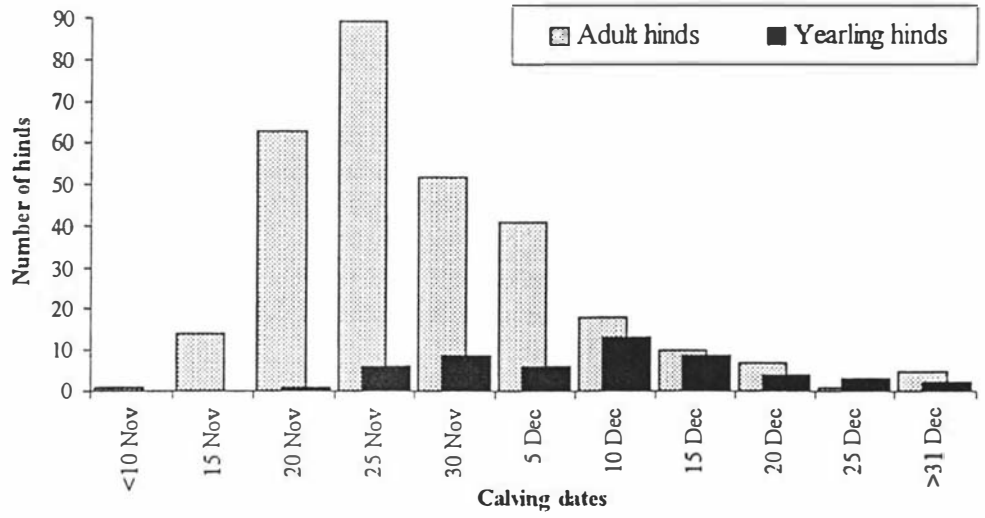


Figure 3.22 : Calving date distributions of yearling (mated at 15 months) and adult hinds in 1992 and 1993. Data from 4 survey farms combined.



reproductive efficiency, while hinds mated but for which the culling decision (or departure from the farm) was made prior to the rut were not included.

Detailed results of weaning rate and reproductive efficiency of breeding herds within each survey farm are presented in Appendix 3.38 and Appendix 3.39. Over two years, weaning rates of yearling and adult hinds ranged between farms from 64.3 to 100.0%, and from 81.4 to 99.3%, respectively, while the reproductive efficiencies ranged from 72.0 to 93.5% and from 42.3 to 91.7% in yearling and adult hinds, respectively. The distribution histogram of yearling and adult hind weaning rates and reproductive efficiencies within study farms are presented in Figure 3.23.

Summary statistics of farm-level weaning rate and reproductive efficiency of yearling and adult hinds in 1992, 1993 and both years combined are presented in Table 3.19. Overall weaning rate and reproductive efficiency of yearling and adult hinds are presented in Table 3.21. Whereas weaning rates of yearling and adult hinds, and the reproductive efficiency of yearling hinds did not significantly differ between years, there was a statistically significant ($p<0.05$) increase of reproductive efficiency of adult hinds between 1992 and 1993.

Table 3.21 : Overall weaning rate and reproductive efficiency of yearling and adult hinds in 1992, 1993 and both years combined.

	1992	1993	Both years combined
	Weaning rate (%)		
Yearling hinds	81.6	86.1	84.1
Adult hinds	91.5	91.7	91.6
	Reproductive efficiency (%)		
Yearling hinds	62.6	77.4	70.0
Adult hinds	81.1	88.9	83.6

Weaning rate and reproductive efficiency are defined in the text

The stag:hind ratio at weaning was 0.97 in 1993, 1.02 in 1994, and 1.00 (1587/1592) both years combined.

3.3.1.4 Weaning weights and productivity of breeding hinds.

The mean weaner stag and hind bodyweights (± standard deviation) on April 1 (at 3-4 months of age) on each farm in 1993 and 1994 (from hinds mated in 1992 and 1993, respectively) are presented in detail in Appendix 3.40 and summarised in Figure 3.24. From 4 farms that recorded dam-offspring pairs, mean bodyweights on April 1 within farms of weaners born from adult hinds were significantly higher than those of weaners born from yearling hinds ($p<0.01$)(see Table 3.22). Summary statistics of farm-level weaner production parameters in 1992, 1993 and both years combined are presented in Table 3.23.

Mean weaner stag bodyweights on April 1 within farms were significantly higher than those of weaner hinds ($p<0.01$). Whereas there was no significant difference between year in weaner hinds, there was a significant increase of mean weaner stag bodyweights from 1993 to 1994 ($p<0.05$).

The productivity of the breeding herd as the number of kilograms of weaner bodyweight on April 1 per hind mated and per hind at calving is summarised in Table 3.23. There was no significant difference in hind productivity between the two years of study.

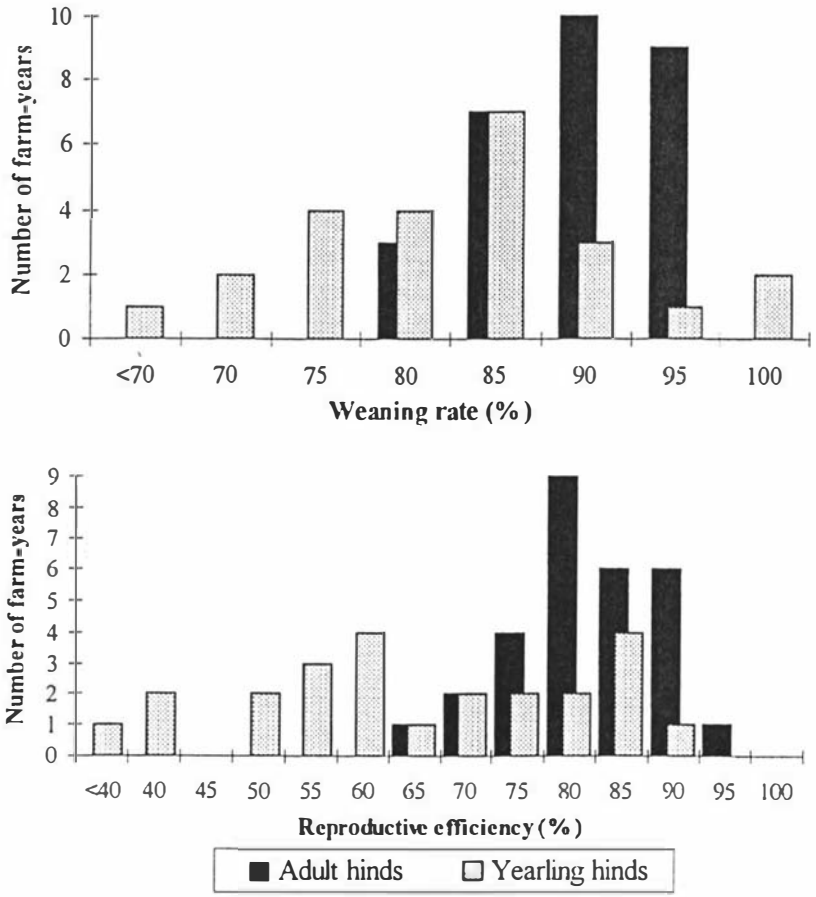
All hinds, farms and years combined, individual mean weaner bodyweight on April 1 produced per hind mated and per hind at calving, respectively, were 38.5 and 42.7 kg (stags and hinds combined).

Table 3.22 : Mean, range, quartiles and standard deviation of individual bodyweights standardised to April 1 of weaner stags and hinds born from yearling and adult hinds, respectively. Data from 1992 and 1993 combined.

Year	Sex	Number of weaners	Min	25th percentile	Mean	75th percentile	Max	SD
Yearling hinds	Stags	73	33.4	42.7	47.1	52.4	63.5	6.1
	Hinds	72	29.6	39.2	42.6	45.8	58.1	5.1
Adult hinds	Stags	304	28.8	49.1	53.3	57.7	69.4	6.7
	Hinds	364	19.9	45.0	48.4	52.3	62.8	6.0

Min = minimum, Max = maximum, SD = standard deviation.
Note : data is from 4 farms on which dam-offspring pairs were recorded. Data from all farms, yearling and adult hinds combined is presented in Appendix 3.45.

Figure 3.23 : Distribution histograms of yearling and adult hind weaning rates and reproductive efficiency within study farms. Data from 1992 and 1993 combined.



Note = weaning rate and reproductive efficiency are defined in the text.

Table 3.23 : Summary statistics of farm-level weaner (3- to 4-month-old deer) production parameters in 1992 (weaning 1993), 1993 (weaning 1994) and both years combined.

Mean weaner bodyweight on April 1

Class of hind	Year	Number of farm-years	Weaner stags Min	25th percentile	Mean	75th percentile	Max	SD	Weaner hinds Min	25th percentile	Mean	75th percentile	Max	SD
Yearling hinds*		6	44.7	45.7	47.8	49.6	55.0	3.3	40.2	40.4	42.7	44.7	45.3	2.1
Adult hinds*		8	50.0	50.9	53.5	55.3	58.6	2.7	44.6	45.3	48.4	50.9	53.6	3.0
All hinds combined														
	Year 1992 (crop April 1993)	14	43.2	45.7	48.9	51.8	55.5	3.8	39.3	40.3	45.3	47.6	50.5	3.6
	Year 1993 (crop April 1994)	14	42.0	49.2	52.2	53.5	59.0	4.4	39.7	44.4	47.3	48.8	51.3	3.2
	Both years combined	28	42.0	47.2	50.6	53.2	59.0	4.4	39.3	44.0	46.3	48.8	51.3	3.5

Mean weaner weight on April 1 per hind

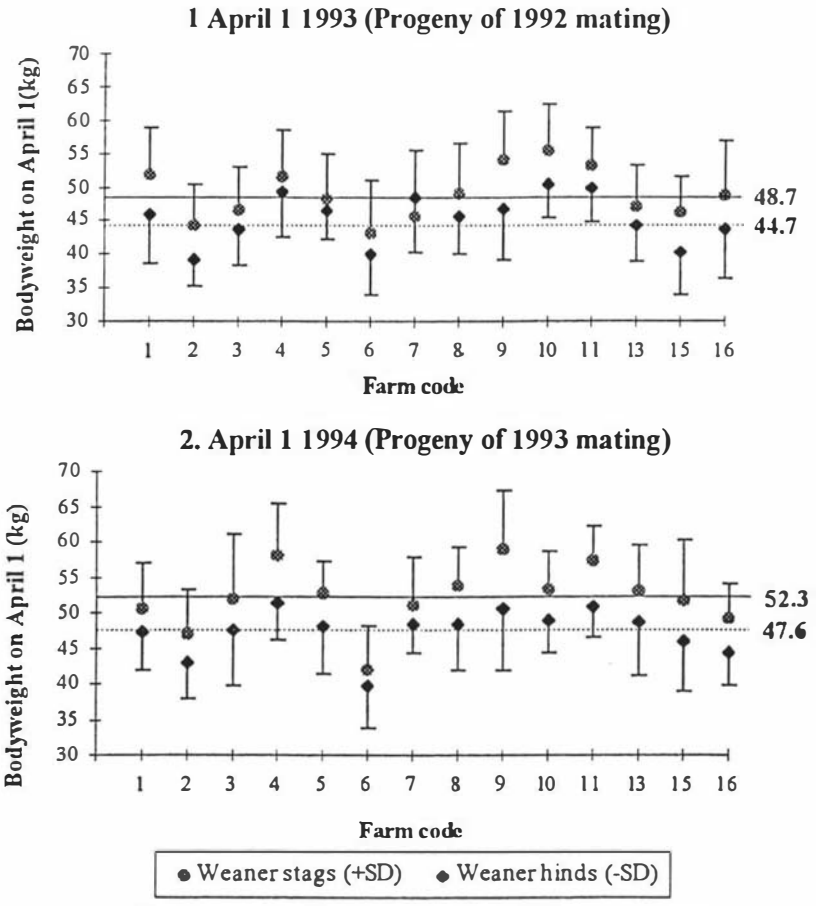
	Number of farm-years	per hind mated Min	25th percentile	Mean	75th percentile	Max	SD	per hind at calving Min	25th percentile	Mean	75th percentile	Max	SD
All hinds combined													
Year 1992 (crop April 1993)	14	29.7	31.3	36.7	38.9	44.9	4.7	35.0	37.9	42.2	46.4	48.7	4.5
Year 1993 (crop April 1994)	14	31.7	35.9	40.6	45.3	49.6	5.6	35.3	38.2	44.3	48.5	52.5	5.7
Both years combined	28	29.7	36.0	38.7	43.4	49.6	5.4	35.0	38.6	43.2	47.5	52.5	5.1

Min = minimum, Max = maximum, SD = standard deviation.

* data from 4 farms that recorded dam-offspring pairs.

Note : descriptive statistics of individual weaner bodyweights per farm are presented in Appendix 3.40.

Figure 3.24 : Mean and standard deviation of bodyweight (kg) of weaner hinds and stags calculated on each survey farm on April 1 1993 and 1994.



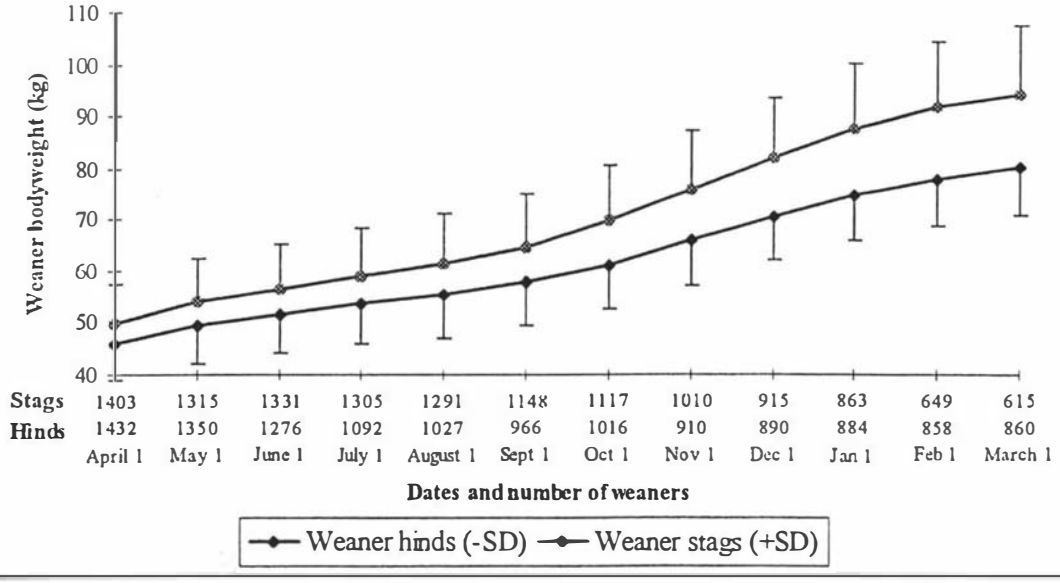
Note : Solid and broken lines are overall mean weaner stag and hind bodyweights, respectively

3.3.2 Weaner growth rates and bodyweights

The minimum, maximum, mean and standard deviation of weaner stag and hind bodyweights calculated at the first day of each month on each survey farm are presented from Appendix 3.41 to Appendix 3.44, and detailed descriptive statistics of all farms combined are presented in Appendix 3.45. The mean bodyweight and standard deviation of weaner stags and hinds from all farms and both years combined are presented in Figure 3.25.

From a mean bodyweight of 50.0 kg on April 1, weaner stags reached 81.9 kg by December 1. The proportion of all weaner stags (those born on each farm or purchased for fattening in autumn) that were known to be over 92 kg by December 1 ranged from 0 to 41% and from 0 to 48% between farms in 1992 and 1993, respectively (Figure 3.25). Overall 8.7 and 14.1% of weaner stags reached 92 kg by December 1 in 1992 and 1993, respectively.

Figure 3.25 : Mean and standard deviation of bodyweights of weaner hinds and stags. All survey farms and both years 1992 and 1993 combined.



Weaner hinds during the same period, grew from 45.8 to 70.3 kg, and were on average 80 kg by 15 months of age. Prior to the rut 5.9% of known 15-month-old hind bodyweights were below 65 kg.

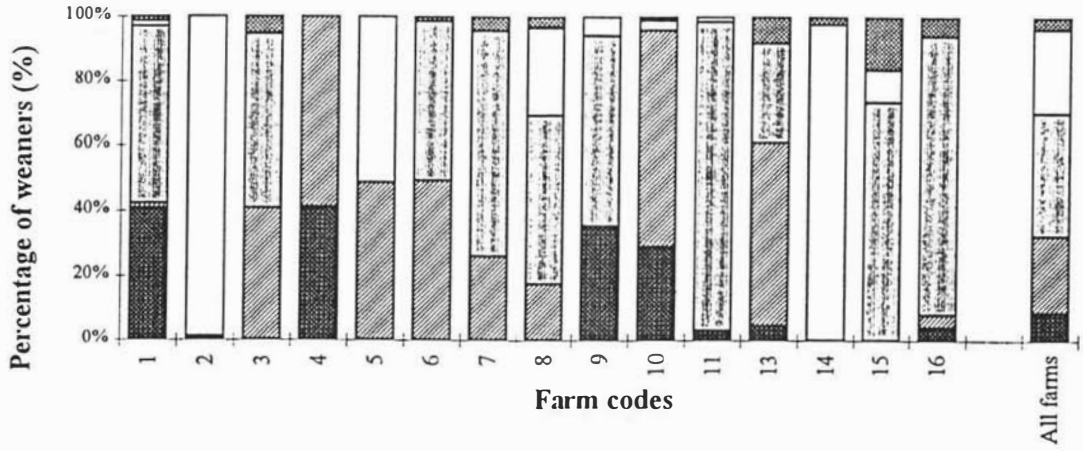
The means, range and standard deviation of seasonal growth rates of weaner stags and hinds on each farm are presented in Appendix 3.46 and Appendix 3.47. Overall mean seasonal growth rates of weaner stags and hinds (see Appendix 3.48 and Figure 3.27) decreased from 95.4 and 114.6 g/d, respectively, during autumn to 52.4 and 90.6 g/d during winter. Spring and summer growth were both about 150 and 200 g/d in weaner hinds and stags, respectively.

The minimum, maximum and median of mean bodyweights of weaner stags and hinds within farms are presented on Figure 3.28. From April 1 (4 months of age) to March 1 the following year (15 months of age), the range of mean weaner stag and hind weights between farms increased from 12.5 and 16 kg, respectively to more than 30 kg (37.3 and 31.2 kg , respectively).

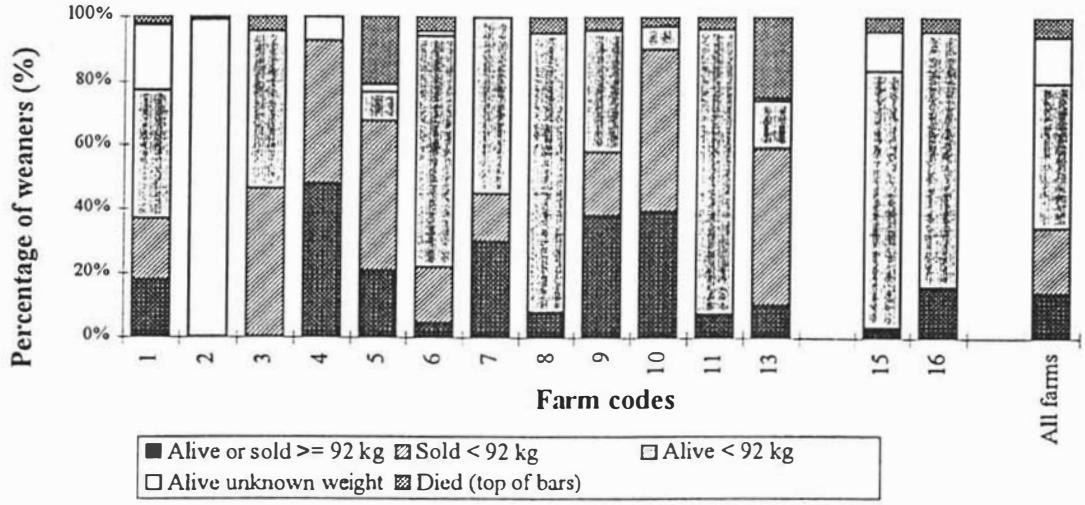
Summary statistics of farm mean weaner (deer 3-15 months old) seasonal growth rates and mean weaner bodyweights, separately in stags and hinds and both years 1992 and 1993 combined, are presented in Table 3.24. The same statistics for the percentage of weaner stags reaching 92 kg by December 1 on each farm are also presented in this table. It is proposed the 75th percentiles of these farm performance parameters could be used as deer industry targets for production of deer less than 15 months of age.

Figure 3.26 : Proportion of weaner stags that reached 92 kg bodyweight by December 1 (%), that did not reach 92 kg by December 1 (sold or not), and that died before December 1 on each survey farm in 1992 and 1993.

a. Year 1992



b. Year 1993



Note : The bodyweight on December 1 of weaners sold in November was estimated from their last bodyweight record (in October or in November) and their Spring growth rate.

· Sold<92kg includes weaner sold alive, slaughtered or taken away by their owner.

· Died includes weaners that died, escaped or were missing, or were killed by the farmer because of injuries or diseases.

Figure 3.27 : Mean and standard deviation of seasonal growth rates of weaner hinds and stags. Data from 1992 and 1993 combined.

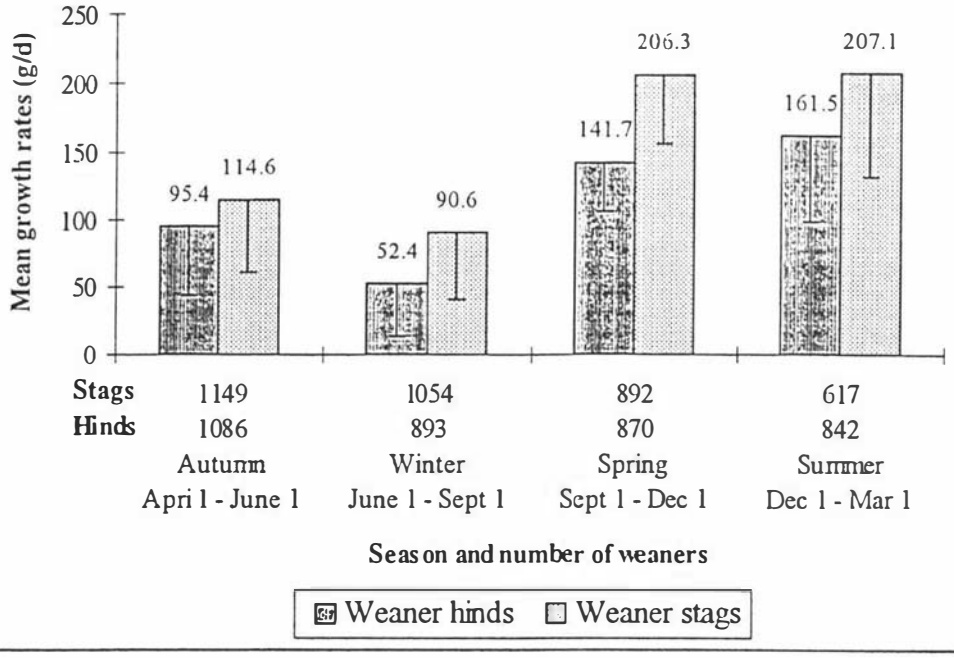


Figure 3.28 : Median (line) and range (dots) of farm mean bodyweights of weaner hinds and stags. Data from 1992 and 1993 combined.

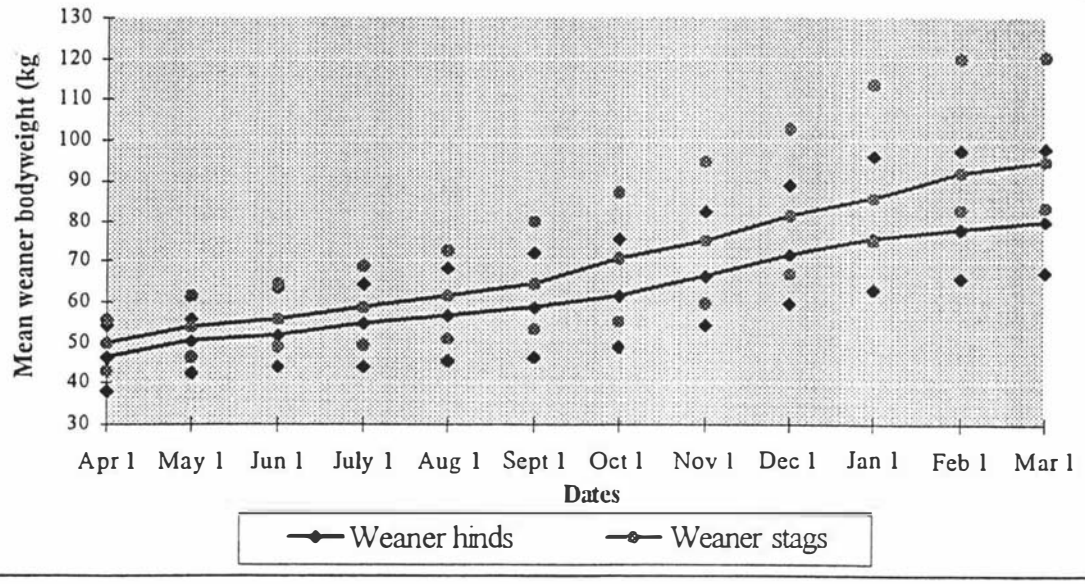


Table 3.24 : Summary statistics of farm mean weaner (deer 3-15 months old) seasonal growth rates and bodyweights both years 1992 and 1993 combined.

		Weaner stags							Weaner hinds						
Date	Code*	Number of farm-years	Min	25th percentile	Mean	Median	75th percentile	Max	SD	Number of farm-years	Min	25th percentile	Mean	Median	75th percentile	Max	SD
April 1	n	25	12	33	56	54	68	119	26	25	8	33	57	54	76	136	29
	MW4	25	43.0	46.5	49.6	49.8	52.0	55.5	3.5	25	38.3	43.8	46.1	46.4	48.3	54.4	3.9
	n	24	12	30	48	39	59	119	26	24	8	31	45	40	56	136	27
	MGR46	24	53.9	90.0	118.0	120.0	145.6	203.5	40.5	24	33.9	69.0	100.2	99.6	132.0	170.4	38.6
June 1	n	26	23	32	51	42	64	119	24	27	8	32	47	41	59	136	26
	MW6	26	49.1	51.4	56.5	55.9	61.4	64.4	5.0	27	44.0	47.2	52.0	51.8	55.6	63.4	5.2
	n	24	16	31	44	36	56	98	20	25	5	25	36	35	49	63	18
	MGR69	24	7.5	74.8	95.9	94.2	125.8	185.2	42.8	25	4.7	34.9	54.9	54.8	66.6	137.1	32.2
September 1	n	26	19	30	44	39	53	98	19	26	5	26	37	35	50	74	19
	MW9	26	53.2	56.8	65.2	64.4	70.6	79.5	8.1	26	46.4	51.7	58.0	58.5	62.7	71.8	6.9
	n	21	22	31	42	38	47	96	16	25	5	24	35	35	47	61	17
	MGR912	21	120.4	182.3	205.6	203.2	224.9	292.0	40.3	25	86.1	122.8	141.0	142.3	159.2	191.9	27.5
December 1	n	21	22	32	44	38	50	97	17	25	5	25	36	35	48	68	18
	MW12	21	66.7	76.1	82.3	81.2	86.5	102.9	8.9	25	59.4	65.0	71.0	71.4	75.3	88.9	7.7
	WS92	29	0	0	15.4	7.5	29.5	48.0	16.4								
	n	18	4	24	35	32	47	66	16	24	5	27	35	37	50	63	18
	MGR123	18	111.7	167.3	211.1	209.6	255.8	305.3	54.6	24	53.5	99.8	154.2	157.5	196.5	262.5	57.8
March 1	n	17	4	25	37	32	47	68	17	24	5	28	36	37	50	64	19
	MW3	17	83.2	85.2	95.4	94.6	100.3	120.4	9.8	24	67.1	75.9	80.7	79.9	87.9	98.3	8.1

n = number of weaners in the mob; Min = minimum, Max = maximum, SD = standard deviation.

* Codes are described in Table 2.37.

Note : descriptive statistics of individual weaner bodyweights per farm are presented in Appendices 3.41 to 3.44 (mean bodyweights) and in Appendices 3.46 and 3.47 (mean growth rates).

3.3.3 Performance of velvetting stags

3.3.3.1 Stag bodyweights

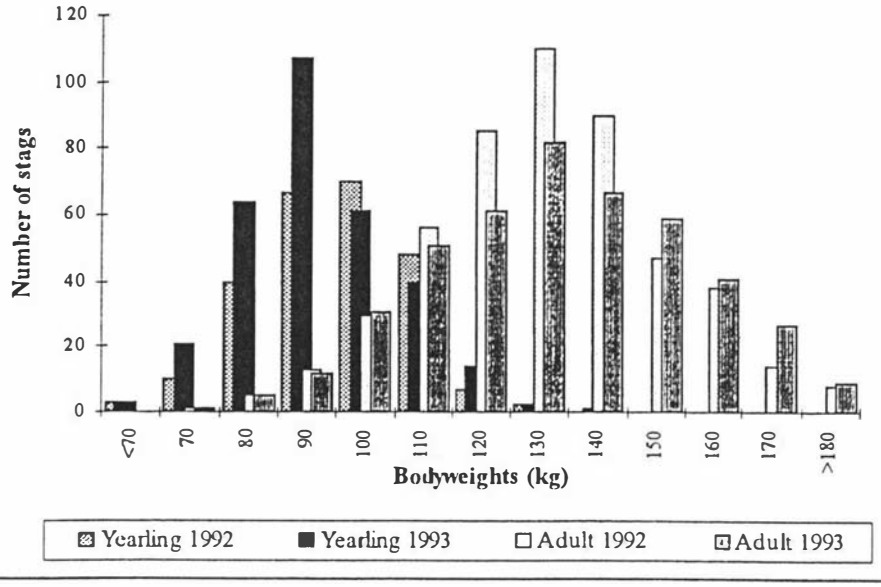
Post-rut bodyweights of yearling and adult stags are presented in Figure 3.30. Detailed descriptive statistics of three-monthly bodyweights of yearling and adult stags between farms in 1992 and 1993 are presented in Appendix 3.49 and Appendix 3.50.

Bodyweight changes of yearling and adult stags on each farm between June and September or between June and the time of velvet antler removal are presented in Appendix 3.50.

Bodyweights of yearling and adult stags were recorded from only a limited number of farms, as weighing was not easy to carry out in June when stags were still in the rut. Six farmers weighed as scheduled, although some data were occasionally missing. Other farmers recorded weights of yearling stags only, as they were generaly easier to handle than adult stags, or those of all stags at the time of velvet antler removal, when they are quiet and safe to handle.

Adult stags lost on average 106 g/d between June and September, although individual bodyweight changes ranged from -432 to +305 g/d. Stags losing this amount of bodyweight were possibly diseased (a clinical condition called fading in this thesis) but were not identified and recorded as such by farmers, and therefore were included in these statistics. This bodyweight loss was consistent between the two years. In contrast, yearling stags over the two years lost on average only 11 g/d during the same period, with individual data ranging from -222 to +236 g/d.

Figure 3.29 : Bodyweight distribution of yearling (18 months) and adult stags in June 1992 and 1993.



Between June and the time of velvet antler removal, an average gain of 115 and 76 g/d was observed for yearling and adult stags, respectively. Yet, some yearling and adult stags were still recorded with bodyweight losses up to 160 and 300 g/d, respectively. In contrast, some adult stags gained up to 50% of their pre-winter bodyweight.

3.3.3.2 Velvet antler production

3.3.3.2.1 Spike removal of weaner stags (one year old)

The monthly distribution of spike removal on survey farms is presented on Figure 3.30.

The recording of spike removal was not exhaustive and the state of growth of the spike at the time of cutting may not have been similar between weaner stags. However, when recording was carried out by the farmer, it is believed most spikes were removed at a velvet stage. On farms where spikes were removed at a variable calcified stage, there was usually no recording done. Antler spike weights were not recorded.

There was a highly significant correlation coefficient between the date of spike removal and weaner stag bodyweights in June 1 ($r = 0.56$) which explained 32% of the variation of removal date.

The regression line predicting the date of velvet spike removal (SPIKE) from the weaner stag bodyweight standardised to June 1 (W6) is presented in Figure 3.31.

Figure 3.30 : Distribution histogram of the time of spike removal in weaner stags (< 15 months).

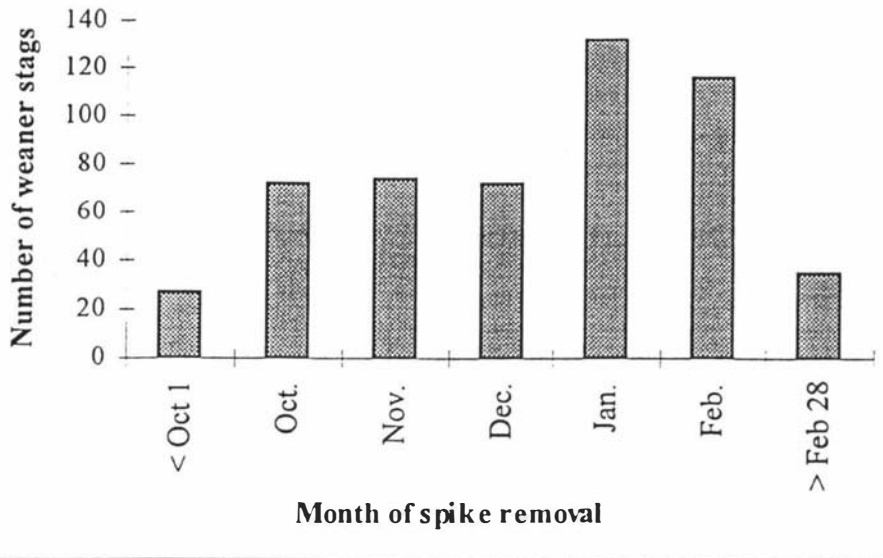
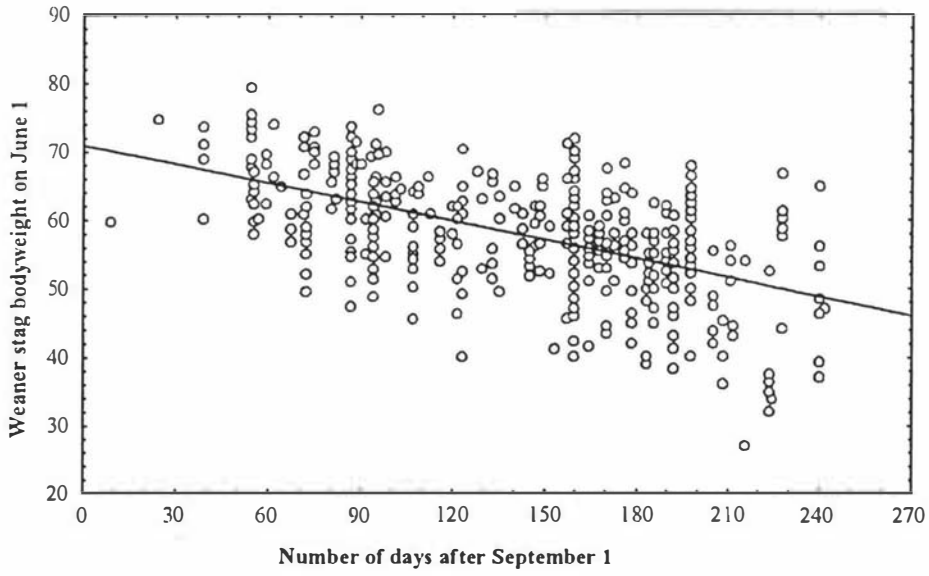


Figure 3.31 : Regression line predicting spike removal dates of weaner stags (< 15 months) from their bodyweights standardised to June 1.



The regression line is :

SPIKE (number of days after September 1) = 344.37 - 3.48 W6 ($p < 0.001$).

W6 = weaner stag bodyweight standardised to June 1

3.3.3.2.2 Velvet antler grades and weights

The velvet antler production (grades and average weights) of yearling (rising 2-year-old) and adult stags in 1992 and 1993 is presented in Figure 3.33 and Figure 3.32. The means (±SD) and range of velvet antler weight per stag age is presented in Figure 3.34. The grade distributions and average velvet weights per grade on each survey farm are presented in Appendix 3.52 and Appendix 3.53.

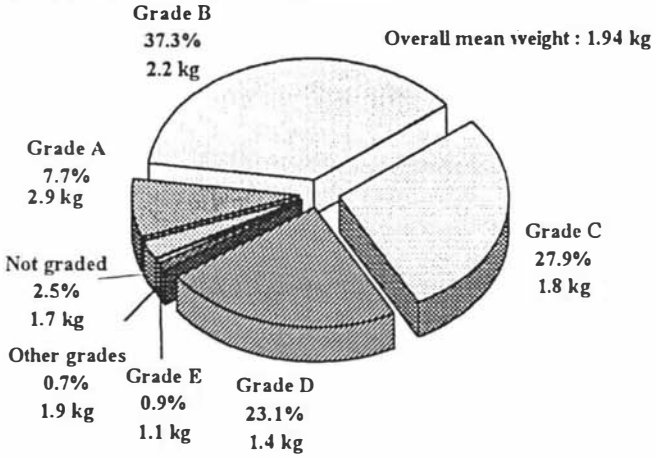
There were wide ranges of velvet weights within farms in yearling and adult stags, and velvet weight of yearling and adult stags significantly differ (ANOVA, $p<0.01$) between farms in 1992 and 1993. Velvet weights significantly increased with age (ANOVA, $P<0.01$). The regression line predicting the velvet antler weight (WEIGHT) of adult stags from their age at the time of velvet antler removal (AGEV) is :

WEIGHT (kg) = 0.755 + 0.281 AGEV (year) ($r=0.63$, $p<0.01$)

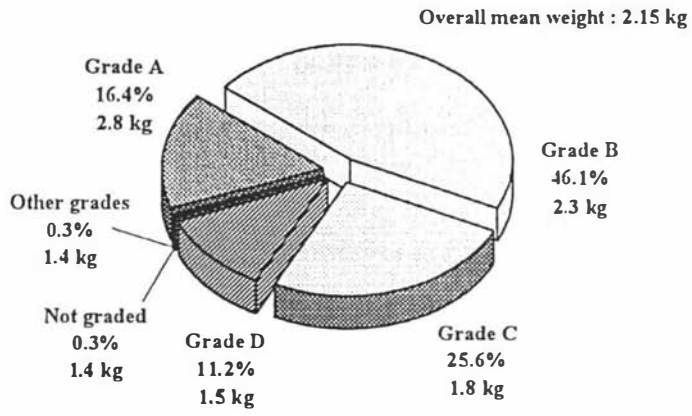
This formula is used for the calculation of mean corrected velvet antler weights (MCVW) and thus remove the effect of age to compare performance between farms (see Table 2.37 and in Appendix 3.52 and Appendix 3.53). Summary statistics of MCVW in 1992, 1993 and both years combined are presented in Table 3.25. Further analyses of the relationship between stag age and velvet weight are presented in section 4.5.

Figure 3.32 : Velvet antler production from yearling (rising 2-year-old) and adult stags in 1992 and 1993.
Percentage of each grade (%) and average velvet weight per stag within each grade (kg), and overall mean velvet weight.

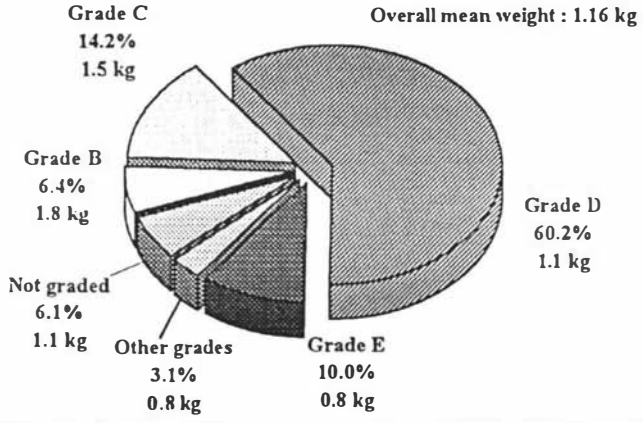
1. Yearling (2-year-old) stags YEAR 1992



YEAR 1993



2. Adult stags



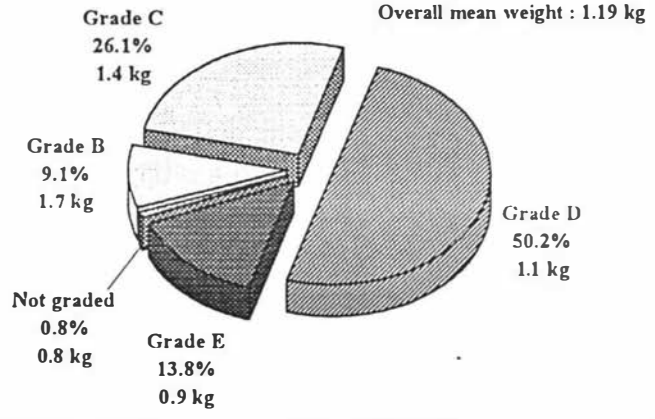
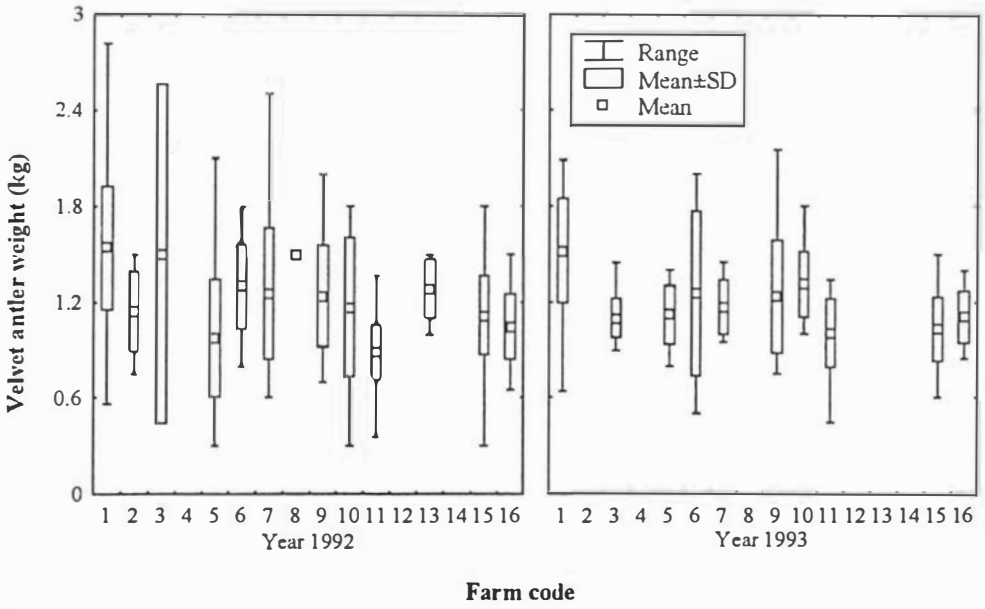


Figure 3.33 : Means (±SD) and ranges of velvet antler weight of yearling (rising 2-year-old) and adult (>2 years old) stags within each farm in 1992 and 1993.

a. Yearling stags



b. Adult stags

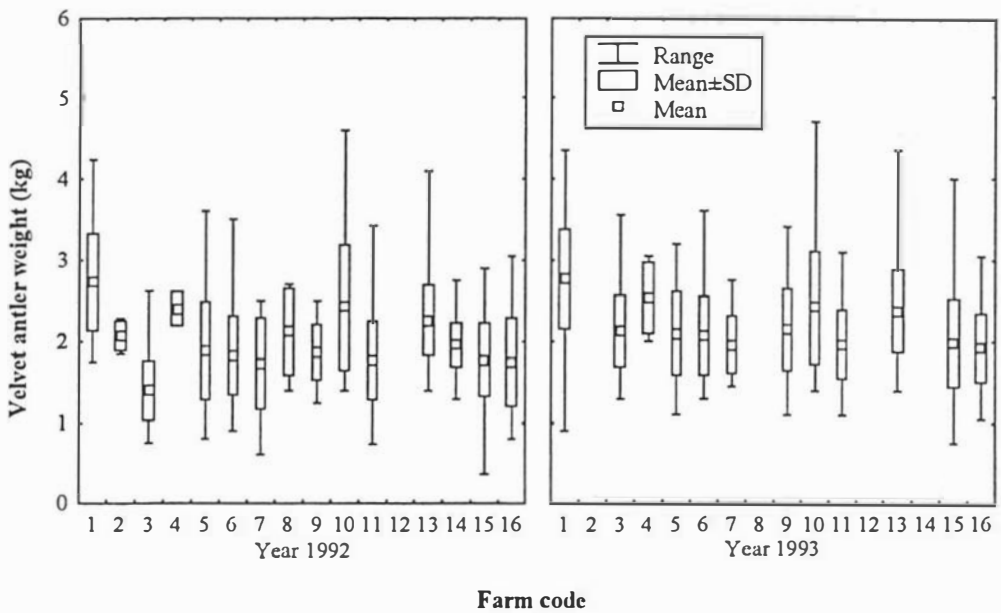
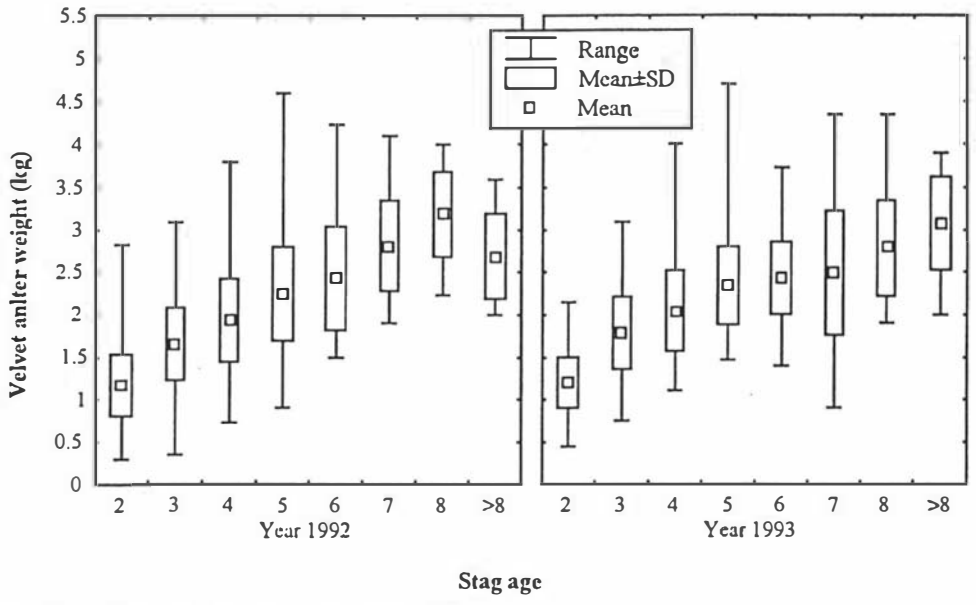


Table 3.25 : Summary statistics of farm mean velvet weight of 2-year-old stags (MWEIGHT), and mean corrected velvet antler weight (MCVW) of adult stags in 1992, 1993 and both years combined.

Year	Number of farm-years	Min	25th percentile	Mean	75th percentile	Max	SD
2-year-old stags (MWEIGHT)							
1992	11	0.89	1.05	1.18	1.29	1.54	0.18
1993	10	1.01	1.04	1.18	1.24	1.52	0.15
Both years	21	0.89	1.05	1.18	1.25	1.54	0.16
Adult stags (MCVW)							
1992	15	0.39	0.55	0.78	1.12	1.28	0.30
1993	12	0.56	0.70	0.91	1.21	1.37	0.26
Both years	27	0.39	0.62	0.84	1.12	1.37	0.29

Min = minimum, Max = maximum, SD = standard deviation.
Note : the calculation of mean corrected velvet weight is described in Tables 2.36 and 2.37.

Figure 3.34 : Means (±SD) and ranges of velvet antler weight of stags within each class of age in 1992 and 1993.



Note : the age is that at the time of velvet antler removal.

There was a statistically significant increase of the proportion of adult stags producing velvet antler of grade A (or SA) and grade B from 7.7 and 37.3% in 1992 to 16.4 and 46.1% in 1993, respectively. This was associated with a significant decrease of the proportion of grade E and D velvet, while that of grade C velvet remained about 25%. This was associated with a significant increase (t-test $p<0.001$) of the average velvet yield per stag from 1.94 to 2.15 kg between the two years.

There was an apparent 10% shift of the proportion of velvet antler of yearling stags from grade D to grade C from 1992 to 1993, but it was not statistically significant. Within each grade, except grade C, and all grades mixed, there were no velvet antler weight differences between the two years. Mean weight of C grade velvet was significantly lower in 1993 (1.4 kg) than in 1992 (1.5 kg). The overall mean velvet weight of yearling stags was 1.16 kg in 1992 and 1.19 kg in 1993.

3.3.4 Health problems

3.3.4.1 Mortalities

3.3.4.1.1 Mortalities of deer over 3 months

3.3.4.1.1.1 Overall and seasonal mortality rates

The monthly distribution of weaner, stag and hind mortalities (Figure 3.35) show a seasonal pattern. There was a peak of weaner mortalities from March to July both years, with a significant decrease in spring and summer. In contrast, mortalities of hinds and stags over 15 months old were more prevalent and spread over time between May and December.

Annual and seasonal mortality numbers and rates are presented in Table 3.26.

Figure 3.35 : Monthly distribution of weaner (<15 months), hind and stag mortalities from March 1992 to March 1994

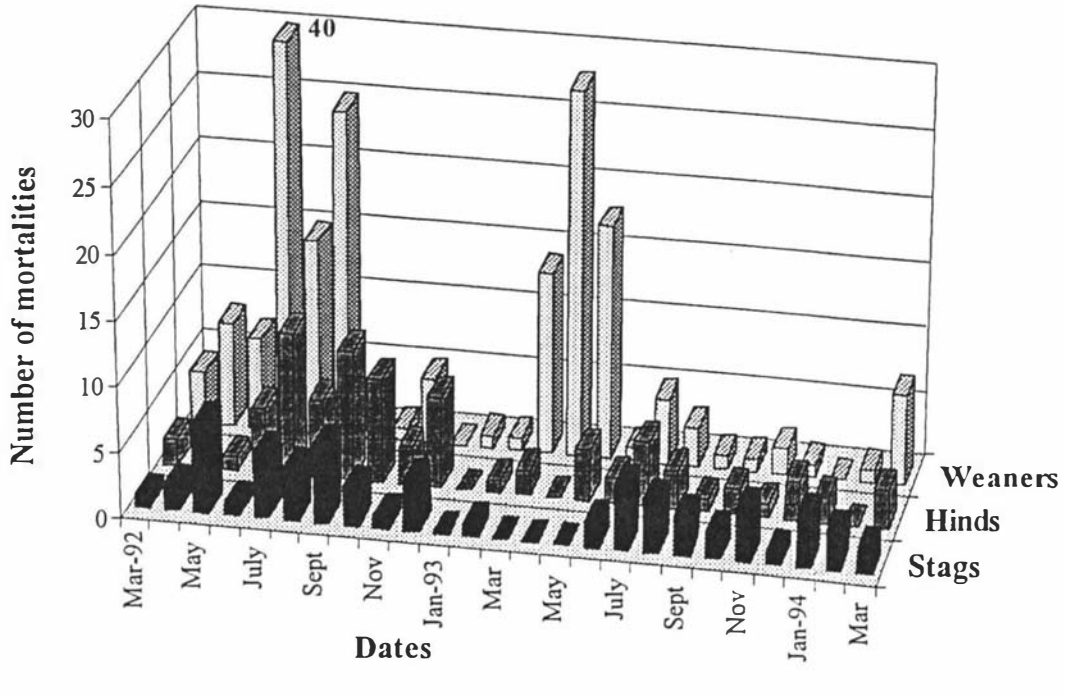


Table 3.26 : Number of hind, stag and weaner (3-15 months) mortalities and mortality rates (/100 deer-3 months) over autumn, winter, spring, summer, and all seasons combined (/100 deer-years). Data from 1992 and 1993 combined.

	AUTUMN March 1 - June 1*		WINTER June 1 - September 1		SPRING September 1 - December 1		SUMMER December 1 - March 1		ALL SEASONS April 1 1992 - April 1 1994	
	Number of occurences	Mortality rates	Number of occurences	Mortality rates	Number of occurences	Mortality rates	Number of occurences	Mortality rates	Number of occurences	Mortality rates
HINDS										
Unconfirmed	6	0.11	15	0.31	19	0.44	5	0.12	45	0.96
Dystocia					1	0.02	7	0.17	8	0.17
MCF**			7	0.15	1	0.02	0		8	0.17
Misadventure	4	0.07	10	0.21	1	0.02	0		15	0.32
Miscellaneous	3	0.05			3	0.07	1	0.02	7	0.15
Total hinds	13	0.23	32	0.67	25	0.58	13	0.32	83	1.77
Total number of deer-periods at risk***		5550		4774		4297		4071		4683
STAGS										
Unconfirmed	6	0.21	9	0.35	11	0.47	1	0.05	27	1.10
MCF**	1	0.03	4	0.16	6	0.26	2	0.09	13	0.53
Misadventure	4	0.14	7	0.28	2	0.09	7	0.33	20	0.81
Miscellaneous			1	0.04	0		2	0.09	3	0.12
Total stags	11	0.38	21	0.83	19	0.82	12	0.57	63	2.56
Total number of deer-periods at risk***		2856		2541		2321		2108		2459
WEANERS										
Unconfirmed	23	0.68	80	2.35	6	0.19	1	0.03	110	3.44
Yersiniosis	32	0.94	3	0.09					35	1.09
Misadventure	18	0.53	5	0.15	5	0.16	3	0.10	31	0.97
Osteochondrosis	7	0.21			2	0.06	0		9	0.28
MCF**			1	0.03					1	0.03
Miscellaneous	2	0.06							2	0.06
Total weaners	82	2.41	89	2.62	13	0.42	4	0.14	188	5.87
Total number of deer-periods at risk***		3401		3402		3086		2919		3202

* This period includes March 1993 and 1994, and May-June 1992 and 1993.

*** Number of deer at risk during the period concerned (3 months for each seasons or 12 months all seasons combined)

Note : Farm 14 was excluded from these calculations

Overall mortality rates (number of losses per 100 deer-years) were 1.77, 2.60 and 5.87 in hinds, stags and weaners, respectively. Summary statistics of mortality rates of weaners, stags, hinds are progeny loss rates are presented in Table 3.27.

Table 3.27 : Summary statistics of farm mortality rates of weaners (3-15 months)(MRW), stags (MRS) and hinds (MRH), and progeny loss rates to weaning (PROLOSS) in yearling and adult hinds.

Year	Number of farm-years	Min	25th percentile	Mean	Median	75th percentile	Max	SD
Mortality rates †								
MRW	14	0.35	2.15	5.51	2.61	5.24	30.30	7.56
MRS	14	0.00	0.99	2.38	1.83	2.47	9.62	2.38
MRH	14	0.00	0.36	1.81	1.88	2.37	4.33	1.31
PROLOSS ‡								
Yearling hinds	27	0.0	9.7	15.4	14.3	22.9	38.6	9.3
Adult hinds	28	0.0	5.4	9.0	9.7	12.1	18.6	4.8

Min = minimum, Max = maximum, SD = standard deviation.
† Data from 1992 and 1993 were combined for the calculation of rates within each farm.
‡ see section 3.3.4.1.2

3.3.4.1.1.2 Disease diagnoses

Diagnoses of mortalities in hinds, stags, weaners and calves are presented in summary in Table 3.28 and in detail between farms from Appendix 3.54 to Appendix 3.57.

Identified hind mortalities were mainly caused by dystocia, broken bones and malignant catarrhal fever (MCF). More than half of hind mortalities (54.2%) were from unconfirmed causes. However 15.7% of those were associated with poor body condition (fading).

Malignant catarrhal fever was the most common confirmed cause of stag death (23.4%) killing 0.53 stag per 100 stag x year at risk. A large proportion of mortalities were associated with misadventure (31.7%) including injuries, either self-inflicted or caused by other stags (15.6%). 42.9% of stag mortalities remained unconfirmed with 6.3% associated with fading.

Yersiniosis was confirmed in 18.6% of weaner deaths. This disease killed 1.09 weaner per 100 weaner x year, during the first 6 months after weaning (the case specific mortality during autumn and winter was 0.94 and 0.09/100 weaner x 3 months, respectively). Yersiniosis was suspected in a further 41% of mortalities, although post-mortem examinations were either not performed or inconclusive. Thus yersiniosis could have caused up to 58.6% of all weaner mortalities. Misadventure accounted for 15.4% of weaner mortalities, killing 0.53 weaner per 100 weaner x 3 months in autumn (the annual case specific mortality rate was 0.97). On one farm, 9 weaners were euthanased because of osteochondrosis lesions (4.8% of weaner mortalities). MCF was confirmed in one weaner stag in August 1993 (8-9 months of age) which is unusually young for that disease.

3.3.4.1.2 Progeny loss

Summary statistics of progeny loss rates (from pregnancy diagnosis to weaning) in yearling and adult hinds are presented in Table 3.27, while the detailed calculations of these rates on each farm are presented in Appendix 3.58.

Half of identified calf losses were related to the hind-calf relationship (50.5%) and were perinatal mortalities, mainly due to dystocia (22.1%) and stillbirth (9.5%). Most unconfirmed calf losses were suspected to be perinatal mortalities. The remainder of losses (20%) were directly related to the management of calving mobs with 8.4% of dead calves lost outside the calving paddock boundary. However, a large proportion of dead calves (estimated 77.3%) were not found. From ultrasound pregnancy testing and other reproduction data, both years combined, calculated progeny loss rates (loss from time of pregnancy diagnosis to weaning) were 17.0% and 9.1% in yearling and adult hinds, respectively, ranging from 0 to 38.6% in yearlings and from 0 to18.6% in adult hinds between farms as shown in Figure 3.36 and in Table 3.27. The overall apparent progeny loss rate was 10.4% of all hinds combined. These calculations exclude data from hinds that were culled.

It was not possible to estimate precisely the rate of foetal loss in this study since individual hind pregnancy diagnoses before calving were not undertaken. However, on many farms, bodyweight changes during late pregancy, udder palpation and physical appearance (ie. signs indicative of advanced pregnancy) were used to identify hinds carrying their foetus to term. All hinds identified not pregnant by this method were confirmed not lactating at weaning. From the 8 farms that carried out these observations, foetal loss was calculated to be 0.66% (2/303) and 0.79% (13/1639) in yearling and adult hinds, respectively.

Figure 3.36 : Distribution histogram of progeny loss (%) in yearling (2 years old at calving) and adult hinds within farms each year. Data from 1992 and 1993 combined.

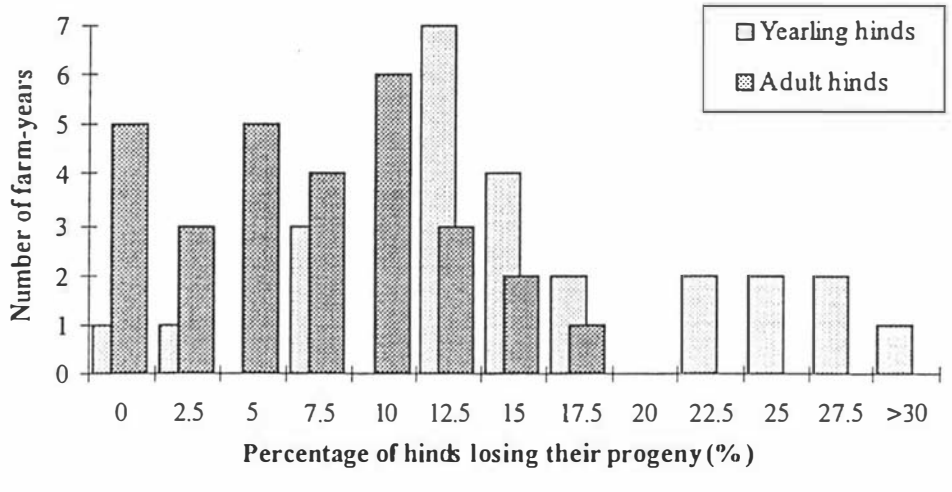


Table 3.28 : Mortalities and estimated mortality rates of hinds, stags, weaners (3-15 months) and calves, from April 1 1992 to April 1 1994.

HINDS

Diagnosis	Number	%	Mortality rates (/100 hind-years)
Unconfirmed			
Fading	13	15.7	0.28
Ataxia	1	1.2	0.02
Pneumonia	1	1.2	0.02
Enteritis	2	2.4	0.04
Rumenitis	1	1.2	0.02
Dystocia ?	2	2.4	0.04
No diagnosis	25	30.1	0.53
Total Unconfirmed :	45	54.2	0.96
Dystocia	8	9.6	0.17
MCF			
Acute	7	8.4	0.15
Chronic	1	1.2	0.02
Total MCF :	8	9.6	0.17
Misadventure			
Drowned	7	8.4	0.15
Injury	1	1.2	0.02
Broken neck	5	6.0	0.11
Broken leg	3	3.6	0.06
Other	1	1.2	0.02
Total misadventure :	17	20.5	0.36
Miscellaneous			
Enzootic ataxia	3	3.6	0.06
Liver cancer	1	1.2	0.02
Volvulus	1	1.2	0.02
Total miscellaneous :	5	6.0	0.11
Total mortalities :	83	100.0	
Mortality rates (/100 hinds x year)			1.77
Number of hind-years at risk			4683

STAGS

Diagnosis	Number	%	Mortality rates (/100 stag-years)
Unconfirmed			
Fading	5	7.9	0.20
Interstitial nephritis	1	1.6	0.04
Black-leg	1	1.6	0.04
Johnes disease	1	1.6	0.04
No diagnosis	19	30.2	0.77
Total Unconfirmed :	27	42.9	1.10
MCF			
Acute	10	15.9	0.41
Chronic	3	4.8	0.12
Total MCF :	13	20.6	0.53
Misadventure			
Handling stress	2	3.2	0.08
Broken neck	3	4.8	0.12
Broken leg	2	3.2	0.08
Stag fight	2	3.2	0.08
Injury	3	4.8	0.12
Other	8	12.7	0.33
Total misadventure :	20	31.7	0.81
Miscellaneous			
Facial abscesses	2	3.2	0.08
Gun shot	1	1.6	0.04
Total miscellaneous :	3	4.8	0.12
Total mortalities :	63	100.0	
Mortality rates (/100 stags x year)			2.56
Number of stag-years at risk			2459

WEANERS

Diagnosis	Number	%	Mortality rates (/100 weaner-years)
Unconfirmed			
Yersiniosis ?	77	41.0	2.40
Lungworm	1	0.5	0.03
Lameness	3	1.6	0.09
Swollen joint	1	0.5	0.03
Fading	1	0.5	0.03
Septicaemia	1	0.5	0.03
Hepatitis	1	0.5	0.03
Enteritis	1	0.5	0.03
No diagnosis	26	13.8	0.81
Total unconfirmed :	112	59.6	3.50
Yersiniosis	35	18.6	1.09
Misadventure			
Broken neck	15	8.0	0.47
Broken leg	7	3.7	0.22
Injury	1	0.5	0.03
Stress at weaning	1	0.5	0.03
Other	5	2.7	0.16
Total misadventure :	29	15.4	0.91
Osteochondrosis	9	4.8	0.28
MCF*	1	0.5	0.03
Miscellaneous			
Malformation	1	0.5	0.03
Blind	1	0.5	0.03
Total miscellaneous :	2	1.1	0.06
Total mortalities :	188	100.0	
Mortality rate (/100 weaner-years)			5.87
Number of weaner-years at risk			3202

CALVES

Diagnosis	Number	%
Hind-calf relationship		
Dystocia	21	22.1
Stillbirth	9	9.5
Small weak fawn	2	2.1
Overmothered	1	1.1
Mismothering	6	6.3
Fawn victimised	6	6.3
Ruptured stomach	3	3.2
Total :	48	50.5
Calf diseases		
Malformation (scoliosis)	1	1.1
Cryptosporidiosis	1	1.1
Liver abscess (navel infection)	1	1.1
Total :	3	3.2
Direct management related		
Weather stress	2	2.1
Handling stress	1	1.1
Fawn lost	1	1.1
Lost through fence	8	8.4
Left behind	2	2.1
Misadventure	2	2.1
Broken neck	1	1.1
Broken leg	1	1.1
Broken back	1	1.1
Total :	19	20.0
Unconfirmed	25	26.3
Total diagnoses :	95	100.0

* This weaner died on August 28 1993 (8-9.5 months)
? Diagnosis based on circumstantial evidence
MCF = malignant catarrhal fever

3.3.4.2 Clinical diseases

Health problems of weaners, hinds and stags which did not lead to death are listed in Table 3.29. Detailed description of occurrence on each survey farm is presented in Appendix 3.59.

The most prevalent diseases of weaners were yersiniosis and osteochondrosis which occurred mainly through outbreaks as described in section 3.3.4.3. Osteochondrosis was identified on one farm, and only suspected on another farm from the observation of lame weaners and associated mortalities. A few weaners were found to scour but the cause was not identified. A number of injuries and abscesses were recorded on 3 farms, including 6 weaners with broken legs that were not subsequently treated or killed.

Enzootic ataxia affected one adult hind on one farm for the duration of the study period, but bred successfully both years. Two adult hinds and one adult stag on another farm (that with severe osteochondrosis in calves) were affected with enzootic ataxia but not killed. Occasional abscesses, injuries, lameness, scouring and fading syndromes were recorded on almost every farm, but with a higher prevalence from two farms.

Table 3.29: Summary of health problems which did not lead to death from March 1 1992 to April 1 1994. All farms combined.

Health problem	Symptom or lesion	WEANERS	HINDS	STAGS
Bacterial infections	Abscess	5	2	4
	Foot abscess		3	4
	Enteritis			2
	Yersiniosis	45		
	Osteomyelitis		1	
	Balanoposthitis			1
Injuries	Broken leg	6		
	Other injuries	2	1	3
Copper deficiency	Osteochondrosis	10		
	Enzootic ataxia		4	1
Miscellaneous	Blind			1
	Fading	1	4	3
	Ryegrass staggers	1		
	Scouring	5	2	1
	Lameness	4	2	4
	Pink eye	1		
Total		80	19	24

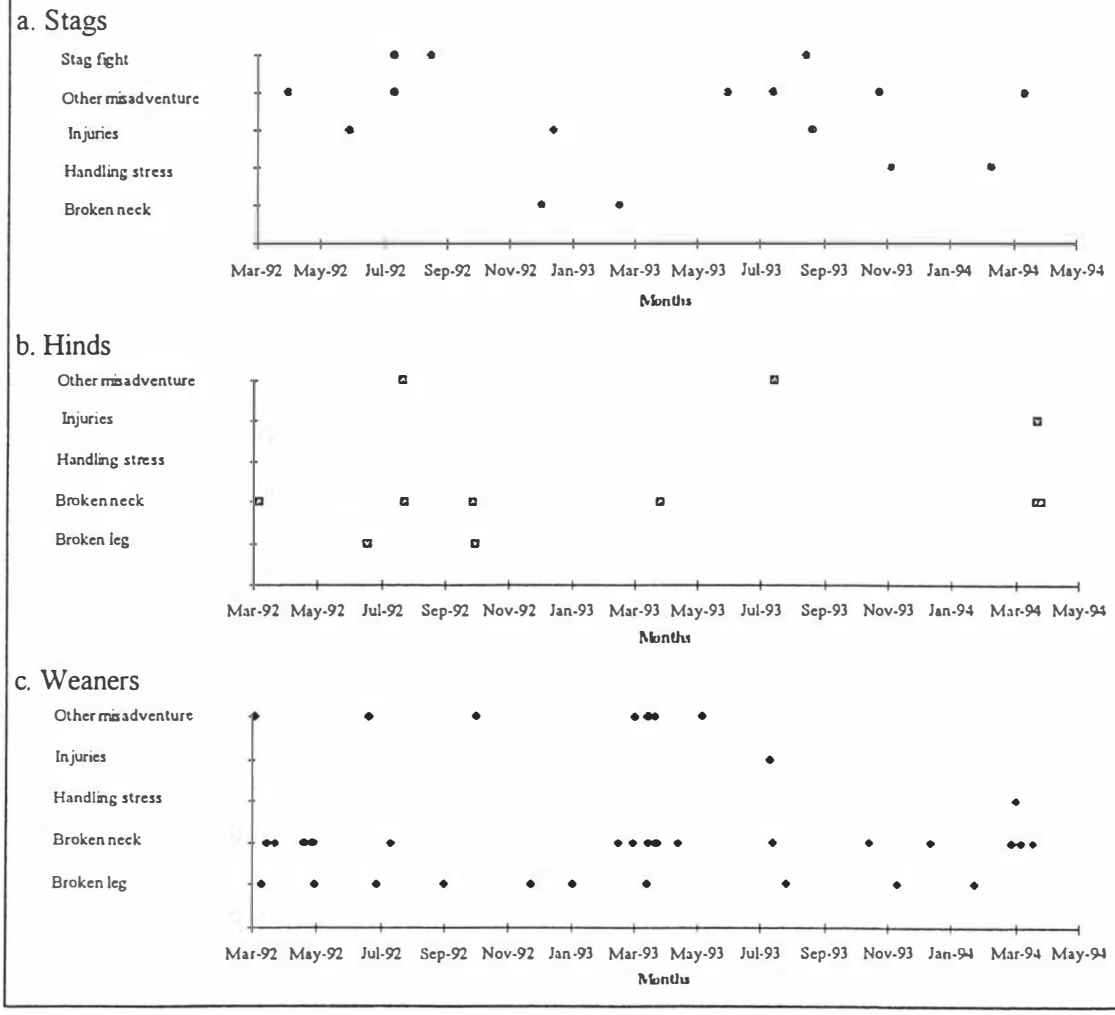
3.3.4.3 Common health problems

3.3.4.3.1 Misadventure

Misadventure was a significant cause of losses on deer farms. The detailed chronology and description of losses by misadventure is presented in Appendix 3.60. A graphical representation is presented in Figure 3.37.

Whereas there was no obvious seasonal trend in hinds and stags, misadventure in weaners predominantly occurred between March and May each year. Broken necks in particular were more prevalent during the first few weeks of the post-weaning period. In contrast, broken legs occurred all year round.

Figure 3.37 : Chronology of losses of stags, hinds and weaners (<15 months) by misadventure from March 1 1992 to April 1 1994, all farm combined.



3.3.4.3.2 Yersiniosis and weaner mortality outbreaks

Weaner mortalities confirmed or suspected to be caused by yersiniosis occurred on 4 farms in 1992 and again on 4 farms in 1993, with 1 farm involved both years. The circumstances of occurrence are described in Appendix 3.60.

On each of these farms, weaner mortalities were first noticed between late April to early June and were spread over a few days or weeks, although on one farm, weaners died from June to August. In 1992, on paddocks where mortalities occurred, the pasture was grass dominant and between 4 and 8 cm high, whereas in 1993, mortalities occurred on mixed ryegrass/clover swards 13 and 18 cm high. The size of weaner mobs ranged from 37 to 461 deer, and the number of deer that died ranged from 1 to 38, with mortality risks ranging from 0.01 to 0.16 between farms. On four farms, only weaners were individually examined for clinical symptoms of yersiniosis, and *Yersinia pseudotuberculosis* was identified on three of them. There was veterinary involvement in every case but two. Treatment of affected weaners with antibiotics were implemented on 1 farm in 1992 and 3 in 1993, and Yersiniavax (yersiniosis vaccine) was used in response to these mortalities on all affected farms in 1993.

3.3.4.3.3 Osteochondrosis

Both years, one farm that was diagnosed copper deficient experienced outbreaks of osteochondrosis in calves. The chronology of observations, post-mortem examinations and laboratory investigations and have been fully reported elsewhere (Audigé et al., 1993a; Thompson et al., 1994; Audigé et al., 1995).

3.3.4.3.4 Malignant catarrhal fever

Malignant catarrhal fever was one of the most common causes of mortalities in hinds and stags over 15 months old. The description of each case is presented in Appendix 3.62.

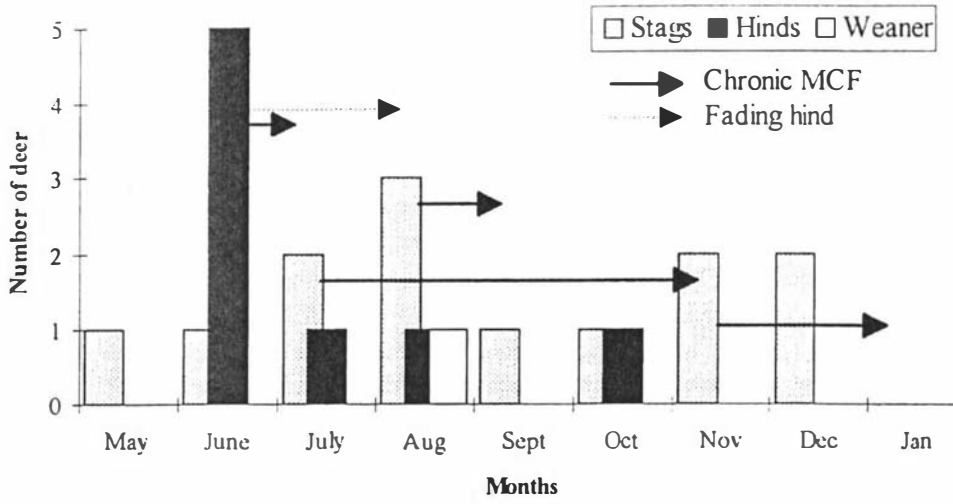
Eight hinds (including 2 yearlings), 13 stags (including 2 yearlings) and one weaner died from malignant catarrhal fever confirmed by histological investigation. Most were from the acute form of the disease, although deer were observed diseased (two were observed fading) before death. Four (1 hind and 3 stags) died from chronic malignant catarrhal fever following weeks of physical deterioration (eg severe weight loss). Most affected hinds were observed early winter (June/July), while the sequence of occurrence spread during winter and spring as shown in Figure 3.38.

3.3.4.3.5 Dystocia

During two calving seasons, 22 dystocias were recorded from 9 farms. Their descriptions are presented in Appendix 3.63. The risk of dystocia in yearling and adult hinds was 0.0104 (7/761) and 0.0043 (15/3500), respectively.

There was a range of calf presentations causing dystocia, including 5 with the head back and 8 with a posterior presentation. Three times out of the 15 interventions, veterinarians were involved. In most cases, calves were already dead when assisted (or died soon after), while hinds survived the intervention. Four hinds were found dead due to dystocia in calving paddocks and 2 were killed by the farmer without intervention.

Figure 3.38 : Chronology of occurrence of mortalities due to acute and chronic malignant catarrhal fever in stags, hinds and weaners (3-15 months). Data from 1992 and 1993 combined.



Note : Deer affected by chronic malignant catarrhal fever were noticed and died in the months shown by the beginning and the end of solid arrows, respectively. One hind was fading before dying from acute malignant catarrhal fever as shown by broken.

3.3.4.4 Inspection at Deer Slaughter Premises

Carcasses of all deer sent for slaughter were inspected at Deer Slaughter Premises. Unfortunately, some farmers sending their deer for slaughter did not forward the "MAF slaughter report" (Appendix 2.18) to enable inspectors to recognise trial farms and specifically record gross lesions for this study. Moreover, DSPs involved were those of Venison New Zealand Ltd which went into receivership before the end of the project during the main slaughter period in spring 1993. Consequently deer were sent to other slaughter plants where MAF veterinarians did not record gross lesions for this project. Therefore, these data were not complete. Further, because of time limitations, no attempts could be made to standardise observations between slaughter plants and meat inspectors, so recordings were variable. Thus, this data was of limited validity and not analysed.

3.4 SENTINEL DEER AND BIOLOGICAL MARKERS

3.4.1 Physical characteristics of sentinel deer and behavioural observation at sampling

Multiple-way ANOVA were carried out using SAS to investigate the variation of each measurement due to year, farm, visit, and age (or sex) within weaners, hinds (>15 months) and stags (>15 months). Separate descriptive statistics were subsequently computed at each level of significant factors. Means, ranges and standard deviations of shoulder height, thoracic girth, coat length and coat density of sentinel deer over all farms are presented in Appendix 3.64. Means and standard deviations of these physical measurements and of the body condition score of sentinel hinds and stags for each survey farm are presented from Appendix 3.65 to Appendix 3.68. The distributions of deer with signs of hair loss, deer easily blood sampled, and deer lying down, stressed or aggressive at sampling are presented in Appendix 3.69.

The body conditon scores of sentinel stags did not vary between years, visits and class of age. These scores ranged from 1 to 5 with a mean of 3.24 (standard deviation 0.64). There was variability in sentinel hind body condition scores between farms and visits. As hind body condition scores have been investigated in more detail earlier in section 3.3.1.2, this data is only presented in Appendix 3.65.

3.4.1.1 Shoulder height

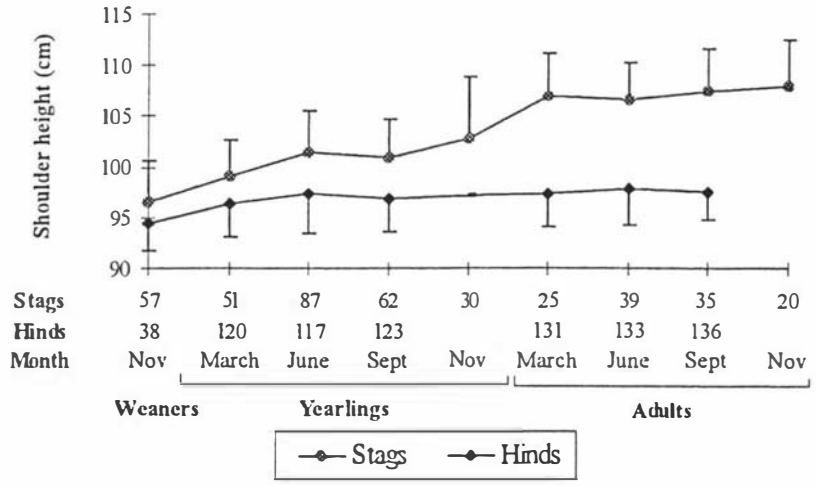
The shoulder height (SIZE) of stags 12-to 36-months old ranged from 91.4 to 116.8 cm, while that of hinds ranged from 91.4 to 106.7. Mean size of stags and hinds are presented in Figure 3.39. ANOVA showed a positive age effect (yearling versus adult) on size on both stags and hinds ($p<0.01$).

3.4.1.2 Thoracic girth

The thoracic girth of stags and hinds from weaning to 3 years of age was significantly greater ($p<0.01$) in 1992 than in 1993 (Figure 3.40). This difference was particularly marked in yearling and adult deer during the March and June visits. There was a significant increase in thoracic girth with age in stags and hinds ($p<0.01$), associated with seasonal fluctuations. The thoracic girths of stags and hinds over 15 months old decreased both years during winter. These seasonal variations were more pronounced in 1992.

There were highly significant correlations between thoracic girth and bodyweight in weaners, hinds and stags (correlation coefficients were 0.82, 0.70 and 0.89, respectively). The regression equations predicting the bodyweight (kg) from the thoracic girth (cm) in these class of deer are presented in Table 3.30.

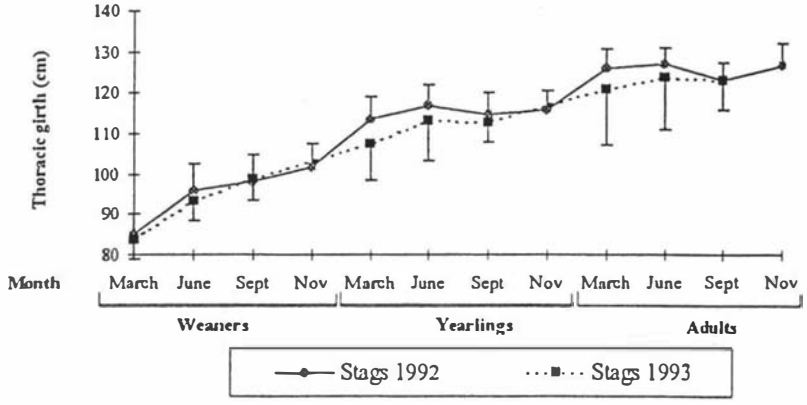
Figure 3.39 : Shoulder height (±SD)(cm) of sentinel stags and hinds from 12 months to 34-36 months of age recorded at successive farm visits. Data from 1992 and 1993 combined.



Note : number of deer measured are under the X axis.

Figure 3.40 : Thoracic girth (±SD)(cm) of sentinel weaner, yearling and adult stags (a) and hinds (b) at each farm visit in 1992 and 1993.

a. Stags



b. Hinds

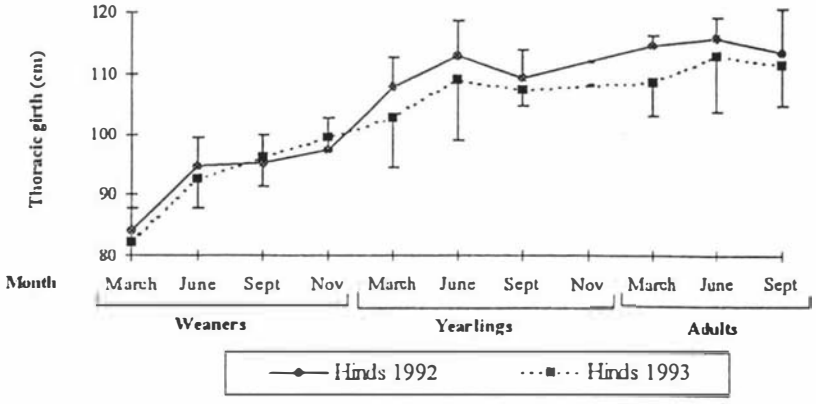
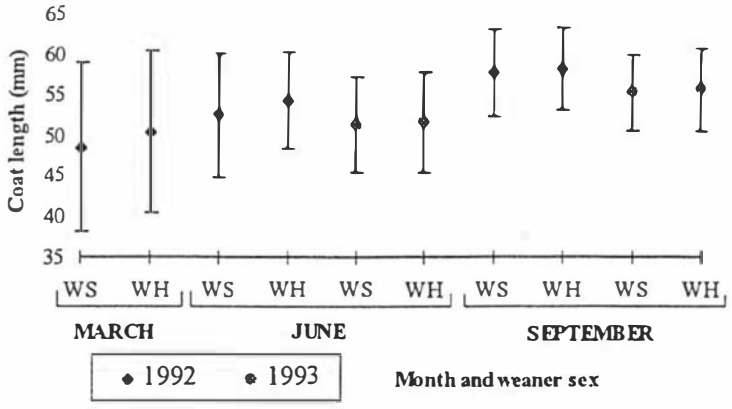
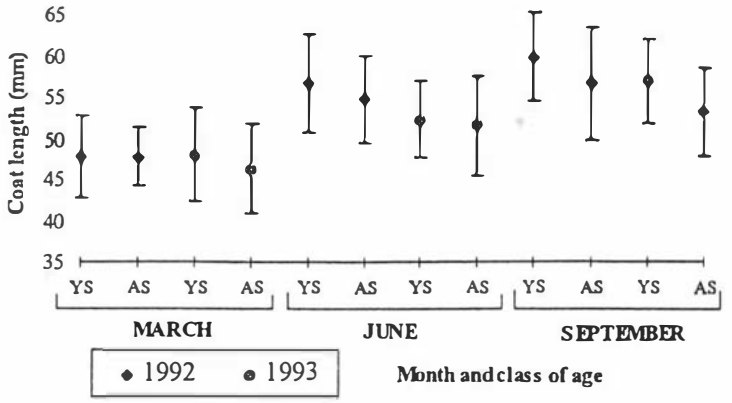


Figure 3.41 : Mean (±SD) of coat length of weaner hinds (WH) and stags (WS), yearling (YS) and adult (AS) stags, and yearling (YH) and adult (AH) hinds, sampled in March, June and September in 1992 and 1993.

1. WEANERS



2. STAGS



3. HINDS

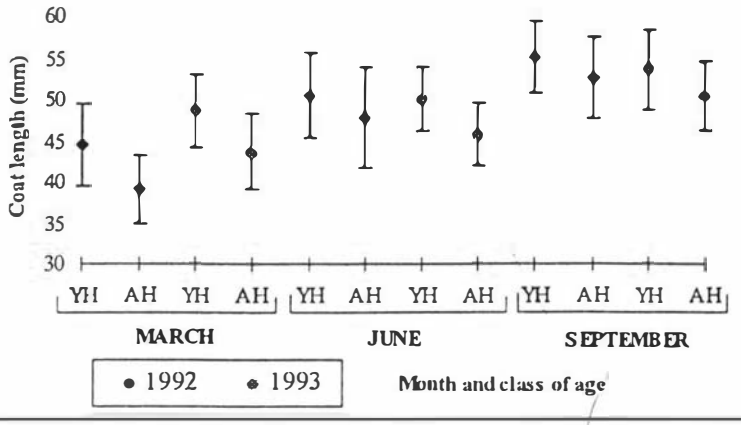


Table 3.30 : Regression equations predicting the bodyweight of weaners (3-15 months), hinds and stags (kg) from their thoracic girth (cm).

Class of deer	Regression equation	Bodyweight range (kg) Min	Maxi	R	p value	R^2
Weaners	63.8 + 0.032 GIRTH	33.7	79.5	0.82	0.000	0.68
Hinds	74.3 + 0.382 GIRTH	59.2	121.2	0.70	0.000	0.49
Stags	-174.1 + 2.440 GIRTH	70.0	174.0	0.89	0.000	0.78

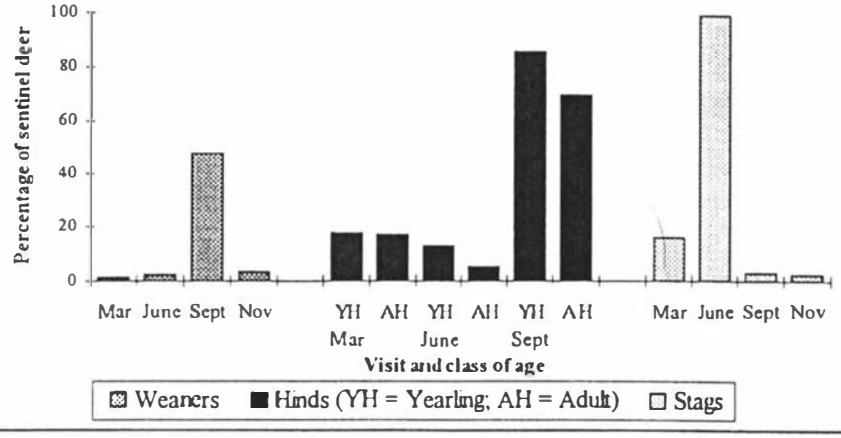
3.4.1.3 Coat length and density

Means and standard deviations of weaner, stag and hind coat lengths are presented in Figure 3.41. Coat length ranged from 24 to 75 mm and from 30 to 70 mm in hinds and stags, respectively, while that of weaners ranged from 31 to 70 mm. Coat length was significantly shorter in 1993 than in 1992 in stags (>15 months)($p<0.01$) and in weaners ($p<0.01$), was significantly longer in September (winter coat) than in June or March in all deer ($p<0.01$), and was significantly longer in yearling than in adult hinds and stags ($p<0.01$). Weaner hinds had significantly longer outer coat than weaner stags using ANOVA ($p<0.05$).

The coat density measured through the weight of hair as described in section 2.4.1.1 ranged from 0.59 to 3.28 g, from 0.59 to 3.03 g and from 0.98 to 2.40 g, in weaners, stags and hinds, respectively, in June. This patch of coat was significantly lighter in March in weaners and hinds. There was a highly significant correlation between the coat density and the coat length of weaners and hinds in June (correlation coefficients were 0.71 and 0.45, respectively, $p<0.01$).

Hair loss on the back (a sign of victimisation) of sentinel deer was observed in all classes of age and both sexes, with a significantly higher prevalence in September in weaners and in hinds, and a significantly higher prevalence in June in stags ($p<0.01$)(Figure 3.42). A higher proportion of sentinel yearling hinds than adult hinds was observed with hair loss in June and September ($p<0.01$).

Figure 3.42 : Percentage of sentinel weaners, hinds and stags observed with signs of hair loss on their back (victimisation).



3.4.1.4 Teeth

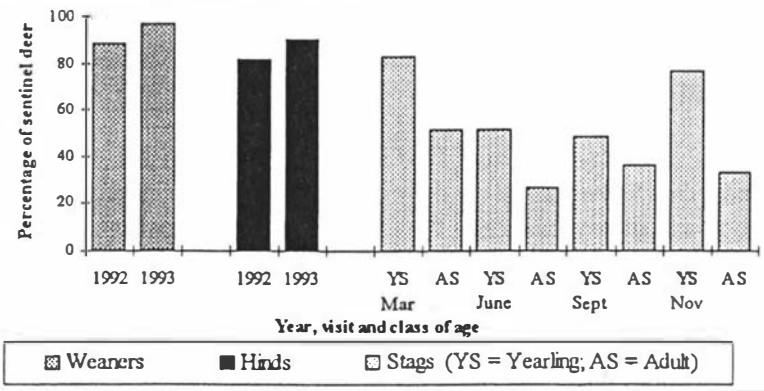
Of the 83 adult stags and 129 adult hinds that were examined for teeth wear during the study, 22.9 and 30.2% had moderately worn teeth (score 2), while 8.4 and 20.9% had severely worn teeth (score 1), respectively (see Table 2.22 for teeth scores).

3.4.1.5 Ease of blood sampling

As shown in Figure 3.43, 88.2 and 97.1% of weaners, and 81.3 and 90.1% of hinds were blood sampled without physical restraint by another person in 1992 and 1993, respectively (see Figure 2.4). These year differences were statistically significant in weaners and hinds ($p<0.01$). There was no year difference in the behaviour of stags during sampling. A significantly higher proportion of stags were sampled in a physical restraining device in June and September, and adult stags required physical restraint in a crush more than yearling stags ($p<0.01$).

Weaners lay on the floor of the pen during sampling more often in March (3.6% of weaners) and June (5.0%) than in September (1.2%) and November (1.6%). There was no sex difference in this behavioural characteristic. At each visit, over all farms, one or 2 weaners had to be released from the pen because of stress.

Figure 3.43 : Percentage of sentinel weaners, hinds and stags that were blood sampled without physical restraint during farm visits.



Three hinds became stressed at sampling in 1992, while none did in 1993. Signs of aggression (see Table 2.22) were recorded on 10 occasions, 9 of which were observed in 1992. Adult hinds (3.6% of all sentinel hinds) were more often aggressive during sampling than yearling hinds (1.2%). The recording of signs of stress or aggression was difficult since many went through the physical restraining device (crush) and thus this observation is not reported here.

3.4.2 Blood markers

3.4.2.1 Individual deer blood characteristics

Means, standard deviations and ranges of individual blood characteristics of weaners, hinds and stags are presented in Table 3.31 to Table 3.33.

Blood characteristics were analysed by multiple-way ANOVA to explore variability between sex, age and visit (where appropriate) using SAS. Descriptions of models tested are presented in Appendix 3.70 and Appendix 3.71. Initially, standard ANOVA were run separately on 1992 and 1993 data as if sentinel animals were randomly selected each time, then data from both years were pooled for analyses of repeated measures. Weaner blood characteristics were analysed using repeated measures ANOVA including weaners that were sampled three times from March to September (the November visit was excluded from this analysis). When the interaction term SxV(Y) (Sex x Visit within year) was significant, standard ANOVA were carried out per visit to identify when sex differences were significant. Hind and stag blood characteristics were analysed using the paired t-test on data subsets including hinds and stags sampled twice within a year, animals sampled both years were considered statistically independent. Sex, age and visit differences were identified from all test results combined although emphasis was put on repeated measures tests.

3.4.2.2 Farm blood markers

Whether blood characteristics of sentinel deer can be used as potential farm markers for various farm production outcomes was investigated. The variance components of these blood characteristics due to year and farm differences were calculated using SAS for each visit, class of age or sex (as appropriate). Data from weaners, hinds and stags were analysed separately, and results are presented in Appendix 3.72, Appendix 3.73 and Appendix 3.74, respectively.

The percentages of variability of weaner, hind and blood characteristics due to farm differences ranged from about 5 to 90%, but the majority of these percentages in weaners and hinds were over 30%. Some blood characteristics such as the glutathione peroxidase activity and the blood urea nitrogen concentration showed variabilities due to farm consistently over 40%, while those of only the gamma glutamyl transferase activity were over 25% only once.

Consequently, farm mean values (or geometric means where appropriate) of blood characteristics were used for graphical presentation. Means, standard deviations and ranges of these means are presented from Figure 3.44 to Figure 3.51.

Table 3.31 : Mean, range and standard deviation of individual blood haematological and biochemical characteristics of weaner stags (WS) and weaner hinds (WH) (3-15 months) at each visit. Data pooled over all farms and both years 1992 and 1993.

			MARCH					JUNE				
	Units	Class of deer	Number of deer	Mean	Min	Max	SD	Number of deer	Mean	Min	Max	SD
WEANERS BOTH SEX COMBINED												
Haematological characteristics												
White Cell Count*	10E9/l		279	5.34	2.30	29.50	2.21	286	5.87	2.30	55.00	4.93
Neutrophils	%		279	34.95	12.0	76.0	12.53	286	32.69	5.0	63.0	10.11
Eosinophils**	%		279	2.32	0.0	19.0	3.39	286	3.23	0.0	30.0	4.05
Bands**	%		279	1.00	0.0	9.0		286	1.00	0.0	14.0	
Lymphocytes	%		279	59.09	23.0	85.0	12.13	286	59.33	29.0	91.0	10.82
Monocytes**	%		279	0.00	0.0	7.0		286	0.00	0.0	5.0	
Basophils*	%		279	0.49	1.0	10.0	1.40	286	1.21	0.0	10.0	1.84
Unusual Lymphocytes**	%		139	0.00	0.0	6.0		286	0.00	0.0	7.0	
MCHC*	g/dl		278	40.38	32.1	74.8	5.37	283	38.87	31.3	70.3	5.06
Biochemical characteristics												
Total Protein	g/l		280	63.07	50.50	82.90	3.99	286	70.17	51.60	87.70	5.31
Albumin	g/l		280	35.71	22.9	43.4	3.32	286	33.78	14.0	45.2	4.56
Globulin	g/l		280	27.38	19.1	42.1	3.91	286	35.94	24.9	65.2	5.45
Phosphorus	mmol/l		280	2.97	1.3	4.8	0.52	286	2.82	0.7	4.0	0.49
GGT*	IU		280	28.35	13.00	809.00	55.00	286	44.64	18.00	403.00	42.73
Blood Urea Nitrogen	mmol/l		280	9.25	3.1	18.2	1.90	286	10.95	6.0	15.4	1.64
Copper	µmol/l		280	12.22	1.40	29.00	4.84	286	12.42	2.20	34.00	4.29
Vitamin B12*	pmol/l		280	188.70	<70.0#	3000.0	332.47	273	150.60	<70.0#	1900.0	192.85
GSHPx	kIU/l		84	6.62	0.7	32.2	6.09	88	9.43	0.1	23.6	5.46
WEANERS SEPARATED BY SEX												
Haematological characteristics												
Haemoglobin	g/dl	WS	139	16.68	7.8	25.8	2.31	145	16.04	6.0	24.4	2.24
		WH	140	17.23	10.9	27.3	2.75	140	16.72	11.4	28.1	2.72
Packed Cell Volume	%	WS	138	0.41	0.21	0.55	0.06	145	0.42	0.16	0.54	0.05
		WH	140	0.42	0.25	0.59	0.05	140	0.42	0.28	0.54	0.05
Biochemical characteristics												
Pepsinogen*	mU Tyrosine/l	WS	140	154.02	0.0	628.0	104.61	145	330.45	0.0	1490.0	235.08
		WH	139	177.60	0.0	581.0	105.67	141	370.29	0.0	1351.0	229.76

			SEPTEMBER					NOVEMBER				
	Units	Class of deer	Number of deer	Mean	Min	Max	SD	Number of deer	Mean	Min	Max	SD
WEANERS BOTH SEX COMBINED												
Haematological characteristics												
White Cell Count*	10E9/l		285	5.86	2.90	38.40	3.50	140	5.44	2.30	10.40	1.74
Neutrophils	%		285	35.06	14.0	84.0	11.90	140	36.58	16.0	62.0	10.24
Eosinophils*	%		285	2.49	0.0	32.0	4.00	140	3.59	0.0	20.0	3.96
Bands**	%		285	0.00	0.0	7.0		140	0.00	0.0	2.0	
Lymphocytes	%		285	58.00	10.0	82.0	12.33	140	57.22	35.0	79.0	10.13
Monocytes**	%		285	0.00	0.0	3.0		140	0.00	0.0	3.0	
Basophils*	%		285	1.79	1.0	11.0	2.22	140	0.58	1.0	5.0	0.96
Unusual Lymphocytes**	%		285	0.00	0.0	3.0		140	0.00	0.0	4.0	
MCHC*	g/dl		285	37.57	27.9	62.0	5.07	140	40.39	36.4	53.7	2.85
Biochemical characteristics												
Total Protein	g/l		285	66.47	55.00	90.70	4.18	140	68.12	54.10	80.40	4.17
Albumin	g/l		283	32.74	25.9	39.6	2.60	139	34.97	23.4	42.4	3.01
Globulin	g/l		285	33.74	23.20	60.60	4.50	140	33.15	23.20	45.60	4.37
Phosphorus	mmol/l		283	2.39	1.3	3.6	0.39	139	2.64	1.5	3.9	0.43
GGT*	IU		285	28.48	13.00	278.00	17.48	140	29.29	13.00	96.00	11.98
Blood Urea Nitrogen	mmol/l		283	9.32	4.1	12.9	1.55	139	9.10	5.9	12.6	1.52
Copper	µmol/l		285	11.89	2.10	44.00	4.47	140	14.57	1.00	25.00	4.02
Vitamin B12*	pmol/l		283	159.97	<70.0#	1500.0	170.93	139	161.51	<70.0#	1600.0	214.99
GSHPx	kIU/l		85	10.59	1.4	29.2	6.10	44	9.79	1.0	22.6	6.21
WEANERS SEPARATED BY SEX												
Haematological characteristics												
Haemoglobin	g/dl	WS	146	16.56	8.7	24.6	2.58	71	16.30	8.2	22.7	2.09
		WH	138	16.80	10.8	25.5	2.66	69	17.14	13.2	20.1	1.41
Packed Cell Volume	%	WS	146	0.44	0.24	0.64	0.05	71	0.40	0.22	0.56	0.04
		WH	138	0.45	0.32	0.58	0.05	69	0.43	0.33	0.52	0.03
Biochemical characteristics												
Pepsinogen*	mU Tyrosine/l	WS	144	429.29	47.00	1309.00	233.97	69	492.93	152.80	1528.00	255.52
		WH	139	502.81	140.00	2609.00	327.79	69	531.87	152.80	1375.20	221.36

			ALL VISITS COMBINED				
	Units	Class of deer	Number of deer	Mean	Min	Max	SD
Lymphocytes	%		990	57.21	10.0	91.0	11.65
Haemoglobin	g/dl	WS	501	16.41	6.0	25.8	2.36
		WH	487	16.95	10.8	28.1	2.58

Min = minimum; Max = maximum; SD = standard deviation; WH = Weaner hinds; WS = Weaner stags

* Geometric means are reported instead of means

** Medians are reported instead of means because data was not normally distributed. Data were not subject to ANOVA as described in Appendix 3.70.

9 values were below assay sensitivity (<70 pmol/l) in March, and 19, 13 and 4 in June, September and November, respectively.

Values < 70pmol/l were entered arbitrarily as 65 pmol/l for statistical analyses.

MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferase activity; GSHPx = glutathione peroxidase activity

Note : In the repeated measures ANOVA of lymphocytes percentages and haemoglobin concentration, only the interaction term VxF(Y) was significant ($p<0.01$), so data from all visits combined are also presented (see Appendix 3.70).

Note : Lymphocytes includes "Unusual lymphocytes".

Table 3.32 : Mean, range and standard deviation of individual blood haematological and biochemical characteristics of yearling (YS) and adult (AS) stags by visit and age group (where appropriate). Data pooled over all farms and both years 1992 and 1993.

			JUNE					NOVEMBER				
	Units	Class of deer	Number of deer	Mean	Minimum	Maximum	SD	Number of deer	Mean	Minimum	Maximum	SD
HAEMATOLOGICAL CHARACTERISTICS												
White Cell Count*	10E9/l	AS	108	4.59	2.40	18.90	2.39	45	4.84	2.70	9.30	1.53
		YS	114	5.66	2.50	24.40	3.54	38	4.52	2.70	8.90	1.50
Neutrophils	%	AS	108	41.02	17.00	67.00	9.85	45	54.58	25.00	77.00	12.84
		YS	114	35.04	7.00	71.00	10.88	38	39.42	17.00	68.00	12.22
Eosinophils*	%	AS & YS	307	5.79	0.00	30.00	5.34					
Bands**	%	AS	108	1.00	0.00	14.00		45	0.00	0.00	1.00	
		YS	114	1.00	0.00	7.00		38	0.00	0.00	0.00	
Lymphocytes	%	AS	108	47.15	23.00	72.00	10.15	45	40.02	17.00	71.00	12.48
		YS	114	53.67	23.00	90.00	10.63	38	52.87	30.00	76.00	11.13
Monocytes**	%	AS	108	0.00	0.00	4.00		45	0.00	0.00	3.00	
		YS	114	0.00	0.00	3.00		38	0.00	0.00	2.00	
Basophils*	%	AS & YS	222	1.20	0.00	17.00	2.02	83	0.25	0.00	2.00	0.52
Unusual Lymphocytes**	%	AS	108	0.00	0.00	4.00		45	0.00	0.00	3.00	
		YS	114	0.00	0.00	6.00		38	0.00	0.00	2.00	
Haemoglobin	g/dl	AS & YS	222	17.25	11.70	27.20	2.85	83	17.97	12.00	27.70	2.52
Packed Cell Volume	%	AS & YS	307	0.44	0.32	0.58	0.04					
MCHC*	g/dl	AS	108	39.42	30.21	58.14	5.97	45	41.79	30.18	61.86	5.96
		YS	114	38.27	30.00	58.68	4.16	38	39.61	36.28	45.32	1.68
BIOCHEMICAL CHARACTERISTICS												
Total Protein	g/l	AS	109	76.83	60.90	90.00	5.61	45	74.80	62.70	83.50	5.20
		YS	114	72.50	58.60	85.00	5.12	38	68.27	61.90	78.60	4.01
Albumin	g/l	AS	109	35.72	25.00	45.60	3.63	45	38.17	32.80	44.10	2.83
		YS	114	34.95	28.40	42.10	2.84	38	35.91	31.10	41.50	2.65
Globulin	g/l	AS	109	41.11	31.30	56.70	4.45	45	36.64	26.00	45.60	4.88
		YS	114	37.55	24.50	48.50	4.47	38	32.36	23.50	44.80	4.33
Phosphorus	mmol/l	AS	155	2.44	1.20	4.99	0.55					
		YS	153	2.59	1.06	4.33	0.54					
GGT*	IU	AS & YS	223	46.53	22.00	316.00	26.64	83	31.27	18.00	145.00	14.60
Blood Urea Nitrogen	mmol/l	AS	109	13.43	9.22	18.78	2.09	45	10.32	6.82	15.12	1.87
		YS	114	12.51	8.09	16.35	1.69	38	10.26	7.56	13.48	1.42
Copper	umol/l	AS	156	15.02	2.20	48.00	6.27					
		YS	154	13.31	1.00	33.00	5.71					
Vitamin B12*	pmol/l	AS & YS	300	198.06	<70.0#	3000.00	219.23					
GSHPx	kIU/l	AS & YS	108	7.67	1.80	35.20	7.10					
Pepsinogen*	mU Tyrosine/l	AS & YS	307	550.43	0.00	3334.00	419.50					

* Geometric means are reported instead of means

** Medians are reported instead of means because data was not normally distributed. Data were not subject to ANOVA as described in Appendix 3.71.

4 values were <70 pmol/l in June, the lower level of analytical sensitivity (2 value was <70 pmol/l in November). Values < 70pmol/l were entered arbitrarily as 65 pmol/l for statistical analyses.

SD = standard deviation; MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferaseactivity; GSHPx = glutathione peroxidaseactivity

Note : Lymphocytes includes "Unusual lymphocytes".

Table 3.33 : Mean, range and standard deviation of individual blood haematological and biochemical characteristics of yearling (YH) and adult (AH) hinds by visit and age group (where appropriate). Data pooled over all farms and both years 1992 and 1993.

			MARCH					SEPTEMBER				
	Units	Class of deer	Number of deer	Mean	Minimum	Maximum	SD	Number of deer	Mean	Minimum	Maximum	SD
HAEMATOLOGICAL CHARACTERISTICS												
White Cell Count*	10E9/l	AH	140	5.37	2.5	15.3	1.99	143	4.43	2.3	29.6	2.54
		YH	135	5.39	2.8	22.0	2.19	130	4.86	2.4	16.1	2.08
Neutrophils	%	AH	282	45.56	16.0	76.0	13.74					
		YH	265	36.00	11.0	75.0	11.69					
Eosinophils*	%	AH	139	5.73	0.0	25.0	4.32	143	5.76	0.0	25.0	4.81
		YH	135	3.83	0.0	17.0	3.69	130	4.71	0.0	26.0	4.38
Bands**	%	AH	139	1.00	0.0	7.0		143	0.00	0.0	7.0	
		YH	135	1.00	0.0	7.0		130	0.00	0.0	3.0	
Lymphocytes	%	AH	139	43.42	18.0	81.0	14.75	143	45.52	16.0	76.0	12.40
		YH	135	55.33	23.0	82.0	12.85	130	55.98	12.0	80.0	11.03
Monocytes**	%	AH	139	0.00	0.0	2.0		143	0.00	0.0	3.0	
		YH	135	0.00	0.0	5.0		130	0.00	0.0	1.0	
Basophils*	%	AH	139	0.82	1.00	10.00	1.70	145	1.72	1.00	12.00	2.44
		YH	135	0.72	1.00	9.00	1.65	130	1.68	1.00	12.00	2.58
Unusual Lymphocytes**	%	AH	70	0.00	0.0	4.0		143	0.00	0.0	4.0	
		YH	70	1.00	0.0	3.0		130	0.00	0.0	3.0	
Haemoglobin	g/dl	AH	140	16.26	8.80	28.10	3.52	145	18.03	12.20	26.70	3.36
		YH	135	16.79	12.10	26.60	2.18	130	17.38	13.00	25.30	2.28
Packed Cell Volume	%	AH	140	0.39	0.2	0.5	0.04	143	0.44	0.3	0.6	0.04
		YH	135	0.42	0.3	0.5	0.04	130	0.47	0.4	0.6	0.04
MCHC*	g/dl	AH	283	40.88	26.7	77.4	7.70					
		YH	259	38.39	27.5	73.9	4.96					
BIOCHEMICAL CHARACTERISTICS												
Total Protein	g/l	AH	283	69.95	55.7	86.2	5.04					
		YH	265	68.59	56.2	83.2	4.08					
Albumin	g/l	AH	140	35.04	28.50	41.50	2.77	145	32.74	24.40	39.10	3.04
		YH	135	36.15	30.00	42.90	2.78	130	32.91	26.50	39.00	2.97
Phosphorus	mmol/l	AH	140	2.37	1.1	3.8	0.52	143	1.93	0.8	3.0	0.43
		YH	135	2.60	1.5	3.5	0.40	130	2.06	1.1	3.1	0.41
GGT*	IU	AH	140	36.90	17.00	211.00	23.16	145	24.14	10.00	422.00	33.86
		YH	135	29.54	16.00	139.00	13.77	130	24.62	12.00	83.00	9.75
Blood Urea Nitrogen	mmol/l	AH	140	10.91	6.7	16.0	1.79	143	10.69	5.8	15.3	1.93
		YH	135	10.15	6.5	13.5	1.38	130	11.15	5.7	14.7	1.56
Copper	umol/l	AH & YH	275	13.11	1.0	24.0	4.27	273	9.66	0.2	23.0	4.81
Vitamin B12*	pmol/l	AH & YH	275	151.20	<70.0#	1500.0	111.14	273	238.68	<70.0#	1100.0	146.09
GSHPx	kIU/l	AH & YH	85	7.56	0.9	29.7	6.89	88	9.96	1.7	29.9	6.78
Pepsinogen*	mU Tyrosine/l	AH	282	278.08	0	2719	403.34	142	365.82	0.0	2368.0	558.00
		YH	131	269.59	18.0	1522.0	527.92	127	373.56	0.0	2310.0	660.29

* Geometric means are reported instead of means

** Medians are reported instead of means because data was not normally distributed. Data were not subject to ANOVA as described in Appendix 3.71.

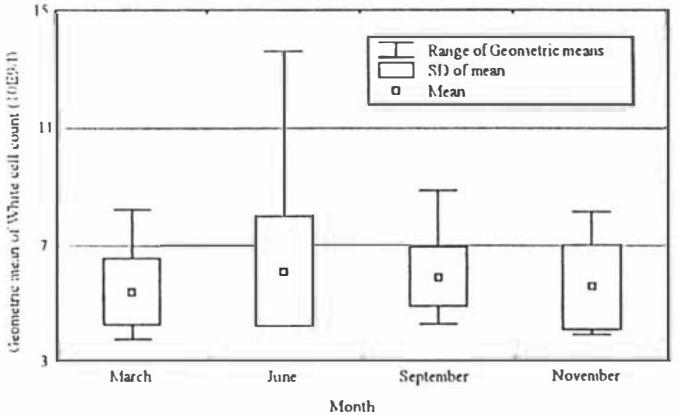
8 values were <70 pmol/l in March, the lower level of analytical sensitivity (1 value was <70 pmol/l in September). Values < 70pmol/l were entered arbitrarily as 65 pmol/l for statistical analyses.

SD = standard deviation; MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferase activity; GSHPx = glutathione peroxidase activity

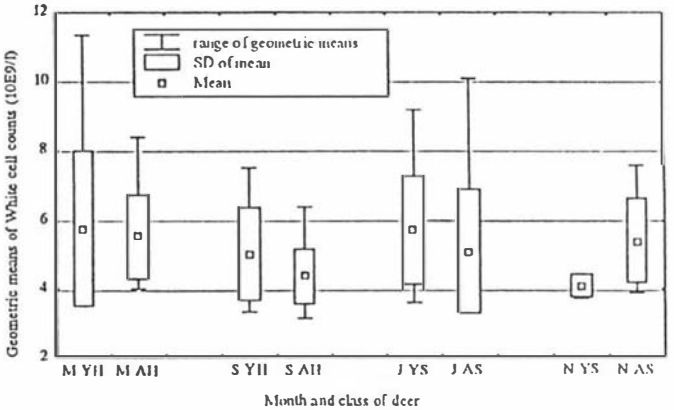
Note : Lymphocytes includes "Unusual lymphocytes".

Figure 3.44 : Means, standard deviation (±SD) and ranges of geometric mean white cell counts (10^9/l) and mean haemoglobin concentrations (g/l) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

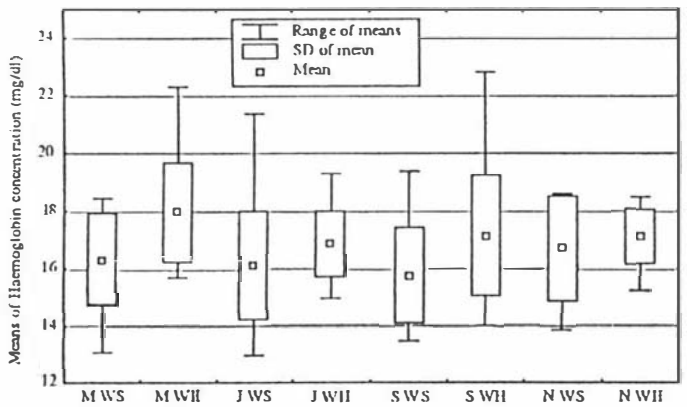
a. White cell count of weaners



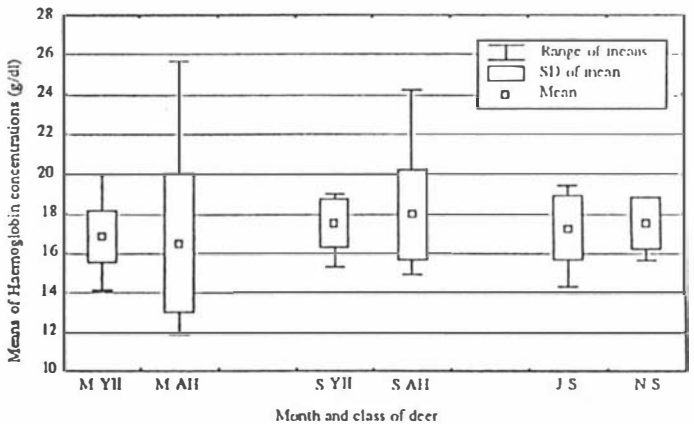
c. White cell count of yearling and adult hinds and stags



b. Haemoglobin of weaners



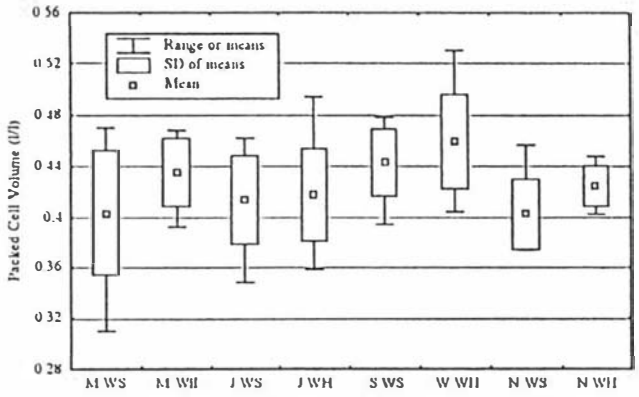
d. Haemoglobin of yearling and adult hinds and stags



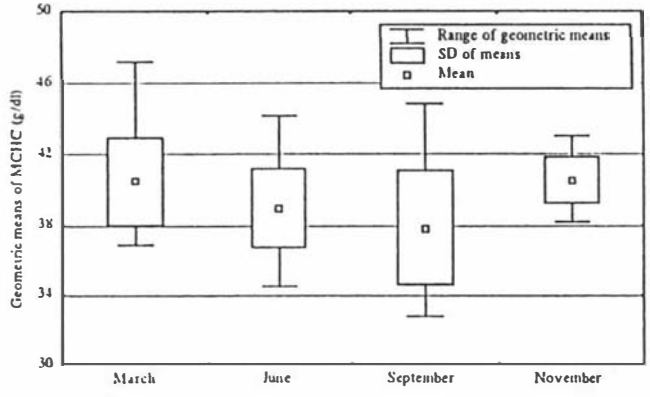
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags.

Figure 3.45 : Means, standard deviations (±SD) and ranges of mean packed cell volume (l/l) and geometric mean of mean cell haemoglobin concentrations (MCHC) (g/l) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

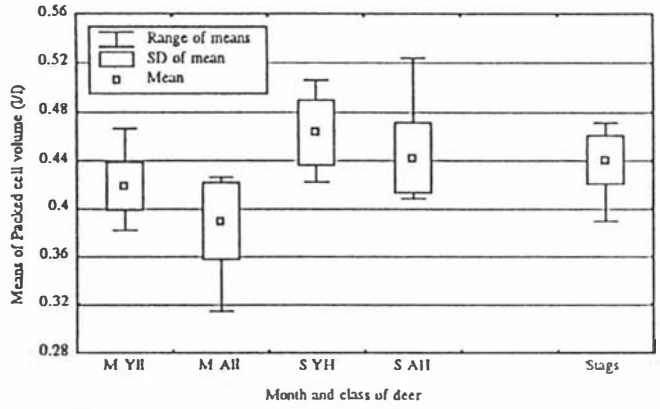
a. Packed cell volume of weaners



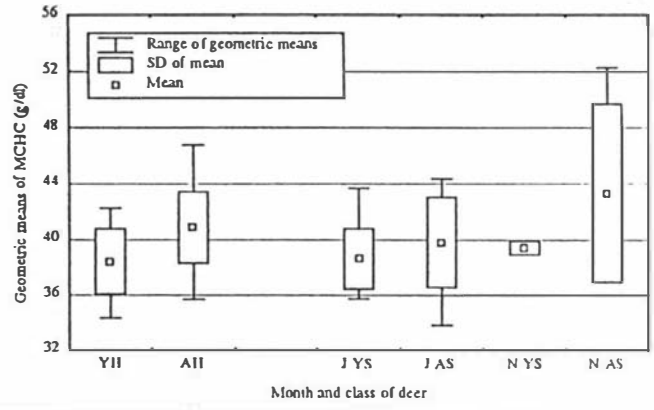
b. MCHC of weaners



c. Packed cell volume of yearling and adult deer



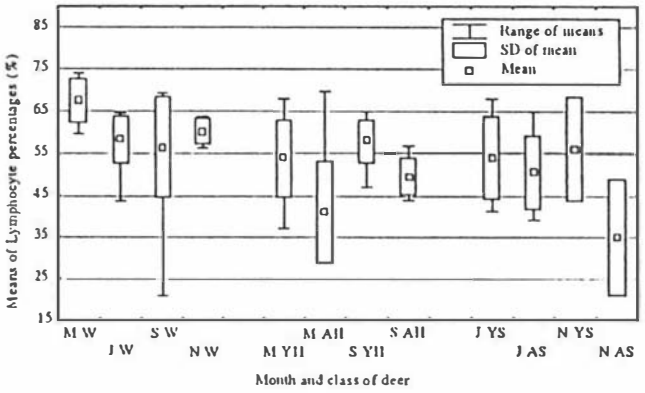
d. MCHC of yearling and adult hinds and stags



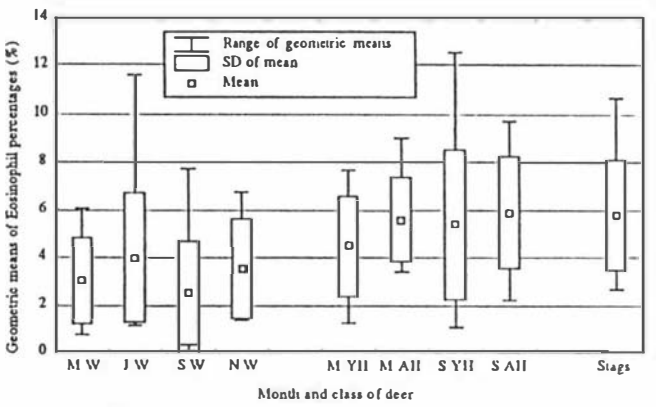
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags.

Figure 3.46 : Means, standard deviations (±SD) and ranges of mean lymphocyte, neutrophil, eosinophil and basophil percentage (%) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

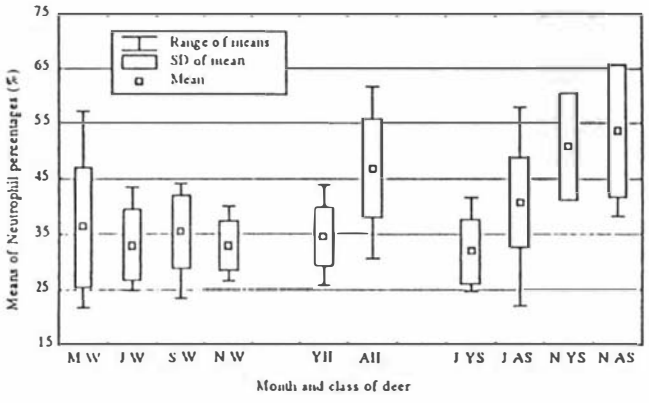
a. Lymphocyte percentage (%)



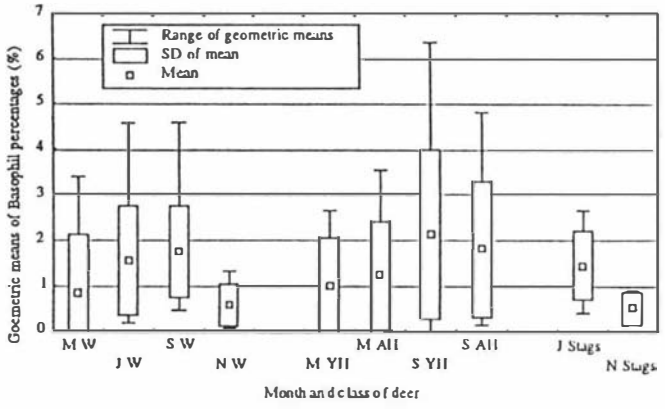
c. Eosinophil percentage (%)



b. Neutrophil percentage (%)



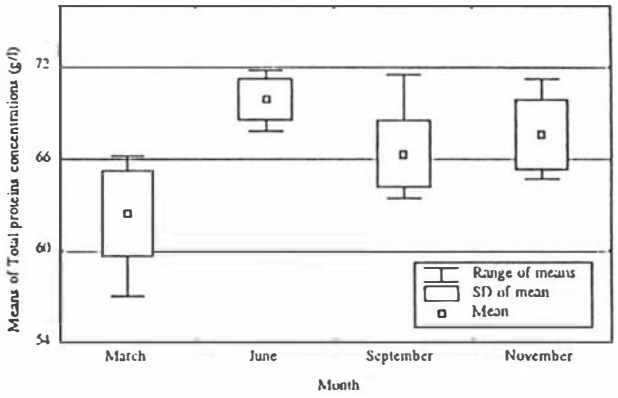
d. Basophil percentage (%)



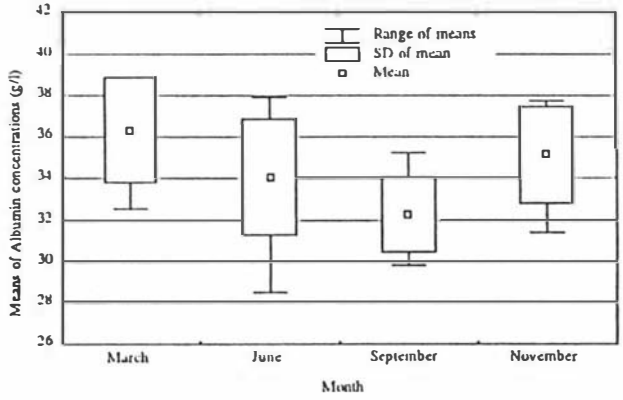
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags

Figure 3.47 : Means, standard deviations (±SD) and ranges of mean serum total protein and albumin concentrations (g/l) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

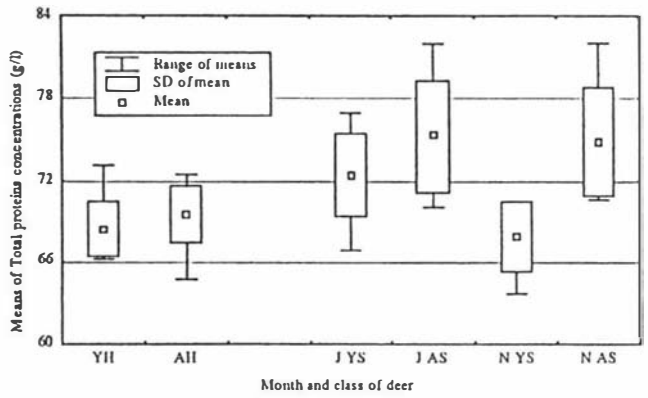
a. Serum total protein of weaners



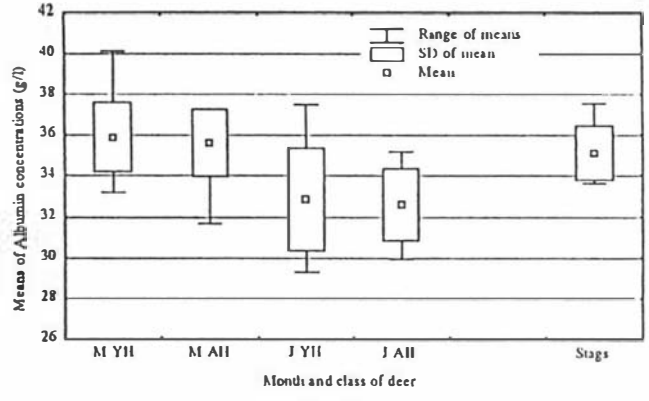
b. Serum albumin of weaners



c. Serum total protein of yearling and adult deer



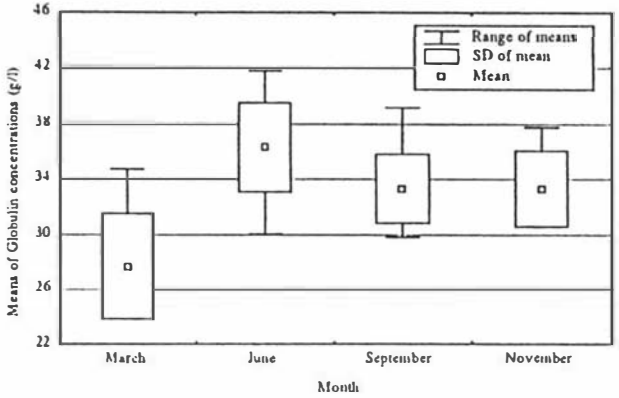
d. Serum albumin of yearling and adult deer



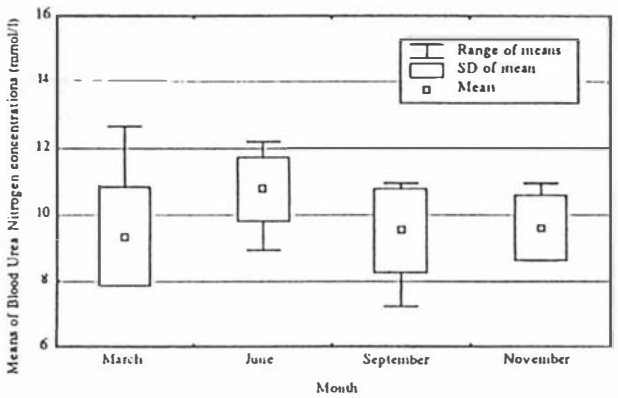
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags.

Figure 3.48 : Means, standard deviations (±SD) and ranges of mean serum globulin (g/l) and blood urea nitrogen concentrations (mmol/l) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

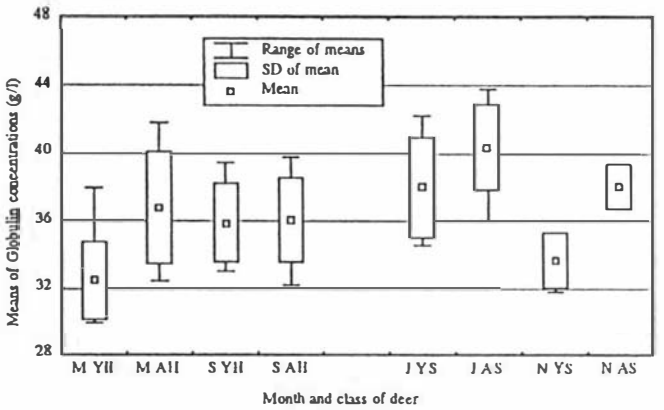
a. Serum globulin of weaners



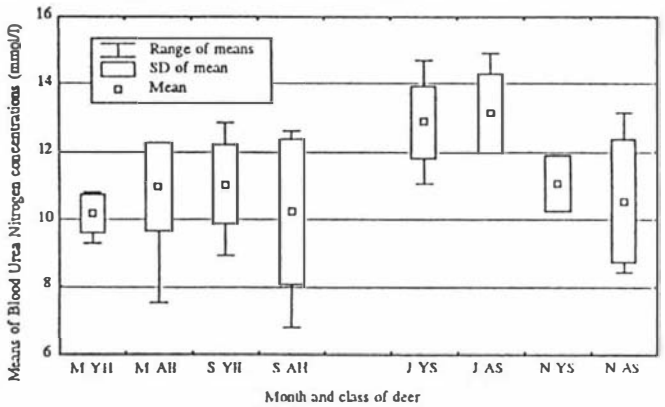
b. Blood urea nitrogen of weaners



c. Serum globulin of yearling and adult deer



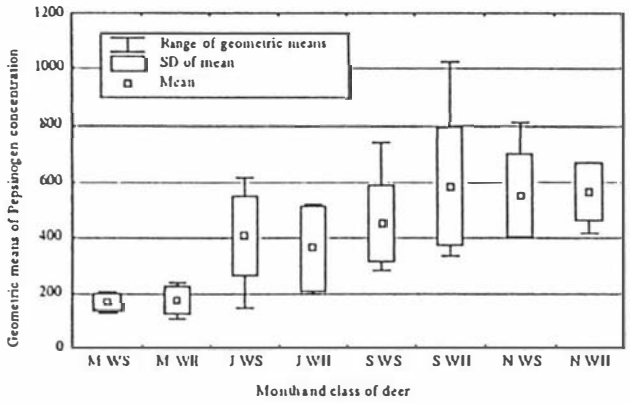
d. Blood urea nitrogen of yearling and adult deer



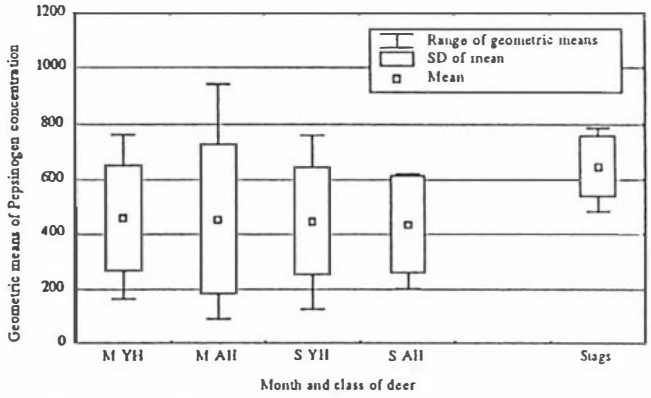
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags

Figure 3.49 : Means, standard deviations (±SD) and ranges of geometric mean pepsinogen (mU Tyrosine/l) and gamma glutamyl transferase activities (GGT) (IU) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

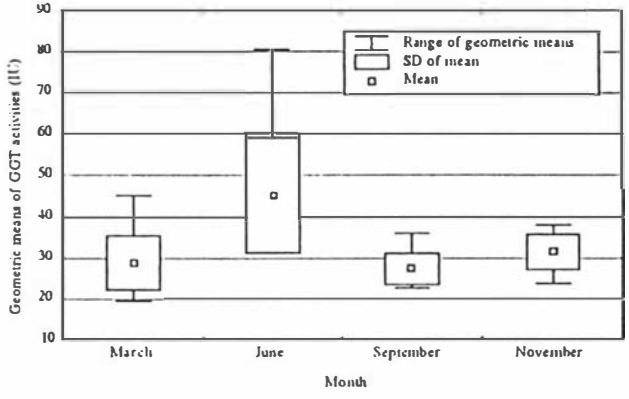
a. Serum pepsinogen of weaners



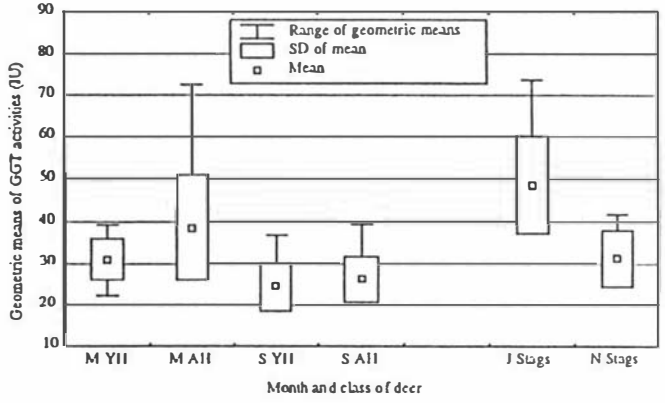
c. Serum pepsinogen of yearling and adult deer



b. GGT of weaners



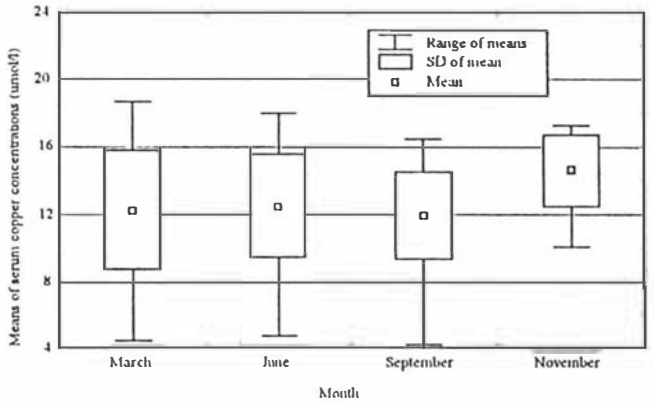
d. GGT of yearling and adult deer



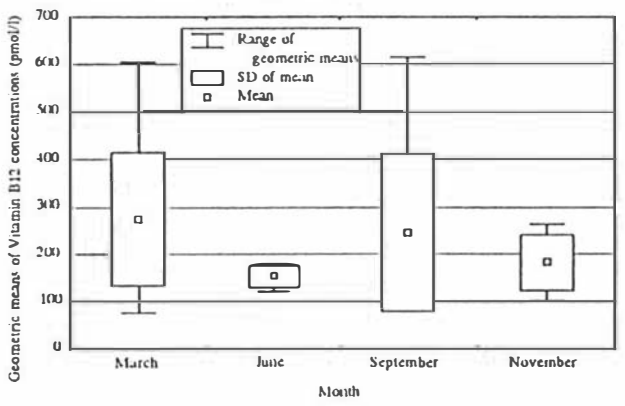
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags.

Figure 3.50 : Means, standard deviations (±SD) and ranges of mean serum copper (µmol/l) and vitamin B12 concentrations (pmol/l) of 10 weaners, 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

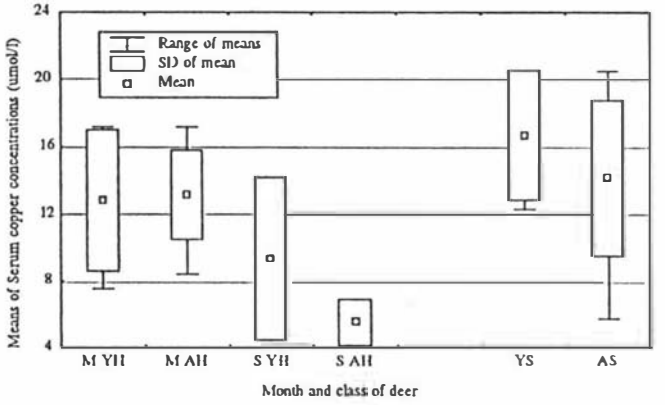
a. Serum copper of weaners



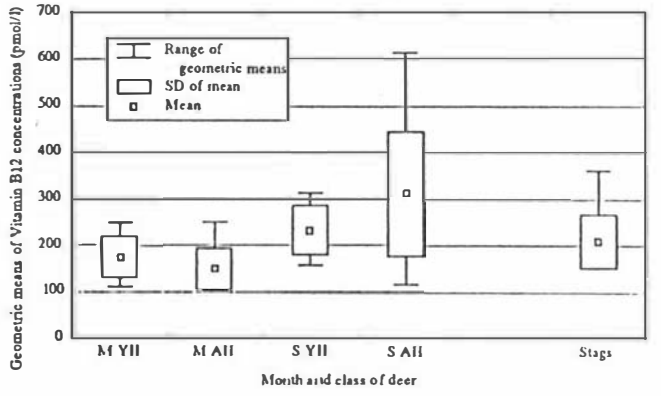
b. Serum vitamin B12 of weaners



c. Serum copper of yearling and adult deer



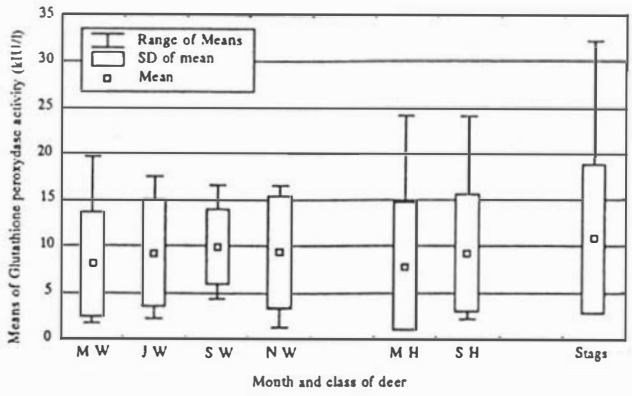
d. Serum vitamin B12 of yearling and adult deer



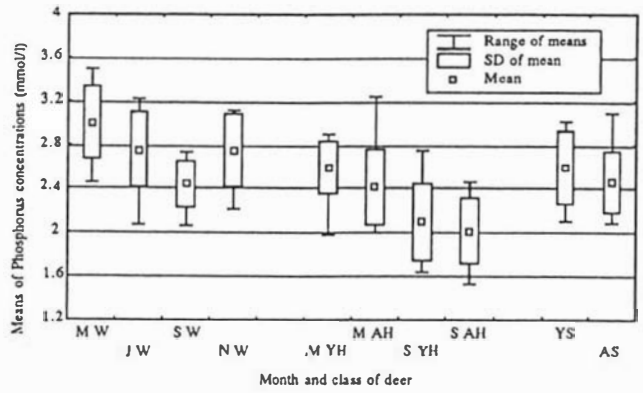
Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags.

Figure 3.51 : Means, standard deviations (±SD) and ranges of mean glutathione peroxidase activities (kIU/l) and serum phosphorus concentrations (mmol/l) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.

a. Glutathione peroxidase activity



b. Serum phosphorus concentrations



Note : Deer were sampled as described in section 2.4.1.1. Data were analysed separately for weaners, hinds (>15 months) and stags (>15 months), and were pooled for presentation where appropriate when there was no statistically significant difference between month, age or sex (see section 3.4.1.2 and Appendices 3.70 and 3.71).
M = March; J = June; S = September; N = November; WH = Weaner hinds; WS = Weaner stags; YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags.

3.4.3 Faecal egg and larval counts

3.4.3.1 Sentinel weaners

The distribution of faecal egg counts (FEC), and mean and range of geometric means of positive faecal larval counts (FLC) of sentinel weaners at each visit during the study are presented in Table 3.34. Distribution of faecal egg counts, geometric mean and range of positive lungworm larval counts of sentinel weaners on each farm and at each visit are presented in Appendix 3.75 and Appendix 3.76.

Table 3.34 : Percentage of sentinel weaners shedding faecal parasite eggs and lungworm larvae, and mean and range of geometric means (larvae/g) of positive faecal larval counts at each visit in 1992, 1993 and 1994.

Year and visit	Number of weaners	Weaners with FEC>0 (%)			FLC>0	Geometric mean FLC>0		
		50	100-150	> =200	%	Mean	Min	Max
February March								
1992†	129	19.4	13.2	9.3	65.9	14.5	0.3	162.0
1993‡	119	27.7	25.2	12.6	95.8	54.7	0.3	1807.5
1994‡	135	21.6	28.8	33.6	99.2	15.2	0.3	299.3
June								
1992	149	15.4	6.7	3.4	49.0	3.7	0.3	576.5
1993	139	20.1	15.8	2.2	48.9	3.6	0.3	173.3
September								
1992	150	18.7	6.7	1.3	70.7	4.3	0.3	108.5
1993	138	12.3	8.0	1.4	26.1	1.5	0.3	30.5
November								
1992	150	11.3	1.3	0.0	32.7	1.1	0.3	60.3

† 7 farmers had drenched their 10 sentinel calves before sampling
‡ Calves were sampled before the commencement of anthelmintic treatment
FEC = faecal egg count (egg per gram); FLC = faecal larval count (larvae per gram)
Min = minimum; Max = maximum

Prior to commencement of anthelmintic treatment, which started between January 28 and March 31 during the study years 1992-1994, 22.7, 24.9 and 21.1% of 313 calves shedded 50, 100-150 and 200 or more parasite eggs in the faeces, respectively (6 farms in 1992, all farms in 1993-1994). The percentage of these calves shedding lungworm larvae was 93.9%, with a range 0.25-1807.5 larvae per g. The second highest faecal larval count (FLC) was 855.8 larvae per g. No calves showed clinical signs of internal parasite infestation. There was no significant difference between stag and hind calves. Geometric means of positive faecal larval counts (FLC) ranged from 1.6 to 165.4 larvae per g, with a mean of 30.6 larvae per g. These geometric means were significantly higher ($p<0.01$) prior to commencement of drenching in 1992 than in 1993.

At the June visit, 13.5, 8.5 and 2.1% of 269 weaners shed 50, 100-150 and 200 or more parasite eggs in the faeces, respectively, and 37.4% had positive FLC, but many had been treated with anthelmintics from 1 to 66 days before sampling (see Appendix 3.77 and Appendix 3.78. There

was no significant reduction in the number of weaners shedding eggs in their faeces if they were sampled within 21 days post treatment (called here the treated group)(using the Chi-square test) compared with other weaners, but there was a significant ($p<0.01$) reduction in weaners shedding lungworm larvae. There was also a reduction of larval output in treated weaners. On one farm, however, the geometric mean of positive FLC was 19.7 larvae/g 3 days after anthelmintic treatment. These weaners were given 3 ml of Systamex, which is the recommended dosage for 15-kg weaners (see Table 3.12), whereas their bodyweights were on average 48 and 54 kg for hinds and stags, respectively, on May 1.

In September, 15.9, 7.4 and 1.4% of 283 weaners shed 50, 100-150 and 200 or more parasite eggs in the faeces, respectively, and 50.2% had positive FLC, which do not differ significantly ($p>0.05$) from June observations (using the Chi-square test). Here again, some farmers had treated their weaners with anthelmintics before the visit. However, weaners sampled within 21 days post-treatment shed significantly fewer ($p<0.01$) lungworm larvae, but not eggs, in their faeces than other weaners. Regardless of treatment group (there were not more treated weaners in 1993 than in 1992), there were less weaners shedding lungworm larvae, but not eggs, in September 1993 than in September 1992.

In November, only 3 farms had treated their weaners within 15 days of sampling which resulted in 6 weaners shedding faecal eggs and none shedding lungworm larvae. The rest of the sentinel weaners had low FEC and FLC compared to previous visits.

3.4.3.2 Sentinel hinds and stags

Distribution of faecal egg counts, geometric means and ranges of positive lungworm larval counts of sentinel hinds in March and June, and of sentinel stags in June and in November-December are presented in Appendix 3.77 and in Appendix 3.78.

The distributions of FEC of sentinel hinds in March and September and of sentinel stags in June and Nov-December over all farms are presented in Figure 3.52. One farm in March 1992 treated sentinel hinds with anthelmintics one day prior to sampling, and one farm treated sentinel stags 4 days prior to sampling. On the other farms, sentinel hinds and stags were sampled more than 25 days after anthelmintic treatment, when given. More than 65% of the time, faecal parasite eggs were not found, and no more than 11% of hinds or stags shed more than 100 eggs per g of faeces. The proportion of sentinel hinds shedding eggs in their faeces (and with higher counts) significantly increased ($p<0.01$) from March to September, and a similar observation was made in sentinel stags from November to June. There was no significant FEC distribution difference between years in hinds in March and stags in June, whereas the proportion of hinds shedding eggs in September was significantly higher ($p<0.01$) in 1993 (41.3%) than that in 1992 (26.5%).

The percentage of sentinel hinds in June and in September and stags in June and in November-December with positive faecal lungworm larval count (FLC) and respective geometric means of FLC over all farms are presented in Figure 3.53.

Figure 3.52 : Distributions of faecal egg counts (FEC in eggs/g) of sentinel hinds in March and September and of sentinel stags in June and in Nov-December. Data from 1992 and 1993 combined.

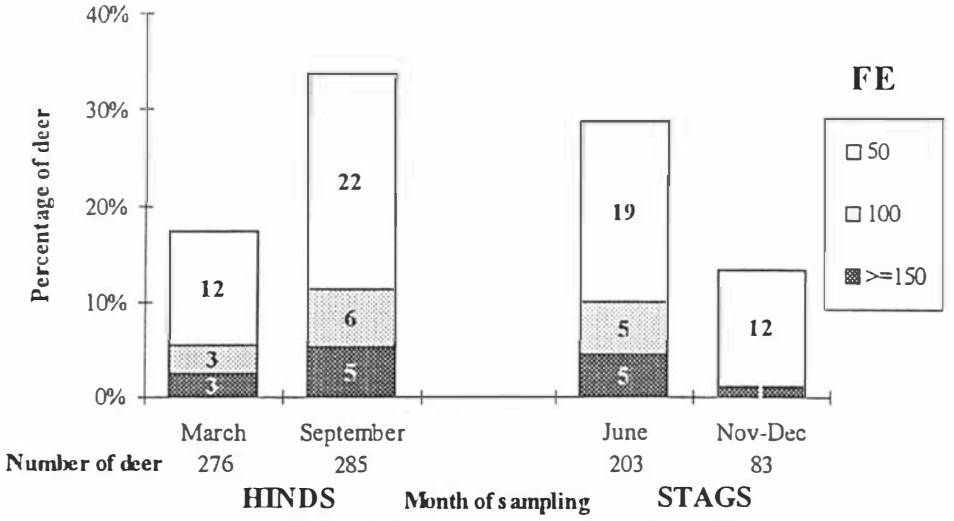
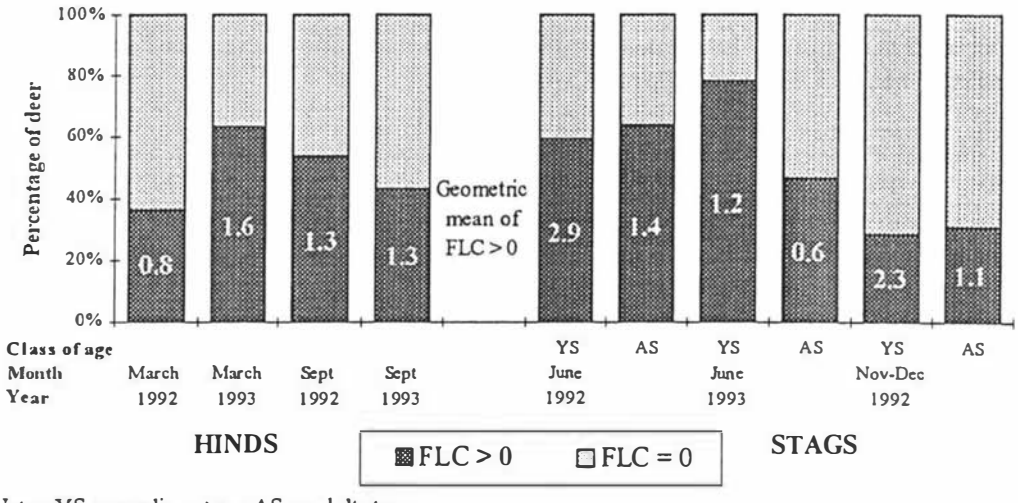


Figure 3.53 : Percentage of sentinel hinds in June and September and stags in June and November-December with positive faecal lungworm larval count (FLC) and respective overall geometric means of FLC all farms combined.



Note : YS = yearling stags; AS = adult stags

There was no significant difference in FLC between yearling and adult hinds (using the t-test). The number of sentinel hinds with positive FLC was significantly higher ($p<0.01$) in March 1993 than in March 1992, but there was no difference between years at the September visit, and between March and Setember both years combined (using the Chi-square test). The maximum FLC observed in hinds was 21.8 larvae/g in March and 31.5 larvae/g in September.

In contrast, yearling stags had significantly higher FLC than adult stags at each visit. However, the maximum geometric mean of FLC from both ages within farms at each visit was 3.9 larvae/g. The

maximum FLC observed in yearling and adult stags were 37.5 and 95.3 larvae/g in June, and 4.0 and 3.0 larvae/g in November-December, respectively. A higher proportion of yearling stags (but not adult stags) had positive FLC in June 1993 than in June 1992, although the overall geometric mean of FLC was lower. Significantly higher ($p<0.01$) proportions of both yearling and adult stags had positive FLC in June than in November-December (using the Chi-square test).

3.4.4 Serological investigations

3.4.4.1 Yersiniosis

The distribution of seroprevalences against *Yersinia pseudotuberculosis* in weaners in June and in September is presented in Figure 3.54. The overall seroprevalences are presented in Table 3.34. Detailed descriptions of seroconversions on each survey farm are presented in Appendix 3.79.

The distributions of seroprevalences were investigated using the Chi-square test. There was a significantly higher proportion ($p<0.01$) of weaners with positive serological test in June than in September for all three serotypes and both years, except serotype I in 1993. There was no seroreactivity distribution differences between the three serotypes in June both years and in September 1992. A significantly higher proportion ($p<0.01$) of weaners reacted against serotype I in June 1992 than in June 1993, and the converse was observed in September. A higher proportion of weaners were seropositive against serotypes II and III in September 1993 than in September 1992, but this was not observed in June.

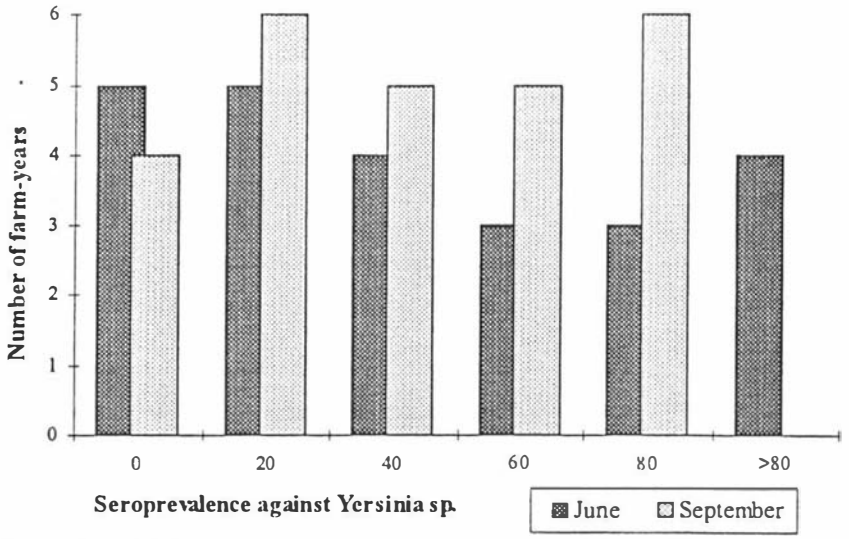
The maximum prevalence against serotype I, II or III within each farm ranged from 25 to 100%, and from 0 to 100% in June 1992 and 1993, respectively. In September, this seroprevalence ranged from 0 to 37.5% in 1992 and from 0 to 80% in 1993.

Table 3.35 : Seroprevalence (%) against *Yersinia pseudotuberculosis* in June and September 1992 and 1993 all farm combined.

Farm code	Number of deer†	Seroprevalence (%) against serotype : I	II	III
JUNE				
1992	106	54.7	39.6	43.4
1993	123	30.1	31.7	39.8
SEPTEMBER				
1992	84	7.1	2.4	6.0
1993	118	31.4	18.6	13.6

† Number of deer sampled in March and in June (JUNE) or in March and September (SEPTEMBER)

Figure 3.54 : Distribution of seroprevalence against *Yersinia pseudotuberculosis* in 10 weaners between farms. Data from 1992 and 1993 combined.



Notes : The method of measurement of seroprevalence is described in chapter 2 and Appendix 3.79

3.4.4.2 Leptospirosis

Serological investigations of antibodies against *Leptospira hardjo, L.pomona* and *L.copenhageni* were carried out, but the culture of *L.hardjo* was contaminated by *L.pomona* during the investigations, thus invalidating results. Serum titres were being further reanalysed at the time of writting and therefore this data is not presented in this thesis.

3.5 DISCUSSION

This chapter presents the most extensive collection of health and production data from commercial red deer farms currently available anywhere in the world. Previous studies have been of retrospective data by mail (Asher and Adam, 1985) or on-farm surveys (Friedel and Hudson, 1994) which are not as accurate as longitudinal studies to estimate population production parameters (Martin et al., 1987). On-farm longitudinal surveys of deer farms have been limited and generally involved a small number of farms for a limited period of time (Asher and Adam, 1985).

The amount of data collected during this study is substantial and covers a wide range of topics. This chapter is essentially descriptive. Statistical analyses were carried out to identify between year, farm, visit or animal variations. The objective of this section is to present information collected during the study and discuss farm management practices, animal individual characteristics and production outcomes of importance for the New Zealand industry.

Descriptive statistics of farm health and productivity parameters (see Table 2.37) are presented along with individual deer performance results. These statistics are complementary and are brought together to allow investigation of productivity of individual deer as well as that of farms as a whole. Although productivity targets may differ between farms or deer because of various constraints, it is suggested the 75th percentiles of performance parameters (and the 25th percentile of mortality rates) can be used on most farms as reasonable targets to improve productivity, and therefore may be adopted as such at the deer industry level.

Multivariate statistical and epidemiological analyses using this data are presented in Chapter 4, while the potential use of these data is presented in chapter 5.

3.5.1 Farm characteristics

3.5.1.1 The farmer profile

Farmer characteristics and farm productivity are often correlated (Faye, 1986; Tarabla and Dodd, 1990). Successful dairy farmers for instance were generally those able to create a farming environment which reduced animal stress and those who reacted promptly when production-limiting conditions arose. The nature of the human-animal relationship, which somehow is reflected in management practices, may impact on animal welfare and production (Hemsworth et al., 1991).

The personal characteristics of farmers presented in this chapter set the conditions under which the study was carried out. During farm visits, behavioural observations of farmers and deer were recorded but this data was deemed too subjective for further analysis. To use such data would have required independent observation which was beyond the scope of this project.

3.5.1.2 The deer stock

The sizes of deer herds in this study were representative of deer farms in New Zealand at the time of selection. In June 30 1990, there were 5210 deer farms in New Zealand and 976,290 deer. Half of the farms had between 100 and 1000 deer, and they contained 67% of all deer (Hutching, 1991). Thus, targeting farms in that size range was more likely to provide information applicable to the majority of farms.

Weaner blood line percentages at the start of the survey were better estimated when farmers had previous good records (eg on 5 farms). On these farms, English or European blood lines had already been introduced. On the other farms, weaners were of pure New Zealand origin, according to the farmers'recollection, thus this estimation may be less accurate. However, blood line percentages were more accurately recorded in 1993 since the composition of mating mobs in March-April 1992 was known.

3.5.2 Farm layout, handling facilities and paddock characteristics.

There was a wide range of yard design amongst survey farms, as also observed by other authors (Yerex ed, 1982; Moore et al., 1985; Hart, 1986; Haigh and Hudson, 1993; Fletcher, 1994). All systems were adequate except on one farm where stags could not be handled safely during the rut without a restraining device (on other farms, either stags were quiet enough to be handled in a pen, or a restraining device was used).

In this study, farms were mapped to compute paddock areas and facilitate farmers'recording of grazing management. Yards and lane measurements were taken with the original objective of investigating risk factors for overall behavioural pattern of deer mobs. However, since behavioural observations were subsequently deemed too subjective, yard characteristics were not analysed in this thesis. Descriptive data have been presented to provide baseline for further studies.

Deer paddocks were described with multiple variables (Table 2.4) used for calculation of mean paddock variables (see section 2.6.2.2.1.2.) and further analyses in Chapter 4. The multivariable analysis of 18 paddock variables in section 3.1.2.1.1. showed there are many significant interrelationships allowing a general farm profile to be established.

Fence pacing is commonly observed on deer farms and may be a response to the natural tendency of deer to move freely in the search of optimal environmental conditions (eg nutrition levels, social relationships, and shelter)(Moore et al., 1985). The fence pacing scores which measure the effect of such behaviour were considered high when over 2. If the assumption that fence pacing is a manifestation of deprivation of the freedom to express natural behaviour (one of the 5 freedoms in the definition of animal welfare (Mellor, 1992)), it could be proposed that 9-17% of paddocks on survey farms may not be optimal for deer. Further investigations (which was beyond the objectives of this study) are needed. Preliminary analyses of this data, however, suggested the fence pacing score to be negatively associated with the amount of trees in the paddock. Further evaluation of the role of trees in deer welfare will be necessary.

3.5.3 Farm management practices

3.5.3.1 Reproductive management

3.5.3.1.1 Culling and selection of breeding hinds

In New Zealand, the productive life of red hinds was thought to be around 10 years (Yerex ed, 1982), but red hinds have bred successfully up to 15 years (Hamilton et al., 1984 cited by Hamilton, 1988). The age pyramid of hinds in this study demonstrate that a large proportion of hinds are culled before 10 years of age, although some hinds with unknown age were likely to be over that age. The percentage of yearling hinds in the breeding herd (17.4%) was higher than the 8% of

replacement hinds recorded in Scotland (Hamilton, 1986 cited by Hamilton, 1988), which may be related to livestock prices. The culling of hinds increased in New Zealand following a drop in hind prices in 1991. However, the wide range of percentage of yearling hinds (0.8-35.8%) reflected the variety of management practices and/or development policies between farms.

Whereas culling of yearling hinds resulted mainly from poor reproductive performance, that of adult hinds resulted also from old age and/or severe teeth wear associated with poor body condition. It seems justified to cull old hinds with poor reproductive result as they may be exposed to ovarian failure (Fisher et al., 1994a). However, the 20.5% of yearling hinds culled during the first breeding season is considered high and suggests research should be implemented to identify the reasons for culling. Furthermore, culling hinds before 3 calvings has been shown to be not sustainable (Fennessy and Thompson, 1989).

3.5.3.1.2 Mating, pregnancy diagnosis, calving and lactation

It was believed the large variety of mating strategies, calving management practices and grazing management practices during lactation would include the key management factors explaining differences in reproductive success between farms and herds (see section 4.1).

Pregnancy testing by ultrasonography was not commonly practiced on survey farms before the study started. For commercial purposes, this technique can be used to identify and cull non-pregnant hinds at an early stage thus minimising food shortage during winter. Considering conception results of yearling hinds observed in this study, it may be appropriate to pre-select yearling hinds before mating (see section 4.1 for specific individual hind risk factors) and then keep only hinds conceiving early. Thus, investigation of pregnancy diagnosis related to reproductive outcomes has yielded a useful, practical and economical way for monitoring reproductive performance in commercial deer herds.

At weaning, it was a widespread practice to check the development of the udder to identify non-lactating (dry) hinds, which were often culled. In this study, however, over 4212 hinds weaned, there were 37 more calves weaned than lactating hinds recorded at weaning. Thus some cross-suckling occurred, and while the hinds were considered dry at weaning, some offspring had obviously survived.

This discrepancy may be caused by twinning, although it has been recorded only rarely in red deer (Guinness and Fletcher, 1971 and MacNally, 1982 cited by Fisher et al., 1989). Twinning rates from 1:100 to 1:200 have been reported (Wilson, 1984c). The discrepancy may also be caused by cross-suckling which is not uncommon in red deer (Haigh and Hudson, 1993; Fisher et al., 1994b). On one farm that kept good records in 1992, 27 calves were weaned from 26 hinds (all lactating) in one mob, while 35 calves were weaned from 36 hinds in another mob, of which 32 were lactating). Six calves were significantly lighter than other calves in the mob, which suggests 3 hinds reared 2 calves each. Whereas in the first mob there must be twins, it was believed twinning was unlikely in the second mob. Alternatively, discrepencies may have resulted from mis-observation or mis-recording. Palpation of the udder was thought the most accurate technique, but actually very few farmers performed it. Instead, udders were observed from a distance behind the hind which was often done quickly and this may not be the most accurate method. However, this data is the first confirming the occurrence of surrogate rearing of calves in commercial deer herds.

3.5.3.1.3 Weaning procedures

There was a wide range of weaning procedures between farms which were often motivated by the desire to minimise the stress of calves associated with weaning, thus minimising the risk of losses through injuries or temporary reduction of food intake. Although basic requirements for weaning deer calves are known, limited research to date has been carried out on weaning procedures specific for deer (Pollard et al., 1992). Most farmers weaned their calves prior to joining hinds with sire stags, although some weaned in late March. There are practical advantages in weaning prior to mating (Wilson, 1979, 1984c). Pregnancy diagnosis confirmed that the first oestrus in red hinds occurred in the second half of March, as suggested by Asher and Fisher (1991).

3.5.3.2 Nutrition

Nutrition of red deer has been well reviewed (Kay and Staines, 1981).
In this study, estimation of nutrition of deer was based on assessment of pasture quantity, quality and deer body condition, rather than through a planned feed budgeting exercise (Fraser and Stantiall, 1988). Feed supplementation usually occurred during periods of pasture shortage (eg during winter) or for animal handling purposes (eg supplementation of weaners after weaning). Nutrition management practices recorded by farmers for each mob of deer (pasture characteristics and food supplements) were analysed specifically as risk factors for health and production outcomes, and therefore are presented and discussed in Chapter 4.

The recording of pasture characteristics over the whole farm during farm visits by the researcher assessed overall farm management and validated comparison between farms. The accuracy of the pasture plate used to estimate pasture covers is limited (Thomson, personnal communication) as its calibration varies according to topography, pasture type and quality (eg there are seasonal variations). However it was a valid technique to identify between-farm variations. The highly significant correlation between mean pasture covers and mean sward heights shows the use of a simple ruler may be as effective in estimating the overall farm pasture cover as it is cheaper, easier and quicker to carry out.

On most farms, pasture covers and sward heights were low during winter. It was impossible to investigate the relationship between overall pasture covers and farm performance because of the diversity of production and management systems (eg velvet antler, reproduction, venison, use of other domestic livestock) between farms. Therefore, analyses were carried out on the grazing history of individual deer (section 2.6.2.2.1) as identified from grazing records of deer mobs (see Chapter 4 in all sections).

3.5.3.3 Health management

Implementation of disease control programmes were essentially motivated by "traditional" practices, and farmer's personal perception on what should be done, based on their knowledge and previous experience of health problems. This is against veterinary advice that disease control programmes should be tailored made, along with other management practices, and adapted to the actual health status of the deer herd (Scott, 1987). However, this survey would suggest that lack of planned and controlled approach to deal with health and production issues is widespread in New Zealand deer farms. In this study, since farmers were not aware of laboratory test results, it is believed sub-clinical and clinical problems were more likely to develop without farmer's intervention (ie copper deficiency with or without osteochondrosis and enzootic ataxia (Audigé et al., 1993a, 1995)).

3.5.3.4 Velvet antler harvesting

The choice of technique of velvet antler removal varied according to farmer's ability and desires and the adequacy of handling facilities. The requirement for antler quality, achieved through financial penalties put on overgrown velvet, ensures velvet antlers were harvested at the right stage of growth. Therefore, antler production between farms can be compared. Ideally, however, weights should be corrected for days of growth, but recording of antler casting date which would have allowed this adjustment was performed by only 5 farmers, thus preventing this analysis.

The timing of harvesting of spikes at 1 year of age was recorded, but not the spike weight, because it was not considered a major outcome. Furthermore many farmers cut spikes at various stages of growth (from velvet to calcified spike), thus limiting the validity of the data for comparison between farms. The harvesting of velvet regrowth was not recorded because of its limited significance compared with the first harvest.

3.5.4 Herd health and production outcomes

3.5.4.1 Hind performance

3.5.4.1.1 Hind weights and condition scores

There was a wide range of pre-mating bodyweights for both yearling and adult hinds, but almost all hinds were over the threshold weight of 65 kg under which they were reported to be at risk of not conceiving (Hamilton and Blaxter, 1980). Bodyweights of breeding hinds at 15 months of age were 49.7-63.0 in the UK (Blaxter et al., 1981), while Suttie et al. (1987), in New Zealand, recorded yearling hind bodyweights of 71-101 kg. These latter hinds, however, were fed indoors ad libitum, so their bodyweight cannot be used to estimate that of hinds on commercial farms. Overall, in this study, yearling hinds achieved the minimum mean pre-mating bodyweight of 80 kg that is required to acheive 90% fertility rate (Fennessy et al., 1986). Moore et al. (1988c) estimated the percentage of mature bodyweight (the mean bodyweight of 5-7 year old hinds) of yearling hinds pre-mating to be 72%. Such calculation was not possible in this study because of blood line differences between yearling and adult hinds (see Table 3.7). Adult hind pre-mating bodyweights in this study averaged 97-98 kg which approximates those reported by Moore et al. (1988c). These latter authors pointed out the large difference in mature hind bodyweight between Invermay (mean 100 kg plus) and Glensaugh (mean 82 kg in Blaxter et al., 1981) research station, which reflects variation in genetic and environmental conditions.

The intensive investigation of body condition scores (BCS) of farmed red hinds presented in this thesis is, to the authors'knowledge, unique. No other conditon scores for use in deer have been published in the scientific literature. Comparison with other studies therefore can not be made. There was a range of condition scores throughout the study within and between farms which allows further investigation of associations with farm management practices and reproductive performance (see next chapter). From mating to weaning, there was a clear drop in body condition score of yearling hinds, and this may reflect the nutritional stress imposed upon these hinds during their first reproductive and lactational season. Adult hinds were not affected as much, although seasonal variation occurred. In 1993, the mean BCS of adult hinds dropped during lactation, possibly because of the rather dry environmental conditions encountered, resulting in poor nutrition. The scoring system developed in this study appeared to be a very valuable tool to investigate the

adequacy of farm management practices (including nutrition levels) on red hinds, and this warrants its use for further hind nutrition studies.

Consequently, the validation of this scoring chart was justified, as scoring differences may occur between assessors (Janssen et al., 1985). In this study, there was no significant interaction between hind and score, so the corresponding interaction term was removed for final calculations. This was expected since the hind body condition could not have changed between the two assessments that were done the same day no more than 2 hours apart (Evans, 1978b). The repeatability and reproducibility of BCS in both yearling and adult hinds were above 0.78, which were higher than those observed in cows and ewes (Evans, 1978b). These results were considered satisfactory.

That the interaction term "hind x assessor" was statistically significant suggests the scoring chart should be carefully described. Training of assessors may be necessary to ensure consistency of scoring and close interpretation of condition status if comparisons are to be made between studies (Janssen et al., 1985).

3.5.4.1.2 Hind conception

This is the first major published study of reproduction on commercial deer herds that has employed ultrasonography to determine pregnancy status. In other surveys, only calving rates were reported as the measure of hind fertility (Hudson et al., 1991; Friedel and Hudson, 1994). The development of ultrasound pregnancy diagnosis and foetal ageing in red deer in New Zealand (Bingham et al., 1990; Wilson and Bingham, 1990; Revol and Wilson, 1991) enabled the investigation of pregnancy status at an earlier stage. The conception rates of red deer presented in this chapter are currently the most accurate estimates for the farmed red population of New Zealand.

The overall pregnancy rates of adult hinds is satisfactory, although the range between farms suggests improvement is acheivable for herds having fewer than 90% of hinds conceiving before May 1. Data suggests also that 2-3% of empty adult hinds is very common, which is close to the 4.3% reported from wapiti farms (Friedel and Hudson, 1994). The higher percentage of adult hinds not pregnant in one farm in 1993 (15.4%) was caused by the failure of a newly introduced young stag in one mating mob (the conception rate was 62%), exacerbated by a lack of back-up stag and a mating interval that concluded in late April.

As pregnancy test results were available, most farmers culled not pregnant or late conceived hinds in winter (Appendix 3.15). This practice may have had a positive effect on pregnancy rates in 1993, since hinds rearing a calf at weaning were identified more likely to conceive before May 1 than hinds not rearing a calf the previous season (see section 4.1).

Pregnancy rates of yearling hinds were low and represent a considerable waste factor for the industry. A similar result was recorded by Fennessy et al. (1986). Despite an overall increased percentage of hinds conceiving before May 1 in 1993, there was still a wide range of results between farms and between mating mobs, suggesting that substantial productivity gains can be made in some herds.

3.5.4.1.3 Calving

The overlap of calving date distribution between early and late conception groups can be explained by the variability of pregnancy duration between individual hinds. Gestation lengths were reported to be about 233 days in red deer (Asher and Fisher, 1991), but may be increased when large sires of European origin are used, as observed with wapiti cross sires (Fisher and Fennessy, 1985; Moore, 1985). Individual characteristics such as the calf birth weight (Fennessy et al., 1990), which is associated with the dam age in wapiti (Hudson et al., 1991), affect gestation length.

Observations of foetuses suggested first conceptions occurred late March, which is earlier than those recorded 15 years ago (Kelly and Moore, 1977). Consequently, median calving dates in this study ranged from Nov 26-Dec 6 and from Nov 26-Dec 15 in adult and yearling hinds, respectively. This compares with earlier reported starting dates of Nov 29-Dec 5 (Kelly and Moore, 1977), all hinds combined. Median calving dates of red hinds (10% of which were yearling hinds) in New Zealand in 1980 and 1981 were Dec 14 and Dec 7, respectively (Asher and Adam, 1985), while Moore et al. (1988c) reported a shift from Dec 6-22 to Nov 16-Dec 6, from 1973-74 to 1982-83 (most hinds were adults). This suggests that a considerable shift of calving dates occurred in the decade before the early 1990's as seen in this study.

In this study there was no evidence of younger hinds producing more female calves as observed in a wild environment (Clutton-Brock et al., 1982), nor male calves as observed in farmed wapiti hinds (Hudson et al., 1991; Haigh and Hudson, 1993). There was also no birth date difference between male and female calves as observed in wapiti (Hudson et al., 1991; Friedel and Hudson, 1994)).

From conception rates and foetal loss estimates and accounting for deer removed from properties, the overall calving rates (calves produced / hinds mated) were 84% and 96% in yearling (Y) and adult (A) hinds, respectively, which was higher than most calving rates recorded earlier in red deer in New Zealand (90% with 10% of Y in the mob)(Asher and Adam, 1985), in fallow deer in New Zealand (76-91% with 2-20% of Y does, respectively) (Asher and Adam, 1985) and Australia (87%, the proportion of Y unknown)(Mulley and English, 1991) and wapiti herds in Canada (90% of A)(Hudson et al, 1991). These estimates, however, were reported as "minimum calving rates" which may indicate that calving rates were underestimated, and were not an absolute estimate of hind fertility in these studies. Friedel and Hudson (1994) recorded calving rates of 81 and 96% in yearling and adult wapiti cows, respectively, using farmers'pre-existing records, which are significantly higher than those reported by Hudson et al. (1991) from a limited number of research cows.

3.5.4.1.4 Weaning rates and reproductive efficiency

Other authors generally agree that adult red hinds can achieve weaning rates between 85 and 90% (Kelly and Moore, 1977; Hamilton et al., 1984 cited by Hamilton, 1988; Haigh and Hudson, 1993). In contrast, there was a lack of published information on the actual performance of yearling red hinds on commercial farms. Reports from wild populations show highly variable breeding percentages (ranging from 0 to 50% ovulation rate)(Wegge, 1975). In this respect, the reproductive efficiency of yearling hinds in this study (70%) is very close to the 73.6% recorded on wapiti farms in Canada (Friedel and Hudson, 1994). This study showed, however, that there is a vast range of reproductive efficiency between farms (from 25 to 91.7%), with a mean of 68.7%, which suggests that 80% (the upper quartile is 81.2%) is a realistic goal for commercial farms, and thus considerable improvement can be achieved on some farms.

The sex ratio was 50:50 overall, which is consistent with observations made by Blaxter and Hamilton (1980) This is also consistent with the observation of Moore et al., 1988c, who reported a 50:50 ratio at weaning, although there was an overall 51:49 ratio in favour of females at birth, but the authors suggested it may be related to a highest mortality rate being in light calves (most often females). These authors, however, reported that calf sex ratios were very inconsistant over the years, ranging from 61:39 to 40:60 (Moore et al., 1988c).

Average weaner weight produced per hind at mating has been used as an index for performance (Blaxter and Hamilton, 1980). These authors recorded on average 25-30 kg weaner weight produced per hind mated, which is well below the 42.7 kg recorded in this study.

3.5.4.2 Weaner growth and venison production

Bodyweights and growth rates of weaner deer presented in this thesis are currently the best estimates of what is achieved on commercial red deer farms in New Zealand.

Data confirms the seasonal bodyweight gain patterns of weaners, which is intermediate in autumn, low in winter and high in spring as reported elsewhere (Fennessy, 1982; Kay, 1985; Semiadi et al., 1992). The reduced potential for growth in winter due to reduced appetite is well documented (Barry et al., 1991).

Suttie et al., 1987 showed a pattern of growth for weaner hinds from about 48 kg at 3 months to 89 kg (range 71-101 kg) at 15 months of age. Weaner stags (Fennessy and Corson unpublished cited by Suttie et al., 1987) show a similar growth during winter and then higher in spring-summer up to about 110-120 kg. This was related to the development of sexual dimorphism at about 6 months of age caused by the increased secretion of testosterone (Suttie et al., 1984).

To the author's knowledge, there have been few published bodyweights and growth rates from commercial farms. Most come from research stations in the UK (Blaxter et al., 1981; Hamilton and Blaxter, 1981; Milne et al., 1987) and in New Zealand (Moore et al., 1988a, 1988c)(Table 1.3), while occasional data from monitored commercial farms can be found (Adam and Asher, 1986). These latter authors reported similar growth rates for weaner stags to those recorded in this study.

Grazing experiments are useful to evaluate the potential benefit of management options for existing pastures or alternative forages (Ataja et al., 1989,1992); Semiadi et al., 1992; Barry et al., 1993; Semiadi et al., 1992; Niezen et al., 1993; Semiadi et al., 1993), but growth rates and bodyweights cannot be extrapolated to commercial farms. At best that data highlights the genetic potential of the deer for growth under optimal conditions.

This study shows there are wide variations of mean weaner bodyweights and growth rates between farms. For example, mean winter growth rates of weaner stags ranged from 7.5 to 185.2 g/d (see Appendix 3.47), or mean weaner stag bodyweights on December 1 ranged from 76.1 to 102.9 kg. This suggests that improvement is achievable on many farms. Target bodyweights for New Zealand red deer reported by Haigh and Hudson (1993) (48, 60, 70 and 80 kg bodyweight for weaner stags at 3, 6, 9, 12 months of age) are close to mean bodyweights recorded in this study, but this may be due to the 25% wapiti genes in many weaners in 1993.

Furthermore, this study has shown that, overall, only 8.7 and 14.2% of weaner stags (born on the farm or bought before winter) reached the target of 92 kg by December 1, in 1992 and 1993, respectively. Achievement of this target ranged from 0 to 41%, and from 0 to 48% between farms in 1992 and 1993, respectively, which suggests there is room for considerable improvement. However, it may be difficult to achieve more than 50% of weaner stags grazing on conventional ryegrass/white clover pasture reaching that target weight, despite the claim that up to 75% of red weaner stags can reach 92 kg by the end of November under high plane of nutrition. (Semiadi et al., 1992, 1993). On perennial ryegrass/white clover pasture grazed at 10 cm height, 42% of weaner stags reached 92 kg by the end of November, while none of those grazing on 5-cm swards did (Ataja et al., 1992).

It is also believed that weaner hind bodyweight can be improved as nutritional allowances may not have been optimal on most farms. The importance of hind bodyweight at 15 months of age as been stressed elsewhere (see section 4.1). Risk factors for weaner bodyweight and growth are presented in sections 4.3 and 4.4.

3.5.4.3 Stag bodyweight and velvet antler production

The relationship between bodyweight and date of spike removal was expected as, in weaner stags, the timing of pedicle initiation and consequently velvet growth is a function of weight associated with diet and age (Fennessy, 1982; Suttie and Kay, 1982).

Stag bodyweights were similar to data presented by Moore et al. (1988b), in which bodyweights of stags at 15 months of age were 95-101 kg, 123-131 kg at 26 months, and 161-183 kg over 26 months. In this study, however, wider ranges of bodyweights were recorded (see Appendix 3.49 and Appendix 3.50) due to farm variations and the larger number of stags under investigation. The importance of stag bodyweight with regard to velvet production is discussed in section 4.5.

Between the 1992 and 1993 harvesting season, there was a minor change in the grading system of velvet antler which increased the proportion of high grade categories (Isaacs, GIB, personal communication) although it is not known whether it was statistically significant. Over the whole New Zealand velvet herd, the largest increase was in B grade, rising from 18 to 30% of total (Anonymous, 1994a). The average weight of adult stag velvet in this study increased from 1.94 to 2.15 kg from 1992 to 1993, but there was no such increase in yearling (rising-2-year-old) stags. This suggests that farmers may have culled from their adult velvet herd between 1992 and 1993 based on previous velvet records, which did not affect yearling stags. A further explanation could be the ageing of the velvet herd (Anonymous, 1994a) (see Table 3.5). Fennessy (1981) reported velvet weights of red deer to be 1-1.2, 1.5-1.6, 1.9-2.0 and 2.1-2.4 kg at 2, 3, 4 and 5 years old, respectively. Haigh and Hudson (1993) presented a similar weight curve with a slower increase from 4 to 8-9 years old up to 3-3.5 kg velvet. A significant increase of velvet weight between 3 and 5 years of age has also been shown by Moore et al. (1988b)(0.73-0.89 kg at 3 years, 0.96 kg at 4 years and 1.16 kg at 5 years old). A more detailed discussion of the effect of age on velvet production is presented in section 4.5. Alternatively, there may have been a better velvet antler growing season in adult stags (see section 4.5 for risk factor analysis).

In 1978-1982, yearling stags (rising-2-year-old) at Invermay produced 0.48-0.51 kg of velvet (Moore et al., 1988b), which is significantly lower than the 1.16 and 1.19 kg recorded in this study in 1992 and 1993, respectively.

The 10% shift of grade D velvet to grade C velvet in yearling stags (rising-2-year-old) may be essentially related to the change in the grading system, which is further supported by the minor decrease of the mean velvet antler weight in the C grade category.

3.5.4.4 Health problems and mortality rates

Final mortality results presented in this paper do not differ greatly from preliminary estimations presented previously (Audigé et al., 1993b). This is the first survey of deer mortality on commercial farms carried out in New Zealand, although attempts have been made to estimate the relative prevalence of diseases observed on farms (Beatson, 1981, 1985; Gladden, 1981).

The monthly distribution of deer mortalities confirms a seasonal variation with the highest mortality rates for yearling and adult deer were between June and October. During the survey, about 20-30 deer were recorded as missing but it was not possible to know whether they died, escaped from the mob when being mustered to the yards, escaped outside the farm or simply lost their ear-tag. These deer were not included in the mortality list.

3.5.4.4.1 Adult deer

Over two years, annual mortality rates of 1.77 and 2.56 per 100 hind-years and stag-years, respectively, were higher than the 1.3 and 1.9 recorded for hinds and stags at Invermay over 11 years (Moore et al., 1988c). In the UK, Blaxter et al. (1981) reported a mean annual hind mortality rate of 1.84% (17/924) from the Glensaugh research farm. This shows mortality in farm deer over 15 months is not a major production limiting factor, in contrast with the 4.6% mortality rate reported for adult ewes (Quinlivan, 1971).

Malignant catarrhal fever (MCF) alone killed 0.53 stags and 0.17 hinds per 100 deer-years at risk, respectively, with an overall annual mortality rate due to this disease of 0.31 per 100 yearling and adult deer-years at risk in this study. This figure is lower than the 1.1% mortality rate (risk) due to MCF estimated by Beatson (1984) in Canterbury, although this may reflect a regional difference. Beatson (1984) also observed a higher incidence of MCF in stags (0.8% versus 0.4% in hinds). No chronic cases presented with nasal or ocular discharges occasionally observed elsewhere with this condition. Most deaths occurred after a prolonged period of fading that lasted up to 4 months, with or without scouring. It was difficult to ascertain whether MCF was the primary cause or a complication of the fading condition. One chronic case had extensive thickening of blood vessels ("periarteritis nodosa-like") in many organs (eg liver, kidneys, pampiniform plexus) reported in the chronic form of MCF in deer (Wilson et al., 1983; Johnstone, 1993). In this study, it is possible that most chronic cases of MCF have been diagnosed as they are easily noticed by farmers. Since a significant proportion of cause of death could not be confirmed, it is possible that many of them be due to acute MCF. Therefore the proportion of cases of MCF diagnosed in this study being chronic forms may be overestimated. It is possible, however, that some unconfirmed deaths associated with fading may be caused by acute or chronic MCF.

3.5.4.4.2 Weaners

Mortality rates of weaner deer on most farms were between 2 and 3 per 100 weaner-years, but on some farms losses were considerably higher, raising the overall figure to 5.87 per 100 weaner-years. Blaxter et al. (1981) recorded a 11.6% mortality rate (risk) of weaner deer through winter and summer, with a peak (12.9%) in the two months after weaning, followed by a decrease in summer

(0.5%). These authors concluded that year to year variations of weaner mortality was due to peculiar rather than regular causes and thus weaner mortality could be reduced. The lower mortality rate recorded in this study may be related to differences in environmental conditions, ie climate, husbandry and nutrition, between the UK and New Zealand. However, seasonal distributions are consistent.

In this study, the most frequent mortality factors overall were related to misadventure, which include injuries, broken bones and acute stress problems. Most occurred in autumn and were related to yarding around weaning. Although misadventure may affect individual weaners randomly, it was believed to be a herd or farm problem. It is the author's personal view that the behaviour of calves at weaning may be related to that of their dam and to handling and weaning practices. This will need to be evaluated.

Yersiniosis is an important cause of weaner mortality. One farm in 1993 lost 17.5% and 11.5% of weaner deer at risk during autumn and winter, respectively, through an outbreak of yersiniosis. Since almost all weaners on that farm were sold before the end of June, and no weaner died in the second half of the year, the calculated annual mortality rate of 30.3 per 100 weaner-years may be better expressed as 15.2 per 100 weaner-6 months. Clinical yersiniosis occurred on one farm in 1993 where the suspected environmental risk factors, ie lack of shelter, poor nutrition, or adverse weather conditions (Mackintosh, 1992b), were not recorded. Thus specific risk factors may have triggered the clinical manifestation of the disease on these farms (see section 4.7).

A second farm experienced an outbreak of osteochondrosis associated with copper deficiency (Audigé et al., 1993a, 1995), which clinically affected up to 12% of calves at weaning and resulted in 9 weaners being euthanased over the study period. This outbreak was considered a sporadic event but should be of significance to herds with low copper status. Osteochondrosis may occur more frequently than recorded in this study, and go undiagnosed, given the large number of farms with low copper status in New Zealand (Harrison et al., 1989), and the possibility of confusing it with polyarthritis.

However, current knowledge of these health problems would suggest that many mortalities may be preventable through planned disease control programmes or appropriate handling. This study was carried out before the vaccine Yersiniavax was widely used. Farmers started vaccinating in 1993, mostly in the face of a clinical yersiniosis outbreak rather than preventively. Since most farmers in this study used this vaccine in 1994 after this study concluded, it would be appropriate to further monitor this health problem and the overall success of vaccination strategies. It was interesting to note that on one farm, 7 of 13 severely clinically affected weaners (including the ones that died) came from the same sire compared with 5 stags siring the remainder, thus supporting a similar observation by Mackintosh et al. (1990a) during a vaccination trial.

3.5.4.4.3 Progeny loss

Foetal and calf mortalities are a significant cause of loss to the farmer with an overall 17% and 9.1% of yearling and adult hinds, respectively, losing their progeny between June (date of pregnancy diagnosis) and weaning. This is higher than the 5-10% death rate from birth to weaning that was used as reference value 15 years ago (Round-Turner, 1979), or the 5.6% and 7.3-7.9% in red deer in the UK (Blaxter and Hamilton, 1980) and in New Zealand (Asher and Adam, 1985), respectively. Progeny loss rates of 9.5 and 4.4% were reported in yearling and adult wapiti hinds, respectively, in Canada (Friedel and Hudson, 1994). From 6 more closely monitored farms with 8.4% of yearling

hinds, however, Asher and Adam (1985) reported a 12.4% calf loss, which is similar to the equivalent figure of 10.4% recorded in this study. The higher calf mortality rate on these farms may be related to tagging and weighing at birth (see section 4.2). In contrast to these records, Hudson et al. (1991) reported 17% and 31% of wapiti calves from adult and yearling hinds, respectively, died before weaning in a research herd in Canada, but with limited hind numbers.

To the author's knowledge, the only published abortion rates in deer were a 2.6% (2/96) from Invermay (Fennessy et al., 1986), and 0.02% (1/4218) from a mail survey (Asher and Adam, 1985). However, a mail survey cannot possibly give accurate data because it would describe only observed abortions, when in fact most would not be observed.

In this study, from the estimates of foetal loss during pregnancy, the considerable majority of the 9.1-17% average losses between conception and weaning occurred at or shortly after birth. Of those losses, 77.3% could not be identified. It is likely that on these commercial farms, dead calves were simply not found because of the extensive nature of the operation, or perhaps were removed by scavengers.

The 6.3% death rate of calves through starvation (or mismothering) in this study is close to the 5.1% reported by Asher and Adam (1985), although they suggested the handling/tagging of calves in their study may have triggered mismothering. As observed in the wild (Clutton-Brock and Guinness, 1974), calves often changed sites when disturbed. The overmothering syndrome was observed in this study on a farm where calves were tagged at birth. Although a rare event, it is thought to be associated with excessive human intervention (Haigh and Hudson, 1993). Misadventure was also identified by Haigh and Hudson (1993) as an important factor of calf mortality (20%), but most of those calves were found hung in fences, a situation which was not observed in this study.

Data showing 22.1% of calf mortalities were associated with dystocia in this study supports the observation of Asher and Adam (1985) and Gill (1985) in red deer and in wapiti (Friedel and Hudson, 1994) that this factor may be a significant cause of calf mortality in a farming environment. Friedel and Hudson (1994) reported in wapiti 62.3% of calf mortalities occurred from dystocia. However, this may be an overestimation, since data was collected by retrospective survey, and it is believed dystocia may be more easily observed and remembered than other causes of calf mortality. It is possible that some stillbirths may have resulted from dystocia, but this could not be proven.

Another significant proportion of calves died from being victimised, which may result from aggressive behaviour associated with the stress of calving in confined areas and high stocking rates (Kelly and Whateley, 1975). Observations of aggression were confirmed by one farmer. In wapiti, the larger the paddock area per hind, the higher the weaning rate observed (Friedel and Hudson, 1994).

As observed by Blaxter and Hamilton (1980), diseases in calves were rarely the cause of mortality. Cryptosporidiosis was identified only in one calf probably because diagnostic confirmation needs laboratory examinations which were not performed in other cases. Although outbreaks of this disease can cause significant calf losses for the individual farmer (Gill, 1994; Hicks, 1994), it is likely to be a sporadic problem. Liver abscesses, due to *Fusobacterium necrophorus*, also have been reported previously in New Zealand (Bertram, 1986), but were not seen in this study.

Despite these limitations, most identified losses may be related to farm management. In this study, the wide ranges of progeny loss rates (0-38.6% and 0-18.6% in yearling and adult hinds, respectively) suggest risk factors need to be further investigated (see section 4.2).

3.5.4.4.4 Dystocia

Dystocia is not a major problem in red hinds, with only 1% and 0.4% of yearling and adult hinds, respectively, needing human assistance or dying at calving in this study. This is lower than the 2.1 and 2.3% recorded by Asher and Adam (1985) by farm monitoring and mail survey, respectively. In contrast, they recorded assisted calving rates of 1.4 and 1% in fallow deer. Individual deer monetary values were substantially higher in the early 1980s than when the present study was conducted and observations of dystocia were therefore more common (Wilson, personal communication). However, the number of dystocias recorded in this study may not be complete, as some farmers did not observe their hinds during calving. Since lesions consistent with dystocia were observed on dead calves, and a majority of dead calves could not be found, it was suspected some hinds lost their calves through dystocia but survived. The potential negative effect of calving difficulties through mismothering should also be considered, and needs further study.

3.5.5 Sentinel deer

3.5.5.1 Deer physical characteristics

To the author's knowledge, this thesis contains the first published records of red deer shoulder height (size) and thoracic girth. The highly significant relationship between thoracic girth and bodyweight was known in other domestic species such as pigs or cattle. This suggests a weigh-band can be designed for red deer, which would be a cheap and useful alternative assessment of bodyweight on farms not possessing a weighing scale.

The coat length of weaners was not recorded in March 1993 as many weaners were moulting. Red deer moult twice a year (Ryder and Kay, 1973; Ryder, 1977) and in New Zealand, they develop their winter coat starting in March (Fisher et al., 1990). Although moulting was not obvious in 1992, higher variability of the coat length at that time compared with other visits suggests that either moulting occurred during this visit, or the coat of calves is more variable in length than that of older deer. The coat length of hinds did not exceed 60 mm, as recorded by Ryder (1977). The potential relationship between coat length and individual deer performance is investigated in Chapter 4.

Signs of hair loss may be the result of regular harassment and victimisation, which occurs frequently in farmed deer (Moore et al., 1985). The higher proportion of weaners and hinds showing signs of hair loss in September may result from supplementary feeding, as interactions between deer are more likely to increase during access to food. Yearling hinds were more often victimised than adult hinds presumably because of their lower social rank in the mob. In contrast, the increased signs of hair loss in stags observed in June may be related to the mating season. During the rut stags are more aggressive and fights are commonly observed.

3.5.5.2 Biological markers

3.5.5.2.1 Behaviour of deer during blood sampling

That more than 80% of weaners or hinds were sampled without restraint in a pen shows that blood sentinel deer is not difficult and that a restraining device is often not necessary. With experience, it is also quicker and less stressful to the deer. In contrast to weaners and hinds, stags can be very aggressive during the rut and the use of a restraining device is required.

Occasionally calves and young weaners lay on the floor during handling in response to stress, but only 5% behaved that way. This behaviour diminishes with age since only 2 hinds and 3 stags over 15 months lay down during sampling.

That adult hinds at sampling were more often aggressive than yearling hinds is consistent with the higher frequency of hair loss observed in this latter age group. Yearling hinds are usually in the lower social rank and thefore less likely to show signs of aggression and more likely to be victimised by other hinds.

3.5.5.2.2 Blood markers

The analyses of individual blood characteristics were carried out to identify risk factors for inclusion in the multivariable statistical analysis, but were analysed in their own right to investigate variability due to age, sex, seasons (ie farm visits) and farms (as appropriate). Data were pooled according to statistical test results (see Appendix 3.70 and Appendix 3.71) to provide relevant reference values for blood characteristics of red deer sampled during normal handling practices. There are numerous publications of blood characteristics of deer as summarised by Kay (1994) and Jones (1994), in which deer were sedated or shot for sampling, but these are believed to be unsuitable for on farm veterinary investigation.

Normal values of blood characteristics have been already defined in farmed red deer sampled during normal handling practice (Wilson and Pauli, 1983a, 1983b). This study, however, reports wide variation of results between farms and suggests herd differences should be taken into account in the interpretation. Payne et al. (1970) explained the limitations of such tests if they are not interpreted with full knowledge of the property.

The highly significant farm effect explained a large proportion of the variability of most blood characteristics (see Appendix 3.72 to Appendix 3.74), suggesting they may be related to farm management practices. Therefore, mean blood characteristics within farms may be useful as blood markers for health or production outcomes. In dairy cows, metabolic profiles were designed to monitor the metabolic state of dairy herds and assess the adequacy of dietary intake for production. (Payne et al., 1970). A "normal" metabolic profile test refers to a test result which approaches overall mean blood values and in which no significant number of animals fall outside the 95% CI. (Payne et al., 1970). In this study, means, standard deviations and ranges have been presented for each blood marker to allow herd investigations. However, it was not the objective in this thesis to discuss in detail the range of values and variability of all investigated blood characteristics. This will be the subject of a subsequent publication. The significance of each blood marker with regard to production outcomes has been investigated in Chapter 4.

3.5.5.2.3 Parasitology

This study presents the most extensive evaluation of internal parasite egg and lungworm larvae output in the faeces of deer under normal farming conditions in New Zealand. To the author's knowledge, there are only few reports of "normal" values of FEC and FLC (Mason and Gladden, 1983; Wilson, 1984a; Anderson, 1985). Recent publications on management and diseases of farmed deer do not mention egg and larval counts (Haigh and Hudson, 1994; Munro, 1994a, 1994b).

In this study, results support that young deer are the most susceptible class of deer to internal parasites, in particular the lungworm *D.viviparus* before weaning (Munro, 1994a). Calves can shed up to 1800 lungworm larvae per gram of faeces (l/g)(the second highest count was 850 l/g) prior to commencement of anthelmintic treatment without showing clinical signs of disease. It was known that deer can bear higher levels of infestation by the lungworm *D.viviparus* than cattle without pulmonary distress or coughing (Corrigall et al., 1982; Corrigall, 1985), but infested deer may lose condition, and slow their growth. The reduction of FLC in June, September and November may be caused by treatment with anthelmintics, but also through acquired immunity against internal parasites. There is experimental evidence that undrenched weaners may be highly susceptible to heavy infestation in autumn (Hoskin, personal communication), and that acquired immunity results in reduced larval output in the faeces (Corigall et al., 1982; Mackintosh et al., 1984). This is further supported by the low FLC recorded in deer over 15 months in this study (see Appendix 3.77 and Appendix 3.78). This study supports the observation that mature deer usually shed less than 5 lungworm larvae per gram (Mason and Gladden, 1983) in their faeces. The increase of faecal parasite egg output of hinds in September (FEC), and of stags in June, may be caused by reduced nutritional intake and subsequent impaired immunity. Wilson (1984a) reported that undrenched farmed weaners and adults shed 11.5 and 11.2 lungworm larvae/g, respectively, which was low in weaners and high in adults compared with respective reference data in this study.

Most faecal egg counts (FEC) in weaners were below 200 eggs/g (see Table 3.33), the maximum recorded being 650 eggs/g and no more than 11% of deer over 15 months, at any time, shed more than 100 eggs/g, which supports previous observations in Australia (English, 1988) and New Zealand (Mason and Gladden, 1983; Wilson, 1984a).

It is recognised FLC and FEC should be interpreted with full knowledge of the farm and its management practices, eg stocking rate, sward characteristics, climate, drenching regime, etc (Haigh and Hudson, 1993). However, the investigation of the interrelationships between these management factors and FEC and FLC of weaners and deer over 15 months of age was beyond the scope of this thesis. Preliminary investigation, however, of the usefulness of a farm parasite index is presented in section 4.3.

3.5.5.2.4 Yersiniosis serology

The distribution of seroprevalences against *Yersinia pseudotuberculosis* in weaners in June and in September is difficult to interpret because of the following points (Mackintosh, personal communication) :

- Test results (optical density (OD)) in March were used as the baseline level for each sentinel weaner, which implies that the immune response to *Yersinia pseudotuberculosis* developed only after March. This may not be correct although clinical yersiniosis has never been reported in deer in March.

- The use of a 20-unit increase of OD as a threshold for seropositivity is subjective and based on previous research experience (Griffin, personal communication)
- There is cross reactivity between *Y.pseudotuberculosis* serotypes and *Y.enterocolitica* that may be carried by weaners (Mackintosh and Henderson, 1985).
- The 3-monthly interval between sampling may be too large to identify peaks of antibody titres. Should subclinical or clinical yersiniosis occur early in autumn, the immune response may be significantly reduced by June.
- Immune responses were affected by vaccination with Yersiniavax. Five farmers vaccinated their weaners preventively in 1993, while 3 others vaccinated in response to clinical yersiniosis.

All three serotypes I, II and III of *Y.pseudotuberculosis* have been isolated in deer in New Zealand (Henderson and Hemmingsen, 1983; Hogdes et al., 1984a). Serotype III was reported the most prevalent in the North Island in association with other domestic livestock such as cattle and pigs (Hogdes et al., 1984a). However, in this study none of the three serotypes appeared to prevail immunologically.

Although there was an apparent zero prevalence on one farm in 1993, it seems that the vast majority of weaner mobs, if not all, had experienced yersiniosis infection. This supports the theory that *Y.pseudotuberculosis* infection is widespread in farmed weaner deer. Mackintosh and Henderson (1984b) suggested wildlife animal species such as rodents and birds may act as reservoirs of the bacteria.

Although the actual prevalence of seropositivity in individual weaners is difficult to assess due to diagnostic difficulties, this study suggests it may be around 40-55% in June and below 30% in September, which is higher than the 5 to 20 % isolation rate of *Y.pseudotuberculosis* from their faeces (Hodges et al., 1984a; Bosi, 1992; Mackintosh, 1992b).

3.6 CONCLUSION

This chapter presents a substantial range of data defining the survey farms and summarising measurements made.

Health and production performance parameters were tabulated and graphed to provide reference data on a wide range of topics, ie reproduction, weaner growth, velvet production, clinical health problems and biological markers. This information describes the profile of red deer farms studied in the lower part of the North Island of New Zealand. Until further research is set up to monitor deer farms in other areas of New Zealand to validate this data, it is currently the best estimation of health and productivity parameters of New Zealand red deer farms. These reference data will be useful to deer farmers, farm advisers, veterinarians and deer industry personnel to implement future strategic planning at the farm or industry level.

The key health and production parameters to deer farmers and the deer industry identified in this study are :

- early conception (before May 1) and conception *per se*.
- weaner bodyweight on April 1 and seasonal growth rates.
- velvet antler grade and weight.
- progeny loss between conception and weaning.
- weaner mortality during the first 6 months after weaning.

- the occurrence of dystocia in hinds and malignant catarrhal fever in deer over 15 months old.
- Of potential concern to the individual farmer was the occurrence of osteochondrosis in calves associated with low copper status.

The wide range of performance results between farms in all these area is striking. This strongly suggests there is a large potential for improvement of productivity on many farms and, therefore, for the deer industry as a whole. From the data presented in this chapter reasonable targets can be set for improvement.

However, this potential improvement is subject to the identification of management factors associated with high and low performance results, and whether these factors could be modified. For many health and production parameters, the current knowledge already allows us to draw some conclusions on preventive measures likely to improve performance, but the relative importance of different management options is not yet known.

The wide range of deer characteristics and management practices recorded in this study, along with the range of productivity results, suggests some combination of management practices are better than others. Nothing happens in isolation of farms, ie environmental factors, management practices and health and production parameters are interrelated. Therefore, this data was used for further investigations of risk factors associated with key health and production parameters. These are presented in Chapter 4.

CHAPTER 4
ANALYTICAL EPIDEMIOLOGY

INTRODUCTION

Herd health and production profiling combines descriptive investigations of the production system under study with the investigation of risk factors associated with health and production outcomes. The description of individual deer characteristics, environmental factors, management practices, health and production outcome, and biological markers have been presented in Chapter 3.

Analytical epidemiology is the study of the determinants of diseases, also called risk factors, and, in the context of this study, has also been applied to the study of production outcomes. The outcomes investigated were recognised as key health and production parameters for deer farmers and the deer industry in New Zealand.

This chapter investigates risk factor analyses for each outcome, ie hind conception, hind lactational status at weaning, weaner bodyweight on April 1, weaner seasonal growth rates, velvet antler production and health problems, ie the occurrence of yersiniosis, malignant catarrhal fever and dystocia (see Table 2.38).

Path analysis was the main multivariable statistical technique used and the general principles have been presented in section 2.7. However, other techniques were used for some analyses depending on the structure of the data. Summaries of multivariable analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. A further description of analytical methods used for each risk factor analysis is described within each section in this chapter.

It must be remembered that path diagrams are built on the basis of current knowledge of deer production, and biologically sound theoretical considerations, determined by research in deer, where appropriate in other domestic species, and field experience. Statistical tests are carried out to test whether the putative theory is statistically sound, but statistical significance alone does not mean the model derived from this research is accurate in all or even in most respects. Path modelling as used here generates hypotheses which conform to current biological understanding (as represented in the null hypothesis path model) and which also have statistical support (as represented in the final path model). However the path model cannot alone prove that factors in the model actually cause variation in the outcome variable. Proof of causation must be established from appropriately designed prospective research studies.

In this chapter, inferences of putative causality will be made only when associations are supported by previous observations and experimental findings.

Table 4.1 : Summary of multivariable statistical analyses carried out using path analysis

		Explanatory variables and percentage of variability explained by final models			Outcome under investigation
Section 4.1 : Risk factors for hind early conception and conception *per se*					
Note : Analyses were carried out independently for yearling and adult hinds					
Step 1 :	Block 1	Animal management Individual hind characteristics Mating management			ADVC Conception before May 1
		Adult hinds :	ADVC	7.65	
			CONC	10.12	CONC Conception
		Yearling hinds :	ADVC	10.99	
			CONC	5.47	
Step 2 :	Block 2 alone	Environment and grazing management			ADVC Conception before May 1
		Adult hinds :	ADVC	3.46	
			CONC	9.76	CONC Conception
		Yearling hinds :	ADVC	12.13	
			CONC	6.14	
Step 3 :	Block 1	Animal management Variables significantly associated with the outcome in step 1			ADVC Conception before May 1
	Block 2	Environment and grazing management			CONC Conception
		Adult hinds :	ADVC	8.55	
			CONC	13.39	
		Yearling hinds :	ADVC	15.24	
			CONC	11.33	
Section 4.2 : Risk factors for hind rearing a calf (ie lactating) up to weaning					
Note : Analyses were carried out independently for yearling and adult hinds					
Step 1 : Data 1992 & 1993 combined	Block 1	Individual hind characteristics Adult hinds :		4.73	WET Hind lactating at weaning
		Yearling hinds :		0	
Step 2 : Data 1992 & 1993 analysed separately with variable WET-1 included	Block 1	Individual hind characteristics Adult hinds :	Data 1992	6.02	WET Hind lactating at weaning
			Data 1993	6.50	
Step 3 :	Block 2 alone	Calving paddock characteristics and calving management Adult hinds :		2.34	WET Hind lactating at weaning
		Yearling hinds :		7.44	
Step 4 : For adult hinds only	Block 1	Individual hind characteristics Variables significantly associated with the outcome in step 1			WET Hind lactating at weaning
	Block 2	Calving paddock characteristics and calving management			
		Adult hinds :		6.47	
Step 5 :	Block 3 alone	Grazing management between November 1 and January 1 Adult hinds :		4.59	WET Hind lactating at weaning
		Yearling hinds :		0	
Step 6 : For adult hinds only	Block 1	Individual hind characteristics Variables significantly associated with the outcome in step 1			WET Hind lactating at weaning
	Block 3	Calving paddock characteristics and calving management			
		Adult hinds :		9.57	

Appendix 4.1 (Cont'd)

		Explanatory variables and percentage of variability explained by final models	Outcome under investigation

Section 4.3 : Risk factors for weaner bodyweight standardised on April 1

Note : Analyses were carried out separately for weaner hinds and stags, with null hypothesis path diagrams built from risk factors positively or negatively significantly associated with the outcome in both sexes.

Step 1 : Block 1

Individual animal characteristics
Dam and calf characteristics
Weaner hinds : 29
Weaner stags : 33

→ W4 Weaner bodyweight standardised on April 1

Step 2 : Block 2

Individual calf characteristics →

Lactation and weaning management
Environment and grazing management
Disease prevention before April 1 →

→ W4 Weaner bodyweight standardised on April 1

Weaner hinds : 29
Weaner stags : 27

Step 3 : Block 3

Individual calf characteristics
Weaning date →

Post-weaning grazing management
from weaning to April 1 →

→ W4 Weaner bodyweight standardised on April 1

Weaner hinds : 30
Weaner stags : 29

Section 4.4 : Risk factors for weaner seasonal growth rates

Note : Analyses were carried out independently for weaner hinds and stags, with null hypothesis path diagrams built from risk factors positively or negatively significantly associated with the outcome in both sexes.

Step 1 : Block 1

Individual weaner characteristics →
Disease control risk factors →
Environment and grazing management from April 1 to June 1 →
Health problems →

→ GR46 Weaner growth rates between April 1 and June 1

Weaner hinds : 53 ; without the variable SUN : 53 (see text for explanation)
Weaner stags : 49 ; without the variable SUN : 50

Step 2 : Block 1

Individual weaner characteristics →
Disease control risk factors →
Environment and grazing management from June 1 to September 1 →
Health problems →

→ GR69 Weaner growth rates between June 1 and Sept 1

Weaner hinds : 51
Weaner stags : 54

Step 3 : Block 1

Individual weaner characteristics →
Disease control risk factors →
Environment and grazing management from September 1 to December 1 →

→ GR912 Weaner growth rates between Sept 1 and Dec 1

Weaner hinds : 37 ; without the variable SUN : 35 (see text for explanation)
Weaner stags : 34 ; without the variable SUN : 32

Step 4 : Block 1

Individual weaner characteristics →
Disease control risk factors →
Environment and grazing management from December 1 to March 1 →

→ GR123 Weaner growth rates between Dec 1 and March 1

Weaner hinds : 62
Weaner stags : 59

Table 4.1 (Cont'd)

	Explanatory variables and percentage of variability explained by final models	Outcome under investigation

Section 4.5 : Risk factors for velvet production, ie stag velvet antler grade and weight

Note : Analyses were carried out independently for 2-year-old and adult stags, with null hypothesis path diagrams of grazing management blocks built from risk factors positively or negatively significantly associated with the outcome in both age group.

Step 1 : Block 1

Individual stag characteristics

	GRADE	WEIGHT
2-year-old stags :	24	59
Adult stags :	43	71

→ WEIGHT (velvet antler weight)

→ GRADE (velvet antler grade)

Step 2 : Block 2

Individual stag characteristics
Variables significantly associated with the outcome in step 1

Winter grazing management
from June 1 to September 1
Disease control risk factors

	GRADE	WEIGHT
2-year-old stags :	17.5	12.7
Adult stags :	2.9	4.5

→ WEIGHT (velvet antler weight)

→ GRADE (velvet antler grade)

	GRADE	WEIGHT
2-year-old stags :	34	66
Adult stags :	46	74

Step 3 : Block 3

Individual stag characteristics
Variables significantly associated with the outcome in step 1

Pre-velvetting grazing management
from September 1 and velvet harvesting
Disease control risk factors

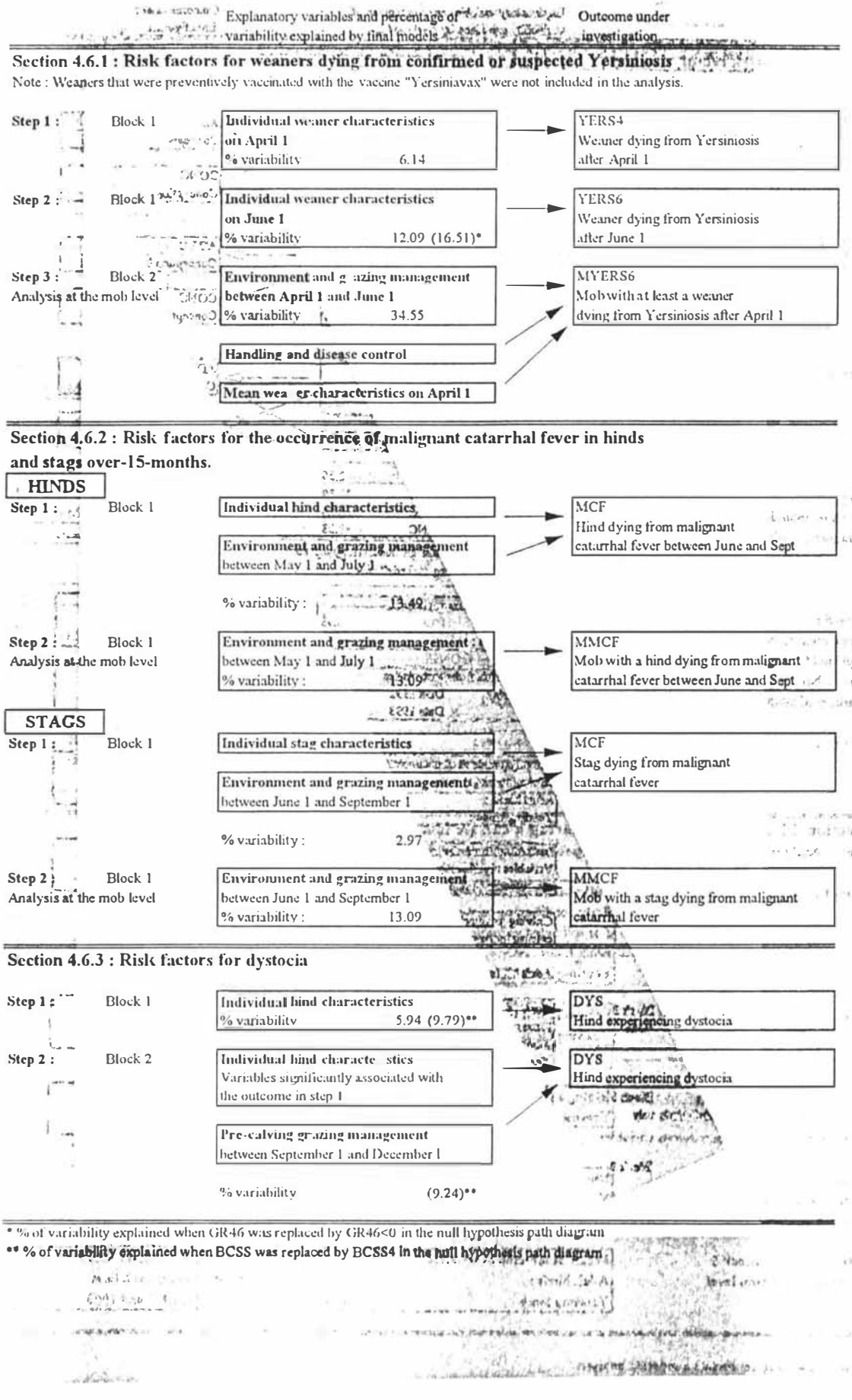
	GRADE	WEIGHT
2-year-old stags :	6.6	7.2
Adult stags :	3.7	2.5

→ WEIGHT (velvet antler weight)

→ GRADE (velvet antler grade)

	GRADE	WEIGHT
2-year-old stags :	34	67
Adult stags :	47	73

Appendix 4.1 (Cont'd)



* % of variability explained when GR46 was replaced by GR46<0 in the null hypothesis path diagram

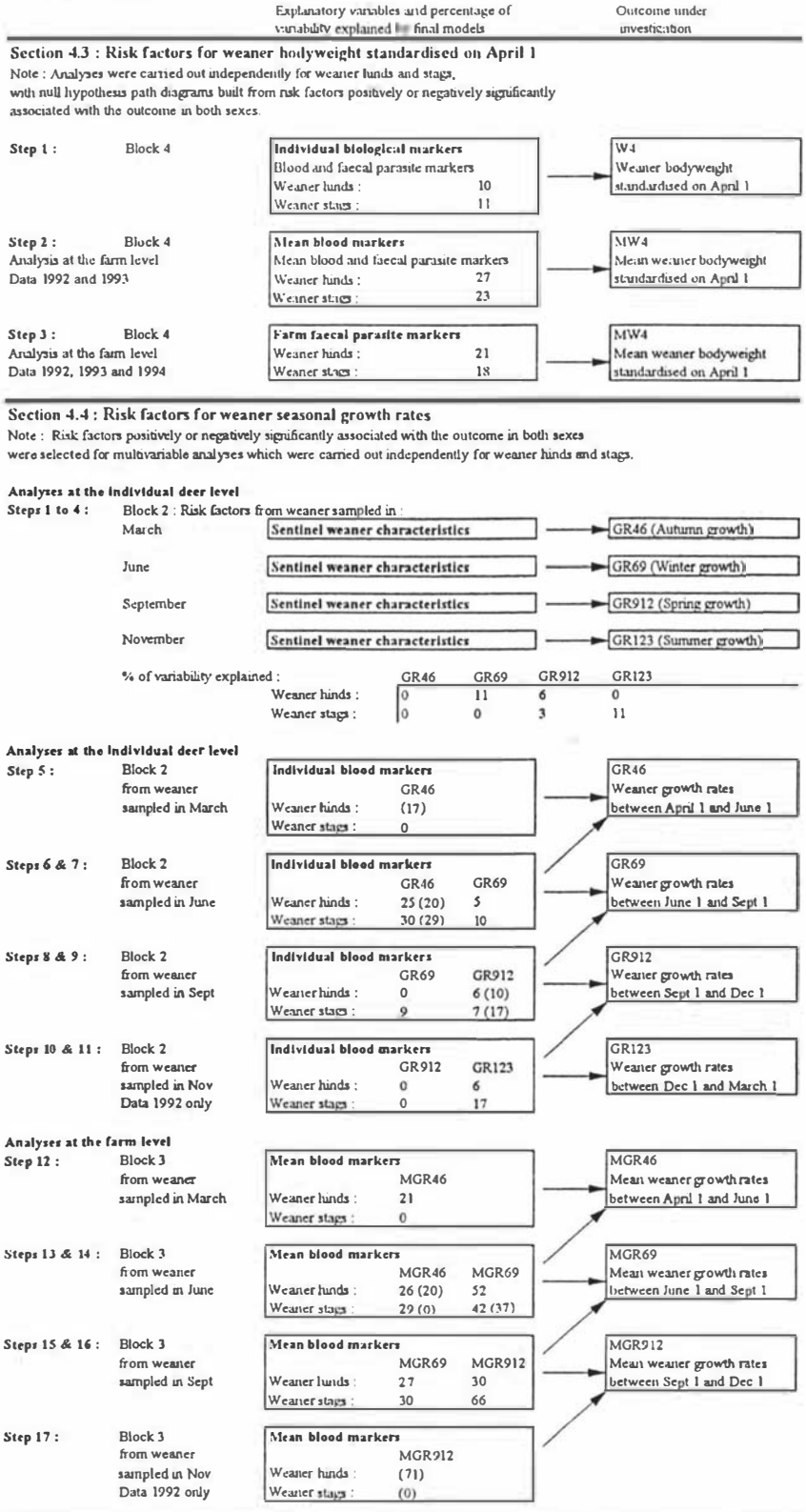
** % of variability explained when BCSS was replaced by BCSS4 in the null hypothesis path diagram

Table 4.2 : Summary of multivariable statistical analyses carried out without the use of path analysis

	Explanatory variables and percentage of variability explained by final models			Outcome under investigation
Section 4.1 : Risk factors for hind conception				
Note : Analysis were carried out independently for yearling and adult hinds				
Step 1 : Block 1 Follow-up analysis of body condition score variables	**Individual hind characteristics** Body condition score variables *The following variables were included :* Adult hinds : AGE3, WET, WEAN Yearling hinds : YSPM			ADVC Conception before May 1 CONC Conception
Step 2 : Block 3 Follow-up analysis of back-up mob management	**Back-up mob management** Adult hinds : Yearling hinds :	CONC ADVC CONC	2.06 0 5.81	ADVC Conception before May 1 CONC Conception
Step 3 : Block 4	**Sentinel hind characteristics** Adult hinds : Yearling hinds : 	ADVC CONC ADVC CONC	27.78 16.77 0 0	ADVC Conception before May 1 CONC Conception
Step 4 : Block 4 Analyses include only continuous variables	**Biological markers** Adult hinds : Yearling hinds : 	ADVC CONC ADVC CONC	12.56 34.85 10.74 26.87	ADVC Conception before May 1 CONC Conception
Step 5 : Block 4 Some continuous variables replaced by categorical variables **Note :** No categorical biological markers of adult hinds were selected for multivariable analysis	**Biological markers** Yearling hinds :	ADVC CONC	8.28 26.94	ADVC Conception before May 1 CONC Conception
Step 6 : Follow-up analyses	**Mean blood markers** blood markers significantly associated with ADVC or CONC in step 4 or 5			ADVCR or CONCR Early conception rate Conception rate
Section 4.2 : Risk factors for hind rearing a calf (ie lactating) up to weaning				
Note : Analysis were carried out independently for yearling and adult hinds				
Step 1 : Block 1	**Individual hind characteristics** Body condition score variables *The following variables were included :* Adult hinds : AGE3, ADVC Yearling hinds : none			WET Hind lactating at weaning
Step 2 : Block 4 Yearling hinds only	**Sentinel hind characteristics** Yearling hinds :		0	WET Hind lactating at weaning
Step 3 : Block 4 Yearling hinds only Analyses include only continuous variables	**Biological characteristics** Yearling hinds :		0	WET Hind lactating at weaning
Step 4 : Block 4 Yearling hinds only Some continuous variables replaced by categorical variables	**Biological characteristics** Yearling hinds :		0	WET Hind lactating at weaning
Step 5 : Block 5 Analysis at the farm level	**Mean blood characteristics** Adult hinds : Yearling hinds :		15.0 15.8	WEANING RATE within each farm in 1992 and 1993

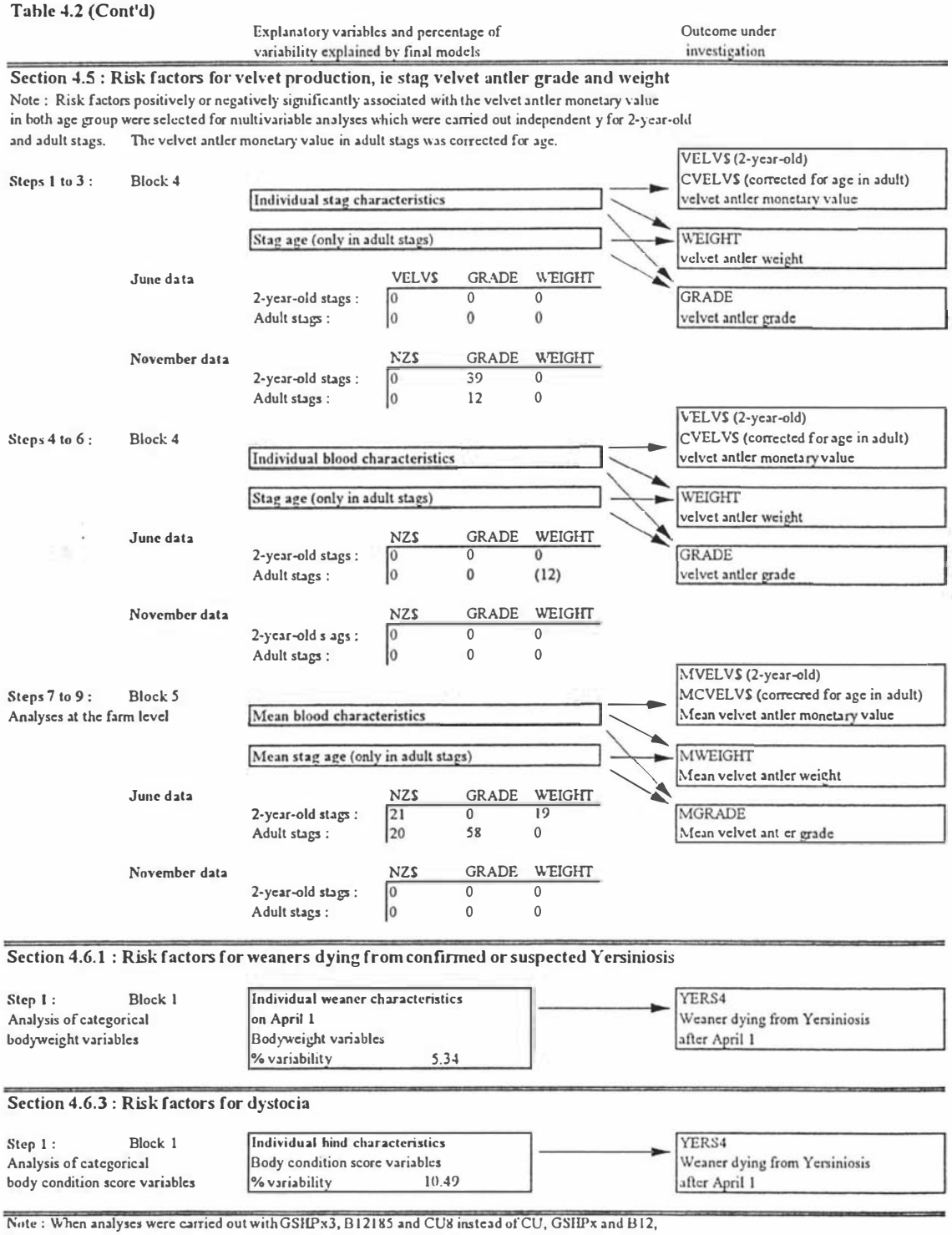
Note : each step represents a separate analysis

Table 4.2 (Cont'd)



Note : when analyses were carried out with GSHPx3, I312185 and CU8 instead of CU, GSHPx and B12, the percentage of variability explained by the model is presented in brackets.
Note : each step represents a separate analysis

Table 4.2 (Cont'd)



Note : When analyses were carried out with GSHPx3, B12185 and CU8 instead of CU, GSHPx and B12, the percentage of variability explained by the model is presented in brackets.
Note : each step represents a separate analysis

Conclusions are presented at the end of each section, along with proposals for further research investigations. It is also the intention of the researcher to provide guidelines for deer farmers based on descriptive data, risk factors analyses and personal experience. These putative management proposals are presented under the heading "researcher's advice". It is acknowledged that some specific advice, eg dates or numbers are speculative, and those suggestions should be targeted for further research.

4.1 RISK FACTORS FOR HIND CONCEPTION

4.1.1 Introduction

Reproductive performance of hinds, in particular yearling hinds, is recognised as a major determinant of productivity and economic viability of commercial farms (Hamilton, 1988). Reproduction data (section 3.3.1.3) showed 84% of 791 yearling (YH) and 96.9% of 3745 adult hinds (AH) conceived, with 63.4% and 90.3%, respectively, conceiving early (before May 1) over two years. Failure of conception of yearling hinds appears to be a major loss for farmers in this study, and by extrapolation, to the New Zealand deer industry as a whole.

McNamus and Thompson (1993) stated that when choosing a breeding programme, it is crucial to identify breeding objectives and consequently, selection criteria that will help meet these objectives. They also recognised that it was not known whether the ability of hinds to conceive early was related to management practices or if it was a heritable factor.

Traditionally, pre-mating target bodyweights have been considered as the critical factor affecting conception and calving date in yearling hinds (Mitchell et al., 1976; Kelly and Moore, 1977; Hamilton and Blaxter, 1980; Moore et al., 1985; Hamilton, 1988). With the increased level of imported blood lines in the New Zealand herd, the mature hind size and weight has increased. Thus the optimum threshold bodyweights cited by these authors for increased risk of conception may have changed, and indeed, may differ between farms.

The reproductive success of farmed hinds depends on combining high pregnancy rates, low abortion rates, early birth date, and low perinatal and postnatal mortality rates, leading to high weaning rates. Every management step from mating to weaning is therefore likely to be important. Management strategies may differ depending on whether farmers want to give priority to weaning rates (and thus allow for late conception) or weaning weights, or both.

There has been interest in finding ways of advancing the breeding season in farmed red deer in New Zealand using melatonin (Fennessy and Fisher, 1988; Wilson, 1989a). However, as the use of hormones did not have the support of the deer industry, there was a need to look more closely at "acceptable" management practices to achieve good reproductive performance.

When considering the economic significance of conception before May 1, the reader should refer to the investigation of risk factors for weaner bodyweight (section 4.3). Early calving hinds produced weaner stags and hinds which were to 5.5kg and 2.7kg heavier on April 1 (as post-weaning weight), respectively. With the emphasis placed on production costs, hinds that conceive early in the season take better advantage of the spring pasture growth and this may be particularly important for farmers supplementing hinds for lactation in dry areas (Yerex and Spiers, 1987).

This section presents analyses to identify risk factors associated with the likelihood of conceiving *per se* or conceiving early (before May 1) for both yearling and adult hinds.

4.1.2 Materials and methods

About 2700 hinds were individually monitored for reproductive success in each of the two years according to methods presented in sections 2.3.1.4, 2.3.3.2, and 2.4.1. During farm visits in March 1992, 10 randomly selected hinds (5 yearling (15 months) and 5 adult) were blood sampled to define their haematological, biochemical and blood mineral profile (see sections 2.4.1.1 and 2.5).

Risk factors potentially affecting the probability of conception before May 1 (ADVC) or of conception *per se* (CONC) were identified and classified according to the area of data collection they described as presented in Table 4.3.

Environmental factors and grazing management risk factors were calculated as described in section 2.6.2 for the period between March 15 and May 1, and between March 15 and June 1, as potential risk factors for ADVC and CONC, respectively.

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 andTable 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in section 2.7.

- Data from both years of study were combined for statistical analyses.
- Yearling and adult hind data were analysed separately at all stages.
- The individual outcomes ADVC and CONC were investigated using SAS, while the farm outcomes ADVCR and CONCR were investigated using Statistica.

- Path analysis was only used for the analysis of block 1 and block 2.

  Path diagrams were first formulated within each block (steps 1 and 2 in Table 4.1). However, grazing management risk factors (block 2) were also analysed with statistically significantly important animal management risk factors included (step 3), since they may otherwise be important confounding factors (as in step 2). Therefore null hypothesis path diagrams for block 2 have been analysed twice, with and without animal management risk factors. "Overall final path diagrams" were formulated from these latter analyses.

- Categorised body condition score variables, back-up mob characteristics, sentinel hind characteristics and biological markers were analysed separately without the use of path analysis. Each step described in Table 4.2 represents a separate analysis.

  In the analyses of block 1, hind body condition score (BCSM) prior to mating was included as a continuous discrete variable and forced into all null hypothesis path diagrams because of its potential significant biological effect on hind early conception or conception *per se*. However, to explore the possibility of a threshold score under which the ability of a hind to conceive could be impaired, BCSM was transformed to several categorical variables as described in Table 4.3 and analysed together by multivariable logistic regression analyses.

Table 4.3 : Potential risk factors for hind conception before May 1 or hind conception *per se*.

Risk factor code	Unit	Description
BLOCK 1 : Animal management		
Individual hind variables		
AGE3	D	Hind over 3 years old at mating
NZ	%	Percentage of New Zealand blood lines
NZ100	D	Pure New Zealand type hind
WET	D	Hind lactating at weaning
BSCM	Dis. 1-5;0.5	Pre-mating body condition score (recorded in March)
W4	kg	Bodyweight standardised to April 1 (as pre-mating body weight)
GR46	g/d	Growth rate between April 1 and June 1
Categorised body condition score variables		
BCSM25	D	Pre-mating body condition score below 3
BCSM4	D	Pre-mating body condition score over 3.5
Mating management		
YSPM	D	Yearling hinds grazing with yearling stags up to mating
YSMATE	D	Yearling hinds left with their yearling stag mates during the rut
WEAN	day	Number of days between February 15 and weaning
JOIN	day	Number of days between February 15 and joining with sire stag(s)
AH		Number of adult hinds in the mating mob
YH		Number of yearling hinds in the mating mob
CLAH	D	Presence of adult hinds in the mating mob
SSIRE	D	Single sire mating
RATIO	Hinds/sire	Hinds to sire stag ratio
EXP	D	Use of at least one experienced sire stag
YS	D	Presence of exclusively one or more yearling sires
NZS	D	Presence of only New Zealand red sire stag
WAPS	D	Presence of one or more wapiti-type sire stag(s)
BACK	D	Use of at least one back-up stag before May 1
CHS	D	Use of at least one back-up stag
REMD	day	Number of day between April 1 and the date of sire stag removal
BLOCK 2 : Environment and grazing management		
Grazing and food supplementation variables		
ISWH	cm	Mean pre-grazing pasture sward height
CLOVER	Score 1-3	Mean pasture clover score
PASTT	Score 1-3	Mean pasture type score
MACRO	D	Hinds grazing in at least one paddock with macrocarpa tree
STOCK		Number of times the mob composition was changed
SHIFT		Number of times deer were shifted between paddocks
DEER		Average number of deer in the mob
DEER/Ha	Deer/ha	Average number of deer per deer-fenced hectare (grazing density)
M%AH	%	Mean percentage of adult hinds in the hind mob
OTHERST	D	Paddocks shared with stock other than deer at least one day
Food supplementation : risk factors for hind conception *per se* only.		
FSUP	D	Food supplementation before the end of May (risk factor for conception *per se*)
NUMFS*		Number of food supplementation episode before the end of May
SUPEN*	MJME/day	Estimated daily individual energy intake through food supplement in May

* Food supplementation variables were calculated but investigated as risk factors only if FSUP was a significant factor.

Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".
D = Dichotomous variables

Table 4.3 (Cont'd)

Risk factor code	Unit	Description
BLOCK 2 (Cont'd)		
Environmental variables		
FAREA	ha	Mean paddock size (deer-fenced area)
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt
BLOCK 3 : Back-up mob characteristics*		
BACKD	day	Number of days between April 1 and the first back-up used before May 1
BACKM	D	Use of a back-up sire after May 1
CHD	day	Number of days between April 1 and the use of the first back-up sire
AH2		Number of adult hinds in the back-up mob
YH2		Number of yearling hinds in the back-up mob
SSIRE2	D	Single sire mating
RATIO2		Hinds to sire stag ratio
USED	D	Sire stag(s) already used in the first mating mob
EXP2	D	Use of at least one experienced sire stag
CHS2	D	Use of at least one more back-up stag a second time during mating
BLOCK 4 : Sentinel hinds and biological markers		
Sentinel hind characteristics		
SIZE	cm	Shoulder height
GIRTH	cm	Thoracic girth
COATL	mm	Length of the upper coat
VICTIM	D	Visible hair loss (sign of victimisation) on the back of the deer
TEETH	Dis. 1-3; 1	Incisor teeth score
EASES	D	Hind blood sampled without firm physical restraint
Biological markers recorded in March 1992 and 1993		
Individual hind and mean blood characteristics (for farm mean blood markers, codes start with "M")		
White cell count (WCC), neutrophil percentage (NP), lymphocyte percentage (LP), eosinophil percentage (EOP), haemoglobin (HB), packed cell volume (PCV); total protein (TP), albumin (ALB), phosphorus (P), gamma glutamyl transferase (GGT), blood urea nitrogen (BUN), copper (CU), vitamin B12 (B12), pepsinogen (PEPS), glutathione peroxidase (GSHPx). mean glutathione peroxidase from 3 hinds (MGHSPx).		
CU8	D	Serum copper concentration >= 8 µmol/l
B12185	D	Serum vitamin B12 concentration >= 185 pmol/l
MGSHPx3	D	Mean glutathione peroxidase activity from 3 hinds >= 3 kIU/l
Hind faecal parasite markers		
FEC	egg/g	Faecal egg count
FLC	larvae/g	Faecal lungworm larval count
FEC>0	D	Positive faecal egg count
FLC>0	D	Positive faecal larval count

* A "back-up mob" is a mob of hind after the sire has been replace by a back-up sire stag.

Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-3;1" means "Discrete variable from 1 to 3 with 1 unit increments".
D = Dichotomous variables

The risk factors YSPM (yearling hinds), AGE3, WET and WEAN (adult hinds) were included in these analyses where appropriate, since they may otherwise be confounding factors (see final path diagrams in Figure 4.1 and Figure 4.7).

Back-up mob characteristics were investigated as follow-up analyses, only where the use of back-up sire(s) was identified as an important management practice in the analysis of block 1. Biological markers were initially investigated at the individual hind level, and farm mean blood markers were investigated in association with conception rates in follow-up investigations of the most important individual biological markers. Some biological markers were categorised and analysed as discussed in section 2.8.12.3. Scatterplots of mean blood markers against conception rates (ADVCR or CONCR) were drawn up where appropriate.

For each final model, the deviance was reported as a goodness of fit statistic. The proportionate reduction in deviance observed when including significant risk factors in the model, compared with an intercept-only model is interpreted as the proportion of variance in the data "explained" by the variables included in the model (Frome and Checkoway, 1985).

4.1.3 Results

4.1.3.1 Animal and grazing management risk factors

Results of univariate tests of association between each potential risk factor and outcome variables are presented in Appendix 4.1 to Appendix 4.3.

4.1.3.1.1 Adult hinds

Null hypothesis and final path diagrams of animal and grazing management risk factors for adult hind early conception (ADVC) and conception (CONC) are presented in Figure 4.1 to Figure 4.4. Overall final path diagrams of risk factors for adult hind ADVC and CONC are presented in Figure 4.5 and Figure 4.6, respectively.

Final models, along with beta coefficients and their standard errors, of risk factors predicting the likelihood of ADVC and CONC, and adjusted odds ratios of categorical risk factors are presented in Table 4.4 and Table 4.5, respectively.

Final path diagrams present significant ($p<0.05$) paths of association between risk factors, which allow the identification of direct and indirect effects on the outcome.

4.1.3.1.2 Yearling hinds

Null hypothesis and final path diagrams of animal and grazing management risk factors for yearling hind ADVC and CONC are presented from Figure 4.7 to Figure 4.10. Overall final path diagrams of risk factors for yearling hind ADVC and CONC are presented in Figure 4.11 and Figure 4.12, respectively.

Final models along with beta coefficients and their standard errors of risk factors predicting the likelihood of yearling hind ADVC and CONC, and adjusted odds ratios of categorical risk factors are presented in Table 4.6.

4.1.3.2 Body condition score

Beta regression coefficients and adjusted odds ratios of categorised body condition risk factors for yearling and adult hind conception before May 1 or conception *per se* are presented in Table 4.7. Odds ratios of variables BCSM25 and BCSM4 are interpreted with regard to the body condition class not included in the analysis, ie scores 3 and 3.5. Adult hinds with a body condition score of less than 3 were significantly less likely to conceive before May 1 or to conceive at all than hinds scoring 3 or 3.5. The effect of BCSM4 at the other end of the scale was not significant for either outcome. Thus the threshold score for the effect of BCS appears to be between 2.5 and 3.

In contrast, yearling hinds with body condition scores over 3.5 were significantly less likely to conceive before May 1 than those scoring 3 or 3.5. BCSM25 was not significant ($p = 0.056$). Neither BCSM25 or BCSM4 predicted the likelihood of yearling hind conception.

4.1.3.3 Back-up mobs

Results of univariate tests of association between each potential risk factor and outcome variables are presented in Appendix 4.1 and Appendix 4.4.

Characteristics of back-up mobs that significantly predicted the likelihood of yearling or adult hind conception are presented in Table 4.8. Yearling hinds exposed to a second back-up sire stag were about 5 times less likely to conceive, and the later the back-up sire was removed, the more likely the adult hinds conceived *per se*. No significant back-up mob factors were identified in the analysis of yearling hind conception before May 1.

4.1.3.4 Sentinel hind characteristics and biological markers

Results of univariate tests of association between each sentinel hind characteristic and biological marker and outcome variables are presented in Appendix 4.1, Appendix 4.5 and Appendix 4.6.

Sentinel hind characteristics and biological markers that significantly predicted the likelihood of yearling or adult hind conception are presented in Table 4.9. Sentinel hind characteristics were associated with ADVC or CONC in adult hinds but not in yearling hinds. Adult hinds that were pure New Zealand, lactating at weaning, tall and quiet at blood sampling were more likely to conceive before May 1. Pure New Zealand sentinel adult hinds were also more likely to conceive *per se*.

In yearling hinds, the serum copper concentration was negatively associated with the probability of early conception and conception *per se*, mean glutathione peroxidase (and MGSHPX over 3 kIU/l) was associated with the probability of early conception, and serum albumin, vitamin B12 and a zero faecal lungworm larval count were positively associated with the probability of conception *per se*. In adult hinds, there was an inverse relationship between serum phosphorus concentration and the probability of early conception and conception *per se*, and the percentage of neutrophils was positively associated with the probability of early conception.

Table 4.4 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of animal and grazing management risk factors predicting the probability of adult hinds conceiving before May 1 (direct effects).

Total number of hinds included in the analysis : 2601
Number of hinds conceiving before May 1 (ADVC) = 2405

BLOCK 1 :
Animal management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
1390.38	1283.97	106.40	7.65

Risk factor codes*	coefficient estimates	Std error	p value	Adjusted OR	95% CI
AGE3	0.417	0.189	0.028	1.52	1.05 2.20
NZ100	0.657	0.220	0.003	1.93	1.25 2.97
WET	0.962	0.223	0.000	2.62	1.69 4.05
BCSM	0.239	0.113	0.034		
WEAN	-0.026	0.006	0.000		
JOIN	-0.043	0.010	0.000		
RATIO	-0.015	0.005	0.004		
EXP	0.401	0.178	0.024	1.49	1.05 2.12
WAPS	0.581	0.245	0.018	1.79	1.11 2.89

BLOCK 2 :
Environment and grazing management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
1390.38	1342.25	48.12	3.46

Risk factor codes*	coefficient estimates	Std error	p value	Adjusted OR	95% CI
Intercept					
SHIFT	-0.135	0.039	0.001		
ISWH	0.067	0.024	0.004		
AVMAT	-0.150	0.044	0.001		
CLOVER	-0.451	0.200	0.025		
M%AH	0.010	0.005	0.043		
SUR	-0.004	0.002	0.036		
TREES	0.260	0.078	0.001		
OTHERST	-0.644	0.225	0.004	0.53	0.34 0.82

Environment and grazing management
controlled by significant animal management risk factors

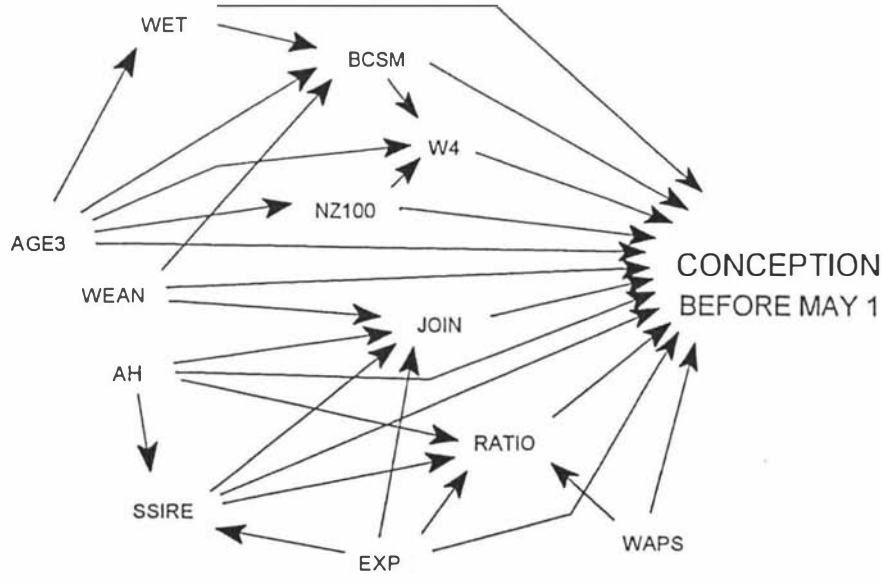
DEVIANCE			
Intercept	Model	Chi-Square	% variability
1390.38	1271.54	118.83	8.55

Risk factor codes*	coefficient estimates	Std error	p value	Adjusted OR	95% CI
NZ100	0.842	0.213	0.000	2.32	1.53 3.53
WET	1.138	0.217	0.000	3.12	2.04 4.77
BCSM	0.282	0.110	0.010		
WEAN	-0.021	0.007	0.002		
JOIN	-0.036	0.009	0.000		
RATIO	-0.013	0.005	0.013		
EXP	0.454	0.185	0.014	1.57	1.10 2.26
ISWH	0.101	0.026	0.000		
RSWH10	-0.574	0.202	0.005	0.56	0.38 0.84
CLOVER	-0.551	0.196	0.005		

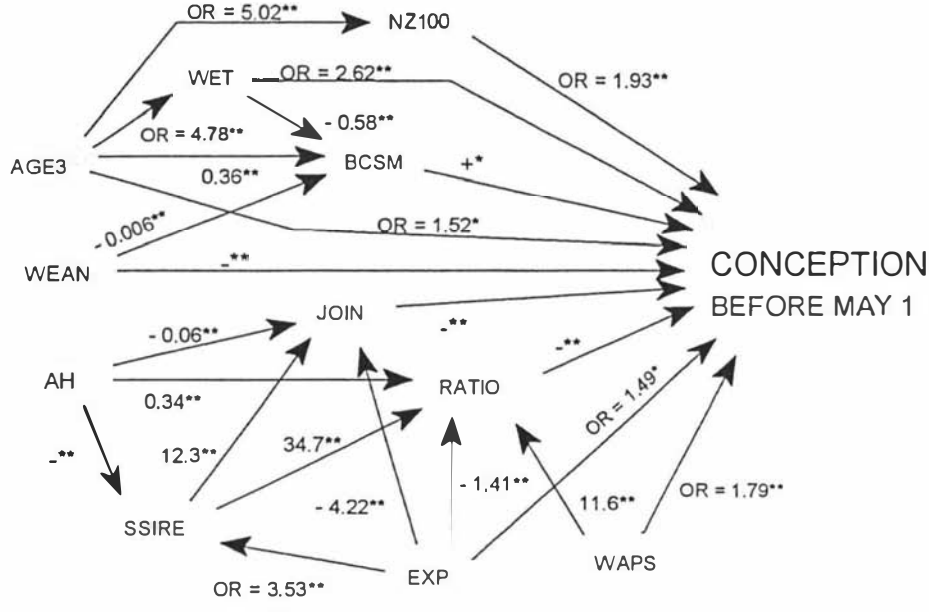
* Risk factor codes are described in the glossary and Table 4.3.
OR = odds ratio; Std error = standard error; 95% CI = 95% confidence interval
Note : Intercept = deviance of an intercept only model; Model = deviance of the model
% variability = (Model - Intercept) x 100 / Intercept

Figure 4.1 : Null hypothesis and final path diagrams of animal management risk factors for adult hinds conceiving before May 1.

1. Null hypothesis path diagram



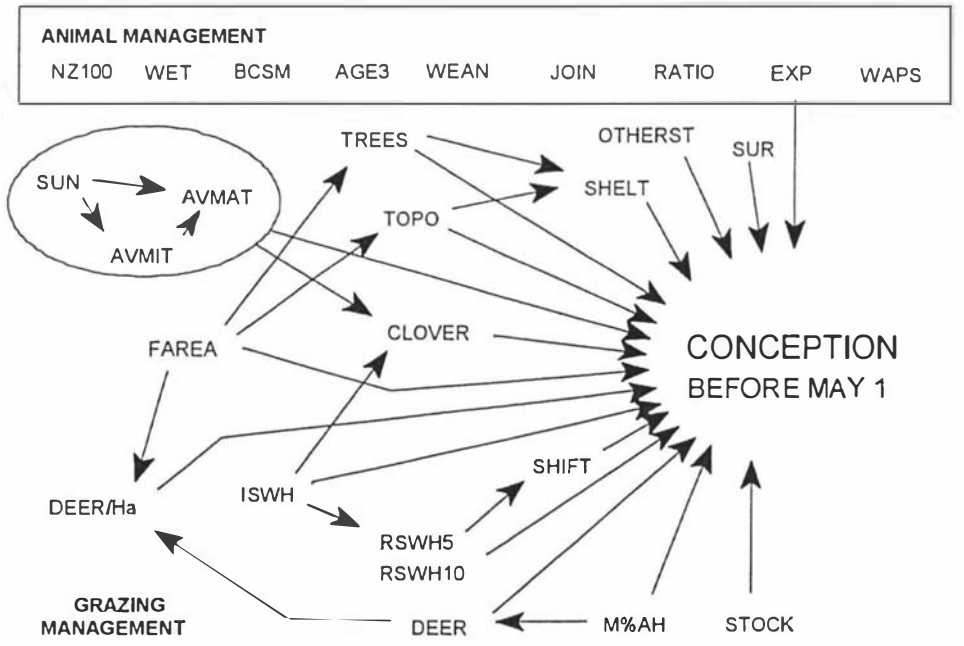
2. Final path diagram



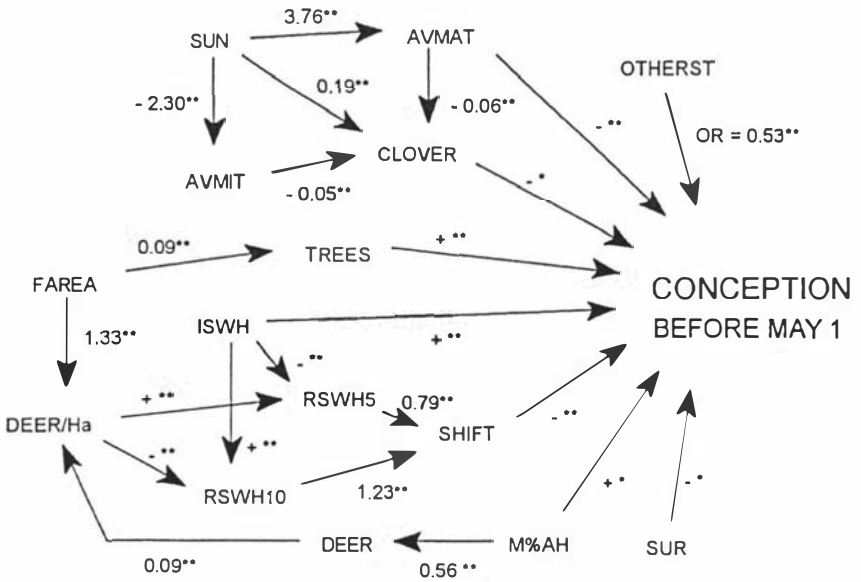
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 7.65%.

Figure 4.2 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for adult hinds conceiving before May 1.

1. Null hypothesis path diagram



2. Final path diagram (animal management variables were not included in this analysis)



Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 3.46%.

Table 4.5 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of animal and grazing management risk factors predicting the probability of adult hinds conceiving *per se* (direct effects).

Total number of hinds included in the analysis : 2603
Number of hinds conceiving (CONC) = 2513

BLOCK 1 :
Animal management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
782.482	703.32	79.16	10.12

Risk factors codes*	coefficient estimates	Std error	p value	Adjusted OR	95% CI
NZ100	1.097	0.256	0.000	3.00	1.81 4.95
WET	1.217	0.298	0.000	3.38	1.88 6.05
BCSM	0.621	0.162	0.000		
EXP	0.818	0.240	0.001	2.27	1.42 3.62
CHS	0.686	0.245	0.005	1.99	1.23 3.21

BLOCK 2 :
Environment and grazing management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
782.482	706.14	76.34	9.76

Risk factors codes*	coefficient estimates	Std error	p value	Adjusted OR	95% CI
SHIFT	-0.339	0.059	0.000		
STOCK	0.915	0.190	0.000		
RSWH10	-0.720	0.287	0.012	0.49	0.28 0.85
AVMIT	-0.545	0.113	0.000		
RAIND	0.410	0.177	0.021		
SUR	-0.012	0.004	0.002		
SHELT	-0.052	0.018	0.003		

Environment and grazing management
controlled by significant animal management risk factors

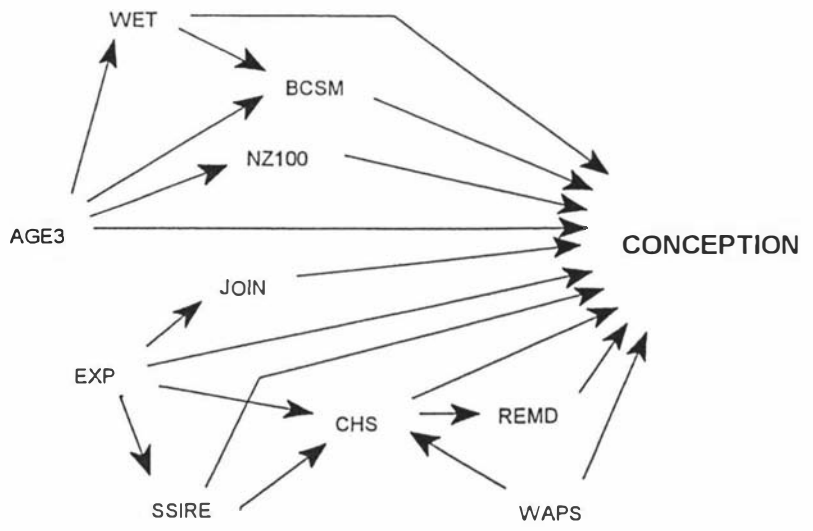
DEVIANCE			
Intercept	Model	Chi-Square	% variability
782.482	677.67	104.81	13.39

Risk factors codes*	coefficient estimates	Std error	p value	Adjusted OR	95% CI
WET	1.317	0.305	0.000	3.73	2.75 5.06
BCSM	0.575	0.165	0.001		
NZ100	0.612	0.302	0.043	1.84	1.36 2.49
EXP	0.763	0.288	0.008	2.14	1.61 2.86
SHIFT	-0.225	0.047	0.000		
STOCK	0.807	0.207	0.000		
AVMIT	-0.338	0.116	0.004		
FAREA	-0.059	0.022	0.008		
SUR	-0.010	0.004	0.009		

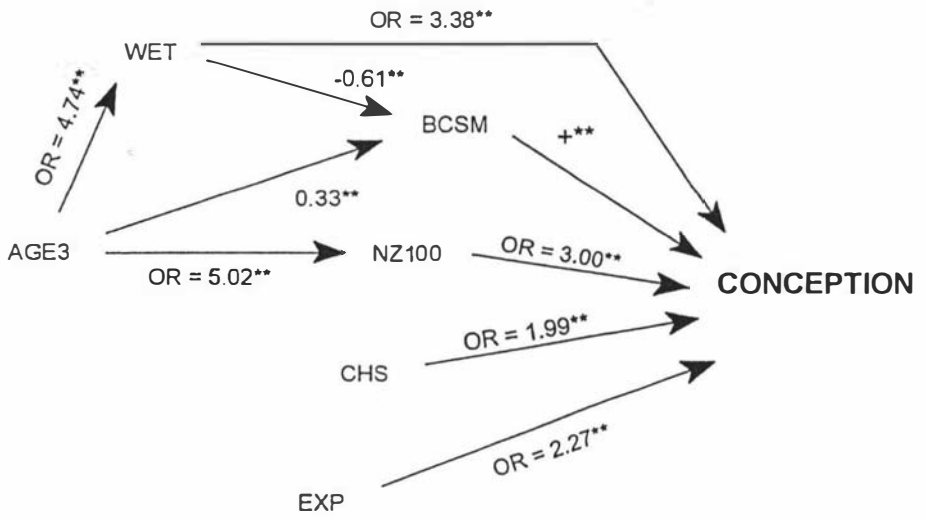
* Risk factor codes are described in the glossary and Table 4.3.
OR = odds ratio; Std error = standard error; 95% CI = 95% confidence interval
Note : Intercept = deviance of an intercept only model; Model = deviance of the model
% variability = (Model - Intercept) x 100 / Intercept

Figure 4.3 : Null hypothesis and final path diagrams of animal management risk factors for adult hinds conceiving *per se*.

1. Null hypothesis path diagram



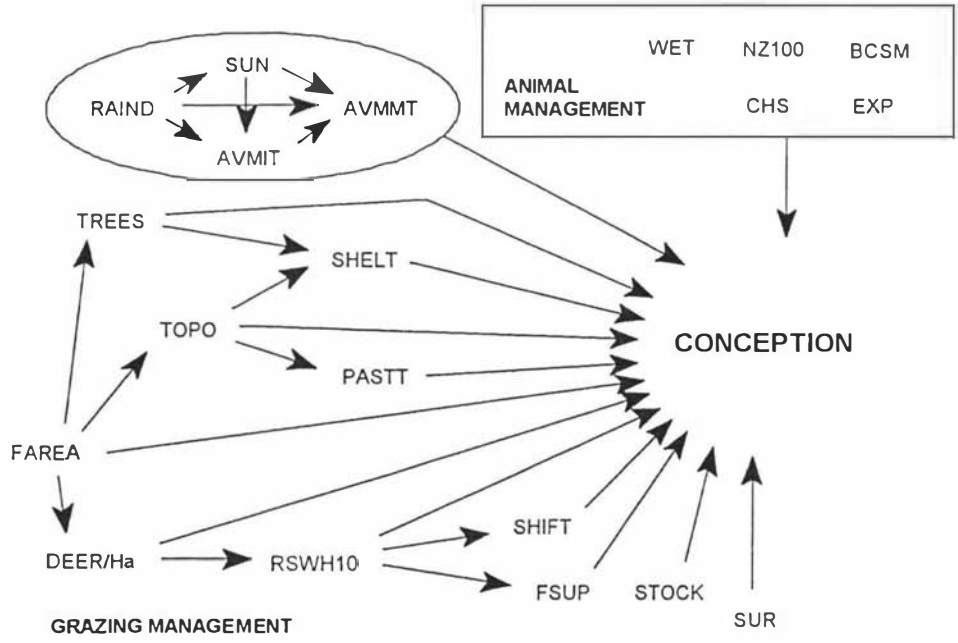
2. Final path diagram



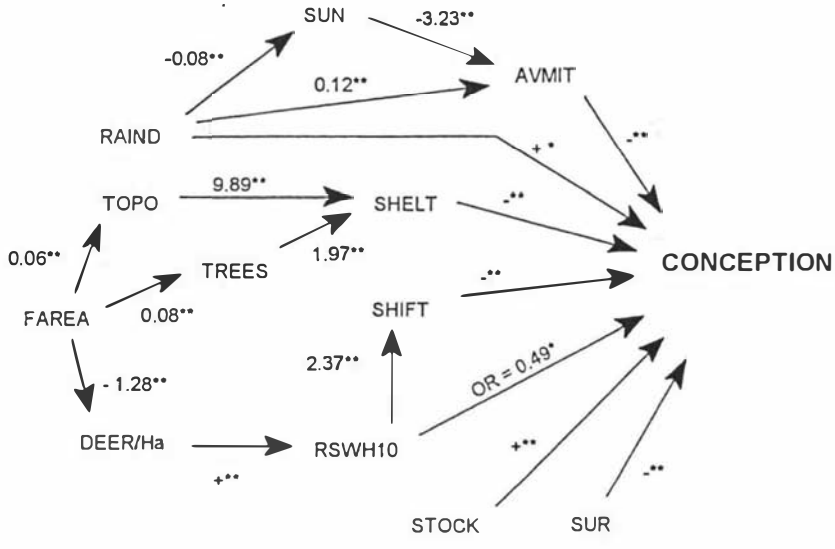
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 10.12%.

Figure 4.4 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for adult hinds conceiving *per se*.

1. Null hypothesis path diagram

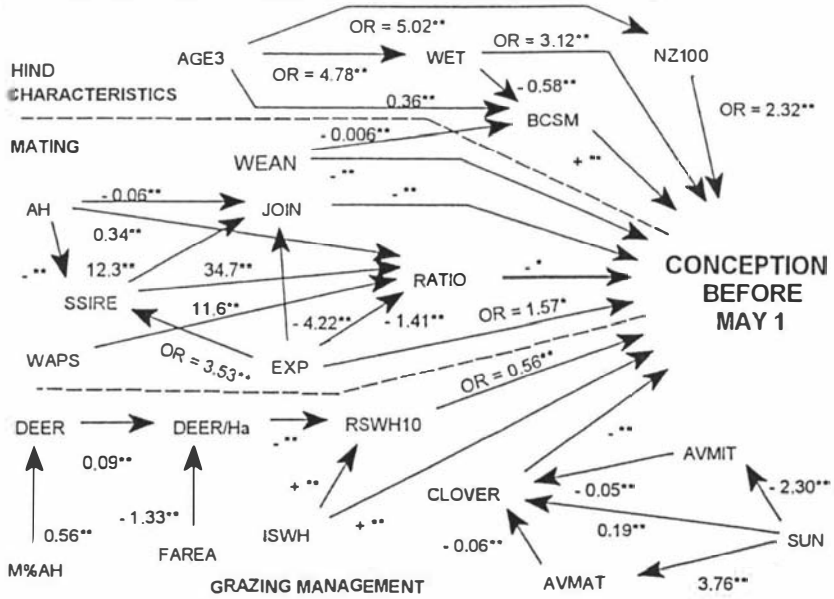


2. Final path diagram (animal management variables were not included in this analysis)



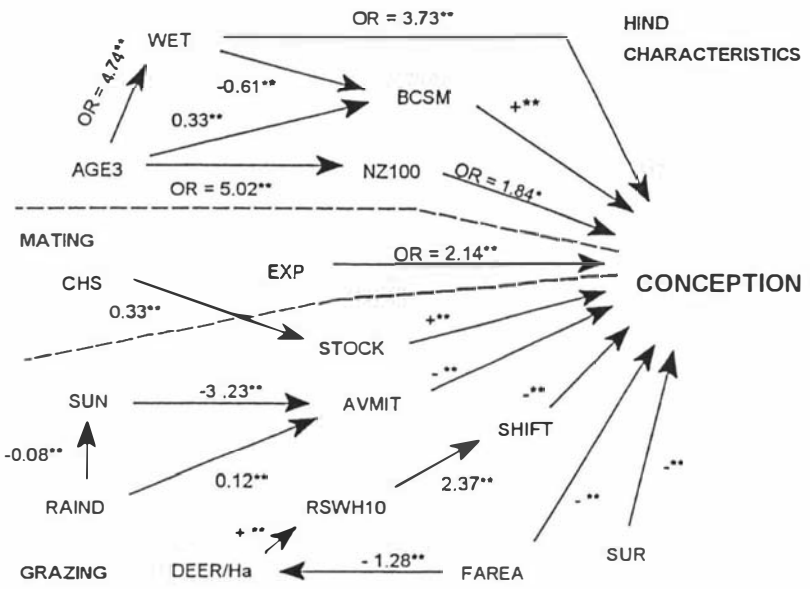
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 9.76%.

Figure 4.5 : Overall final path diagram of animal management, grazing management and environmental risk factors for adult hinds conceiving before May 1.



Note : Null hypothesis path diagram is in Figure 4.2. Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 8.55%.

Figure 4.6 : Overall final path diagram of animal management, grazing management and environmental risk factors for adult hinds conceiving *per se*.



Note : Null hypothesis path diagram is in Figure 4.4. Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 13.39%.

Table 4.6 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of animal and grazing management risk factors predicting the probability of yearling hinds conceiving before May 1 or conceiving *per se* (direct effects).

Yearling hind conception before May 1 (ADVC)

Total number of hinds included in the analysis : 700
Number of hinds conceiving before May 1 (ADVC) = 467

BLOCK 1 :
Animal management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
890.66	792.77	97.89	10.99

Risk factor codes*	coefficient estimates	Std error	p value	Adjusted OR	95%CI
NZ	0.0114	0.0043	0.0073		
BCSM	-0.6611	0.1767	0.0002		
W4	0.0645	0.0141	0.0001		
YSPM	1.0275	0.1811	0.0001	2.79	1.96 3.98
YH	0.0307	0.0067	0.0001		
YS	-0.5726	0.2466	0.0202	0.56	0.35 0.91
BACK	0.9551	0.2838	0.0008	2.60	1.49 4.53

BLOCK 2 :
Environment and grazing management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
890.66	782.60	108.06	12.13

Risk factor codes*	coefficient estimates	Std error	p value
STOCK	-0.3902	0.1950	0.0454
CLOVER	0.5115	0.2342	0.0289
DEER	0.0248	0.0077	0.0012
SUR	-0.0187	0.0028	0.0001
SHELT	-0.0772	0.0141	0.0001

Environment and grazing management
controlled by significant animal management risk factors

DEVIANCE			
Intercept	Model	Chi-Square	% variability
890.66	754.91	135.75	15.24

Risk factor codes*	coefficient estimates	Stderror	p value	Adjusted OR	95%CI
W4	0.0320	0.0122	0.0085		
YSPM	0.9998	0.2434	0.0001	2.72	1.69 4.38
STOCK	-0.9018	0.2278	0.0001		
ISWH	0.0996	0.0273	0.0003		
DEER	0.0202	0.0081	0.0126		
OTHERST	-1.1642	0.2838	0.0001	0.31	0.18 0.54
SUR	-0.0071	0.0031	0.0226		
SHELT	-0.0629	0.0135	0.0001		

Yearling hind conception (CONC)

Total number of hinds included in the analysis : 700
Number of hinds conceiving *per se* (CONC) = 597

BLOCK 1 :
Animal management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
584.81	552.83	31.98	5.47

Risk factor codes*	coefficient estimates	Std error	p value
NZ	0.023	0.005	0.000
W4	0.047	0.016	0.003
GR46	0.009	0.003	0.001

BLOCK 2 :
Environment and grazing management

DEVIANCE			
Intercept	Model	Chi-Square	% variability
584.81	548.91	35.90	6.14

Risk factor codes*	coefficient estimates	Std error	p value	Adjusted OR	95%CI
RSWH5	1.475	0.740	0.046	4.37	1.03 18.64
AVMMT	0.152	0.047	0.001		
TREES	-0.307	0.096	0.001		

Environment and grazing management
controlled by significant animal management risk factors

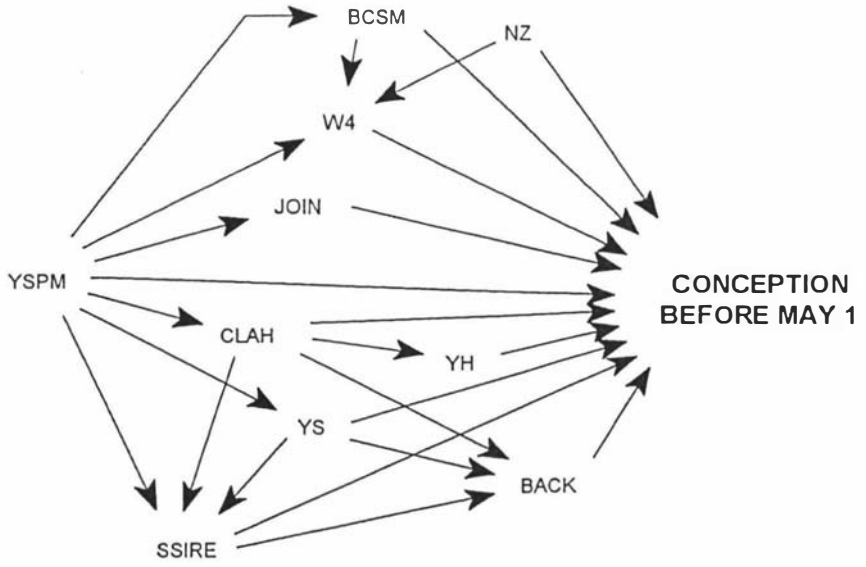
DEVIANCE			
Intercept	Model	Chi-Square	% variability
584.81	518.52	6629	11.33

Risk factor codes*	coefficient estimates	Std error	p value
W4	0.072	0.018	0.000
GR46	0.011	0.003	0.000
AVMIT	1.407	0.426	0.001
AVMMT	0.245	0.057	0.000
TREES	-0.736	0.149	0.000
AVWIND	-0.669	0.303	0.027

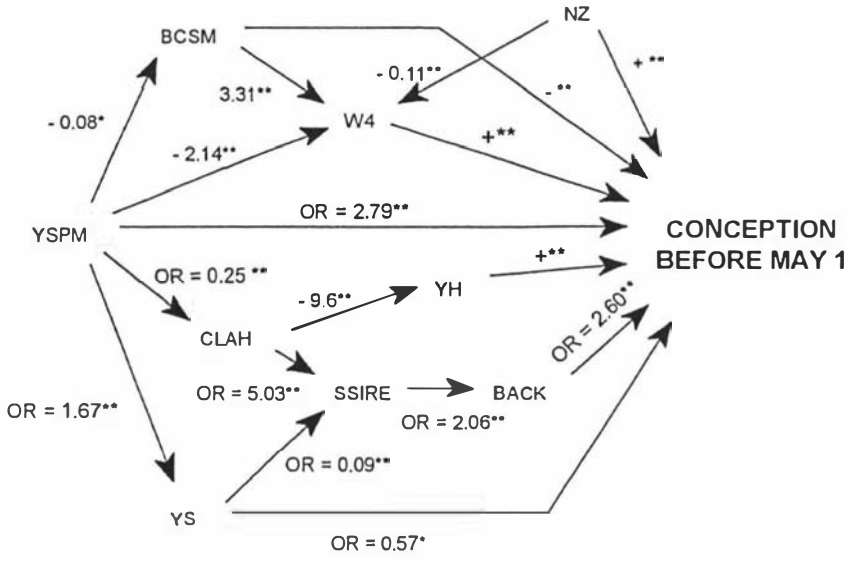
* Risk factor codes are described in the glossary and in Table 4.3.
OR = odds ratio, Std error = standard error, 95% CI = 95% confidence interval
Note : Intercept = deviance of an intercept only model, Model = deviance of the model
% variability = (Model - Intercept) x 100 / Intercept
* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conception after May 1 or not pregnant
CONC = 1 : Hind conceiving, CONC=0 : Hind not pregnant

Figure 4.7 : Null hypothesis and final path diagrams of animal management risk factors for yearling hinds conceiving before May 1.

1. Null hypothesis path diagram



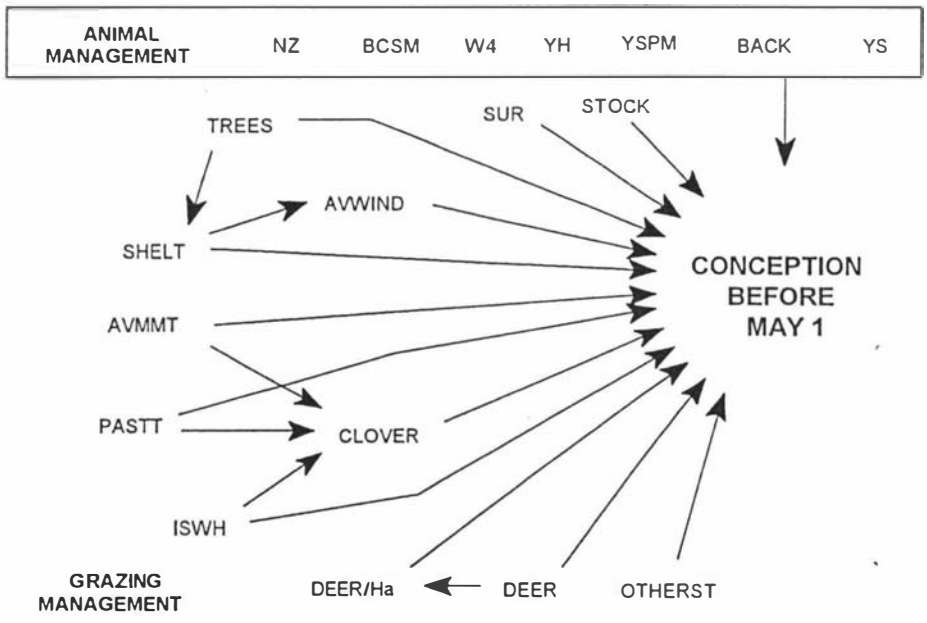
2. Final path diagram



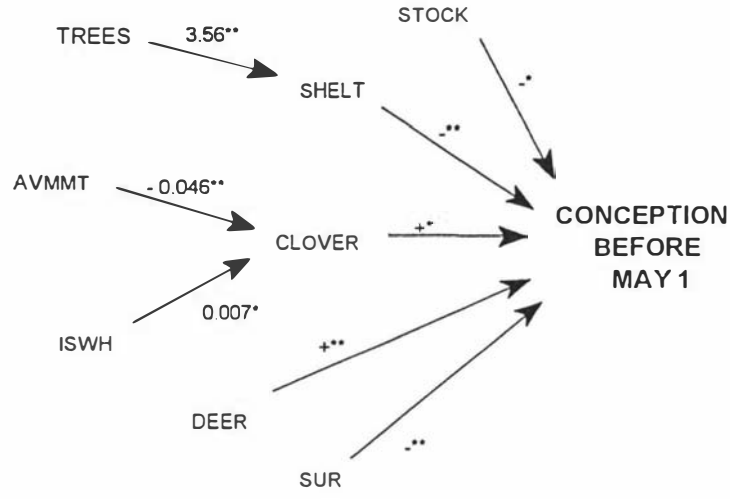
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 10.99%

Figure 4.8 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for yearling hinds conceiving before May 1.

1. Null hypothesis path diagram



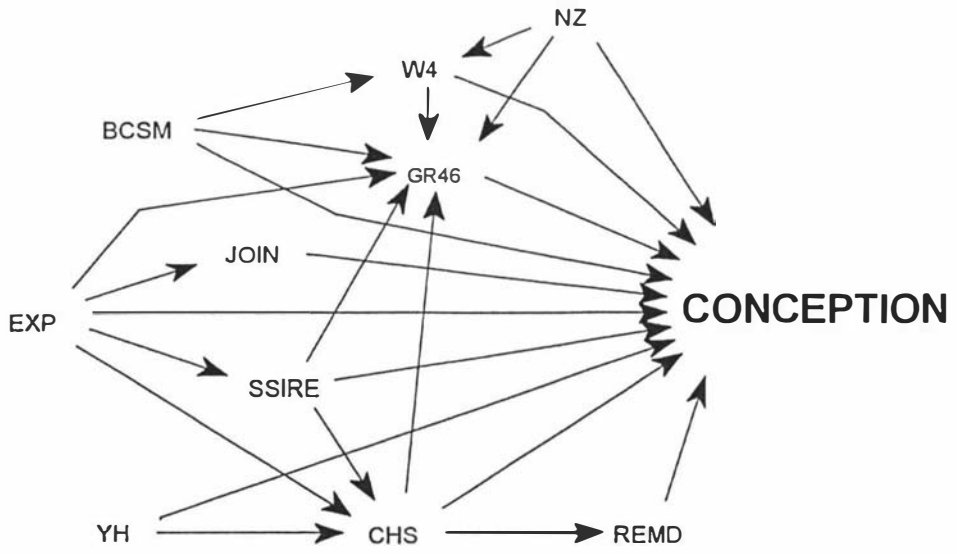
2. Final path diagram (animal management variables were not included in this analysis)



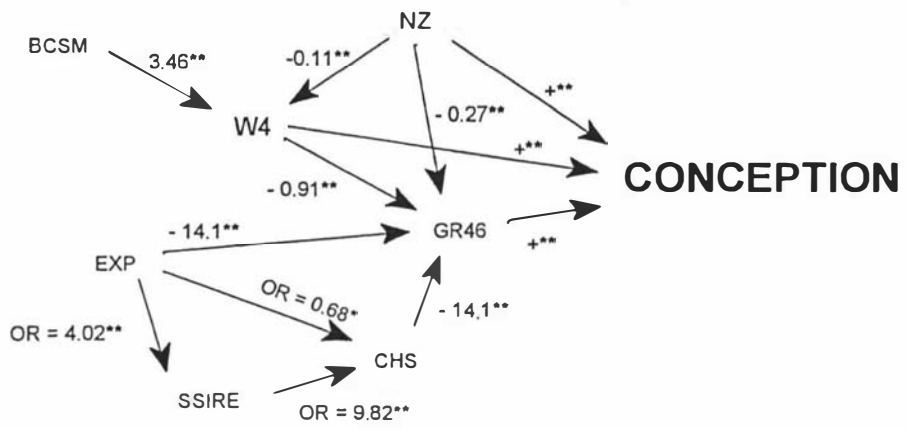
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 12.13%.

Figure 4.9 : Null hypothesis and final path diagrams of animal management risk factors for yearling hinds conceiving *per se*.

1. Null hypothesis path diagram



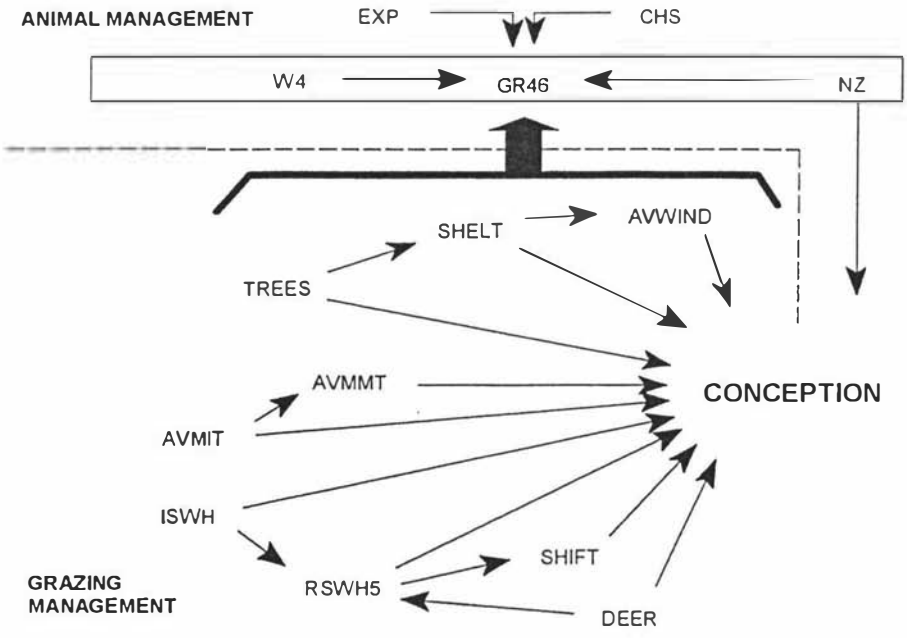
2. Final path diagram



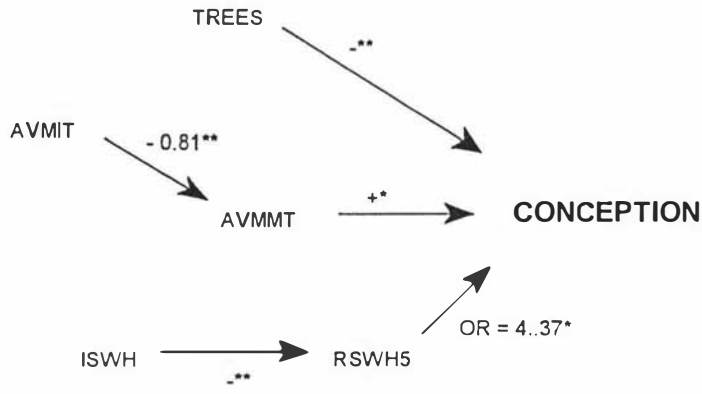
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 5.47%.

Figure 4.10 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for yearling hinds conceiving *per se*.

1. Null hypothesis path diagram

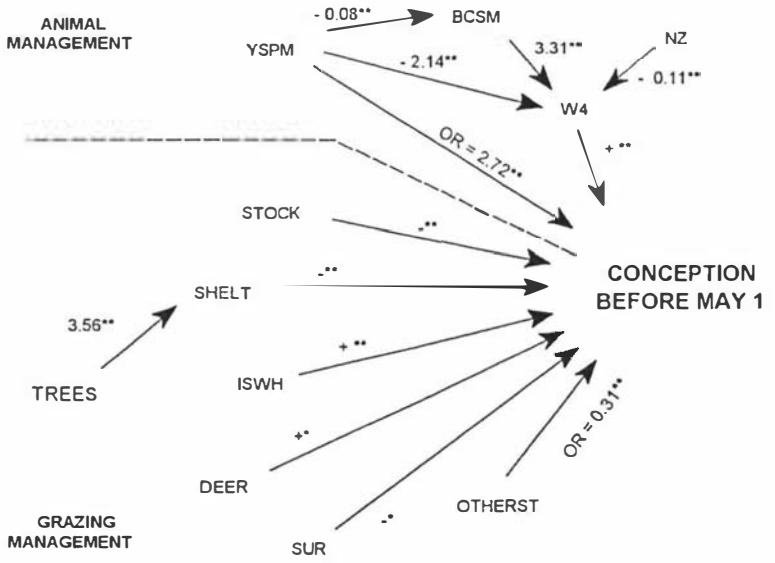


2. Final path diagram (animal management variables were not included in this analysis)



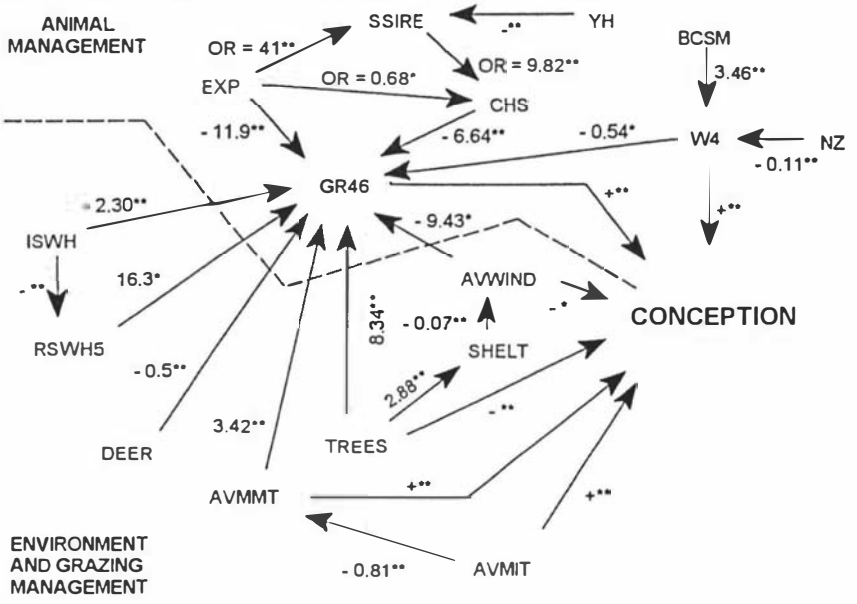
Note : Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 6.14%.

Figure 4.11 : Overall final path diagram of animal management, grazing management and environmental risk factors for yearling hinds conceiving before May 1.



Note : Null hypothesis path diagram is in Figure 4.8. Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 15.24%.

Figure 4.12 : Overall final path diagram of animal management, grazing management and environmental risk factors for yearling hinds conceiving *per se*.



Note : Null hypothesis path diagram is in Figure 4.10. Risk factor codes are described in Table 4.3 and in the glossary. Unstandardised linear regression coefficients, odds ratios (OR) and signs of logistic regression coefficient of continuous risk factors are presented on statistically significant paths (** $p < 0.01$; * $p < 0.05$). The percentage of the variability of the outcome explained by this model is 11.33%.

Table 4.7 : Logistic regression coefficient estimates and adjusted odds ratio (OR) of body condition score variables and confounding factors predicting the probability of yearling and adult hinds conceiving before May 1 or conceiving *per se*.

Risk factor codes	coefficient estimates	Std error	p value	Adjusted OR	95%CI
Hind conception before May 1 (ADVC)					
Adult hinds					
AGE3	0.4781	0.1772	0.0070	1.61	1.14 2.28
WET	1.1208	0.2173	0.0001	3.07	2.00 4.70
WEAN	-0.0095	0.0051	0.0619		
BCSM25	-0.3885	0.1817	0.0325	0.68	0.47 0.97
BCSM4	0.0922	0.1942	0.6349	1.10	0.75 1.60
Yearling hinds					
YSPM	0.7502	0.1653	0.0001		
BCSM25	0.6496	0.3401	0.0561	1.91	0.98 3.73
BCSM4	-0.4079	0.1777	0.0217	0.67	0.47 0.94
Hind conception *per se* (CONC)					
Adult hinds					
AGE3	0.2085	0.2533	0.4106	1.23	0.75 2.02
WET	1.4769	0.3004	0.0001	4.38	2.43 7.89
BCSM25	-1.1774	0.2527	0.0001	0.31	0.19 0.51
BCSM4	0.0305	0.3021	0.9196	1.03	0.57 1.86
Yearling hinds					
BCSM25	0.9383	0.5344	0.0791	2.56	0.90 7.28
BCSM4	-0.2764	0.2264	0.2223	0.76	0.49 1.18

* Outcome variables : Hind conceiving before May 1 (Yes / No) and Hind conceiving (Yes / No)
OR = odds ratio; Std error = standard error; 95% CI = 95% confidence interval
Note : Risk factor codes are described in the glossary and in Table 4.3.

Table 4.8 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of back-up mating group risk factors predicting the probability of yearling and adult hinds conceiving before May 1 or conceiving *per se*.

Hind conception before May 1 (ADVC)

Yearling hinds

No variables were selected by the stepwise procedure at the 5% significance level

Hind conception *per se* (CONC)

Yearling hinds

DEVIANCE			
Intercept	Model	Chi-Square	% variability
142.00	133.75	8.25	5.81

Risk factor code	coefficient estimate	Std error	p value	Adjusted OR	95%CI
CHS2	-1.531	0.270	0.000	0.22	0.13 0.37

Adult hinds

DEVIANCE			
Intercept	Model	Chi-Square	% variability
258.41	253.10	5.32	2.06

Risk factor code	coefficient estimate	Std error	p value
REMD	0.032	0.014	0.023

Note : These data were not subjected to path analysis.
Risk factor codes are described in the glossary and in Table 4.3.
OR = odds ratio; Std error = standard error; 95% CI = 95% confidence interval
* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conception after May 1 or not pregnant
CONC = 1 : Hind conceiving; CONC=0 : Hind not pregnant

Table 4.9 : Logistic regression coefficient estimates and adjusted odds ratios of sentinel hind characteristics and biological markers statistically significantly associated with conception status* of yearling and adult hinds, respectively.

YEARLING HINDS

Sentinel hinds characteristics

No potential risk factor was selected by the stepwise procedures at the 5% significance level

Biological markers

Hind conception before May 1

with continuous risk factors

DEVIANCE			
Intercept	Model	Chi-Square	% variability
134.55	120.10	14.45	10.74

Risk factor code	coefficient estimates	Std error	p value
Cu	-0.1308	0.0573	0.0224
MGSHPx	0.1554	0.0516	0.0026

with categorical risk factors

DEVIANCE			
Intercept	Model	Chi-Square	% variability
134.55	123.40	11.15	8.28

Risk factor code	coefficient estimates	Std error	p value	Adjusted OR	95% CI
MGSHPX3	2.4049	0.8230	0.0035	11.08	4.86 25.23

Hind conception

with continuous risk factors

DEVIANCE			
Intercept	Model	Chi-Square	% variability
79.42	58.08	21.34	26.87

Risk factor code	coefficient estimates	Std error	p value
ALB	0.3257	0.1295	0.0119
CU	-0.2051	0.0889	0.0210
B12	0.0178	0.0081	0.0285

with categorical risk factors

DEVIANCE			
Intercept	Model	Chi-Square	% variability
79.42	58.02	21.40	26.94

Risk factor code	coefficient estimates	Std error	p value	Adjusted OR	95% CI
ALB	0.2930	0.1325	0.0271		
CU	-0.2100	0.0844	0.0129		
FLC>0	-2.2338	1.0998	0.0423	0.11	0.01 0.92

ADULT HINDS

Sentinel hinds characteristics

Hind conception before May 1

DEVIANCE			
Intercept	Model	Chi-Square	% variability
72.75	52.54	20.21	27.78

Risk factor code	coefficient estimates	Std error	p value	Adjusted OR	95% CI
NZ100	2.6855	0.9988	0.0072	14.67	2.07 103.87
WET	1.8860	0.8697	0.0301	6.59	1.20 36.26
SIZE	0.2633	0.1290	0.0412		
EASES	1.9407	0.8606	0.0241	6.96	1.29 37.62

Hind conception

DEVIANCE			
Intercept	Model	Chi-Square	% variability
42.15	35.08	7.07	16.77

Risk factor code	coefficient estimates	Std error	p value	Adjusted OR	95% CI
NZ100	2.6210	0.9622	0.0064	13.75	2.09 90.64

Biological markers

Hind conception before May 1

DEVIANCE			
Intercept	Model	Chi-Square	% variability
79.45	69.47	9.98	12.56

Risk factor code	coefficient estimates	Std error	p value
P	-1.9707	0.6633	0.0030

Hind conception

DEVIANCE			
Intercept	Model	Chi-Square	% variability
42.15	27.46	14.69	34.85

Risk factor code	coefficient estimates	Std error	p value
NP	0.1204	0.0597	0.0437
P	-4.4105	1.7444	0.0115

Note : These data were not subjected to path analysis

Risk factor codes are described in the glossary and in Table 4.3.

OR = odds ratio; Std error = standard error; 95% CI = 95% confidence interval

* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conception after May 1 or not pregnant
CONC = 1 : Hind conceiving; CONC=0 : Hind not pregnant

4.1.4 Discussion

Discussion of materials and methods, in particular the use of path analysis is presented in sections 2.8.13 and 5.1.

4.1.4.1 Animal management risk factors

4.1.4.1.1 Adult hinds

Individual hind characteristics appeared to play an important role in achievement of early and overall conception.

For a given body condition score, hinds still lactating at weaning (WET) appear approximately 2-3 times more likely to conceive before May 1 (or conceive at all) than hinds not rearing a calf to weaning (dry). The total effect of WET on adult hind conception, however, is not as high because of the significant negative effect of WET on hind pre-mating body condition score (BCSM), which has a significant positive effect on the likelihood of conception. In the wild, successful reproduction (thus lactation) reduces the mother's body condition and fertility during the next reproductive season (Clutton-Brock et al., 1983).

Individual pre-mating bodyweight was not identified as significant in this analysis. This was probably because almost all weights were over the threshold for conception of 65-70 kg identified more than 10 years ago (Hamilton and Blaxter, 1980). For each 10 kg increase in pre-mating bodyweight, an advancement of calving date by 2 days has been observed in red hinds (Hamilton and Blaxter, 1980) and wapiti (Friedel and Hudson, 1994), but these authors did not investigate body condition as a possible confounding factor. This study has shown that over a threshold bodyweight, it appears that pre-mating body condition is one of the major risk factors influencing conception. This observation is supported by studies in wild deer (Mitchel and Lincoln, 1973; Albon et al., 1986), and in other domestic livestock such as sheep (Cumming et al., 1975; Pollott and Kilkenny, 1976) and cattle (Garnsworthy and Haresign, 1989).

It should be noted, however, that the relationship found in the path analysis was based on the assumption that there is a linear relationship between BCSM and the likelihood of conception. Further analyses suggested there may be a threshold pre-rut BCS between 2.5 and 3 under which the probability of conception (before May 1 or not) decreases (Table 4.7). Hinds with BCSM over 3.5, after correcting for their lactational status at weaning, were no more likely to conceive (or conceive before May 1) than hinds with a BCSM of 3 or 3.5. This contrasts with the observation that fat ewes (Gunn et al., 1991) and fat cows (Garnsworthy and Haresign, 1989) have reduced reproductive performance. In this study, few hinds had a BCS of 5.

This study, along with observations in wild deer (Mitchel and Lincoln, 1973; Albon et al., 1986) and other domestic livestock suggests there may be a causal relationship between body condition and conception. Garnsworthy and Haresign (1989), suggested that in dairy cows the effect of body condition may be due to underlying disease conditions (ovarian cyst or poor oestrus manifestation) rather than poor nutrition directly, but suggested that poor nutrition may be a causal factor for these reproductive problems. In sheep, poor body condition was associated with low ovulation rates, but did not appear to affect subsequent survival of embryos (Cumming et al., 1975).

Pure New Zealand hinds appeared to be three times more likely to conceive (Figure 4.3), but it is believed this may be partly mediated through age, as hinds over 2 years (AGE3) were 5 times more likely to be pure New Zealand hinds than younger adult hinds. Pure New Zealand hinds, however, were twice as likely to conceive before May 1 than other hinds, after controlling for age (Figure 4.1). This observation has not been reported before and needs further investigation.

Age of the hind could not be used as a continuous variable in these analyses because the age of a large proportion of hinds was not known, although it was likely to be more than 5 years. Recently, Fisher et al. (1994a) reported the observation that 16-to 20-year-old hinds have reduced ovarian activity and thus were less likely to conceive, but very few (if any) such hinds were likely to be present on farms in this study. AGE3 was identified as a direct effect on early conception but not on conception *per se*. This was confirmed through the analyses of categorised body condition score variables. The reason for this is not clear, although it may be related to social factors. Young hinds are likely to be low in the social rank and consequently more often harassed by dominant hinds. The stress imposed upon these young hinds may have a negative impact on ovulation.

AGE3 was also identified as indirectly positively influencing conception through WET and BCSM. In this analysis, hinds over 3 years at mating (AGE3) were 4.8 times more likely than hinds mated for the second season to have reared a calf up to weaning (WET). However, this odds ratio may be overestimated because non-lactating adult hinds were more often culled than non-lactating yearlings. Since overall 17% and 9.1% of yearling and adult hinds lost their progeny, respectively (see section 3.3.4.1.2), the relative risk of adult hinds being WET over yearling hinds is 1.87. Lactation puts yearling hinds under higher nutritional stress than adults, thus lowering their body condition disproportionately (see Figure 3.17). By withdrawing NZ100, WET and BCSM from final models, the total effects of AGE3 can be evaluated. Hinds in their second mating season were 2.25 times more likely to conceive early and 1.83 times more likely to conceive *per se* than older hinds.

The influence of bodyweight change of adult hinds between April 1 and June 1 (GR46) on conception was rejected early in the analysis. Other analyses of reproductive data, however, showed GR46 was significant in predicting post-winter hind body condition scores, which in turn was identified as beneficial for the survival of the progeny up to weaning (see section 4.2).

These results also suggest a beneficial influence of early weaning (WEAN) and early introduction of stags (JOIN) to adult hinds and conception before May 1. This supports a recent report from wapiti farms in Canada which showed herds in which pre-rut weaning was practised had a higher calving percentage (94% versus 91%), and pre-rut weaning resulted in a 5 day advancement in calving dates (Friedel and Hudson, 1994). In the wild, hinds in lactation at mating have a delayed onset of oestrus (Guinness et al., 1978a), which may be caused by the increased prolactin secretion associated with suckling (Loudon et al., 1983). However, there was no significant interaction between WET and WEAN in this study, which means the effect of WEAN on early conception was not significantly different between lactating and non-lactating hinds. However, in this study only one farm in 1992 weaned as late as April 30 and a few others in the last days of March or early April. There is evidence that the mating season (or rut) may have started already on these farms (Asher and Fisher, 1991). Lactating hinds may also not synchronise as much as non-lactating hinds during or just prior to the rut (Iason and Guinness, 1985), again suggesting that early weaning may have a positive effect on oestrus synchrony and early conception. Such putative explanation is consistent with the observation that both WEAN and JOIN did not significantly predict the likelihood of

conception *per se* in adult hinds (Figure 4.3). Part of the negative effect of weaning late on conception before May 1 was also mediated through BCSM, since the later that hinds were weaned, the poorer their condition. The amplitude of this effect, however, was low with only 0.2 decrease in the average hind BCSM for 30 days delay at weaning. In this analysis, a linear relationship was assumed between the date of weaning and the likelihood of conception before May 1, but this may not be the case. There could be a threshold weaning date before which early conception results would be enhanced. This possibility needs further investigation. Some farmers prefer post-rut weaning (eg June). No conclusions can be drawn from this thesis on post-rut weaning because the latest weaning date was April 30, ie during the rut.

Social interactions between hinds and stags may be important in determining the onset of the breeding season in farmed deer (Fisher and Meikle, 1994). The positive "stag effect" has been demonstrated with the use of vasectomised stags (Moore, 1985) or with the use of melatonin implants to advance the reproductive season (Wilson, 1990; Fisher and Fennessy, 1990). Early introduction of sire stags can significantly advance the onset of first oestrus in hinds by up to 6 days (Moore, 1985). Thus, this study supports existing scientific literature.

If all other risk factors were maintained as constant, hinds mated to experienced stags were 1.5 times more likely to conceive early and 2.3 times more likely to conceive at all, than those mated to inexperienced stags. The use of experienced sire stags, however, was negatively associated with the date of introducing stags with hinds (JOIN) and the hind:stag ratio (RATIO), which are related to management decisions and cannot be explained on purely biological grounds. By withdrawing RATIO and JOIN from the model, the odds ratio of EXP increased from 1.49 to 1.64, which suggests a minimal influence of indirect effects through managerial decisions.

In this study, experienced stags were 3.5 times more likely to be used as single sires for mating (SSIRE) and were joined with hinds on average 12 days later, and had a higher hind:stag ratio (about 35 hinds) than when multiple sire mating was used. The number of sire stags was categorised as the use of single versus multiple sire for mating as it was believed the possibility of competition between sires was more relevant than the actual number of sires. Single sire mating appeared to have a negative effect on conception before May 1, but this was identified as an indirect effect through JOIN and RATIO, suggesting the mating management strategies could be changed by decreasing the hind:stag ratio and joining stags earlier to increase the risk of early conception on adult hinds.

Using 15-month-old or older sire stags did not appear to be an issue for increasing the risk of conception, as YS was rejected early in the analysis. This may be because yearling stags did not give poorer results than inexperienced adult sires. Yearling stags are likely to be sexually immature, ie do not show strong rutting behaviour, during the mating season, whereas there is a risk of infertility when using inexperienced adult sire stags. The examination of both wapiti and red deer stags revealed at least 10% may have poor quality semen during the breeding season, which may result in reduced fertility (Haigh and Hudson, 1993) although the collection method may have influenced quality. This suggests inexperienced stags, including yearlings, should be "challenged" for their first mating experience with a limited number of hinds or even culled hinds, which may be pregnancy tested before or at slaughter, and only proven fertile sires should be used with the main breeding herd. This proposal requires appropriate research evaluation, although the use of sires with successful breeding records has been recommended previously (Moore et al., 1985).

The origin of red deer used for mating did not appear an important factor as NZS was rejected early in the analyses. The apparent beneficial direct effect on early conception of using hybrid wapiti sires, shown by initial analyses, was unexpected, because of the belief that such sires are usually shy mating with red hinds (Bringans, 1986). None of the sires used in this study were of pure wapiti. However, this relationship did not remain statistically significant in the overall final diagram (Figure 4.5). In this study, farmers who used wapiti sires did not have greater conception rates as they tended to have higher hind:stag ratios, one of which was the highest ratio reported.

The hind to stag ratio rather than the number of adult hinds in the mating mob appeared to be important for adult hind early conception but not conception *per se*. A low ratio may allow sire stags to mate all hinds coming into oestrus at the beginning of the rut, in particular if they are well synchronised. The negative direct relationship between hind:stag ratio and the likelihood of early conception may not be linear, and further analysis will be necessary to explore the possibility of a threshold value. The recommended hind:stag ratio was about 30 (Kelly and Moore, 1977[#82) with a maximum of 50 (Bray and Kelly, 1979; Moore, 1985). The range reported in this study was 8 to 82.

The use of back-up stags (BACK) was not significant in explaining the variability in early conception but appeared an important practice to increase overall conception. By leaving primary sire stags after May 1, farmers may get a few more adult hinds pregnant, but it seems beneficial to replace the initial sire stag altogether (CHS). This may ensure fertile mating of hinds coming into oestrus late, if initial sires are sexually exhausted or infertile. The non-significance of the use of a back-up stag on the analysis of early conception may be because late conceiving adult hinds did not come into oestrus between the time of introduction of back-up stags (mostly after April 20) and May 1. However, the time of removal of sire stag (REMD) was not significant in the final model possibly because if back-up stags were used (CHS1) they were removed from hinds on average 13 days later than other sires, and the effect may be confounded with that of CHS1. This view was further supported by the positive effect of leaving sire stags late with hinds in the analysis of back-up mob characteristics.

4.1.4.1.2 Yearling hinds

During the establishment stage of a breeding herd, the farmer's objective often is to increase the number of hinds. To obtain maximum fertility and numbers of calves, the mating season may be extended to allow late conception to occur. It is also tempting to keep every yearling hind for breeding to maximise the rate of growth of herd size. However, this may not be the most profitable option (Hamilton, 1988).

The present study suggests that bodyweight on April 1 (W4) and the pre-mating body condition score are the most important individual hind characteristics on which this selection can be based. The positive effect of pre-mating body weight on conception (and thus calving dates) is well known in yearling hinds (Mitchell and Lincoln, 1973; Hamilton and Blaxter, 1980; Hamilton, 1988), and is associated with the onset of puberty (oestrus) (Fisher and Fennessy, 1985; Adam, 1994). This study, therefore, further supports the current scientific literature, and allows the researcher to believe the relationship between W4 and conception status is causal. However, that relationship may not be linear. There is evidence that puberty occurs when yearling hinds reach at least 60% of their mature bodyweight in red deer and wapiti (Haigh and Hudson, 1993), with a 50% probability of conception at 70% of mature bodyweight. This supports the finding that, for the same bodyweight, the higher the percentage of New Zealand genes that yearling hinds carry, the more likely they are

to conceive early and to conceive *per se*. Red hinds with European or English blood lines have a higher mature bodyweight than pure New Zealand hinds (see Figure 3.15 in section 3.3.1.1), which implies they have a higher pre-mating bodyweight requirement. Their onset of puberty may also be delayed. A threshold bodyweight around 65 kg has been proposed more than 10 years ago (Kelly et al., 1982), which was later slightly increased to 65-75 kg by Fennessy et al. (1986)(although there was only 4 hinds in the lower weight category) but this figure may differ between breeds of red deer.

The negative effect of yearling hind pre-mating body condition score on conception before May 1 is intriguing. Further analyses suggested there may be a threshold BCS around 4 over which the probability of early conception decreases (Table 4.7). A similar observation has been reported in Angus and Hereford x Friesian heifers (Sawyer et al., 1991), where the probability of conception increased with BCS up to a threshold value and decreased in fat heifers. As for cattle, the reason for this relationship in deer is unknown. It suggests, however, sexual maturity is a slow process that may not be triggered by improved nutrition immediately prior to the mating season. Flushing small yearling hinds may result in improved bodyweight as shown in Figure 4.7 (one unit increase of BCSM was associated with a 3.3 kg increase in W4), but tall and thin yearlings may be preferable to short and fat ones to maximise the probability of early conception. Yearling hind BCSM, however, was not associated with the probability of conceiving *per se*, while bodyweight was, which suggests flushing may have an beneficial effect on overall conception. The timing of growth and nutrition levels of young hinds, therefore, appears critical to ensure yearling hinds reach the desired body frame (thus body height and bodyweight) early, and do not get fat prior to mating. This suggestion should be prioritised for further nutrition research. Target heights should also be defined for yearling hinds as they have been for heifers (Donovan and Braun, 1987; Heinrichs, 1992).

Although associated with heavy bodyweight, BCSM had a negative effect on conception through reduced growth during the mating season (GR46). The higher the growth rate between April 1 and June 1, the higher the probability of conception. Because fat hinds grew less (or had a lower bodyweight change) than thin hinds, this relationship may be due to BCSM. Yearling hinds in a catabolic state may be more exposed to delayed oestrus, low ovulation rate, or embryo loss by June. However, a multiplicity of management factors in this study have been found to be associated with GR46, which appeared a major factor influencing conception. Further evaluation showed yearling hinds that gained bodyweight during mating were 2.6 times more likely to conceive *per se* than other hinds.

It is interesting to note that no mating management risk factors had an effect on conception *per se* in yearling hinds other than indirectly though GR46, whereas they appeared to directly affect early conception. For instance, the more yearling hinds in the mating mob (YH), the more likely they were to conceive early. But large yearling hind mobs were generally found only when they were mated separately from adult hinds as shown by the negative relationship between CLAH (presence of at least one adult hind in the mob) and YH. This would support the belief that yearling and mature hinds should be run in separate herds for mating (Yerex ed, 1982) because the reproductive success of yearling hinds is likely to be affected by mature hinds (Round-Turner, 1979). The dominance of mature hinds in mating groups may put yearling hinds under social stress (Guinness et al., 1971; Veltman, 1985), which may consequently impair ovulation and conception (Wilson, 1979, Fisher and Fennessy, 1985) through hormonal deregulation (Adam et al., 1985; Jopson et al., 1990). The apparent beneficial effect of mixing yearling and adult hinds for mating observed during data collection, may be due to sire management differences as shown in Figure 4.7. Yearling hinds mixed with adults were 5 times more likely to be single-sire (SSIRE) mated and consequently were more

likely to be backed-up with another sire (BACK). Yearling hinds exposed to a second sire before May 1 were 2.6 time more likely to conceive before that date.

Yearling hinds mated with one or more yearling stags (YS) were less likely to conceive before May 1, suggesting yearling sires may have been unable to mate all oestrous hinds at the onset of the rut. In this analysis, the use of experienced sires (EXP) was not included in the model as it was highly associated with YS. Almost all adult sires used with yearling hinds were experienced. In fact, yearling sires were almost always used in groups, and therefore less likely to be backed-up. This suggests the use of yearling sires, and the associated lack of back-up sire to be partly responsible for the lower early conception rates in yearling hinds than in adults observed in this study.

However, mixing yearling hinds and stags up to the time of joining with sire stags appeared to have a beneficial effect, as yearling hinds left with yearling stags in the same mob during the period immediately prior to mating (YSPM) were 2.8 times more likely to conceive before May 1. This is consistent with the beneficial effect of joining sire stags early with adult hinds, identified earlier in this analysis and the observation of Fisher and Meikle (1994) that yearling hinds isolated from stags reached puberty 5.4 days later than hinds running with stags, and suggests yearling stags have a stimulation effect on the onset of puberty in yearling hinds. Yearling hinds left with yearling stags up to mating, however, were about 2 kg lighter and in slightly lower body condition, which may indicate the occurrence of interactions between these two groups, or alternatively that feeding was less adequate on farms where hinds and stags were left together up to 15 months old. Yearling hinds managed in conjunction with yearling stags, however, were 1.7 times more likely to be mated as yearling groups, and not mixed with adult hinds. It may be that the apparent beneficial direct effect of YSPM is partly caused by not mixing yearling and adult hinds. More research is needed to clarify this point.

Mating management strategies did not appear critical for yearling hind conception other than through their influence on yearling hind growth (GR46). Use of experienced sires had a significantly negative relationship with GR46, possibly because they display more intensive rutting behaviour and keep their harem together more than other stags, thus preventing yearling hinds from grazing freely. Back-up sire stags may display such behaviour more aggressively than tired or exhausted initial sire stags. This negative influence of rutting stags on yearling hind growth is consistent with the negative effect of YSPM on W4 identified in the analysis of early conception. In this study, experienced stags were more often used for single-sire mating but less often as back-up sires. Stags used for single-sire mating, however, were more often changed with back-up stags. Therefore, it was believed the beneficial effect of using adult sire stags, which were almost all experienced in this study, and backup sires on early conception, may be reversed should conception *per se* be considered. Should this be true, it will have important implications for mating management depending on the farmer's objectives for reproductive performance.

4.1.4.2 Grazing management and environmental factors

The analyses of grazing management and environmental factors are more difficult to interpret because there is no pre-existing evidence of causation or biological explanation for many factors. Some factors in this block were chosen based on logical thought without support from the literature, so this discussion is only suggestive of plausible explanations.

The apparently negative effect of changing the mob composition (STOCK) during mating on yearling hind early conception was expected, since mixing deer with unfamiliar groups has been

proven a rather stressful experience (Pollard et al., 1993) and may increase aggressive interactions between hinds. However, the apparently beneficial effect of STOCK on adult hind conception may be because it is confounded with that of using back-up stags.

The negative effects on conception of shifting adult hinds between paddocks (SHIFT) and grazing adult hinds on paddocks close to human presence (SUR) may be associated with disturbance of mating mobs which may occur during oestrus, thus interfering with mating. SUR was also associated with a decrease in the probability of yearling hinds conceiving early. The negative effect of contact with other domestic livestock in adult and yearling hinds is intriguing and will need further investigation.

The significance of sward height variables in preliminary analyses suggests nutrition during mating should be evaluated further. In sheep, body condition at mating and the level of concurrent nutrition in the period immediately prior to and at mating are both known to influence subsequent reproductive performance (Gunn et al., 1991).

For a given class of residual sward height (RSWH10), the higher the initial sward height (ISWH), the more likely adult hinds conceived early. This emphasised that nutrition levels may be critical for good reproductive results. Adult hinds grazing swards below 10 cm, however, were twice as likely to conceive at all, but swards below 10 cm may have been of better quality because of limited amount of roughage and dead material. In this study, a seed head density score was recorded by some farmers, but it was inconsistently assessed and was therefore rejected from analyses. Hinds which grazed pasture over 10 cm high (RSWH10) were more often shifted (SHIFT) than the other hinds, SHIFT may be a confounding factor in the analysis of early conception. Both risk factors were significant in one final diagram (Figure 4.4), suggesting they have their own direct influence on conception. Grazing swards below 5 cm was not significant and will need to be further evaluated as its effect, if any, may depend on the pre-mating body condition of the hind. However there was no significant interactions between RSWH5 or RSWH10 and BCSM in this study.

The initial sward height (ISWH) was also beneficial for early conception of yearling hinds (Figure 4.11). Grazing swards below 5 cm (RSWH5) appeared to have a beneficial effect on conception *per se*, which, in the final diagram (Figure 4.10) was identified as indirect through the hind growth rate. This is contradictory to the observation that grazing below 5 cm in associated with reduced pasture intake, as observed with weaner deer (Ataja et al., 1989), and suggests it may be related to pasture quality (as for adult hinds) or RSWH5 may be a surrogate variable for other important factors not included in this analysis.

The negative effect of high clover content in pasture (CLOVER) for adult hind early conception is unexplained. It is known some type of clover can impair reproductive performance of ewes due to an oestrogenic effect (Shackell and Kelly, 1984), but, in this study, there was predominantly white clover in pastures, a non-oestrogenic clover. This effect, however, conflicts with the positive effect of CLOVER on yearling hind early conception in the analysis of grazing management factors alone, so it may not be an important factor. Alternatively, the negative and positive effect of CLOVER on early conception in adult and yearling hinds, respectively, may be due to a negative effect of sunny weather patterns.

A high score of sun (SUN), had a negative effect on adult hinds early conception through CLOVER and increased average daily maximum temperature (AVMAT)(Figure 4.2), while large mean daily ranges of temperature (AVMMT)(often due to sunny weather) had negative effects on early

conception of yearling hinds through a positive influence on CLOVER (Figure 4.8). There is no easy explanation for these relationships, other than perhaps that such weather patterns may have exposed some survey farms to drought, and thus limited grass quality late summer. Alternatively, one may suggest sunshine or high temperature *per se* may have a negative effect on early conception in adult and yearling hinds. In contrast to its negative effect on early conception, sunny weather appeared to be beneficial for conception *per se* in adult and yearling hinds through low mean daily minimum temperatures (AVMIT) or high mean daily temperature range (AVMMT). The daily average rainfall (RAIN) had a negative effect through the effect of SUN and AVMIT, but a positive direct effect on adult hind conception. This suggests climatic conditions may have an important impact on hind reproductive performance and should be further investigated.

Preliminary results showed shelter risk factors to have a variable influence on hind conception, if any. Trees appeared to have a direct positive effect on early conception, whereas the global amount of shelter (SHELTER) including trees were identified as negatively affecting overall conception. There is no easy explanation for these relationships, although the fact that they did not remain in both overall final diagrams, suggests they may be of marginal significance for adult hinds. That the exposure of adult hinds to wind (AVWIND) did not affect their ability to conceive supports this observation. Alternatively, TREES may protect adult hinds from sunshine and heat in late summer, while this protection may be inappropriate for overall conception. Yearling hinds, however, appeared less likely to conceive before May 1 and to conceive *per se* when mated in sheltered paddock (in particular including trees), although, when protected from the wind (AVWIND) and the presence of trees, they were more likely to gain bodyweight. These associations suggest more specific types of shelter should be investigated. The effect of trees may be worth further evaluation, in particular with regard to protection from sunshine and warm temperatures at the beginning of mating.

Other paddock characteristics such as the topography score (TOPO) and paddock area (FAREA) which were initially selected did not remain significant in final diagrams of adult hind conception (early or not), possibly because of their relationship with paddock shelter variables (see section 3.1.2.1.2). This may further explain why FAREA was identified with a direct negative influence on adult hind conception in the overall final diagram, when SHELT did not. One might propose that sire stags may be more effective in keeping their harem together in paddocks with limited gullies and hills, or in small paddocks, and thus more effectively identify and mate hinds in oestrus. It is recognised such putative explanation may not hold when multiple sire mating is used (Moore, 1985), but single-sire mating was the mating strategy used most often in this study.

The mean percentage of adult hinds in the mating mob (M%AH), but not the mean mob size (DEER), appeared to be associated with increased conception before May 1 in adult hinds. Since adult hinds may display stronger oestrous behaviour than yearling hinds, this observation is consistent with the oestrous synchrony in red deer hinds described previously. Large mob size as positively associated with M%AH, so the positive effect of DEER on early conception of yearling hinds may contradict the effect of adult hinds discussed previously. However, within large mating mobs pre-mating, the "hind-to-hind" stimulating effect on oestrus synchrony (Fisher and Fennessy, 1985; Bringans and Lawrence, 1988) may be beneficial to yearling hinds as well. Later in the mating season, this beneficial effect may be reduced, thus the negative effect of DEER on conception *per se* may prevail. This may occur through limited growth rate as observed in Figure 4.12.

4.1.4.3 Sentinel hinds

It is acknowledged that the meaning of behavioural observations of hinds during sampling may have limitations, ie the fact that recording of the ease of blood sampling (EASES), and whether hinds were stressed (STRESS) and showed signs of aggression (AGGR) may be somewhat subjective, and that behavioural patterns in yards may be influenced by multiple factors related to the yards and the sampling visit itself (windy weather, number of people, time spent in the pen, etc). However, in the context of this study, this recording gives valuable information on the general behavioural pattern at sampling.

Because the number of hinds sampled is substantially less than the total number of hinds monitored, the power of the analyses was lowered. This may be the reason why limited measurements or observations made on sentinel hinds (and in adult hinds only) were found significantly associated with the likelihood of conception before May 1 or conception *per se*. The previous analyses highlighted the importance of a wide range of individual hind characteristics in yearling and adult hinds. A larger number of yearling hinds should therefore be measured, as discussed previously.

The analyses of adult sentinel hinds supported the beneficial effect of New Zealand blood lines, which may be due to age, and lactational status (WET) for early conception. However, only NZ100 was significantly associated with conception *per se*. The wider confidence intervals of odds ratios are due to the lower number of hinds included in the analyses. That shoulder height (SIZE) was significantly positively associated with the likelihood of early conception in adult hinds, where BCSM and W4 were not selected in the model is intriguing and would need further evaluation. However, this relationship supports the need to preferentially select tall hinds for breeding. It is interesting to note that the girth measurement was reported as a poor index of fatness in red deer (Riney, 1955), which may explain why it was not significant. The thoracic girth and bodyweight on April 1 (also not selected) are correlated variables ($r = 0.69$; $p<0.05$). BCSM was not significant in this analysis because the association is not likely to be linear, as identified earlier in the analysis.

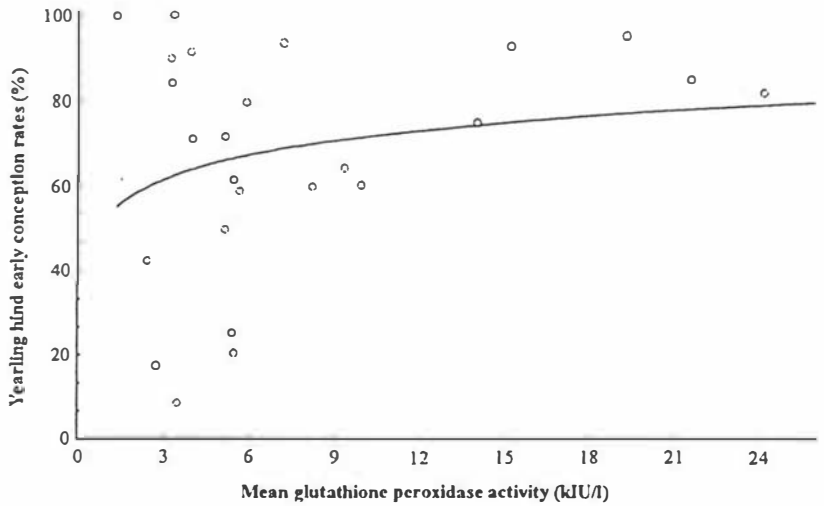
Hinds that were able to be sampled quietly in the pen without firm physical restraint (EASES) were 7 times more likely to conceive early. Although the true odds ratio may be somewhere between 3 and 16.4 due to small sample size, it suggests that hinds with innate quieter temperament or that are managed to be quiet, especially during yarding and handling, may have improved reproductive performance. It is known stress can impair ovulation in red deer (Fisher and Fennessy, 1985; Adam et al., 1985).

Although the wear of teeth was commonly associated with old age and poor body condition of adult hinds, there was no significant effect of the teeth score (TEETH) on the probability of early conception or conception *per se*. Until this is further supported, it suggests that culling hinds on the basis of teeth wear alone is not justified. Severely worn incisors are not always associated with loss of body condition, as the latter depends on grazing management (Orr and Moore, 1989). However, such deer may have lowered feed intake as was observed in sheep (Coop and Abrahamson, 1974), and should they be in poor condition at weaning, they may have difficulty recovering their condition under tight grazing conditions. Food supplementation may be required for these hinds. As advised by Coop and Abrahamson for sheep (1974), hinds should possibly be culled on body condition more than on teeth or age.

4.1.4.4 Biological markers

In this study, it appears that Se deficiency may impair early conception in yearling hinds. This effect was not evident in adults. Individual serum GSHPx activity could not be investigated because only 3 hind samples per farm were analysed. However, as the variability of GSHPx is essentially due to farm difference (66.8% of the total variance)(see Appendix 3.74), the mean GSHPx (MGSHPx) was used as an individual value for every hind within each farm. The higher MGSHPx, the more likely yearling hinds will conceive early. When MGSHPx was over 3 kIU/l, which has been proposed has the minimum threshold value in sheep (MAF Optigrow Animal Health profile), yearling hinds were 11 times more likely to conceive early. Consequently, MGSHPx was plotted against the percentage of yearling hinds conceiving early within each farm (Figure 4.13).

Figure 4.13 : Relationship between mean pre-mating glutathione peroxidase from 3 hinds and yearling hind early conception rates within each survey farm. Data from 1992 and 1993 combined.



Note : The line is a logarithm fitted line

This graph further supports the possible negative effect of low selenium levels on yearling hind early conception, and suggests a threshold value may stand around 5-6 kIU/l, instead of 3 kIU/l as identified in sheep. The reason why this apparently strong relationship was not significant in adult hinds is not known.

In cattle, many studies have failed to identify a significant relationship between blood selenium levels and fertility, and Se supplementation trials have failed to influence the reproductive performance, suggesting Se deficiency does not play an important role in reproductive performance (Spears et al., 1986; Ropstad, 1990; Braun et al., 1991). In sheep, however, the percentage of barrenness was significantly reduced by dosing merino ewes with selenium prior to mating (Scales, 1974), possibly due to reduced embryonic mortality between three to 4 weeks post-conception.

The negative effect of high serum copper concentrations on early conception and conception *per se* is intriguing, as there is currently no logical explanation for it.

High serum albumin concentrations (ALB) were significantly associated with conception in individual yearling hinds, which is consistent with the previous observation of the beneficial effect of high growth rates during mating. This suggests serum albumin may be a useful marker to assess the likelihood of conception in yearling hinds. There are many publications which support the potential benefit of measuring serum albumin concentrations in dairy cattle, including from observation under New Zealand grazing conditions (Wilson et al., 1985). Often authors referred to a reduction in the albumin:globulin ratio in infertile cows (Rowlands et al., 1980). These effects were often in adult cattle and related to metabolic disorders associated with lactation. The non-significance of serum albumin in adult hinds, therefore, may be related to the fact that most hinds were separated from their calves (weaning) prior to mating.

Consequently, serum albumin concentration of yearling hinds was further investigated. Since, farm differences "explained" a significant part of the variability of pre-mating serum albumin concentrations in yearling hinds (32.7%, see Appendix 3.74), the mean albumin concentration of the 5 sentinel yearling hinds was plotted against the conception rates of yearling hinds within each farm (Figure 4.14). There was a statistically significant positive linear relationship, although a linear regression line may not be the line of best fit. The scatterplot in Figure 4.14 suggests a threshold value may stand around 35 g/l, under which reproductive performance may be impaired. This will need to be further investigated.

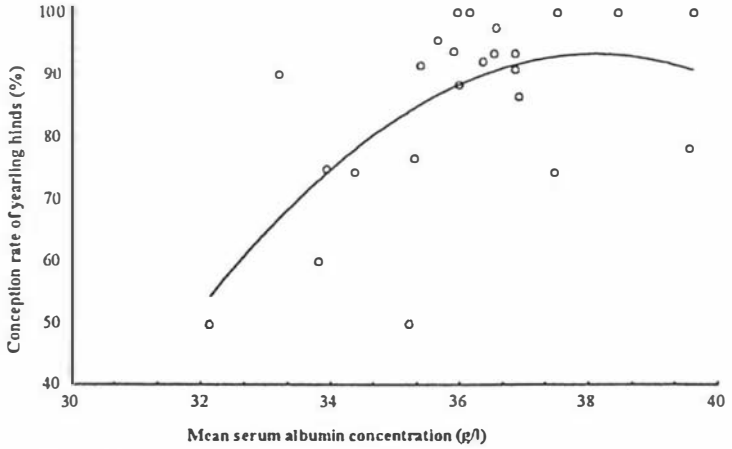
Serum vitamin B12 (B12) was positively associated with the probability of yearling hinds conceiving. B12 is a standard marker for cobalt status of ruminants as it reflects cobalt intake. Cobalt is needed for optimal function of rumen microorganisms and thus optimal forage digestibility (Paragon, 1993). In this study, serum vitamin B12 was also investigated as a dichotomous variable as the relationship was not likely to be linear. Although critical values of serum vitamin B12 in cattle can be around 38-76 pmol/l (Suttle, 1991), concentrations below 185 pmol/l are regarded as deficient in sheep (Clark and Millar, 1983). The categorical variable B12185, however, was not significant, which suggests that 185 pmol/l may not be the appropriate threshold level in deer. In sheep, vitamin B12 deficiency was not associated with lower conception rate, but lower lamb survival (Fisher and McPherson, 1991).

Consequently, B12 of yearling hinds was further investigated. Since, farm differences "explained" 53.9% of the variability of pre-mating B12 in yearling hinds (Appendix 3.74), the geometric mean vitamin B12 concentrations of the 5 sentinel yearling hinds were plotted against the conception rates of yearling hinds within each farm (Figure 4.15). This scatterplot supports that 185 pmol/l is not a threshold minimum value of vitamin B12 concentration in deer, supporting the observation of Clark et al. (1986) following vitamin B12 supplementation trials in deer. Proposing a threshold value from this graph would be too speculative.

When B12185 rather than B12 was included in the analysis, the effect of faecal larval count (FLC>0) became significant in yearling hinds, which were less likely to conceive. The mechanism by which lung parasitism would affect reproductive performance directly is not clear, so it is believed to be mediated through the nutritional status of the animal (Morris and Meek, 1980).

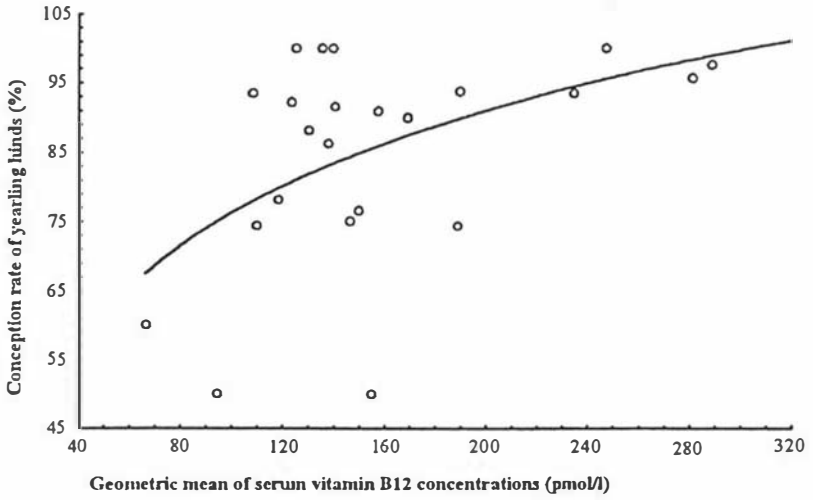
The negative influence of phosphorus concentrations on adult hind conception (early or not) was unexpected. Many trials failed to identify a significant relationship between phosphorus levels and fertility in cattle (Ropstad, 1990; Forshell et al., 1991; Glauber et al., 1993). However, there have been reports that phosphorus concentrations could be too high for optimal fertility (Hewett, 1975).

Figure 4.14 : Relationship between mean pre-mating albumin concentrations of 5 yearling hinds and conception rates of yearling hinds within each survey farm. Data from 1992 and 1993 combined.



Note : The fitted line is an inverse exponential smoothing curve

Figure 4.15 : Relationship between geometric mean pre-mating serum vitamin B12 from 5 sentinel yearling hinds and yearling hind conception rates within each survey farm. Data from 1992 and 1993 combined.

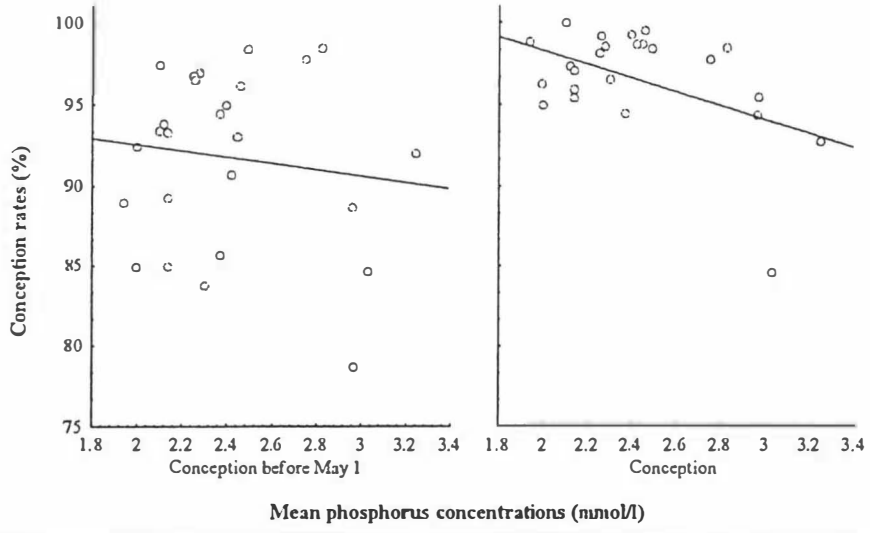


Note : The line is a logarithm fitted line

The non-significance of phosphorus levels on the onset of puberty and conception in yearling hinds is consistent with observations in heifers (Williams et al., 1992).

As farm differences accounted for a significant proportion (37.6 %) of variation in individual phosphorus concentrations in adult hinds, mean phosphorus concentrations within farms were calculated and plotted against conception rates of adult hinds on each farm (Figure 4.16). On these graphs it is not obvious that phosphorus can be used to predict conception rates in adult hinds, although the relationship was significant with overall conception rates.

Figure 4.16 : Relationship between mean pre-mating phosphorus concentrations of 5 adult hinds and conception rates (early and overall conception) of adult hinds within each survey farm. Data from 1992 and 1993 combined.



The neutrophil percentage was positively associated with the probability of conception in adult hinds, but there is no clear explanation for this observation. This may be a spurious association.

In the context of blood profile investigation of hinds prior to mating, it may be that serum glucose may be investigated in the future, as it appeared to be associated with fertility in dairy cows (Forshell et al., 1991).

4.1.5 Conclusion

It must be stressed that the associations found in this study are not proof of causation and further research is required to validate cause and effect relationships unless much stronger evidence of biological associations have been reported elsewhere in the literature. Data analysed here can be used to formulate a putative management strategy for farmers to achieve the highest possible reproductive performance in their deer herd. Some suggestions are made by the researcher on the basis of personal judgment derived from these results. These suggestions may help deer farmers in their reproductive management strategies, but should also be considered for the design and implementation of future research projects.

These proposals would vary between farms depending on overall management goals. If achievement of high reproductive performance was the single goal, the following should be applied to achieve the best result.

4.1.5.1 Management of adult hinds

To achieve a high pregnancy rate early in the mating season, it is proposed that farmers should :

- Wean early and score hinds for body condition at that time.
- Separate hinds with BCS 2.5 and below and provide a high energy ration to have them recover condition before the onset of the rut. Alternatively, these hinds may be culled directly at weaning.
- Cull hinds which failed to rear a calf to weaning and hinds with BCS 2.5 or less when mating commences in late March.
- Cull hinds which cannot be handled easy, or change management to improve handling ability of hinds.
- Join hinds early with at least one stag, which may not be the sire used for mating.
- Use only experienced sires for mating.
- Test-mate inexperienced stags destined to be future herd sires with a small number of hinds and pregnancy test these hinds to evaluate the stags' fertility or, alternatively, use inexperienced stags for multiple-sire mating, along with experienced sires.
- Limit the hind:stag ratio.
- Use at least one back-up sire after the peak of mating.
- Keep mating mobs away from disturbance such as roads, buildings, or houses and avoid shifting or handling before changing to back-up sires.
- Choose paddocks with trees for mating, and avoid grazing other domestic livestock along with mating mobs.

In addition, if the overall conception is the only goal :

- leave sire stags with hinds late to maximise conception rates at the expense of having late born calves. This proposal is contrary to options likely to minimise progeny loss (section 4.2) and maximise weaner bodyweight (section 4.3). Should the previous options be adhered to, the sires may not have to be left in so long.

This study has shown that on farms where these conditions are met all adult hinds can be mated before May 1 and an overall 98 to 99% conception rate achieved. Therefore it is believed there is room for improvement for a majority of farms.

It is the researcher's advice that :

- Hinds should be separated from their calves before March 1.
- Sire stags or teaser stags should be joined with hinds by at least late February - early March.
- The hind:stag ratio at mating should be limited to a threshold of 50 hinds per sire.
- Join back-up sire at least 18 days prior to termination of the chosen mating period.

4.1.5.2 Management of yearling hinds

When considering the economic significance of yearling hind conception, the consequence of low levels of nutrition and poor growth extend well beyond the attainment of puberty. Calves born to small hinds are smaller (see risk factors for weaner weight on April 1) and if they are born later than other calves, they are not likely to compensate by a higher growth rate (see section 4.4) and will therefore remain small. This study confirmed the importance of bodyweight for the attainment of puberty. However, specific management practices of yearling hinds prior to or during mating may prevent the significant losses identified in this study through poor conception.

To increase the probability of yearling hinds conceiving early, this study suggests :

- Yearling hinds should be selected prior to mating for bodyweight and height.
- Avoid overfatness prior to the rut. Tall and hinds in modest body condition (ie BCS 2.5-3.5) are preferred.
- Separate yearling stags and hinds in spring for optimal growth, and then reintroduce yearling hinds with yearling stags before introducing sire stags. Joining other stags (eg velvetting stags after the cut of velvet antler regrowth) well before the rut may have an effect. This option may also have the beneficial effect to limit overfatness in yearling hinds.
- Use a single experienced sire for mating and use a back-up sire before May 1.
- Avoid combining mobs of yearling hinds with large mobs of adult hinds for mating.
- Avoid changing the structure of mating mobs which may result in social stress.
- Select paddocks for mating away from human disturbance, and avoid shifting mating mobs during the peak of mating. Choose paddocks with limited gullies, hills and trees.

To increase the probability of yearling hinds to conceive *per se*, however, management strategies may be slightly different :

- Nutrition during mating should be prioritised to ensure optimal growth rates of yearling hinds. Small hinds (short or light or both) may be mated successfully, provided they are well fed and eat well. They will conceive later.

- Providing they are fertile, the use of inexperienced stags may be preferred and use of back-up stags avoided to minimise their negative effect on hind growth. This can be well achieved by leaving yearling hinds with their yearling male mates for the total duration of the mating season, and has proven successful in this study.

- The size of the mating mob should be limited

Therefore it appears important to carefully set production objectives for yearling hinds as it may have management implications. Mating strategies may differ whether farmers give priority to early conception or conception *per se*. Management options for increasing the probability of early conception may be more risky, but providing all requirements describe above are met, this study suggests 95-100% of yearling hinds can be pregnant by May 1.

It is the researcher's advice that :

- Yearling hinds could be left together for mating and non-dominant quiet adult hinds could be included with them.

- Reintroduction of yearling hinds with yearling stags or other stags should be carried out at least a month before the rut starts. It may be preferable to join actual sire stags early, say early February, instead of waiting until mid to late March, to avoid disturbance and change of mob structure at early mating.

- The change of sire stag should be at least 18 days prior to termination of mating.

- The size of the mating mob should be limited to 30-40 hinds to ensure optimum growth during mating.

4.1.5.3 Biological markers

Whereas no biological markers other than perhaps phosphorus concentrations appeared useful in evaluating the risk of infertility in adult hinds, there is potential for the use of blood markers in yearling hinds.

This study suggests that measurement of selenium status in yearling hinds (through the glutathione peroxidase activity), serum vitamin B12, albumin concentrations, and faecal lungworm larval counts may be useful to trigger management decisions, related to feeding, supplementation or treatment, to improve reproductive performance.

4.1.5.4 Identified areas for further research

This section has identified likely key factors influencing reproductive success and has highlighted areas which deserve priority in research and development designed to improve reproductive management techniques.

It is appropriate to investigate :

- The effect of nutritional allowance immediately prior to and during mating in yearling and adult hinds with various body condition scores.
- The occurrence of a threshold weaning date between late February and late March before which early conception rates of adult hinds may be enhanced.
- Practical options to test-mate inexperience sire stags.
- The threshold hind:stag ratio for single sire mating.
- The potential beneficial effect of introducing teaser stags (yearling or adult stags) well before the mating season and the most appropriate joining date.
- The effect of disturbance during mating.
- The effect of grazing other domestic livestock with mating mobs.
- The underlying physiological process that relate yearling hind growth and conception.
- The negative effect of sunny and warm weather patterns on early conception.
- The beneficial effect of trees in mating paddocks.
- Handling facilities and handling management practices in relation to hind behaviour immediately prior to mating and early conception.
- The use of glutathione peroxidase, serum vitamin B12, serum copper, serum albumin concentrations, and faecal lungworm larval counts in relation with yearling hind nutritional status, growth and ability to conceive.
- The potential beneficial effect of selenium or vitamin B12 supplementation requiring establishment of threshhold levels, and anthelmintic treatment on conception rates of yearling hinds.

4.2 RISK FACTORS FOR HIND LACTATIONAL STATUS AT WEANING

The rates of progeny loss of red deer from pregnancy testing to weaning have been estimated to be 17% and 9.1% in yearling and adult hinds, respectively. They are close to the 7-12% reported previously from New Zealand and the UK (Kelly and Whateley, 1975; Kelly and Drew, 1976; Blaxter and Hamilton, 1980; Asher and Adam, 1985; Moore et al., 1985, 1988) and represented a significant loss for the individual farmer and the New Zealand deer industry. Therefore, further analysis of the data were carried out to investigate risk factors associated with the survival of progeny up to weaning.

4.2.1 Materials and methods

The main outcome under study was whether breeding hinds diagnosed pregnant in June by ultrasound scanning were or were not lactating at weaning (WET), ie a dichotomous outcome.

About 2700 hinds were monitored for reproductive success in each of the two years according to methods presented in sections 2.3.1.4, 2.3.3.2, and 2.4.1. At weaning in 1993 and 1994 (survey years 1992 and 1993, respectively) the udders of hinds were palpated or observed by the farmer and hinds were categorised as lactating (WET) or not lactating (dry). During farm visits in September 1992, 10 randomly selected hinds (5 yearling (15 months) and 5 adult) were blood sampled to define their haematological, biochemical and mineral blood profiles (see section 2.4.1.1 and 2.5).

Risk factors potentially affecting the probability of lactation at weaning (WET) were identified and grouped in 4 blocks of variables as described in Table 4.10. These blocks were individual hind characteristics, calving paddock characteristics and calving management practices, grazing management variables calculated between November 1 and January 1, and observations during sampling and biological markers (for yearling hinds, there were only 4 non-lactating sentinel adult hinds, so block 4 was not analysed for this age group). However, a further evaluation of blood markers was carried out at the farm level rather than individual level, using mean blood markers of yearling and adult hinds as potential risk factors for weaning rates of yearling and adult hinds (WEANR), respectively.

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in section 2.7.

- All hinds diagnosed pregnant in June and present on the farm at weaning were included in the analyses.
- Data from both years of study were combined for statistical analyses. However, because it was not possible to include the risk factor WET-1 (hind lactating the previous year) in the analysis of pooled data, block 1 was reanalysed separately with the 1992 and 1993 data using the same null hypothesis path diagram plus WET-1 included. This was carried out for adult hinds only.
- Yearling and adult hind data were analysed separately at all stages.
  The individual outcome WET was investigated using SAS, while the farm outcome WEANR was investigated using Statistica.

Table 4.10 : Potential risk factors for hind rearing a calf up to weaning.

Risk factor Code	Unit	Description
BLOCK 1 : Animal management block		
Individual hind variables		
AGE3	D	Hind over 3 years old at calving
NZ	%	Percentage of New Zealand blood lines
NZ100	D	Pure New Zealand type hind
WET-1*	D	Hind lactating at weaning the year before
ADVC	D	Hind conceived before May 1 (early conception)
BCSS	Dis. 1-5;0.5	Post-winter body condition score (recorded in September)
BCSD	Dis. 1-5;0.5	Body condition score difference between March (pre-mating) and September (post-winter)
WD6	kg	Post-mating dam bodyweight on June 1
CHW9C	kg	Bodyweight change between September and calving (late October-November)
GR69	g/d	Growth rate between June 1 and September 1
Categorised body condition score variables		
BCSS2	D	Post-winter body condition score below 2.5
BCSS4	D	Post-winter body condition score over 3.5
BLOCK 2 : Calving paddock characteristics and calving management		
SET	day	Number of days between October 1 and the time when hinds were set-stocked for calving
HINDCM		Number of hinds in the calving mob
HIND/Ha	Hind/ha	Number of calving hinds per deer-fenced hectare
%AHCM	%	Percentage of adult hinds (at least 3 years old) in the calving mob
VISIT/W		Number of visits of calving hinds per week by the farmer
VISITCP	D	Close monitoring of calving hinds by moving throughout the calving paddock
ENTERP	Dis. 1-4;1	Frequency of entering calving paddocks during visits
TAGB	D	Tagging of calves at birth
PAREA	ha	Calving paddock area
PTOPO	Score 0-3	Topography score
PGULLY	Dis. 0-3	Gully score
PTREES	Dis. 0-3	Presence of trees (tree score)
PDAM	D	Presence of a dam, pond or swamp
PRIVER	D	Presence of a river or stream all year round in the paddock
PSTUMP	D	Presence of stump, branches, or objects (eg. drums, rubbish) in the paddock
PWIRE%	%	Percentage of paddock fence being wire-and-batten fences close to the ground.
PBULLR	Dis. 0-3	Bull rushes score
PTHISTLE	Score 0-3	Thistle score (calculated from observations during farm visits)
PRAG	Score 0-3	Ragwort score (calculated from observations during farm visits)
PSUR	D	Paddocks proximity to road, buildings or houses (ie signs of human presence)
PFP	Score 0-3	Paddock fence pacing score
BLOCK 3 : Grazing management between November 1 and January 1		
Grazing variables		
ISWH	cm	Mean pre-grazing pasture sward height
RSWH5	cm	Mean residual (ie post-grazing) pasture sward height below 5 cm
RSWH10	cm	Mean residual (ie post-grazing) pasture sward height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
SHIFT		Number of time deer were shifted between paddocks
STOCK		Number of time the mob composition was changed

*Risk factor WET-1 was investigated separately with the 1992 and 1993 data.

Note on units : D = dichotomous variables
"Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Table 4.10 (Cont'd)

Risk factor Code	Unit	Description
BLOCK 3 (Cont'd)		
PASTT	Score 1-3	Mean pasture type score
RAG	Score 0-3	Mean paddock ragwort score (calculated from observations during farm visits)
THISTLE	Score 0-3	Mean paddock thistle score (calculated from observations during farm visits)
DEER		Average number of deer in the mob
DEER/Ha	Deer/ha	Average number of deer per deer-fenced hectare (grazing density)
M%AH	%	Percentage of adult hinds in the hind mob
STAG	D	A least one stag over 15 months old grazed with hinds during hind lactation
CLAHC	D	Paddocks shared with adult hind(s) at least one day at calving (for yearling hinds only)
OTHERST	D	Paddocks shared with other stock than deer at least one day
Environmental variables		
FAREA	ha	Mean paddock size
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
GULLY	Score 0-3	Mean paddock gully score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
BULLR	Score 0-3	Mean paddock bull rushes score
DAM	%	Percentage of time spent in paddocks with a dam, pond or swamp
RIVER	%	Percentage of time spent in paddocks with a stream or a river running all year round
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt
BLOCK 4 : Sentinel hinds and biological markers		
Sampling hind characteristics		
SIZE	cm	Shoulder height
GIRTH	cm	Thoracic girth
COATL	mm	Length of the upper coat
VICTIM	D	Visible hair loss (sign of victimisation) on the back of the deer
EASES	D	Hind blood sampled without firm physical restraint
Biological markers recorded in September 1992 and 1993		
Individual hind and mean blood characteristics (for farm mean blood markers, codes start by "M")		
White cell count (WCC), neutrophil percentage (NP), lymphocyte percentage (LP), eosinophil percentage (EOP), haemoglobin (HB), packed cell volume (PCV); total protein (TP), albumin (ALB), phosphorus (P), gamma glutamyl transferase (GGT), blood urea nitrogen (BUN), copper (CU), vitamin B12 (B12), pepsinogen (PEPS), glutathione peroxidase (GSHPx)		
Individual hind categorised blood characteristics		
CU8	D	Serum copper concentration >= 8 µmol/l
B12185	D	Serum vitamin B12 concentration >= 185 pmol/l
GSHPx3	D	Glutathione peroxidase activity >= 3 kIU/l
Individual hind faecal parasite markers		
FEC	egg/g	Faecal egg count
FLC	larvae/g	Faecal lungworm larval count
FEC>0	D	Positive faecal egg count
FLC>0	D	Positive faecal larval count

Note on units : D = dichotomous variables
"Score 0-1" means "Score ranging from 0 to 1"

- Path analysis was only used for the analysis of blocks 1, 2 and 3.

  Path diagrams were first formulated within each block (steps 1, 3 and 5 in Table 4.1). However, blocks 2 and 3 were also analysed with statistically significantly important individual hind characteristics included (steps 2 and 4), since they may otherwise be important confounding factors (as in step 3 and 5). Therefore null hypothesis path diagrams for blocks 2 and 3 have been analysed twice, with and without individual hind characteristics.

- Categorised body condition score variables, sentinel hinds characteristics and biological markers were analysed separately without the use of path analysis. Each step described in Table 4.2 represents a separate analysis.

  In these analyses, the post-winter hind body condition score (BCSS) has been included as a continuous discrete variable. However, further analyses (see risk factors for dystocia) showed hinds with BCSS over 3.5 were more likely to experience dystocia, which has been also identified as an important factor (through BCSD) of perinatal mortality. To explore the possibility of a threshold score over which hinds would be more likely to be dry at weaning, BCSS was transformed to several categorical variables as described in Table 4.10 and analysed by multivariable logistic regression analyses, separately for yearling and adult hinds.

  Some biological markers were categorised and analysed as discussed in section 2.8.12.3. Scatterplots of mean blood markers against weaning rates (WEANR) were drawn up where appropriate.

For each final logistic model, the deviance was reported as a goodness of fit statistic. The proportionate reduction in deviance observed when including significant risk factors in the model compared with an intercept-only model is interpreted as the proportion of variance in the data "explained" by the variables included in the model (Frome and Checkoway, 1985).

4.2.2 Results

4.2.2.1 Management risk factors

Summary statistics of continuous risk factors screened for association with the lactational status of adult and yearling hinds at weaning, and t-test p values are presented in Appendix 4.7 and Appendix 4.8, respectively. Appendix 4.9 contains Chi-square test p values and unadjusted odds ratios of dichotomous risk factors associated with the lactational status of yearling and adult hinds at weaning.

Null hypothesis and final path diagrams for adult hind individual animal, calving management and grazing management risk factors are presented in Figure 4.17, Figure 4.18 and Figure 4.19, respectively. Because the repeated analyses of block 2 and 3 (see Table 4.11) with and without significant hind characteristics, identified the same risk factors, only final diagrams including hind characteristics are presented. All regression coefficient estimates, adjusted odds ratios of model components, and model deviance are presented in Table 4.11. The null hypothesis and final diagrams of individual hind characteristics in 1992 and 1993 including the risk factor WET-1 are presented in Figure 4.20. Null hypothesis path diagrams of risk factors for yearling hinds are

presented in Figure 4.21. There was no final path diagram to draw for yearling hind risk factors since only one factor was significant in the analysis of calving management practices (Table 4.11).

Adult hinds over 3 years old at calving, hinds conceiving before May 1 and hinds gaining body condition between March and September were more likely to be wet at weaning. As shown with the 1992 data, but not confirmed in 1993, hinds wet at the previous weaning were more likely to be wet again at weaning. Hinds were more likely to be lactating at weaning when calves were not tagged at birth, wire-and-batten fences were not used for calving paddocks, pasture was grazed over 5 cm, hinds were not mixed with mature stags or large paddocks were not used for calving. Sunny weather and high maximum temperatures were positively and negatively associated with the probability of a hind being wet at weaning, respectively. When farmers visited calving paddocks and checked for calving problems, both adult and yearling hinds were about twice as likely to rear a calf up to weaning. This latter risk factor was the only one identified in yearling hinds.

4.2.2.2 Biological markers

Range of values, means and standard deviations of sentinel hind characteristics, and biological markers, and mean yearling and adult hind blood characteristics screened for association with the probability of yearling hinds to be lactating at weaning (individual data,) or weaning rates of yearling and adult hinds (farm data), respectively, in a preliminary univariate analysis are presented in Appendix 4.10. Chi-square test p value and unadjusted odds ratios of dichotomous sentinel hind characteristics, and biological markers associated with the lactational status of yearling hinds at weaning are presented in Appendix 4.9.

Whereas no individual yearling hind characteristics or biological markers were statistically significantly associated with the individual outcome, the geometric mean of pepsinogen concentrations from the 5 sentinel adult hinds was significantly negatively associated with the weaning rates of adult hinds within each farm (Figure 4.22), and the geometric mean of serum gamma glutamyl transferase activities from the 5 sentinel yearling hinds was significantly positively associated with the weaning rates of yearling hinds within each farm (Figure 4.23).

Table 4.11 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of animal and grazing management risk factors predicting the probability of hinds rearing a calf up to weaning and goodness of fit of models.

ADULT HINDS

BLOCK 1 : *1992 and 1993 data combined*

Hind individual characteristics

Total number of hinds : 2850
Number of hinds wet at weaning = 2682

Deviance Intercept only	Model deviance	% of variability explained by the model
1277.15	1216.74	4.73

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE3	1.108	0.169	0.000	3.03	2.17 4.21
ADVC	0.914	0.251	0.000	2.50	1.53 4.08
BCSD	0.306	0.112	0.006		

BLOCK 1 : *Only including 1992 data*

Hind individual characteristics

Total number of hinds : 1495
Number of hinds wet at weaning = 1393

Deviance Intercept only	Model deviance	% of variability explained by the model
744.60	699.78	6.02

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE3	0.952	0.231	0.000	2.59	1.65 4.07
WET-1	0.886	0.263	0.001	2.43	1.45 4.06
BCSD	0.411	0.176	0.020	1.51	1.07 2.13

BLOCK 1 : *Only including 1993 data*

Hind individual characteristics

Total number of hinds : 1355
Number of hinds wet at weaning = 1289

Deviance Intercept only	Model deviance	% of variability explained by the model
527.62	493.31	6.50

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE3	0.934	0.277	0.001	2.55	1.48 4.38
ADVC	1.823	0.354	0.000	6.19	3.09 12.38

BLOCK 2 : *1992 and 1993 data combined*

Calving paddock & management

Deviance Intercept only	Model deviance	% of variability explained by the model
1277.15	1247.26	2.34

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
VISITCP	0.789	0.184	0.000	2.20	1.53 3.16
TAGB	-0.903	0.225	0.000	0.41	0.26 0.63
PWIRE%	-0.005	0.002	0.033		

Calving paddock & management
controled by significant hind characteristics

Deviance Intercept only	Model deviance	% of variability explained by the model
1277.15	1194.53	6.47

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE3	1.018	0.170	0.000	2.77	1.98 3.87
ADVC	0.794	0.255	0.002	2.21	1.34 3.65
BCSD	0.355	0.118	0.003		
VISITCP	0.746	0.189	0.000	2.11	1.46 3.06
TAGB	-0.844	0.236	0.000	0.43	0.27 0.68
PWIRE%	-0.004	0.002	0.033		

* Risk factor codes are described in the glossary and Table 4.10

OR = odds ratio; Std error = standard error

Note : Intercept = deviance of an intercept only model; Model = deviance of the model
% variability = (Model - Intercept) x 100 / Intercept

Table 4.11 : Cont'd

BLOCK 3 (Adult hinds Cont'd) *1992 and 1993 data combined*

Grazing management

November 1 - January 1

Total number of hinds : 2850

Number of hinds wet at weaning = 2682

Deviance		
Intercept only	Model deviance	% of variability explained by the model
1277.15	1218.56	4.59

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
RSWH5	-0.642	0.275	0.047	0.53	0.31 0.90
STAG	-1.391	0.244	0.000	0.25	0.15 0.40
FAREA	-0.051	0.014	0.000		
AVMAT	-0.262	0.074	0.000		
SUN	1.676	0.706	0.038		

BLOCK 3 :

Grazing management

November 1 - January 1

controled by significant hind characteristics

Deviance		
Intercept only	Model deviance	% of variability explained by the model
1277.15	1154.87	9.57

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE3	1.131	0.173	0.000	3.10	2.21 4.35
ADVC	0.889	0.260	0.001	2.43	1.46 4.05
BCSD	0.419	0.120	0.001		
RSWH5	-0.564	0.284	0.047	0.57	0.33 0.99
STAG	-1.604	0.256	0.000	0.20	0.12 0.33
FAREA	-0.064	0.015	0.000		
AVMAT	-0.274	0.075	0.000		
SUN	1.515	0.730	0.038		

BODY CONDITION SCORE

Total number of hinds : 2850

Number of hinds wet at weaning = 2682

Deviance		
Intercept only	Model deviance	% of variability explained by the model
1277.15	1208.97	5.34

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE3	1.072	0.172	0.000	2.92	2.09 4.10
ADVC	0.911	0.252	0.000	2.49	1.52 4.07
BCSS2	-0.912	0.226	0.000	0.40	0.26 0.62
BCSS4	0.028	0.199	0.888		

YEARLING HINDS

BLOCK 1 :

Hind individual characteristics

Total number of hinds : 585

Number of hinds wet at weaning = 509

No risk factor was selected by the stepwise procedure at the 5% confidence level

BLOCK 2 : *1992 and 1993 data combined*

Calving paddock & management

Total number of hinds : 585

Number of hinds wet at weaning = 509

Deviance		
Intercept only	Model deviance	% of variability explained by the model
481.88	446.03	7.44

Risk factor*	Coefficient estimate	Std error	p value	Adjusted OR	95%CI
VISITCP	0.598	0.247	0.000	1.82	1.12 2.95

BLOCK 3 :

Grazing management

November 1 - January 1

Total number of hinds : 585 Number of hinds wet at weaning = 509

No risk factor was selected by the stepwise procedure at the 5% confidence level

* Risk factor codes are described in the glossary and Table 4.10.

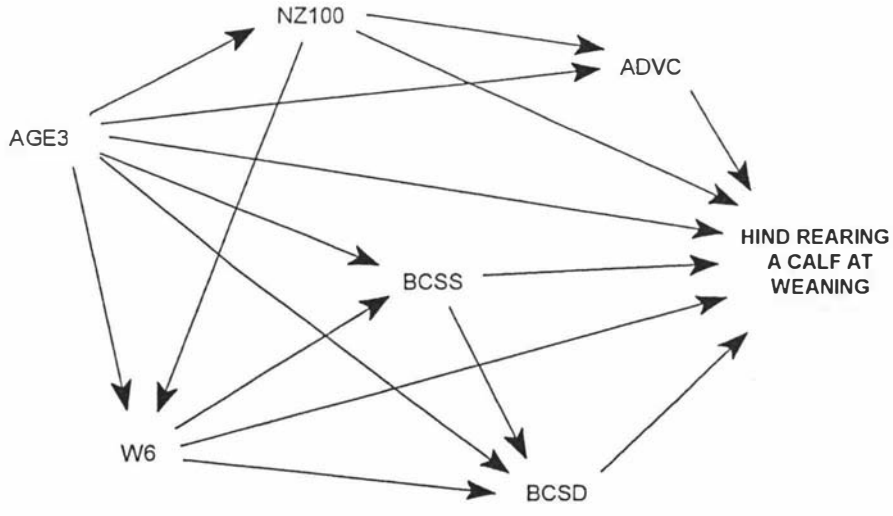
OR = odds ratio; Std error = standard error

Note : Intercept = deviance of an intercept only model; Model = deviance of the model

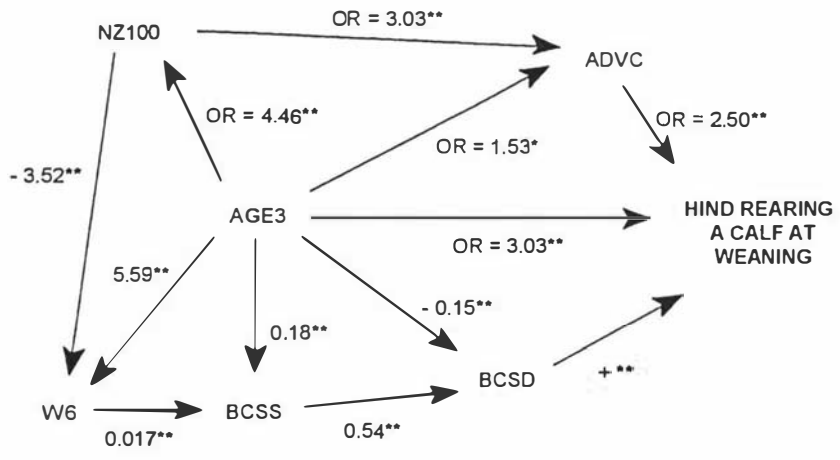
% variability = (Model - Intercept) x 100 / Intercept

Figure 4.17 : Null hypothesis and final path diagrams of individual adult hind risk factors for hind lactational status at weaning. Data from 1992 and 1993 combined.

1. Null hypothesis path diagram



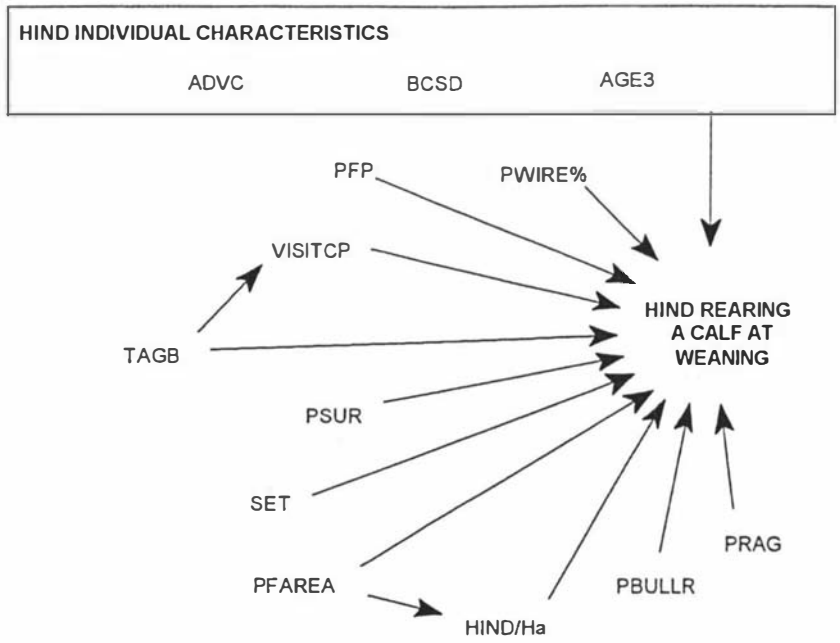
2 . Final path diagram



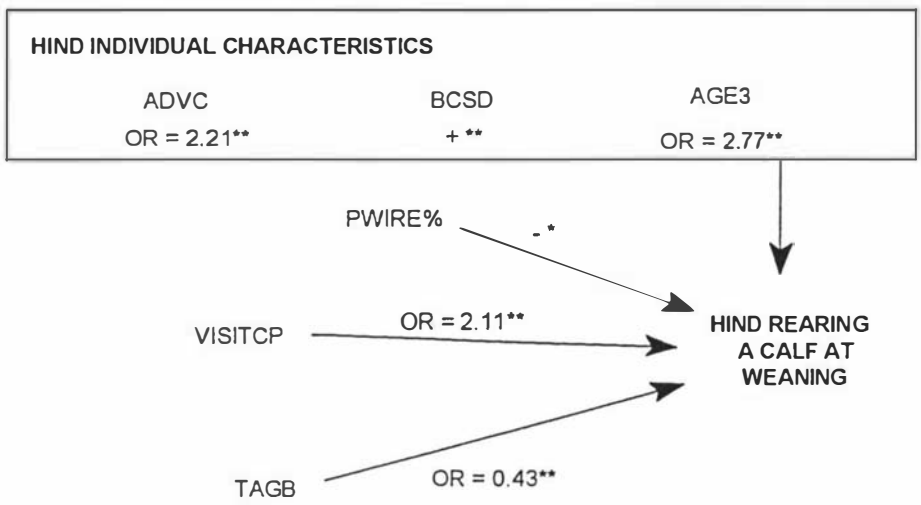
Note : Risk factor codes are described in the glossary and Table 4.10. Odds ratio (OR) or unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01) in final diagrams. The percentage of variability in the outcome explained by this final model is 4.73%.

Figure 4.18 : Null hypothesis and final path diagrams of calving management risk factors for adult hind lactational status at weaning

1. Null hypothesis path diagram



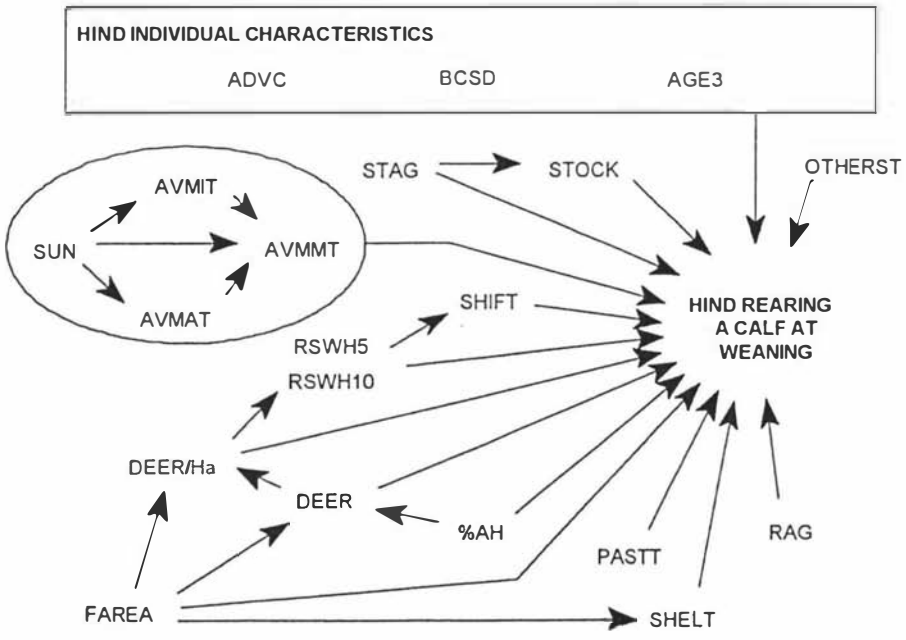
2. Final path diagram



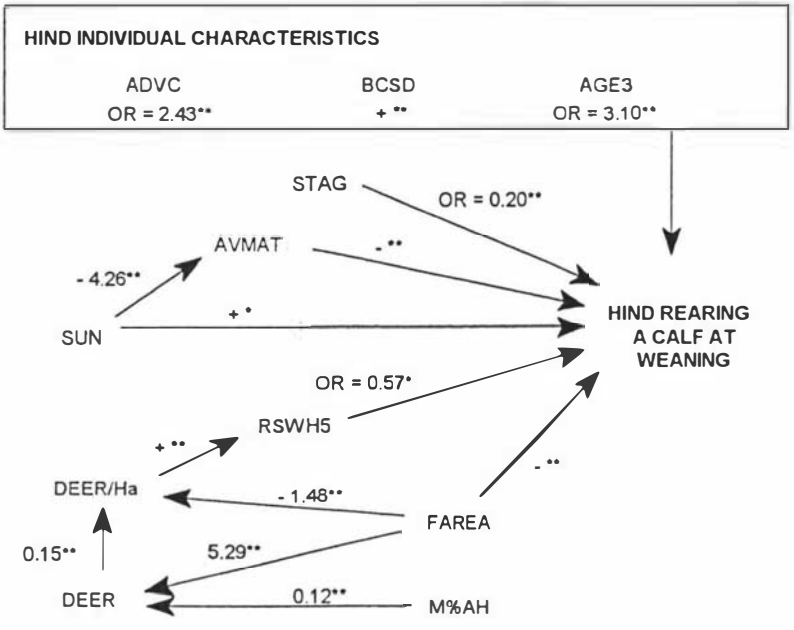
Note : Risk factor codes are described in the glossary and Table 4.10. Odds ratio (OR) or unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01) in final diagrams. The percentage of variability explained by this final model is 6.47%. Only direct effects of individual hind characteristics are presented. Indirect effects are presented in Figure 4.17.

Figure 4.19 : Null hypothesis and final path diagrams of environmental and grazing management risk factors during calving-early lactation (November 1 - January 1) for adult hind lactational status at weaning.

1. Null hypothesis path diagram.



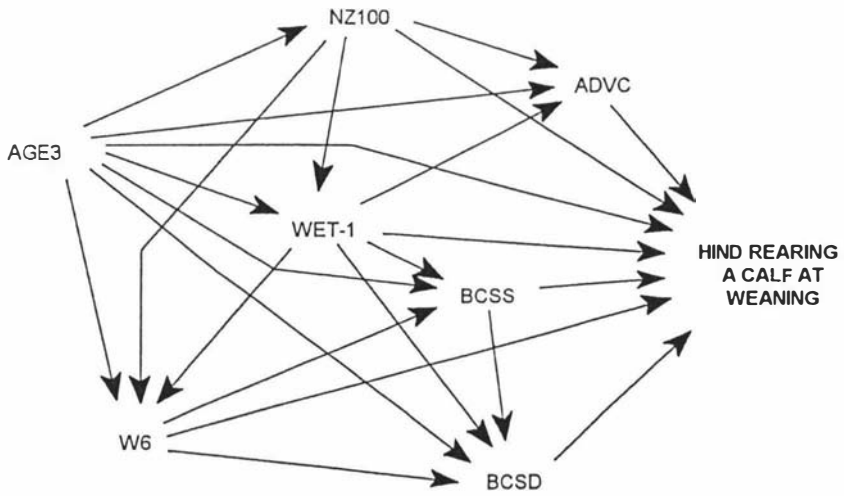
2. Final path diagram



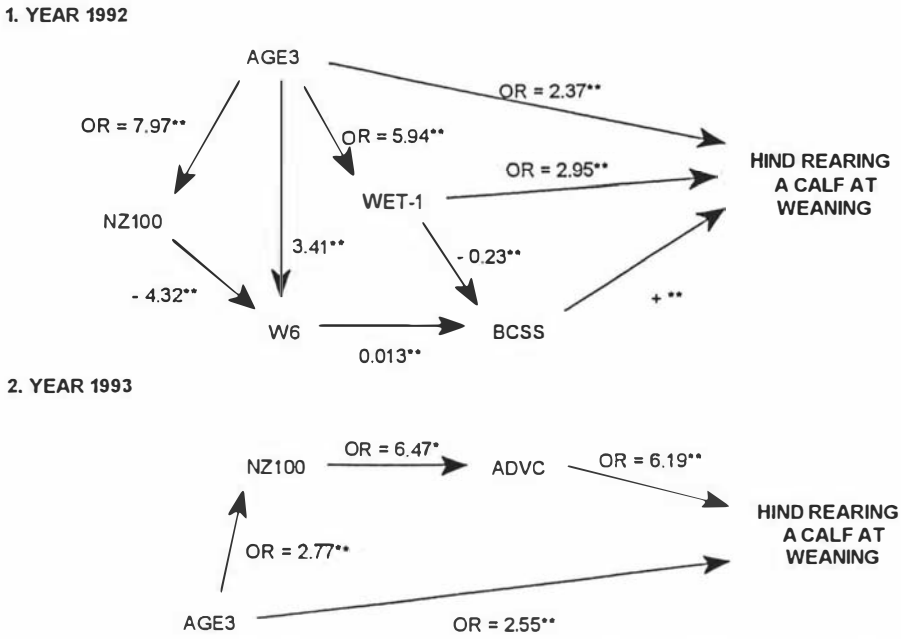
Note : Risk factor codes are described in the glossary and Table 4.10. Odds ratio (OR) or unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01) in final diagrams. The percentage of variability explained by this final model is 9.57%. Only direct effects of individual hind characteristics are presented. Indirect effects are presented in Figure 4.17.

Figure 4.20 : Null hypothesis and final path diagrams of individual adult hind risk factors for hind lactational status at weaning (including the risk factor WET-1).

1. Null hypothesis path diagram

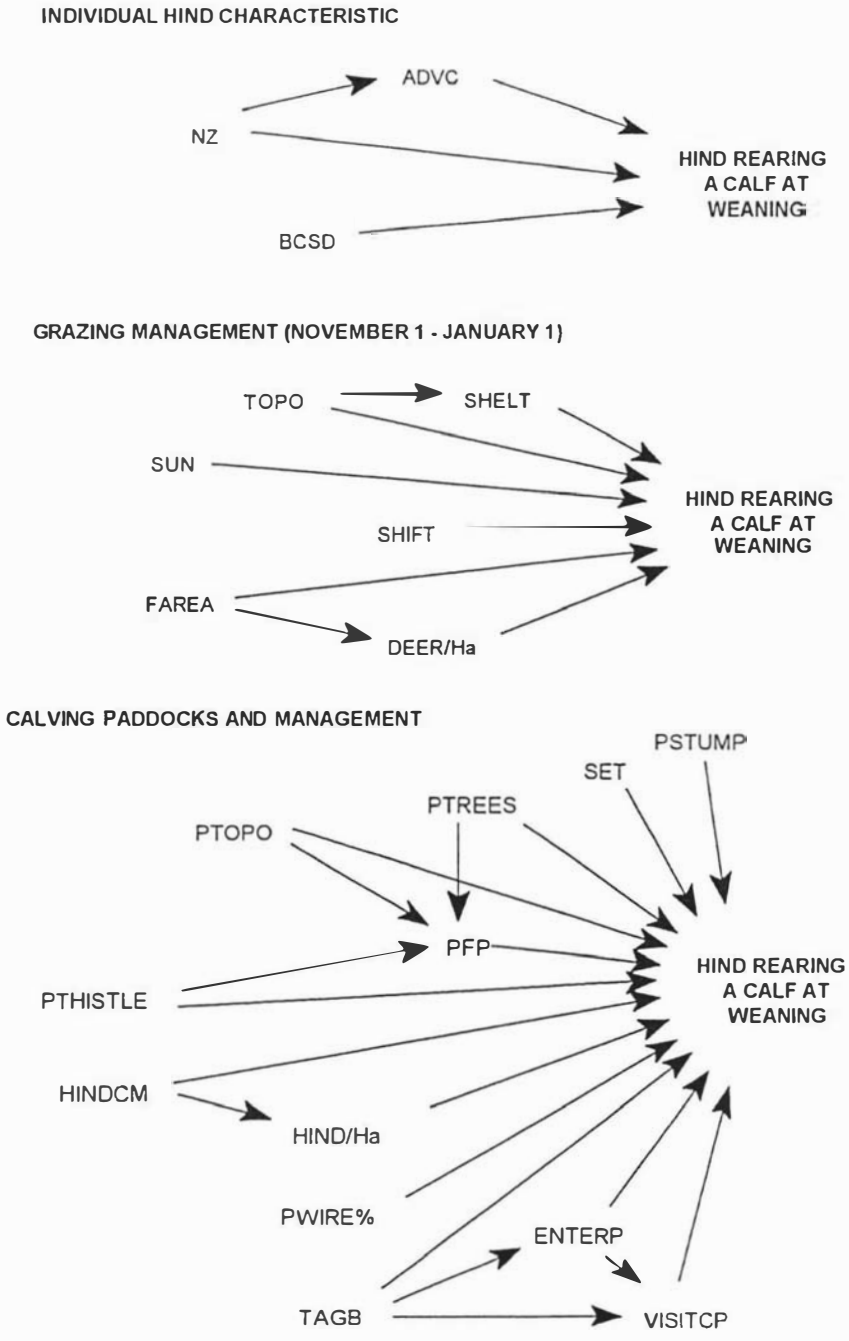


2. Final path diagrams



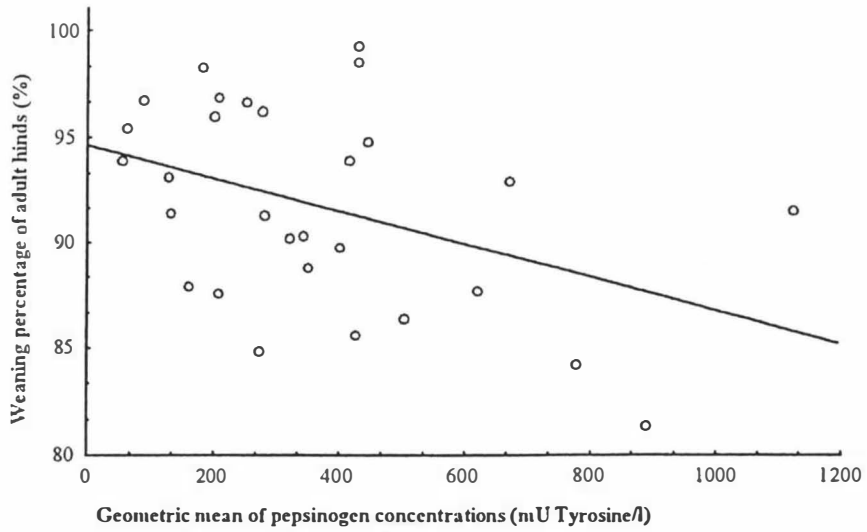
Note : Risk factor codes are described in the glossary and Table 4.10. Odds ratio (OR) or unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01) in final diagrams. The percentage of variability explained by these final models are 6.02 (data 1992) and 6.50% (data 1993).

Figure 4.21 : Null hypothesis path diagrams of individual yearling hind characteristics, grazing management (between November 1 and January1), and calving management risk factors for yearling hind lactational status at weaning.



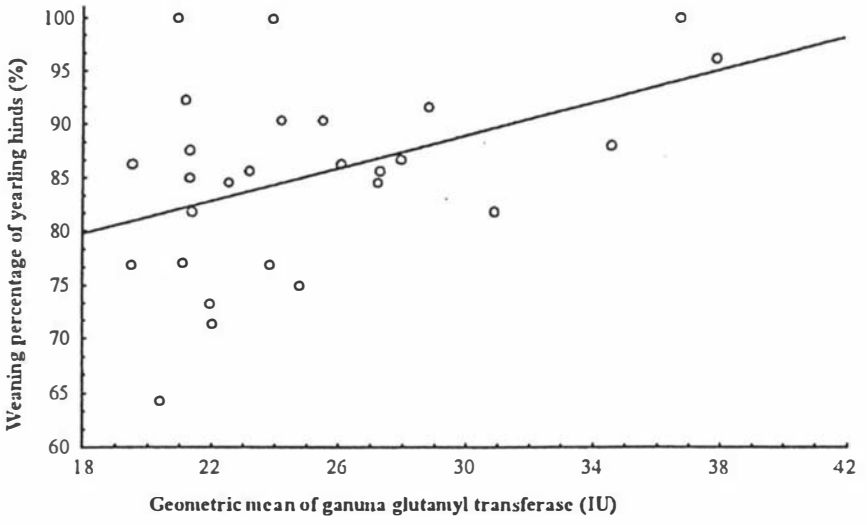
Note : Risk factor codes are described in the glossary and Table 4.10. No final diagrams are presented because only one factor was statistically significantly associated with the probability of yearling hinds to rear a calf up to weaning (see Table 4.11).

Figure 4.22 : Relationship between geometric means of pepsinogen concentrations (MPEPS) from 5 adult hinds and weaning rates (WEANR) of adult hinds within each survey farm. Data from 1992 and 1993 combined.



The regression line is : WEANR = 94.55 (1.11) - 0.008 (0.003) MPEPS (r^2 = 15.8, p = 0.022)

Figure 4.23 : Relationship between geometric means of serum gamma glutamyl transferase activities (MGGT) from 5 yearling hinds and weaning rates (WEANR) of yearling hinds within each survey farm. Data from 1992 and 1993 combined.



The regression line is : WEANR = 66.06 (8.05) - 0.76 (0.31) MGGT (r^2 = 15.0, p = 0.023)

4.2.3 Discussion

This analysis has identified factors associated with the probability of adult hinds rearing a calf to weaning.

A large proportion (77%) of calves missing between birth and weaning were not found by the farmer (see section 3.3.4.1.2) but for the purpose of this investigation, were presumed dead. It was therefore not possible to investigate specific causes of progeny loss. Instead, all losses were grouped as a single outcome. It was found the majority of progeny losses were perinatal or neonatal, and foetal losses in adult hinds were estimated at about 11% of the overall progeny losses, compared with 3.3% in yearling hinds. Therefore it was hypothesised the most important risk factors would be related to individual hind characteristics and management practices during calving. Some factors, however, such as the hind body condition score in September (BCSS) and the change of body condition score during pregnancy (BCSD), which may be an indirect measurement of winter management, may be associated with both embryo survival during pregnancy and calf survival.

Although cross-suckling exists in red deer (Fisher et al., 1994) and was confirmed during this study, the lactational status of hinds as recorded by the farmer at weaning was the best possible method of assessing calf mortality (or progeny loss).

Grazing management and environmental factors were studied between November 1 and January 1 as most hinds calved during this period. In this study median calving dates on 4 farms recording calving dates were November 30 and December 13 in adult and yearling hinds, respectively. The grazing period studied for calving was a compromise to investigate the majority of births and limit the time interval to the first few weeks after birth. It was believed that the grazing management risk factors related to the period after January 1 was more relevant for the study of weaner weights, but of limited significance for the study of weaning rates (progeny loss).

Yearling and adult hinds were analysed separately in this study because of the higher rate of progeny loss observed in the younger group. In wapiti hinds, it is known that first-time calvers, which are mainly yearling hinds, have a higher rate of calf loss and lower weaning rate than adult hinds (Friedel and Hudson, 1994). In most published work on calf mortality in red deer, yearling and adult hinds were not differentiated for analysis and presentation of results (Kelly and Whateley, 1975; Guinness et al., 1978; Blaxter and Hamilton, 1980; Asher and Adam, 1985; Gill, 1985) and the age distribution within breeding herds was often not considered. Arman et al. (1978), however, recorded 16.1% of calf losses from 56 hinds, 50 of which were first calvers, which supports the finding that perinatal calf mortality is quite high in yearling hinds. Blaxter and Hamilton (1980) did not find an age effect after correcting for the pre-mating bodyweight, but it may be because the relationship between the age of the dam and the probability of the calf to survive is not linear. In their analyses, the variable age should have been categorised to separate yearling and adult hinds. The findings in this study support this view since risk factors for calf survival appeared to be different between yearling and adult hinds. Irrespective of the dam size, 2-year-old fallow does produced lighter calves (thus more likely to die) at their first calving (Asher and Adam, 1985), and although their study was inconclusive for red deer, these authors suggested it was likely to be true in that species as well.

Using the same approach to investigate calf mortality in yearling and adult hinds, only the effect of farmers' closely monitoring calving paddocks (VISITCP) was significant. Such a limited number of significant risk factors was unexpected since many factors previously believed to be important, such

as managing yearling and adult hinds separately at calving (Moore, 1985), were not significant in this study. Other factors either not recorded or not analysed in this study may be important. Haigh and Hudson (1993) stated that lactation failure and mismothering are more common in first calvers, which may be related to mothering inexperience and also to the endocrinological maturity of the hind, although no research (to the author's knowledge) has been carried out on this subject. The non-identification of significant risk factors in this analysis, however, suggests it is a possibility that underlying endocrine factors dictate the survival of calves through lactational ability, and therefore research should be prioritised in the future to explore this hypothesis. In the meantime, it appears that progeny loss of yearling hinds may be difficult to prevent on commercial farms.

Consequently, the following discussion will only refer to adult hinds, ie hinds over 2 years old at calving.

4.2.3.1 Hind characteristics

The change of hind body condition during pregnancy rather than pre-calving body condition score *per se* appeared to be an important risk factor in association with survival of the progeny. Hinds losing body condition between March and September (BCSD) were more likely to lose their progeny by weaning. This relationship suggests the nutritional status of adult hinds during early pregnancy may be critical for reproductive success of adult hinds. The underlying biological process is not known, ie whether it may be related to progeny loss during pregnancy or calf mortality. Asher and Adam (1985) stated that "conclusions relating to nutritional effects (on calf birth weight) during the gestation period would be highly speculative", while Moore et al. (1988) suggested reabsorption or abortion of the foetus post-winter may arise in unhealthy and victimised pregnant hinds which have lost bodyweight (thus body condition).

The association between change of body condition and progeny rearing identified in this study is consistent with observations in other domestic livestock. In sheep, it is known that underfeeding during pregnancy results in embryo losses, whereas ewe liveweight, fat cover or condition score *per se* had no effect on embryo survival (Cumming et al., 1975). It may also be that hinds in a catabolic state may produce light calves which are less likely to survive after birth. In elk in North America, cows that lost more than 3% of bodyweight during winter produced calves less likely to survive the first 4 weeks, and the more severe the weight loss in the dam during pregnancy, the lower the calf bodyweight (Thorne et al., 1976). That relationship has not been reported in red deer, but the positive relationship between calf birth weight and calf survival is well documented (Guinness et al., 1978; Blaxter and Hamilton, 1980; Asher and Adam, 1985). This observation, therefore, suggests that hinds should be fed at least to maintenance level between March and September, so they can maintain or gain body condition by September. This supports the view of English (1985) in fallow deer that "there is a critical plane of nutrition during pregnancy for high fawn survival rates and acceptable weaning percentages". In this study, further investigation of BCSS showed that hinds below 2.5 in body condition score were more that twice as likely to lose their progeny than hinds scoring 2.5, 3 or 3.5. Body condition scores over 2.5 did not seem to be critical (Table 4.11). Therefore the hinds more at risk of being dry at weaning appear to be those losing body condition during pregnancy, such that their BCSS is below 2.5 in September.

An alternative explanation may be that the effect of BCSD may be related to the lactational status of the hind at the previous weaning. Analysis of the 1992 data showed that hinds lactating the year before (WET-1) were almost 3 times more likely to rear a calf again up to weaning. These hinds were in poorer body condition than dry hinds prior to the rut (see section 4.1), and in September

(Figure 4.20), and the poorer the pre-mating body condition the higher the increase of body condition during early pregnancy (Audigé et al., publication in preparation). Since hinds included in these analyses were all diagnosed pregnant after mating, this may be related to the mothering ability of the dam rather than poor fertility.

This analysis has also identified that hinds conceiving before May 1 (ADVC) were 2.5 times more likely to be lactating at weaning. In the wild, it is known calves born late are usually small, their growth is reduced and their survival rate lower than calves born early (Guinness et al., 1978). These authors suggested early born calves benefit from a better pasture quality (spring flush) through the milk of their dam. It may also be that reabsorption or abortion of the foetus post-winter may arise in late mated hinds in which the conceptus is still relatively light by the end of winter, as proposed by Moore et al. (1988). In contrast to these observations, Friedel and Hudson (1994) did not identify an effect of calf birth weight, and birth date on survival of wapiti calves, but this may be because data came from farmers' records and was analysed retrospectively. It may be that calves that died (which may be the lightest) were not found (as in this study) and therefore the date and calf weight were not recorded, thus introducing a bias in the result. That ADVC was significant in the 1993 final diagram (Figure 4.20) and WET-1 and BCSS, instead of ADVC, were significant in the 1992 final diagram, however, suggests the effect of these risk factors are confounded.

A highly significant age effect was identified in this study. Hinds over 3 years old (AGE3) at calving were not only 3 times more likely to rear their progeny than second calvers (direct effect), but these hinds also were 1.5 times more likely to conceive early, more likely to be pure of New Zealand origin (NZ100), were on average 5.6 kg heavier in June and fatter in September, and on average lost more body condition during pregnancy (as they were fatter in March) than younger adult hinds (indirect effects). The total effect of AGE3 can be evaluated by withdrawing all intermediate factors (those involved in indirect effects) from the model and, therefore is that shown in Appendix 4.9. This effect does not greatly differ from the direct effect identified in the final diagram in Figure 4.17. It is known adult hinds produce bigger calves at birth (Guinness et al., 1978).

The blood lines of adult hinds and their pre-winter body weight did not appear important other than by their effect on conception or body condition. This supports the observation in wapiti, that cow bodyweight was not related to calf survival (Friedel and Hudson, 1994), although these authors did not investigate body condition scores. In this analysis, for the same class of age (AGE3) a 30 kg increase in hinds pre-winter bodyweight was associated with a 0.5 unit increase in BCSS. This may be related to hind interactions during winter (eg competition for feeding) which may favour big hinds, but it is also likely that hinds heavy in June were already in better body condition than light hinds.

4.2.3.2 Nutrition and shelter

To the authors' knowledge, this study is the first that investigated calving paddock and pasture characteristics as risk factors for progeny loss after adjusting for significant individual hind covariates. It is interesting to note that the effects of ADVC, AGE3 and BCSD did not significantly change when included in the analyses of blocks 2 and 3, whereas Asher and Adam (1985) suspected grazing management variables could be important confounding factors.

Grazing pasture below 5 cm during calving-lactation has been identified as one factor negatively affecting calf survival (Figure 4.19). This is consistent with the belief that swards should be rather high to provide shelter to new born calves and protect them from exposure to adverse weather. In

the wild, calves often seek shelter in long grasses (Clutton-Brock and Guinness, 1974), so it was suggested that calving paddocks should contain sheltered areas (eg long grasses or branches) which enable dam-offspring pairs to isolate from other hinds (Round-Turner, 1979). However, the interpretation of this relationship is not straightforward and other explanations are possible. In this analysis, when the mean residual sward height was below 5 cm (RSWH5), the mean shelter score was also low (t-test $p < 0.001$), so part of the effect of RSWH5 may be due to the lack of other types of shelter as well (eg gully, trees, hill or shelter belt). Young calves often chose the side of gullies or hills, so they can observe the environment from a slightly raised position (Clutton-Brock and Guinness, 1974).

Another hypothesis of the negative effect of RSWH5 can be drawn from a pure nutritional perspective. It is known the maximum feed energy requirement by hind occurs during the first weeks of lactation and the milk production of hinds is related to the level of nutrition (Loudon et al., 1984; Loudon and Milne, 1985). Well-fed hinds can yield a maximum of 1.4 to 2.2 litres/day whereas underfed hinds may produce only 1 litre/day (Arman et al., 1974). In this study, as lactating hinds were not given food supplements during this period, it is likely that hinds grazing below 5 cm would not meet their feed requirements, and therefore milk production and supply to calves was impaired. Small calves, in particular those born late, may suffer from underfeeding and be more exposed to death through starvation and/or adverse weather conditions. To test this hypothesis, the interaction term between ADVC and RSWH5 was included in the model, but it was not statistically significant.

In this analysis RSWH5 was also associated with the highest grazing densities at calving (DEER/Ha), but there is no evidence that DEER/Ha could be a confounding factor since it was not significant in the univariate analyses. This potential risk factor was forced into the model because of the belief that it may have a detrimental effect on calf survival through adverse hind behaviour. Occasionally, hinds have been seen attacking calves in confined areas, although it was thought to be related to some individual hinds (Kelly and Whateley, 1975) which may result from a change in calving management (Kelly and Drew, 1976) instead of high grazing density *per se*. Furthermore, the grazing density at calving was not identified as an important factor influencing calf mortality in wapiti farms (Friedel and Hudson, 1994).

In this study, the apparent negative influence of large sized paddocks was not expected as it is contrary to the current belief that dam-offspring pairs at calving seek isolation and sheltered positions in the wild (Clutton-Brock and Guinness, 1974; Clutton-Brock et al., 1982) as well as in farming conditions (Arman, 1974; Arman et al., 1978; Cowie et al., 1985). It was hypothesised calving hinds were more likely to isolate in large paddocks. Should hinds be prevented from isolation, some hinds may become restless and may pace along the fence (Cowie et al. 1985), while others may show aggressiveness against subordinate hinds or calves (Kelly and Drew,1976) as observed on one farm in this study. Large paddocks in this study offered space and often more shelter than smaller paddocks. However, farmed hinds do not always actively seek sheltered area for calving (Kelly and Wateley, 1975), and, as observed by Kelly and Drew (1976), it was the authors' personal observation that new-born calves on farms were not systematically found in sheltered area.

At this point of the discussion, it is appropriate to question the motivation that determines the location of a bedding site for a calf. Clutton-Brock and Guinness (1974) suggested that calves seek shelter for protection more from predators than from adverse weather. They observed that as calves get older, they tended to lay more frequently on short greens. In farming conditions, it may be that hinds at calving seek shelter to protect their calf more from the rest of the mob or other animals than

from adverse weather conditions. It was therefore hypothesised that grazing densities or mob size may be important factors influencing calf survival. However, the mean grazing density and mob size between November 1 and January 1 (DEER/Ha and DEER) and the grazing density when hinds were set stocked for calving (PDEER/Ha) were not significant in this study. Although the direct negative effect of large mean paddock size grazed by adult hinds during calving and early lactation cannot be rejected, it is likely that other factors such as mob size associated with it may be responsible for this relationship. The final diagram in Figure 4.19 shows there were on average 5 more hinds in calving mobs for each hectare increase in paddock area, but grazing densities were lower in large than in small paddocks.

It was believed providing adequate cover in calving paddocks would keep calves from bedding along the fence, which was thought as one risk factor for calf loss in North America through calves being tangled in the fence or attacked by predators (Haigh and Hudson, 1993). Losses through the fence, in New Zealand, may be associated more with the use of wire-and-batten fence (PWIRE%) as observed in this study (Figure 4.18).

The significance of some weather variables in the final diagram of grazing management practices suggests that moderate weather conditions increase the probability of adult hind to rear a calf up to weaning. Calves survived better in sunny areas but their chance of survival appeared to be decreased under warm conditions. Dry and warm conditions may expose calves to dehydratation, while less sunny weather patterns (which is usually associated with rainfall) may expose calves to hypothermia. In this study, some calves were found dead soon after storm exposure while in a paddock with limited amount of shelter. Therefore protecting calves from extreme weather conditions may help prevent calf losses. Although not significant in this analysis, it is likely this can be done by providing sheltered areas. More research needs to be done on shelter and calf survival.

The significant negative effect of grazing with mature stags (not one-year-old stags, ie spikers) during calving is not clear although stags might be involved in killing calves. Infanticide by adult males has been suspected in red deer kept in parks (Bartos and Madlafousek, 1994) and on a research farm (Wilson, personal communication), which suggests it may happen in an intensive farming environment. Until further study, therefore it may be wise to keep calving mobs separate from mature stags.

4.2.3.3 Human interference

In this study, tagging calves at birth (TAGB) doubled the risk of their dam being dry at weaning which is consistent with previous observations that hinds are more likely to abandon their progeny if the latter is handled soon after birth (Blaxter and Hamilton, 1980; Cowie et al., 1985; Haigh and Hudson, 1993). Such disturbance during the first few days after birth may impair the bonding of dam to calf, and therefore increase the risk of mismothering (Gill, 1985). In intensive farming conditions, disturbance may also trigger adverse hind behaviour (Kelly and Whateley, 1975). Heavy calf loss through intense monitoring of calves (including weighing) was reported by Moore et al. (1988).

When farmers closely monitored calving paddocks for potential calving problems (VISITCP), adult hinds were twice as likely to rear a calf at weaning. The explanation for this relationship is not straightforward since it was suspected this practice would increase the risk of calf mortality through disturbance. However, this relationship was also identified in yearling hinds with almost the same strength as for adult hinds (Table 4.11). The consistency of this result, along with the fact that it was

the only risk factor identified for yearling hinds, suggests the effect of close monitoring of calving paddocks (VISITCP) should be further evaluated. In fact, VISITCP may be one factor that symbolises an overall farm management approach which leads to good reproductive performance (ie weaning rates in this instance). Farmers who closely monitored their hinds at calving also kept good records and, therefore, were more likely to adapt their management accordingly. Refinement of the variable VISITCP in future studies may be necessary to investigate the nature of this relationship.

4.2.3.4 Blood markers

The analysis of individual data from sentinel adult hinds was not done because there were only 4 non-lactating adult hinds amidst 119. The analysis of individual blood markers were carried out only for yearling hinds. As there were only 11 non-lactating yearling hinds amidst 101 sentinel yearling hinds, however, the non-significance of individual hind characteristics and individual blood markers in this analysis may be due to small sample size.

The mean (or geometric mean) blood markers within each farm were evaluated as potential markers for farm level weaning performance, because differences between farms "explained" a significant proportion of the variation of most blood characteristics of yearling and adult hinds in September (Appendix 3.74). It was believed these markers would reflect the nutritional status of the hinds, which may be associated with calf growth and survival.

The positive relationship between geometric mean of serum gamma glutamyl transferase activities and weaning rates of yearling hinds (Figure 4.23) has not been reported elsewhere and since there was no logical explanation, it was suspected to have occurred by chance alone (the Spearman rank order correlation coefficient was not significant at the 5% level). The negative relationship between geometric mean of pepsinogen concentrations with weaning rates of adult hinds, although marginally significant ($r = -0.42$ ($p = 0.02$), but Spearman $r = -0.34$ ($p = 0.07$)), can be interpreted in relation to the nutritional status of the hinds. Pepsinogen concentration is a measure of abomasal damage which may be caused by *Ostertagia* type larvae (Armour et al., 1979; McKellar et al., 1988). High pepsinogen activity associated with abomasal damage and poor body condition has been reported in weaner deer (Connan, 1991), and there were concerns about the potential negative effect of abomasal parasite on body condition in adult deer (Wagner and Mackintosh, 1993). This finding therefore is consistent with the negative effect of BCSD identified earlier (see Figure 4.17). Farm differences explained 37.9% of the variation of post-winter serum pepsinogen in the individual adult hind, which suggests management factors such as treatment with anthelmintics may be associated with it.

4.2.4 Conclusion

The potential risk factors investigated in this study were listed after careful examination of the literature and discussion with farmers at the beginning of data recording. This study was the first attempt in identifying management practices, along with individual hind characteristics, likely to minimise progeny losses on commercial farms. However, it is recognised that, in some areas of New Zealand, specific management practices may be required to avoid calf losses. For instance, in areas where ticks abound, long grass (which are hot spots for ticks) should be avoided, and the grazing management can be integrated with other domestic livestock to control the tick population (Wilson, 1987). Therefore, one must be cautious before extrapolating these results to the whole New Zealand deer farms.

A significant number of risk factors have been identified is association with the likelihood of adult hinds to rear a calf up to weaning. However, only one factor appeared to influence the calf survival of yearling hinds and that was related to human presence at calving. This suggests the mechanism involved for the initiation and support of lactation may be quite different in both age groups, and that further research should be done to explore this difference.

4.2.4.1 Management of adult hinds

Until further research, however, this study has identified management practices associated with the ability of adult hinds to rear a calf up to weaning. It was therefore suggested that farmers :

- Cull non-lactating hinds at weaning, but not disproportionately to limit to the minimum the proportion of replacement hinds in the breeding herds.
- Ensure hinds are in good body condition (score over 2) at mating and do not lose condition during winter. Feed budget prior to winter to ensure feed requirements can be met.
- Maximise the proportion of hinds conceiving before May 1 as described in the previous analysis in this thesis.
- Avoid paddocks with wire-and-batten fence and prefer calf-proof netting fence for calving.
- Graze hinds on pasture not less than 5 cm high.
- Do not mix adult hinds with mature stags at calving.
- Do not tag calves at birth.

Should all these factor be controlled, and given the reservation previously expressed on their causality, many progeny losses could be prevented. A weaning percentage over 95% can be achieved as observed in this study.

4.2.4.2 Identified areas for further research

This section has identified likely key factors influencing progeny survival and has highlighted areas which deserve priority in research and development designed to improve reproductive management techniques.

It is appropriate to investigate :

- The initiation of lactation and lactating behaviour of yearling hinds.
- The nutrition of hinds during early pregnancy in relation with hind body condition score, embryo survival, calf birth weight and neonatal mortality.

- Different type of shelter (eg trees or branches) provided for calves, and whether they are used, in particular under adverse weather conditions.

- Factors associated with the "caring attitude" of the farmer visiting paddocks at the time of calving.

- Factors associated with change in hind body condition during pregnancy, including abomasal parasite infection in association with investigation of serum pepsinogen in yearlings.

4.3 RISK FACTORS FOR WEANER BODYWEIGHT STANDARDISED TO APRIL 1

When considering the prices of live deer in the early days of deer farming, the emphasis was to ensure every hind was pregnant and subsequently reared her calf up to weaning. These issues have been addressed in the previous sections of this chapter. Nowadays, breeders must also produce heavy weaners to guarantee a good financial return for weaner live sales. Alternatively, increasing weaner weights is an important option to ensure weaners can meet target weights so deer be sent to the deer slaughter premises (DSPs) by one year of age (Niezen et al., 1991), and hinds reach puberty early for breeding at 15 months of age.

This section focuses specifically on risk factors for individual weaner bodyweight standardised to April 1 (W4), ie at 4 months of age. W4 is a product of both the periods of lactation and where weaning was before April 1, post-weaning factors. Therefore factors pertaining to lactation and the period between weaning and April 1 are included in these analyses.

4.3.1 Materials and methods

At weaning, calves were identified by calving mob. Weights recorded at or about weaning, on or before March 30, and subsequent weights recorded after April 1 enabled the estimation of individual weaner weights standardised to April 1(W4) (see section 2.6.2.3.1). During farm visits in March 1992 and 1993, 10 randomly selected weaners (5 hinds and 5 stags) were blood sampled to define their haematological, biochemical and mineral blood profiles (see section 2.4.1.1 and 2.5). From February to March 1992, 1993 and 1994, faeces samples were collected from 10 randomly selected calves before commencement of anthelmintic treatment for egg and larval counts.

Risk factors potentially affecting W4 were identified and classified according to the area of data collection as presented in Table 4.12.

The first block includes individual deer characteristics which were recorded from the 6 farms that identified dam-offspring pairs either at birth (while ear-tagging) or before weaning. Variables describing lactation and weaning management practices were grouped in block 2, while post-weaning management variables constitute the third block. In the fourth block, are two distinct groups of biological markers. One group includes individual weaner blood characteristics, while the other, includes mean weaner blood characteristics, and faecal parasite markers within farms. Mean farm biological markers were obtained by averaging data from the 10 weaners where there were no sex differences, and the geometric mean instead of the arithmetic mean was calculated from log-normally distributed blood characteristics. For markers where there was a difference between sexes, means were calculated separately for each sex, ie 5 per farm. Blocks 1-3 and individual biological markers were analysed separately at the individual animal level (ie the outcome variable was the individual weaner bodyweight on April 1 (W4)), while mean weaner biological markers were investigated at the farm level with farm mean weaner stag and hind bodyweight (MW4) as outcome variables.

Table 4.12 : Potential risk factors for individual (W4) or mean mob (MW4) weaner bodyweight standardised to April 1.

Risk factor Code	Unit	Description
BLOCK 1 : Individual animal characteristics		
Individual dam variables at or prior to calving		
ADULT	D	Adult dam (dam at least 3 years old at calving)
NZD	%	Percentage of New Zealand blood lines
ADVC	D	Dam conceived before May 1 (early conception)
BCSS	Dis. 1-5; 0.5	Post-winter body condition score (recorded in September)
BCSL	Dis. 1-5; 0.5	Body condition score change between September and weaning
WD6	kg	Post-mating dam bodyweight standardised to June 1
CHW9C	kg	Bodyweight change between September and calving (late October-November)
Individual calf variables		
BIRTH	day	Number of days between November 1 and the date of birth
NZC†	%	Estimated percentage of New Zealand blood lines
WAPC†	%	Estimated percentage of wapiti (or elk) blood lines
BLOCK 2 : Lactation and weaning management		
Grazing management and food supplementation between November 1 and weaning.		
ISWH	cm	Mean pre-grazing pasture sward height
RSWH10	D	Mean residual (ie post-grazing) pasture sward height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
PASTT	Score 1-3	Mean pasture type score
RAG	Score 0-3	Mean paddock ragwort score (calculated from observations during farm visits)
THISTLE	Score 0-3	Mean paddock thistle score (calculated from observations during farm visits)
STOCK		Number of times the mob composition was changed
SHIFT		Number of times deer were shifted between paddocks
DEER		Average number of deer in the mob
MJME/Ha	MJME/ha	Mean mob daily energy requirements per grazed hectare (effective paddock area)
M%AH	%	Mean percentage of adult hinds in the hind mob
OTHERST	D	Paddocks shared with stock other than deer at least one day
STAG	D	Paddocks shared with stag(s) over 15 months old at least one day
FSUP	D	Food supplementation of deer
Environmental variables		
FAREA	ha	Mean paddock size (deer-fenced paddock)
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score

Risk factor Code	Unit	Description
BLOCK 2 : (Cont'd)		
Environmental variables		
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt
Weaning management and disease prevention management practices before April 1		
WEAN		Number of days between January 1 and weaning
YARDBW	D	Calves handled in yards before weaning
VCLOST	D	Injection of clostridial vaccine (5-in-1)
VYERSI	D	First dose of Yersiniavax vaccine injected into weaners before April 1
SIPC		Number of days between January 1 and the starting date of internal parasite control (first drench)
NANTH		Number of anthelmintic treatments
BLOCK 3 : Post-weaning grazing management (from weaning to April 1)		
Same variables as in BLOCK 2 except weaning management variables and STAG plus :		
ODEER	D	Weaners grazing with deer over 15 months old
4th BLOCK : Biological markers		
Individual and mean calf blood biological characteristics recorded in March 1992 and 1993 (for farm mean blood markers, codes start by "M")		
White cell count (WCC), neutrophil percentage (NP), lymphocyte percentage (LP), eosinophil percentage (EOP), haemoglobin (HB), packed cell volume (PCV), total protein (TP), albumin (ALB), phosphorus (P), gamma glutamyl transferase (GGT), blood urea nitrogen (BUN), copper (CU), vitamin B12 (B12), pepsinogen (PEPS), glutathione peroxidase (GSHPx)		
Individual weaner faecal parasite output recorded in March 1992 and 1993		
Faecal larval count (FLC) and faecal egg count (FEC)		
Calf faecal parasite markers recorded before the commencement of anthelmintic treatment in 1992, 1993 and 1994.		
NFEC>0		Number of calves with positive faecal egg count (over 10 calves)
FLCI	Larvae/g	Calf lungworm larvae index : geometric mean lungworm larval count multiplied by the number of calves with positive count (over 10 calves)

† Estimated from the dam blood lines and those of the sire when single sire mating and matching dam-offspring was performed; otherwise, mean calving mob values were estimated from the mean NZD in each calving mob and the sire blood lines. If multiple sire mating was performed, the sire with the highest foreign blood lines was taken arbitrarily as mating sire.

Note on units : D = Dichotomous variable : Yes=1 ; No=0
"Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in section 2.7.

- Data from both years of study were combined for statistical analyses.
- Weaner hind and stag data were analysed separately. During preliminary data analyses (data screening), however, potential risk factors were selected for multivariable analyses if they were statistically significantly, positively or negatively (eg if both Spearman correlation coefficients have the same sign in the screening of continuous risk factors), associated with W4 at the 20% confidence level for both weaner stags and hinds. Therefore, null hypothesis path diagrams were identical for weaner hinds and stags.
- Data screening of categorical risk factors was carried out using SAS, while the rest of the analyses were carried out using Statistica.

- Path analysis was used only for the analysis of blocks 1, 2 and 3.

  Path diagrams were formulated within each block (steps 1 to 3 in Table 4.1), which were analysed separately. Estimated weaner blood line percentages as described in Table 4.12 were included in all analyses as they were likely otherwise to be important confounding factors.

- Individual biological markers, mean blood markers and farm faecal parasite markers were analysed separately without the use of path analysis. Each step described in Table 4.2 represents a separate analysis. Some biological markers were categorised and analysed as discussed in section 2.8.12.3. Scatterplots of significant biological markers against W4 or MW4 were drawn up where appropriate.

For each final model, the square of the multiple correlation coefficient (r^2) is presented as the proportion of variance in the data "explained" by the variables included in the model (Kleinbaum et al., 1982).

4.3.2 Results

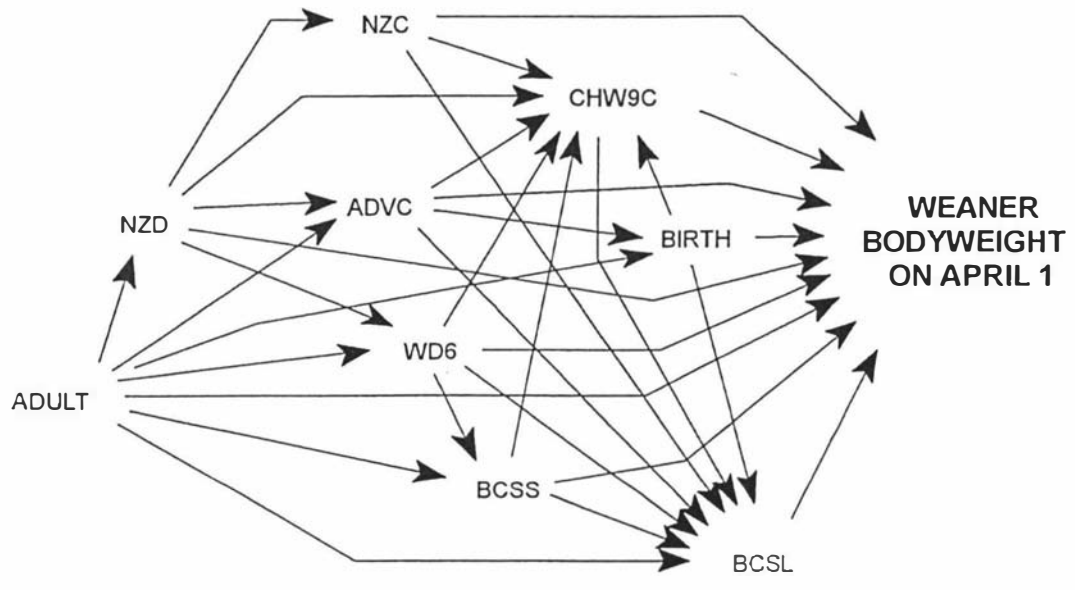
Means and standard deviations of weaner stag and hind W4 at each level of categorical variables are presented in Appendix 4.11. Summary statistics of continuous management risk factors, and biological markers, including Spearmann correlation coefficients and their statistical significance, are presented in Appendix 4.12 and Appendix 4.13, respectively.

Null hypothesis path diagrams of hind-offspring risk factors, lactation and weaning management risk factors and post-weaning management risk factors are presented in Figure 4.24, Figure 4.25 and Figure 4.26. Final path diagrams of associations between significant risk factors and weaner stag and hind bodyweights are presented in Figure 4.27, Figure 4.28 and Figure 4.29, respectively. Unstandardised path coefficients (multivariable regression coefficients) are presented on each statistically significant path in final diagrams ($p<0.05$). Statistically significant direct effects (regression coefficients) of the most important risk factors associated with weaner W4 within each block, and respective model r^2, are summarised in Table 4.13.

High weaner stag and hind bodyweights on April 1 (W4) were associated with dams which were over 3 years old at calving (adult hind), dams that conceived before May 1, early calf birth, high dam pre-winter bodyweight, high dam pre-calving bodyweight gain, high dam post-winter body

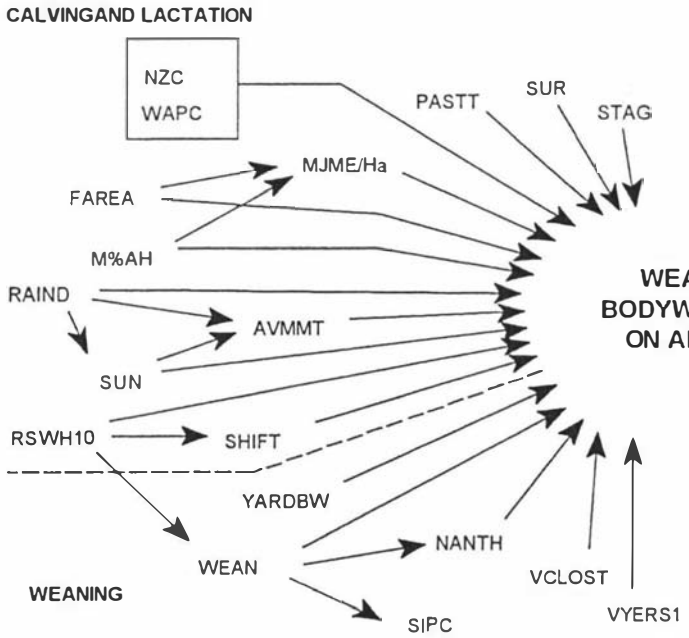
condition score (BCS) and dams with an increasing or static BCS between September and weaning. These dam-offspring risk factors explained 33% and 29% of the weaner stag and hind bodyweight variability, respectively. High W4 was also associated with high mean percentage of adult hinds in lactating mobs, high average daily temperature ranges (average of maximum minus minimum temperatures) during lactation and an increased number of anthelmintic treatments by April 1. After weaning, grazing pasture over 10 cm high was associated with almost 5 kg increase in weaner W4. High daily rainfall and maximum temperatures were negatively associated with W4, while high paddock wind exposure index and grazing paddocks close to signs of human presence (eg houses, road, buildings) were associated with producing heavy weaners. High percentage of wapiti or elk blood lines and low percentage of New Zealand blood lines were also associated with high W4. Many other factors were significant in either the stag or the hind final models as shown in Table 4.13. Significant factors within blocks 2 and 3 explained 27-to-30% of the variability of individual weaner bodyweight on April 1. Individual weaner stag and hind W4 were positively associated with individual serum total protein concentrations, while farm mean stag and hind bodyweights on April 1 (MW4) were positively associated with mean farm serum albumin concentrations. High farm mean weaner stag and hind MW4 were also found on farms with low calf lungworm larvae index.

Figure 4.24 : Null hypothesis path model of individual dam-offspring risk factors for individual weaner bodyweight on April 1



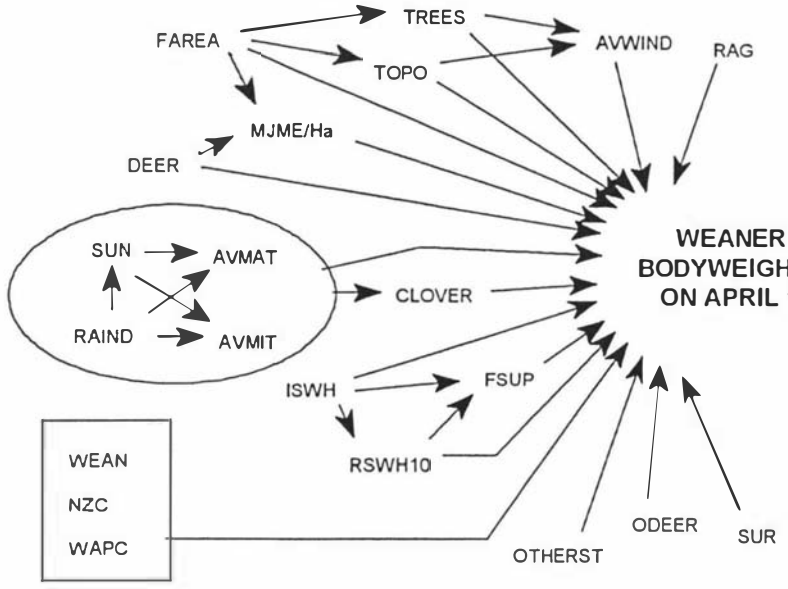
Note : Risk factor codes are described in the glossary and in Table 4.13

Figure 4.25 : Null hypothesis path diagram of grazing management during lactation (December 1 to weaning) and weaning management risk factors for individual weaner bodyweight on April 1.



Note : Risk factor codes are described in the glossary and in Table 4.13. SIPC has been included to illustrate its correlation with WEAN but was not analysed along with WEAN as a risk factor for weaner bodyweight W4 as SIPC and WEAN were highly correlated (see Figure 4.28)

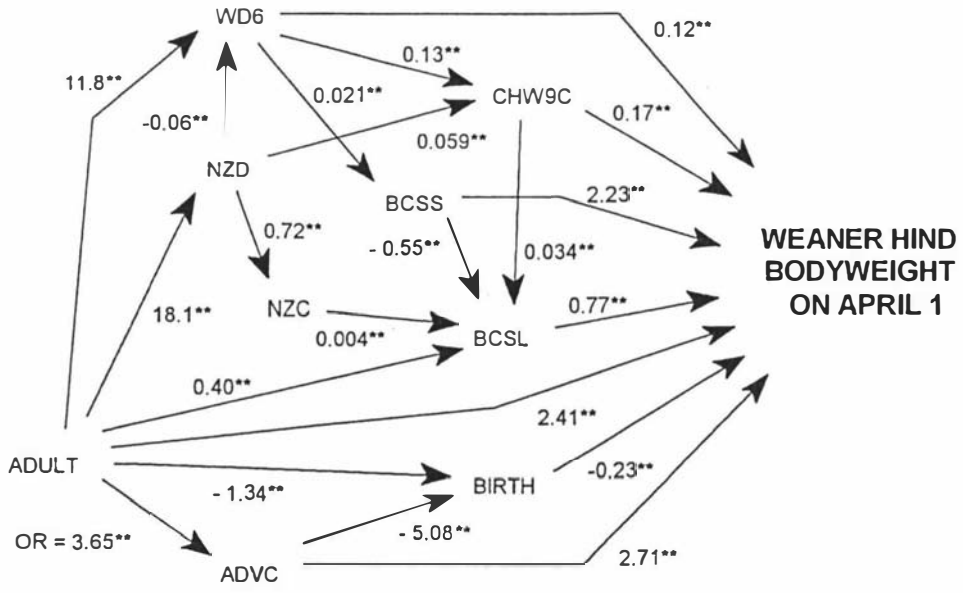
Figure 4.26 : Null hypothesis path diagram of post-weaning grazing management risk factors for individual weaner bodyweight on April 1.



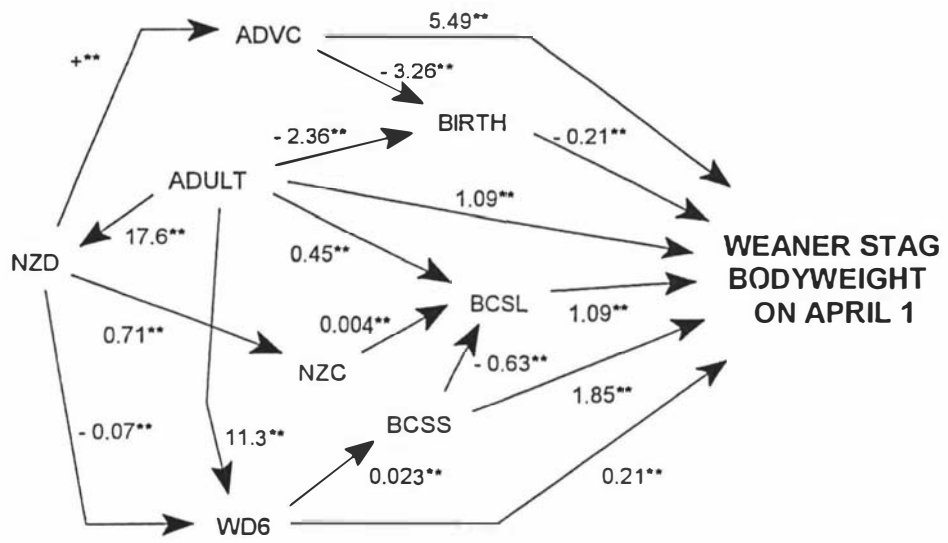
Note : Risk factor codes are described in the glossary and in Table 4.13

Figure 4.27 : Final path diagrams of individual dam-offspring risk factors for individual weaner hind and stag bodyweight on April 1.

1. Weaner hind.



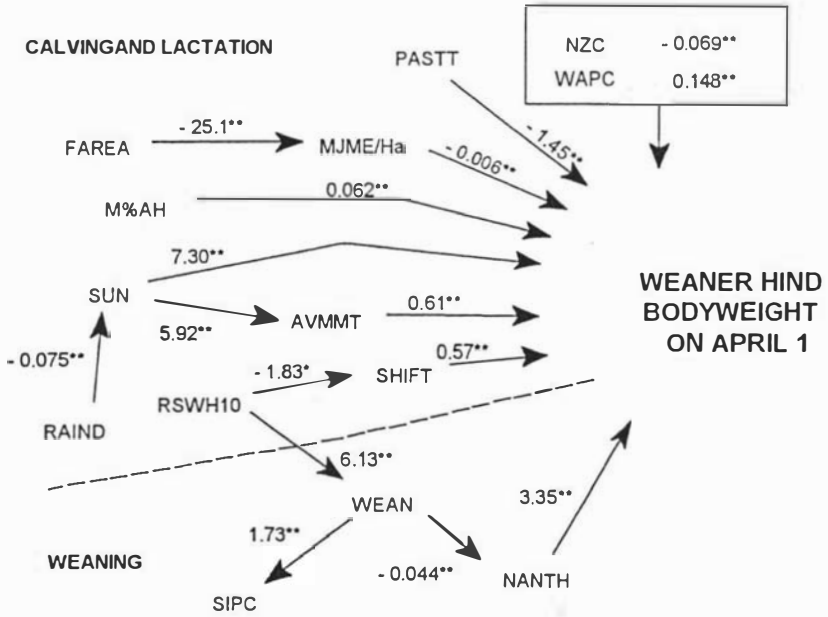
2. Weaner stag.



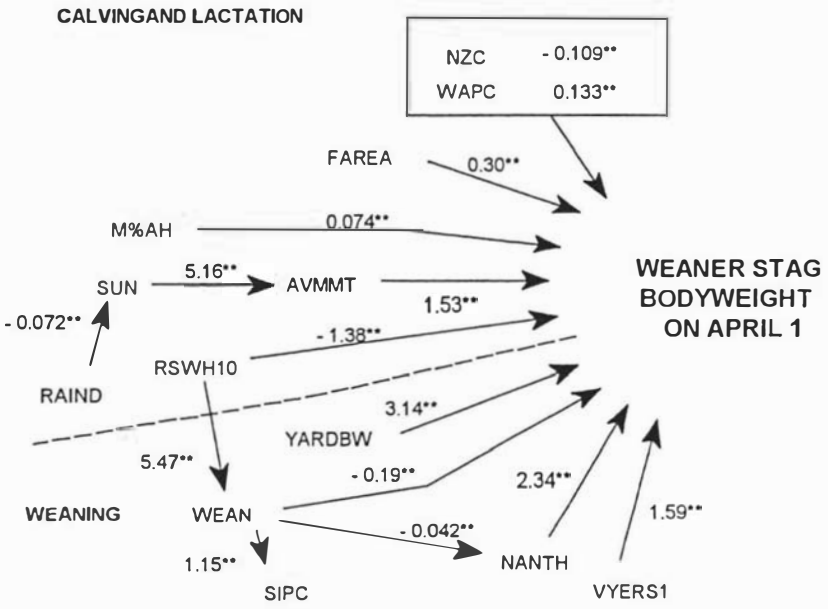
Note : Risk factor codes are described in the glossary and in Table 4.13. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentages of variability of weaner weight explained by final models are presented in Table 4.13

Figure 4.28 : Final path diagrams of grazing management during lactation (December 1 to weaning) and weaning management risk factors for individual weaner hind and stag bodyweight on April 1.

1. Weaner hind.



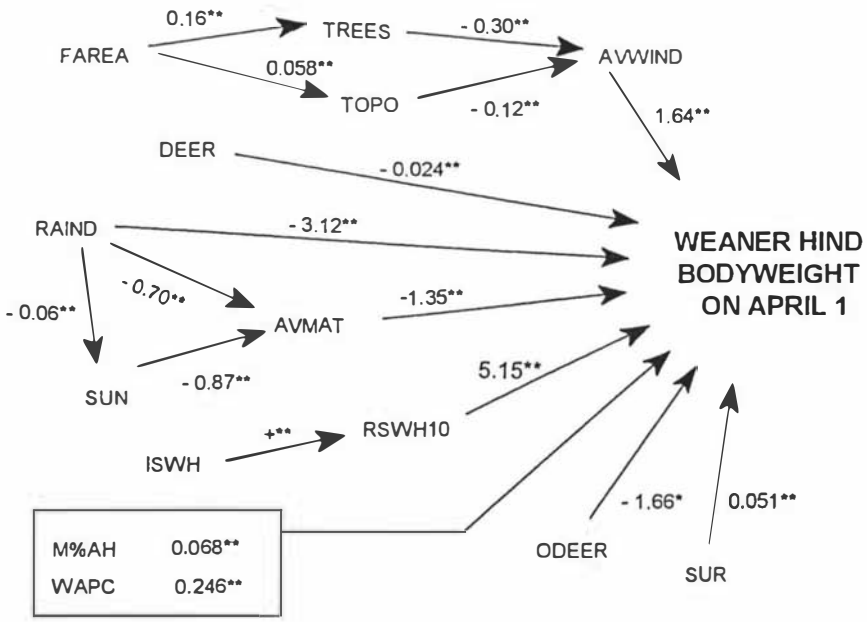
2. Weaner stag.



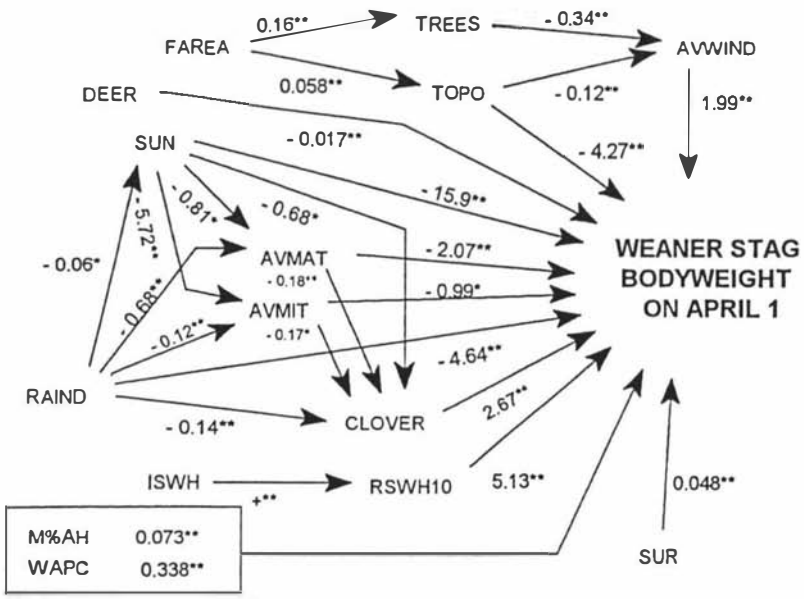
Note : Risk factor codes are described in the glossary and in Table 4.13 Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentages of variability of weaner weight explained by final models are presented in Table 4.13

Figure 4.29 : Final path diagrams of post-weaning grazing management risk factors for individual weaner hind and stag bodyweight on April 1.

1. Weaner hind.



2. Weaner stag.



Note : Risk factor codes are described in the glossary and in Table 4.13. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentages of variability of weaner weight explained by final models are presented in Table 4.13

Table 4.13 : Summary of direct effects of risk factors for weaner stag and hind bodyweight within each risk factor block.

Major risk factors	Units	WEANER STAGS Regr. coef.*	SE	p value		WEANER HINDS Regr. coef.*	SE	p value	
BLOCK 1 : Animal individual characteristics									
Model R square					0.33				0.29
Intercept		20.22	3.60	0.00		23.499	3.17	0.00	
Adult hind	D	2.55	0.78	0.00		2.412	0.69	0.001	
Post-mating dam bodyweight calculated on June 1	kg	0.21	0.03	0.00		0.123	0.03	0.000	
Dam conceiving before May 1	D	5.49	1.00	0.00		2.710	0.80	0.001	
Dam body condition score (BCS) in September	Dis. 1-5; 0.5	1.85	0.46	0.00		2.229	0.40	0.000	
Calf birth date	day	-0.21	0.05	0.00		-0.227	0.04	0.000	
Dam bodyweight change between September and November	kg					0.166	0.07	0.013	
Dam BCS change during late pregnancy and lactation	Dis. 1-5; 0.5	1.09	0.37	0.00		0.771	0.32	0.017	
BLOCK 2 : Lactation and weaning management									
Model R square					0.27				0.29
Intercept		41.36	2.43	0.000		34.72	1.70	0.000	
Estimated percentage of New Zealand Blood lines in the calf	%	-0.11	0.01	0.000		-0.07	0.01	0.000	
Estimated percentage of Wapiti or Elk blood lines in the calf	%	0.13	0.03	0.000		0.15	0.02	0.000	
Mean percentage of adult hind in the mob		0.07	0.01	0.000		0.06	0.01	0.000	
Mean pasture type score	Score 1-3					-1.45	0.30	0.000	
Mean residual pasture sward height over 10 cm	D	-1.38	0.41	0.001					
Mean paddock size	Ha	0.30	0.04	0.000					
Average of daily temperature ranges (maximum-minimum)	°C	1.53	0.14	0.000		0.61	0.12	0.000	
Number of days between January 1 and weaning	day	-0.19	0.03	0.000					
Calves handled in yards before weaning		3.13	0.52	0.000					
Number of anthelmintic treatments before April 1		2.34	0.42	0.000		3.35	0.32	0.000	
Weaners were injected one dose of "Yersiniavax" before April 1	D	1.59	0.41	0.000					
Average daily sunshine score	Score 0-1					7.30	1.22	0.000	
Number of times deer were shifted between paddocks						0.57	0.09	0.000	
Mean mob daily energy requirements per hectare	MJME/Ha					-0.01	0.00	0.000	
BLOCK 3 : Post-weaning grazing management									
Model R square					0.29				0.30
Intercept		105.330	7.971	0.000		70.974	3.157	0.000	
Estimated percentage of Wapiti or Elk blood lines in the calf	%	0.338	0.036	0.000		0.246	0.034	0.000	
Mean percentage of adult hind in the mob during lactation		0.073	0.007	0.000		0.069	0.006	0.000	
Average number of deer in the mob		0.017	0.006	0.005		-0.024	0.004	0.000	
Mean residual pasture sward height over 10 cm	D	5.134	0.595	0.000		5.151	0.760	0.000	
Mean pasture clover score	Score 1-3	2.672	0.741	0.000					
Time spent in paddock close to road, buildings, houses ,...	%	0.048	0.009	0.000		0.051	0.006	0.000	
Weaner grazing with yearling or adult deer	D					-1.656	0.747	0.027	
Average daily rainfall	mm/d	-4.644	0.314	0.000		-3.123	0.241	0.000	
Paddock wind exposure index		1.990	0.345	0.000		1.643	0.283	0.000	
Average daily maximum temperature	°C	-2.071	0.204	0.000		-1.353	0.161	0.000	
Average daily sunshine score	Score 0-1	-15.904	2.815	0.000					
Average daily minimum temperature	°C	-0.994	0.317	0.002					
Average paddock topography score	Score 1-3	-4.275	0.791	0.000					
BLOCK 4 : Biological markers									
Individual calf blood characteristics (calf crop 1992 and 1993)									
Model R square					0.11				0.10
Intercept		10.22	11.06	0.358		19.53	7.80	0.014	
Total protein	g/l	0.65	0.17	0.000		0.45	0.12	0.000	
Farm mean calf blood and faecal parasite markers (calf crop 1992 and 1993)									
Model R square					0.23				0.27
Intercept		28.54	8.61	0.003		19.49	9.68	0.058	
Mean albumin concentration over 10 calves	g/l	0.60	0.24	0.021		0.73	0.27	0.013	
Farm mean calf faecal parasite markers (calf crop 1992, 1993 and 1994)									
Model R square					0.18				0.21
Intercept		52.31	0.95	0.000		47.59	0.78	0.000	
Mean farm calf lungworm larvae index		-0.0048	0.0021	0.029		-0.0044	0.0017	0.017	

* Regression coefficient = Kilogram of weaner bodyweight increase per unit increase of each continuous risk factor, or if dichotomous variables equal to 1, all other factors maintained constant.

SE = standard error;Regr. Coef. = regression coefficient

Note on units : "Score 0-1" means "Score ranging from 0 to 1"

"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

D = Dichotomous variable (Yes=1/No=0)

4.3.3 Discussion

Weaning weight has been one of the key outcomes in the deer production process to be targeted for improvement/efficiency in breeding and venison production units, but weaning dates have seldom been published to enable valid comparisons. When both calving dates and birth weights are recorded, generally from research farms, it is possible to compute calf growth rates and calf weights at a given age. However, this is not practical to the farmer who seeks a reference value on which objective judgement of their performance can be made. Individual weaner stag and hind post-weaning bodyweight standardised to April 1 (W4) can be used for direct comparison between farms. Such calculation was required since farmers did not wean their calves at the same time, thus weaning weights *per se* could not be used for comparison between farms.

Weaner hind and stag bodyweights on April 1 (W4) were analysed separately because it is known birth weight and growth rates during lactation is significantly higher in stag calves (Blaxter and Hamilton, 1980). The selection of potential risk factors to be included in null hypothesis path diagrams, however, was based on the principle that important risk factors would positively or negatively affect both weaner stags and hinds. The most important factors were believed to be those significantly associated with both stag and hind weaner W4 in univariate analyses, while the significance of the other factors identified in stags or hinds may be marginal. In this study, blocks were investigated separately because individual dam-offspring pair identifications were carried out on 6 farms only, while the analysis of post-weaning grazing management could not include farms where calves were weaned on or after April 1.

4.3.3.1 Dam characteristics

Results were relatively consistent between weaner stags and hinds. Main dam factors affecting individual weaner variables are, to some respect, consistent with pre-existing factual or anecdotal evidence. After correcting for dam pre-calving body condition score (BCSS), body condition score change during lactation (BCSL), dam pre-winter bodyweight (WD6), pregnancy status (ADVC), dam pre-calving bodyweight change (CHW9C) and the date of birth (BIRTH), adult hinds (ADULT) produced on average 2.4 and 2.6 kg heavier weaner hinds and stags, respectively. This age effect is substantial and may be related to the ability of adult hinds to produce heavier calves than yearling hinds, as observed in fallow deer (Asher and Adam, 1985). This result somewhat contradicts other observations in red deer that weaner weight was not related to hind age, although Blaxter and Hamilton (1980) analysed "dam age" as a continuous factor without differentiating between yearling and adult hinds, and Asher and Adam, 1985 had only 3.2% (3/173) of yearling hinds in the breeding herd, so their result was not conclusive. It is suggested that the effect of ADULT on weaner weights may be essentially related to a lower milking potential in yearling hinds. This putative explanation would be consistent with the previous analysis of risk factors for progeny loss (section 4.2), and therefore reinforces the need to further investigate the lactation ability of yearling hinds.

Increased dam bodyweight (WD6) has also been associated with heavier calves at birth, and was identified as having a positive impact on calf growth during lactation (Blaxter and Hamilton, 1980; Moore et al., 1988a). Each 20 kg increase in pre-mating red deer hind bodyweight was associated with a 22-to-35 g/d increase in calf growth rate (Blaxter and Hamilton, 1980), and each 10 kg increase of pre-rut hind weight in wapiti was associated with a 30 g/d increase in calf growth rate (Friedel and Hudson, 1994)(These latter authors also reported a 1.9 kg increase in calf weight at

100 days, but to the author's calculations 1.9kg in 100 days makes 19 g/d). In this study, considering an overall median birth date on Nov 29 (from the 4 farms that recorded birth dates), for each 10 kg increase in WD6, there was an overall increase growth rate by 18.7 and 14.3 g/d in stag and hind calves, respectively. Part of this effect was mediated through BCSS and CHW9C, although those indirect effects appeared marginal.

Birth date (BIRTH) had a significant positive effect on post-weaning bodyweight with more than 200 g increase bodyweight for each day earlier that the animal was born, after correcting for conception status (early or late) which produced 2.5 kg and 5.5 kg heavier weaner hinds and stags, respectively. This is consistent with previous observations, with a 0.20 and 0.18 kg bodyweight difference observed at weaning for each day advanced at birth (Adam and Moir, 1987), although weaning was carried out quite late. Advancing calving dates did not change the bodyweight of progeny at the same age but increased the bodyweight by 2.8% at the same date for a 3-weeks advance in calving (Fennessy and Thompson, 1989). The total effect of ADVC in weaner hinds and stags, respectively, (measured by withdrawing BIRTH from final models) were a extra 3.9 and 6.2 kg in W4. This highlights the substantial advantage of early conception. The higher gain in weaner stags is likely to be due to their higher growth rate during lactation (Blaxter and Hamilton, 1980).

It is well recognised calves born early not only have more time to grow by April 1, but also can benefit from the spring pasture flush (Fennessy and Fisher, 1988; Wilson, 1989a). The significant associations of both ADVC and ADULT on BIRTH support the observation that adult hinds are more likely to conceive before May 1. This analysis also shows that adult hinds conceived earlier than yearling hinds in both periods studied, ie before and after May 1, which supports the observation of Bray and Kelly (1979) that yearling hinds conceived 1 to 2 weeks later than adult hinds. There was a significant interaction between ADVC and BIRTH in the weaner hind final model, but not in the stag final model. Weaner hinds born from hinds conceiving before May 1 gained 150 g more per day advanced in birth date compared to weaner hinds born from hinds conceiving late. This further emphasised the advantage of exploiting the spring pasture flush for hind lactation.

Pre-calving hind body condition score may be a major factor influencing weaner bodyweight. Each unit increase of pre-calving body condition score was directly associated with a total increase of 2.23 kg and 1.85 kg of hind and stags W4, respectively. However, the total effect of BCSS was slightly lower as fat hinds lost on average more body condition during lactation than thin hinds. Each unit decrease in body condition during lactation was associated with a 0.77 and 1.09 kg reduction in weaner hind and stag W4. The higher loss in weaner stags may be related to their higher milk requirement for growth, which may not be met by dams which are losing condition. The change of body condition score during lactation was positively associated with the level of nutrition (Loudon et al., 1984). The beneficial effect of quality pasture on hind bodyweight change (thus body condition change) during lactation has also been shown by Niezen et al. (1991). The beneficial effect of BCSS may be due to various factors such as the ability of fat hinds to produce heavier calves at birth and to have higher milk production. Moore et al. (1988c) suggested poor nutrition can adversely affect calf growth to weaning, through lower birth weights and reduced hind milk yield, thus particularly affecting stag calves. In elk in North America, calf bodyweights were reduced when dams lost bodyweight during pregnancy (Thorne et al., 1976). In this study, there was no significant interaction between BCSS and BCSL in both final models (stag and hind), which means that the effect of BCSL did not vary with the level of body condition score of the dam in September.

Yearling hinds lost more body condition than adult hinds, which illustrates the stress of lactation imposed upon first calvers. As yearling hinds conceived later than adult hinds, their demand for lactation peaks when pasture quality may be impaired through an increased proportion of seed head or dead material, whereas adult hinds may have benefited from greener pasture earlier in the season. Thus fat reserves were used to sustain lactation in the younger group. Low quality pasture may affect more late-born calves since, during the first 30 days, they depend almost exclusively on milk for growth (Loudon et al., 1984). Adam and Moir (1987) stated, however, that hinds calving late may gain more weight during late pregnancy - which would result in an increased BCS - and thus may afford to lose weight by weaning without materially affecting their subsequent reproductive performance. Whereas their view appears correct as shown by the relationship between CHW9C and BCSL in the weaner hind final diagram (Figure 4.27), this study suggests lactating hinds cannot afford to lose body condition if optimum performance is to be acheived. There was no significant interaction between ADULT and BCSS, and between ADULT and BCSL, in both final models, which means that body condition appears to be as important for yearling and adult hinds. Therefore, to say that "hinds can safely lose up to 5kg over winter" (Moore et al., 1985) may be correct with regard to hind mortality, but it appears to be an inappropriate management option to optimise both calf survival (see section 4.2) and weaning weight. Moreover, hinds in good condition in September are more likely to be over the threshold pre-mating BCS (at the time of weaning) under which the probability of conceiving early may be impaired (see section 4.1).

Further analyses (Audigé et al., publication in preparation) suggested that BCSS was directly related to the body condition score of hinds at the time of mating (BCSM), and management factors during winter. Small hinds - those with low pre-winter bodyweight (WD6) - were in poorer BCS by about 0.5 units for each 20 kg decrease in WD6, which may be related to social interactions on feeding sites during winter supplementation. This relationship was consistent whether hinds produced male or female offsprings.

The percentage of New Zealand blood lines *per se* (NZD) had no significant direct effects but indirect effects on weaner W4, through lower WD6 and higher NZC, were observed. It was also identified, as in previous analyses (see section 4.1), that older hinds had higher NZD and were more likely to conceive before May 1, which was further supported in this investigation. Amidst hinds conceiving female offsprings, adults were 3.6 times more likely to have conceived before May 1, whereas NZD rather than ADULT was positively associated with the probability of conceiving early in the weaner stag final diagram. The percentage of New Zealand blood lines in the calf (NZC) which relates to that of its dam and the sire used for mating, had a consistent effect on BCSL. Considering part of its effect on W4 may have been taken into account by NZD and WD6, dams rearing offsprings from imported red sires (there was no wapiti sire used on the 6 farms that recorded dam-offspring pairs) lost more body condition than dams rearing offspring from pure New Zealand sires. There was no significant interaction between ADULT and NZC on BCSL in weaner hinds but there was in weaner stags, suggesting the use of imported red sires was more detrimental to yearling hinds than adult hinds. This is consistent with the finding that male offspring with high growing potential (through imported blood lines) have a higher requirement for milk (Clutton-Brock et al. 1982). Consequently, it may be advisable to improve the nutrition levels of first calvers during lactation or use smaller sires to minimise the loss of BCS by weaning and thus improve the probability they will conceive early. It seems important to have a long term view on the reproductive career of the hind to make the system efficient and therefore more profitable.

4.3.3.2 Grazing and weaning management

To the author's knowledge, this study is the first time grazing management practices have been investigated on commercial farms as risk factors for weaning bodyweight. The analyses of grazing management during lactation, weaning and post-weaning grazing management are of particular interest and importance because there is no pre-existing evidence of association or certain biological explanation for some associations. Some factors in these blocks were chosen based on logical thought without back-up from the literature, so this discussion is only suggestive of plausible explanations. Thus this section is of particular relevance in determining priorities for further evaluation of management strategies up to weaning. This lack of knowledge makes the interpretation of these associations more challenging and perhaps more speculative.

In the analyses of grazing management factors, individual factors were included as they may otherwise be important confounding factors. Since ADULT was associated with many individual hind factors in the previous analyses, it was believed that by including the mean percentage of adult hinds in the lactating mob (M%AH) most individual factors have been taken into account. This was further controlled through the inclusion in each null hypothesis path diagram of the estimated percentage of New Zealand (NZC) and wapiti blood lines (WAPC) of individual calves.

Significant lactation and weaning management risk factors explained 27% and 29% of the variability of weaner stag and hind W4, respectively. These analyses support the beneficial effect of introducing imported blood lines or using wapiti-type deer in producing heavy weaners. The more adult hinds in the calving mob, the heavier were the weaners, which is consistent with the previous analysis of dam characteristics.

The positive effect of high temperature ranges during lactation and low daily rainfall after weaning, may indicate the positive influence of sunny weather patterns (providing it is not too dry for adequate pasture growth). Large paddocks were associated with high weaner stag W4, but this may be related to the hind grazing density during lactation as shown by the final diagram of weaner hinds (Figure 4.28), possibly causing less competition for grazing between hinds. The higher demands for feed energy per hectare grazed (MJME/Ha), the lower weaner bodyweights, which suggests feed supply was a limiting factor on some farms. It has been identified, however, that large paddocks had more sheltered areas, including trees (see section 3.1.2.1.), so lactating hinds may have benefited from them. In a recent survey in wapiti in Canada, there was no relationship between grazing densities and calf weight at 100 days, but no effort was made to assess pasture quality (Friedel and Hudson, 1994).

Although possibly marginal in this study, low quality pasture species (measured by a high pasture type score) were associated with low weaner hind W4. Grazing pasture over 10 cm high (RSWH10) during lactation was identified as detrimental for weaner W4 possibly because long pastures were rank and contained large quantities of low energy or dead material. Weaning weight can be adversely affected if the pasture is left rank and not controlled at the vegetative stage (Moore et al., 1985; Moore et al., 1988c). Loudon et al. (1984) showed that the daily growth of calves can vary by 100 g depending on pasture quality, which can account for about 10 kg difference at weaning. This is particularly noticeable when alternative high energy, palatable pasture (eg red clover) is offered for lactation, as it resulted in 8.5 kg increase in weaning weight (Niezen et al., 1991). RSWH10 was also identified as having an indirect negative effect on W4 through the weaning date (WEAN), as lactating hinds grazing pasture over 10 cm were weaned later than other hinds, possibly due to management decisions by the farmer.

"Early" and "late" weaning in this thesis refers to "late February-early March" and "late March-early April" weaning, respectively, and not "pre-rut" or "post-rut" weaning as has been debated for many years. There are many advantages in weaning calves pre-rut (Moore et al., 1985). Only one farmer weaned calves in late April in this study, while the others weaned by early April.

Weaning dates (WEAN) and dates of commencement of anthelmintic treatment (SIPC) were not both included in the regression analysis because they were highly positively correlated, thus avoiding the problem of multicolinearity. An approximate 2-3.5 kg weaner weight increase was associated with each anthelmintic treatment administered before April 1 (NANTH). Although the direct effect of NANTH identified in the weaner hind final diagram (Figure 4.28) is likely to be partly confounded with that of weaning date (WEAN) which was only significant in the weaner stag final diagram, the potential beneficial effect of NANTH on W4 cannot be ignored. The significance of both risk factors WEAN and NANTH in the same diagram of weaner stag risk factors suggests they have specific beneficial effects. In this study some weaners were drenched as early as late January. The positive significant relationships between farm calf lungworm larvae indices and mean weaner bodyweights on April 1 (Table 4.13) further support the potential negative influence of parasitism (in particular lungworm infections) on the growth of calves. Further evaluation of the effect of parasitism on weight gains of calves is warranted.

The later the weaning date, the lighter were weaner stags on April 1. Friedel and Hudson (1994) observed that pre-rut weaning is associated with heavier calf weight by 8% at 100 days of age. By 3 months of age, calves probably receive only 10-20% of their energy requirement from their dam (Loudon and Kay, 1984 cited by Kay, 1985), so good pasture quality is required at any time. It was the author's perception that farmers paid more attention in providing high quality pasture to calves after, rather than before weaning - which is supported by the positive influence of RSWH10 after weaning compared with a negative association before weaning - so calves weaned late may have spent less time grazing on higher quality pasture by April 1. Early weaning may also be associated with an earlier maturity of the rumen for optimum pasture digestibility, as in cattle (Anderson et al., 1987a, 1987b). Also, calves weaned at 4 weeks of age had higher dry matter intake between 9 and 12 weeks than calves weaned at 6 weeks (Anderson et al., 1987a). Although deer in this study were weaned older, calves weaned late February may have eaten more and better digest the post-weaning pasture on offer by April 1. Therefore, this study suggests further research should be carried out to investigate the effect of weaning before March on calf growth and the relationship between age and rumen development.

Yarding calves at least once before weaning was significantly positively associated only with weaner stag W4. This management procedure is thought to minimise the stress associated with weaning and thus limit the period of reduced food intake often encountered a few days after weaning (Moore et al., 1985). There is no obvious explanation of the apparent beneficial effect of weaners being injected a dose of Yersiniavax (vaccine against yersiniosis) before April 1 as seen in the stag model. It was though this vaccination was rather likely to be detrimental to weaner growth since it was likely to produce tissue reactions at injection sites resulting in lower appetite for a few days after vaccination (Mackintosh, personal communication).

4.3.3.3 Post-weaning management

After weaning, residual pasture sward height (RSWH10) should be maintained over 10 cm to produce heavy weaners as shown by the 5.1 kg increase of weaner hind and stag bodyweight

associated with this grazing practice. Although the magnitude of this substantial effect may only be indicative, it strongly supports previous experimental evidence (Ataja et al., 1992), so this relationship is likely to be causal. The amount of clover appeared to be a significant factor for weaner stag growth, although it was not significant in the weaner hind final diagram (Figure 4.29). Niezen et al. (1993) recorded higher weaner growth rates from red clover swards compared with conventional ryegrass/white clover swards.

That large mobs of weaners were associated with low weaner weight is intriguing and needs further evaluation. It may be related, however, to social interactions resulting in more competition for grazing, thus minimising the growth of disadvantaged weaners.

Weaning is often associated with a period of stress resulting in weaners fence pacing, and slowing growth during the few days following weaning (Pollard et al., 1992). To minimise this stress, it has been suggested to join tame hinds with them or give food supplements (Moore et al., 1985). The negative effect of mixing yearling or adult deer with weaners after weaning (ODEER) on weaner hind W4 is contradictory to the observation of Pollard et al. (1992) that putting quiet hinds with weaners settled the latter and increased their post-weaning growth. However, ODEER was not signicant in the weaner stag final diagram. It suggests that this is not a major factor, or that the study of Pollard et al. (1992) needs to be repeated comparing sexes. Food supplementation of deer was not significant in this analysis, suggesting grazing swards over 10 cm, in this study, was more important for weaner growth than alternative feeding. Grazing paddocks close to human activities (houses, buildings, road,...) may be beneficial because it increases the quietness of weaners when handled (shifting between paddocks or yarding), but this will need further investigations.

Weaner W4 was negatively associated with high mean daily rainfall. Sunny weather patterns and resulting high daily maximum temperature had a negative effect on W4, suggesting some weaners may have suffered from drought. Alternatively, these weaners may have suffered from heat stress, associated with reduced appetite (Blackshaw and Blackshaw, 1994). The interrelationships between RAIND, SUN, AVMIT and AVMAT are expected along with their negative effects on mean clover scores (CLOVER), although the relationships between weather variables and CLOVER may not be linear.

The positive effects of exposure to wind (AVWIND) in both final diagram suggests the data should be further explored. Since the paddock wind exposure index (AVWIND) has been calculated from recorded Beaufort scores and paddock scores of potential protection against wind from gully, hill, trees and shelter belt (see section 2.6.2.2.1), this variable should be further refined to identify the important factors. The positive effect of wind *per se* may be associated with reduced heat stress (Blackshaw and Blackshaw, 1994) that may be associated with SUN and AVMAT. Alternatively, it may be that large gullies - which would decrease AVWIND - have a major negative influence on growth through steeper topography (TOPO) and lower feed quality (pastures were often observed long and rank on slopes during the March visit, as farmers could not manage them appropriately, ie by topping). The significant negative effect of TOPO on AVWIND, and its direct negative effect on weaner stag W4 supports this view.

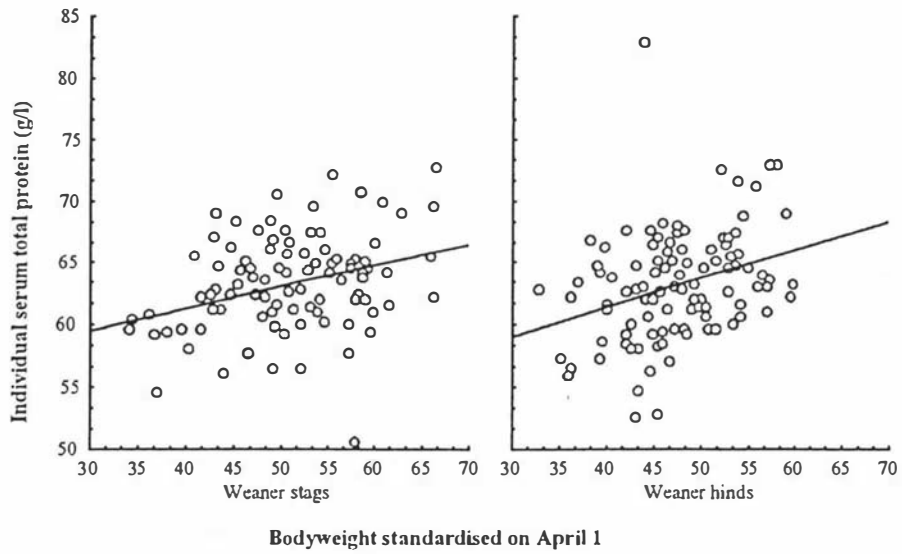
4.3.3.4 Biological markers

The positive relationship between individual calf serum total protein concentrations (TP) and their bodyweights on April 1 is consistent with the finding that mean serum albumin concentrations (MALB) were positively associated with the mean weaner weights on each farm (Table 4.13). This

suggests these biological markers in young ruminants may be useful to monitor adequacy of nutritional intake. This is further illustrated in Figure 4.30 and Figure 4.31 showing the relationships between W4 from individual TP and between MALB and MW4 (in hinds and stags), respectively. The relationship between W4 and TP, although significant, is not strong which is also showed by low r^2 (0.10 and 0.11, see Table 4.13). Scatterplots of MALB against MW4 suggests mean serum albumin concentrations below 35 g/l may be indicative of nutritional deficiency, but further research needs to investigate this hypothesis.

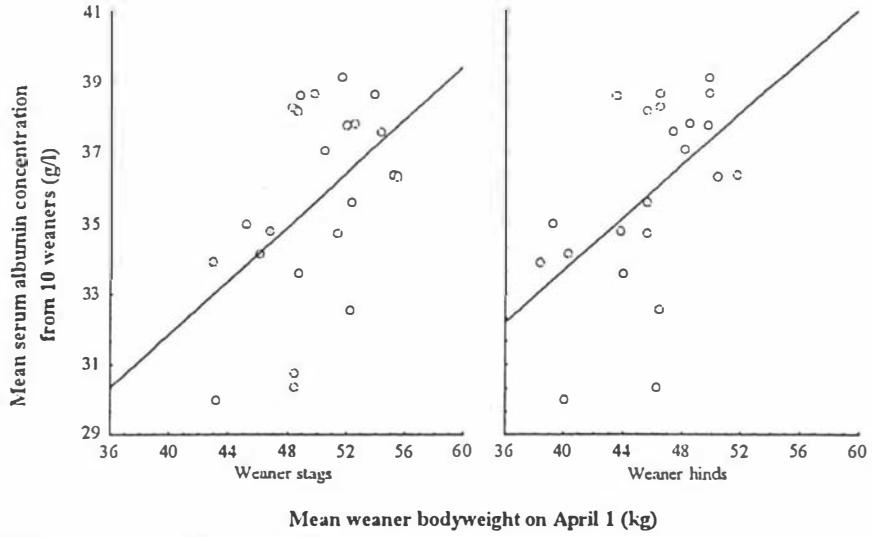
The relationships between the farm lungworm larvae index (FLCI) and mean weaner stag and hind weight presented in Figure 4.32 has been discussed previouly along with the positive effect of weaning/drenching weaners early. These scatterplots further support the need to investigate the timing of internal parasite infestation and its effects on calf growth in future research. In the meantime it suggests the farm calf faecal lungworm larvae index should not be over 400. It will also be appropriate to investigate risk factors recorded in this study that may be associated with this index, such as climatic factors, swards characteristics during summer, and anthelmintic treatment of the dams. This investigation was beyond the scope of this thesis.

Figure 4.30 : Relationship between individual weaner hind and stag bodyweight on April 1 (kg) and individual serum total protein concentration (g/l) from 5 hinds and 5 stags per farm sampled around weaning. Data from 1992 and 1993 combined.



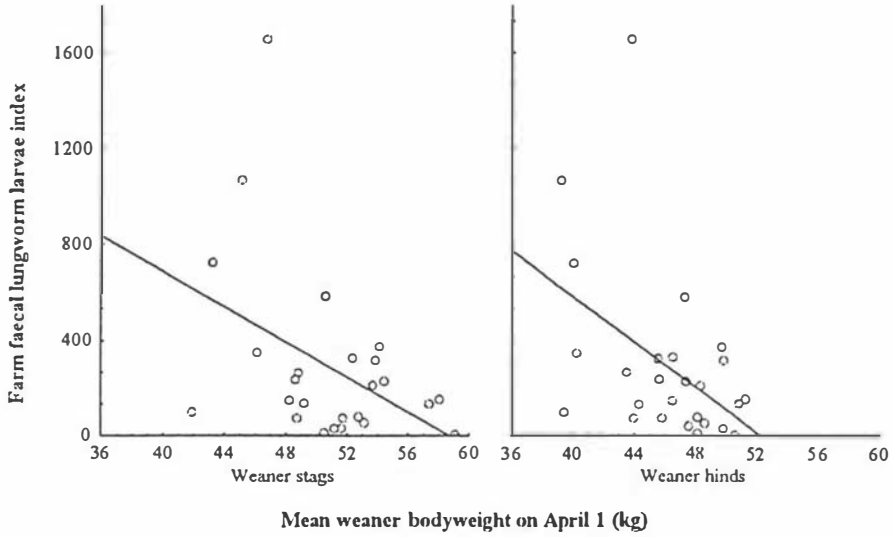
Note : regression lines are presented in Table 4.13

Figure 4.31 : Relationship between mean weaner hind and stag bodyweight on April 1 (kg) and mean serum albumin concentration (g/l) from 10 weaners per farm (5 hinds and 5 stags) sampled at weaning. Data from 1992 and 1993 combined.



Note : regression lines are presented in Table 4.13

Figure 4.32 : Relationship between mean weaner hind and stag bodyweight (kg) and farm calf faecal lungworm larvae index from 10 weaners per farm (5 hinds and 5 stags) sampled before the commencement of anthelmintic treatment. Data 1992, 1993 and 1994 combined.



Note : regression lines are presented in Table 4.13

4.3.4 Conclusion

It is essential that calf growth be optimal during lactation and weaner weight maximised to achieve optimum target weight of stags for slaughter at 12 months of age (Niezen et al., 1991, 1993) and of hinds for attainment of puberty, conception and lifetime reproductive performance. This study has identified management practices likely to improve weaner bodyweights on April 1 on commercial farms which deserve priority for research and development.

These results suggest a farmer can achieve optimum weaner bodyweights on April 1 by applying the following :

- Minimise the proportion of yearling hinds in the breeding herd by minimising the culling percentage of adult hinds through maintaining optimum reproductive efficiency (see section 4.1 and 4.2).
- Select the heaviest hinds for breeding.
- Maximise the proportion of hinds conceiving before May 1 (see section 4.1).
- Manage the breeding herd during winter so hinds are in good body condition in September.
- Ensure high quality pasture for lactation so hinds do not lose body condition between September and March.
- Hinds in poor condition in September should be separated for calving and lactation so their nutrition can be improved before the onset of lactation and during lactation.
- Use imported red or wapiti cross-red type terminal sire on adult hinds.
- Avoid mating yearling hinds with large terminal sire unless the body condition score of yearling hinds can be maintained during lactation.
- Wean calves early.
- Yard dams and calves at least once before weaning.
- Monitor the faecal lungworm larvae output of calves so anthelmintic treatment can be started as appropriate. The calf faecal lungworm larvae index should not be over 400.
- After weaning, allow weaners to graze high quality pasture (including high clover content) no shorter than 10 cm.
- Keep weaner mobs in moderate size.
- Use paddocks close to the farm's house or buildings (or any sign of human presence).

- Use paddock with protection against adverse weather conditions such as heavy rain or dry sunny and warm weather.

- Monitor the serum albumin concentrations from 10 randomly selected calves at weaning to investigate the adequacy of nutritional intake during lactation.

Providing all the factors identified in this study are causal and all these management requirements are met, high weaner hind and stag bodyweight could be achieved on April 1. Weaner bodyweights over 60 kg were observed in this study.

It is the researcher's advice that :

- Considering the increased risk of dystocia identified in hinds over 3.5 in BCS pre-calving (see section 4.6.3), it is proposed this threshold may be the optimum and maximum BCS to target in September.

- Hinds in poor condition in September be those with BCS < 3 since these hinds are also at risk of losing their progeny (see section 4.2). These hinds should be separated from the main mob and preferentially fed prior to calving.

- Lactating hinds should be over a BCS of 3 at weaning, and not below 2.5, to ensure subsequent reproductive success.

- Calves should be weaned before March 1.

- The size of each mob should remain below 120, wich is the mean mob size recorded in this study. Weaners should be split into separate mobs according to bodyweight, in particular separate weaners below 50 kg from the rest of the mob (these weaners are more at risk of dying from yersiniosis, and thus may be a major source of *Y.pseudotuberculosis* (see section 4.6.1)).

4.3.5 Identified areas for further research

This section has identified likely key factors influencing weaner bodyweight standardised to April 1 and has highlighted areas which deserve priority in research and development designed to improve management techniques.

It is appropriate to investigate :

- The potential for lactation in yearling hinds and milk requirements of calves of different sex and blood line.

- The effect of weaning before March and that of age on rumen development.

- The influence of parasitism, in particular that of the lungworm *Dictyocaulus viviparus* on the growth of young deer before April 1.

- Management practices likely to minimise the infestation of calves by the lungworm *Dictyocaulus viviparus*.

- The effect of spliting large weaner mobs after weaning on growth.
- The effect of timing of handling of calves/weaners by the farmer and handling frequency on their behaviour and growth by April 1.
- The potential occurrence of heat stress in young deer, eg through the study of growing patterns at different temperatures.
- The importance of different types of shelter, eg trees or tree belt, against advserve weather conditions.

4.4 RISK FACTORS FOR WEANER[1] SEASONAL GROWTH RATES

In the deer industry in New Zealand, there is an economic advantage of producing deer over 92 kg bodyweight by one year of age. This provides a carcass of more than 50 kg, achieving premium price, at a time of year when demand, and consequently price, is highest. In addition, farmers get rid of most of their weaners at a time when hinds require optimum nutrition to milk their calves thus reducing competition for feed. The hind carrying capacity of the farm can be increased, and the number of calves produced can be maximised. There is also an objective to produce heavy hinds by the time of their first mating season to ensure fertility through the attainment of puberty (Adam, 1994). Consequently, the achievement of target weights throughout the year is very important for the successful farmer.

In the previous sections, management factors to ensure that reproductive efficiency is high, calves are born early and grow well up to weaning have been investigated. This section presents risk factors for weaner stag and hind growth up to 15 months. It focuses on growth during autumn (from April 1 to June 1), winter (from June 1 to September 1), spring (from September 1 to December 1) and summer (from December 1 to March 1).

4.4.1 Materials and methods

During each of the two years of study, about 1400 weaners were monitored for growth. To enable direct comparisons given that deer were weighed on different dates on each farm, calculations were performed to standardise bodyweight on April 1(W4), June 1 (W6), September 1 (W9), December 1 (W12) and March 1 (W3) the following year. Individual weaner growth rates between April 1 and June 1 (GR46), June 1 and September 1 (GR69), September 1 and December 1 (GR912) and between December 1 and March 1 (GR123) were subsequently calculated on each farm (see section 2.6.2.3.1). During farm visits in March, June, September 1992 and 1993, and in November 1992, 10 randomly selected weaners (5 hinds and 5 stags) were blood sampled to define their haematological, biochemical and mineral blood profiles (see sections 2.4.1.1 and 2.5). Serological evidence of *Yersinia pseudotuberculosis* infections were carried out. Grazing and health management histories were recorded and grazing management variables were calculated for each of the periods above.

Risk factors potentially affecting GR46, GR69, GR912 and GR123 were identified and classified according to the area of data collection they describe. Codes and descriptions of variables are presented in Table 4.14.

The first block includes individual deer characteristics, weaning management, disease control measures, grazing management, environmental factors and health problems, depending on the outcome under investigation. Block 2 includes individual sentinel deer characteristics and individual blood markers recorded during farm visits. These two blocks of variables were investigated as potential risk factors for individual weaner growth rates (eg GR46). Mean farm biological markers were obtained by averaging data from the 10 weaners where there were no sex differences, and the geometric mean instead of the arithmetic mean was calculated from log-normally distributed blood characteristics.

[1] Note : for this thesis, the term "weaner" describes deer from 3 to 15 months of age.

Table 4.14 : Potential risk factors for weaner seasonal growth rates.

Risk factor Code	Unit	Description
BLOCK 1		
Individual weaner characteristics		
NZ	%	Estimated percentage of New Zealand blood lines
WAP	%	Estimated percentage of wapiti (or elk) blood lines
Specific risk factors for GR46		
W4	kg	Bodyweight standardised to April 1
PERCW4	%	Percentile of W4 within mobs on April 1
MAXW4	kg	Difference W4- maximum W4 within mobs on April 1
Specific risk factors for GR69		
W6	kg	Calculated bodyweight on June 1
PERCW6	%	Percentile of W6 within mobs on July 1
MAXW6	kg	Difference W6- maximum W6 in the mob on July 1
GR46	g/d	Growth rate between April 1 and June 1
Specific risk factors for GR912		
W9	kg	Calculated bodyweight on September 1
PERCW9	%	Percentile of W9 within mobs on September 1
MAXW9	kg	Difference W9- maximum W9 in the mob on September 1
GR69	g/d	Growth rate between June 1 and September 1
Specific risk factors for GR123		
W12	kg	Calculated bodyweight on December 1
PERCW12	%	Percentile of W9 within mobs on December 1
MAXW12	kg	Difference W9- maximum W9 in the mob on December 1
GR912	g/d	Growth rate between December 1and March 1
Disease control		
Specific risk factors for GR46: Weaning management and disease control management practices before June 1		
VCLOST	D	Vaccination with two doses of clostridial vaccine (5-in-1) 3 to 4 weeks apart
VYERS	D	Vaccination with two doses of Yersiniavax 3 to 4 weeks apart
WEAN	day	Number of days between January 1 and weaning
NANTH		Number of anthelmintic treatments
DRUG		Use of only ivermectin/albemycin or benzimidazole-based anthelmintics
IVE	D	Use of ivermectin/albemycin anthelmintics only
DRENCHI	day	Mean time interval between two anthelmintic treatments
MINSUP	D	Use of mineral supplemented anthelmintics
DOSEOK	D	Weaner receiving at any drench the recommended dosage of anthelmintic
Specific risk factors for GR69 : Disease control management practices before September 1		
NANTH		Number of anthelmintic treatments
STARTD	day	Number of days between June 1 and the next anthelmintic treatment
JUNED	D	Anthelmintic treatment in June (early-winter drench)
JULYD	D	Anthelmintic treatment in July (mid-winter drench)
VYERS	D	Vaccination with two doses of Yersiniavax 3 to 4 weeks apart
COPPER	D	Copper supplementation prior to or during winter (before early July)
Specific risk factors for GR912		
NANTH		Number of anthelmintic treatments
STARTD	day	Number of days between September 1 and the next anthelmintic treatments
LAUGD	D	Anthelmintic treatment in the last 15 days of August
Specific risk factors for GR123		
NOVD	D	Anthelmintic treatment in November
SUMD	D	Anthelmintic treatment during Summer
Grazing management and food supplementation		
ISWH	cm	Mean pre-grazing pasture sward height
RSWH5	D	Mean residual (ie post-grazing) sward height below 5 cm
RSWH10	D	Mean residual (ie post-grazing) sward height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
PASTT	Score 1-3	Mean pasture type score
RAG	Score 0-3	Mean paddock ragwort score (calculated from observations during farm visits)
THISTLE	Score 0-3	Mean paddock thistle score (calculated from observations during farm visits)
STOCK		Number of times the mob composition was changed
SHIFT		Number of times deer were shifted between paddocks
DEER		Average number of deer in the mob
MJME/Ha	MJME/ha	Mean mob daily energy requirements per grazed hectare (paddock effective area)
OTHERST	D	Paddocks shared with stock other than deer at least one day
ODEER	D	Weaners grazing with deer over 15 months old
M%WS	%	Mean percentage of weaner stags in the weaner mob (risk factors for GR912 and GR123)
FSUP	D	Food supplementation of deer
STRIP	D	Strip grazing at least one paddock before June 1 (risk factors for GR46 only)

Note on units : D = Dichotomous variable : Yes=1 ; No=0
"Score 0-1" means "Score ranging from 0 to 1"

Table 4.14 (Cont'd)

Risk factor Code	Unit	Description
BLOCK 1		
Environmental variables		
FAREA	ha	Mean paddock size (deer-fenced area)
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score (combining scores of trees, hill, gully and shelter belt)
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt
Health problems		
Specific risk factors for GR46 (occurrence by June 1)		
YERS1	D	Mob experienced clinical yersiniosis
LAME	D	Mob with observed lameness (including clinical osteochondrosis)
DEATH1	D	Mob experienced natural death other that caused by misadventures
Specific risk factors for GR69		
YERS1	D	Mob has experienced clinical yersiniosis before June 1
LAME	D	Mob with observed lameness (including clinical osteochondrosis)
DEATH2	D	Mob experienced natural death other that caused by misadventure after June 1
BLOCK 2 : Sentinel deer and biological markers		
Sentinel weaner characteristics		
GIRTH	cm	Thoracic girth (March data only)
EASES	D	Weaner blood sampled without firm physical restraint
Specific risk factors for GR69		
COATD	g	Coat density
COATL	mm	Length of the upper coat (June data only)
Specific risk factors for GR912		
COATL	mm	Length of the upper coat (June data only)
VICTIM	D	Visible hair loss (sign of victimisation) on the back of the deer
LYING	D	Deer lying on the floor of the pen during handling
Specific risk factors for GR69		
COATL	mm	Length of the upper coat (June data only)
Individual weaner blood biological characteristics		
White cell count (WCC), neutrophil percentage (NP), lymphocyte percentage (LP), eosinophil percentage (EOP), haemoglobin (HB), packed cell volume (PCV); total protein (TP), albumin (ALB), phosphorus (P), gamma glutamyl transferase (GGT), blood urea nitrogen (BUN), copper (CU), vitamin B12 (B12), pepsinogen (PEPS), glutathione peroxidase (GSHPx).		
CU8	D	Serum copper concentration >= 8 µmol/l
B12185	D	Serum vitamin B12 concentration >= 185 pmol/l
GSHPx3	D	Glutathione peroxidase activity >= 3 kIU/l
BLOCK 3 : Farm weaner biological markers		
Mean values of weaner blood markers (codes start by "M") plus :		
MCU8	D	Mean serum copper concentration >= 8 µmol/l
MB12185	D	Geometric mean serum vitamin B12 concentration >= 185 pmol/l
MGSHPx3	D	Mean glutathione peroxidase activity >= 3 kIU/l
Specific risk factors for GR46		
SEROYERJ	%	Maximum seroprevalence (increase of 20 Unit OD between March and June) against *Yersinia pseudotuberculosis* type I, II or III
Specific risk factors for GR69		
SEROYERJ	%	Maximum seroprevalence (increase of 20 Unit OD between March and June) against *Yersinia pseudotuberculosis* type I, II or III
SEROYERS	%	Maximum seroprevalence (increase of 20 Unit OD between March and September) against *Yersinia pseudotuberculosis* type I, II or III

Note on units : D = Dichotomous variable : Yes=1 ; No=0
"Score 0-1" means "Score ranging from 0 to 1"

Sentinel weaners and blood markers : Blood characteristics recorded in March and June were explored as potential markers for autumn growth, while those recorded in June and September, in September and November were investigated as potential markers for winter and spring growth. Those recorded in November 1992 were also investigated as potential markers for summer growth.

For markers where there was a difference between sexes, means were calculated separately for each sex, ie 5 per farm. Means or geometric means of weaner blood characteristics and *Yersinia* serology variables (block 3) were investigated as biological markers for mean farm weaner growth rates (eg MGR46).

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in section 2.7.

- Data from both years of study were combined for statistical analyses.
- Weaner hind and stag data were analysed separately. During preliminary data analyses (data screening), however, potential risk factors were selected for multivariable analyses if they were statistically significantly, positively or negatively (eg if both Spearman correlation coefficients have the same sign in the screening of continuous risk factors), associated with the outcome under study (eg GR46 or MGR46) at the 20% confidence level for both weaner stags and hinds. Therefore, null hypothesis path diagrams were identical for weaner hinds and stags.
- Data screening of categorical risk factors was carried out using SAS, while the rest of the analyses were carried out using Statistica.

- Path analysis was only used for the analysis of block 1.

  Path diagrams were formulated for the analysis of each outcome, ie individual weaner seasonal growth rates (steps 1 to 4 in Table 4.1). Individual weaner characteristics, disease control risk factors, environmental factors, grazing management factors and health problem variables were analysed together in one path model for each outcome. The percentage of New Zealand blood lines (NZ) and that of wapiti blood lines (WAP) were included in all multivariable analyses to control for genetic differences.

  In these analyses, the mean daily sunshine score (SUN) was statistically significantly associated with weaner stag and hind GR46, but respective regression coefficients were deemed too high to be biologically plausible. Since SUN appeared highly correlated with many other factors in the datasets, the analyses were carried out again after excluding SUN from the stepwise selection procedure. Interpretation of results was based on both final diagrams drawn, with and without SUN included in the stepwise selection procedure, for the investigation of risk factors for GR46. This approach was also taken for the analysis of risk factors for GR912.

- Sentinel weaner characteristics, individual biological markers and farm mean blood markers were analysed separately without the use of path analysis. Blood characteristics recorded in March, June, September and November were investigated as potential markers for autumn, autumn-winter, winter-spring, and spring-summer weaner growth rate, respectively. Each step described in Table 4.2 represents a separate analysis. Some biological markers were categorised and analysed as discussed in section 2.8.12.3. Scatterplots of significant biological markers against individual or mean growth rates (eg GR46 or MGR46) were drawn up, and univariate regression equations were estimated where appropriate.

For each final model, the square of the multiple correlation coefficient (r^2) is presented as the proportion of variance in the data "explained" by the variables included in the model (Kleinbaum et al., 1982).

4.4.1.1 Results

Means and standard deviations of weaner stag and hind autumn growth rates (GR46) or farm mean weaner stag and hind growth rates (MGR46) at each level of categorical variables and statistical significance level of association with respective outcome variable (GR46 or MGR46) are presented in Appendix 4.14. Descriptive statistics, including Spearman correlation coefficients and their statistical significance, of continuous variables are presented in Appendix 4.15 (block 1), Appendix 4.16 (block 2) and Appendix 4.17 (block 3). Similar univariate statistics of risk factors for weaner growth rates during winter, spring and summer are presented from Appendix 4.18 to Appendix 4.28.

Null hypothesis path diagrams of risk factors for weaner GR46, GR69, GR912 and GR123 are presented in Figure 4.33, Figure 4.34, Figure 4.35 and Figure 4.36, respectively. Final path diagrams of risk factors for weaner stag and hind autumn growth rates are presented in Figure 4.37 and Figure 4.38 (analysis without the direct effect of SUN), whereas final diagrams of risk factors for weaner stag and hind winter, spring and summer growth rates are presented in Figure 4.39, Figure 4.40 and Figure 4.41, respectively. Unstandardised multivariable regression coefficients, standard errors of coefficients, p values and model R^2 are presented in Table 4.15 and Table 4.16.

Risk factors within each block of sentinel weaner characteristics and biological markers (block 2 or 3 as appropriate) statistically significantly associated with individual or mean weaner stag or hind growth rates are presented in Table 4.17 along with their regression coefficients. Scatterplots of major blood markers against weaner seasonal growth rates as appropriate are presented from Figure 4.42 to Figure 4.51, and univariate regression lines are presented in Table 4.18.

Because of the complexity of the results, they will be presented with discussion, to avoid confusion and repetition.

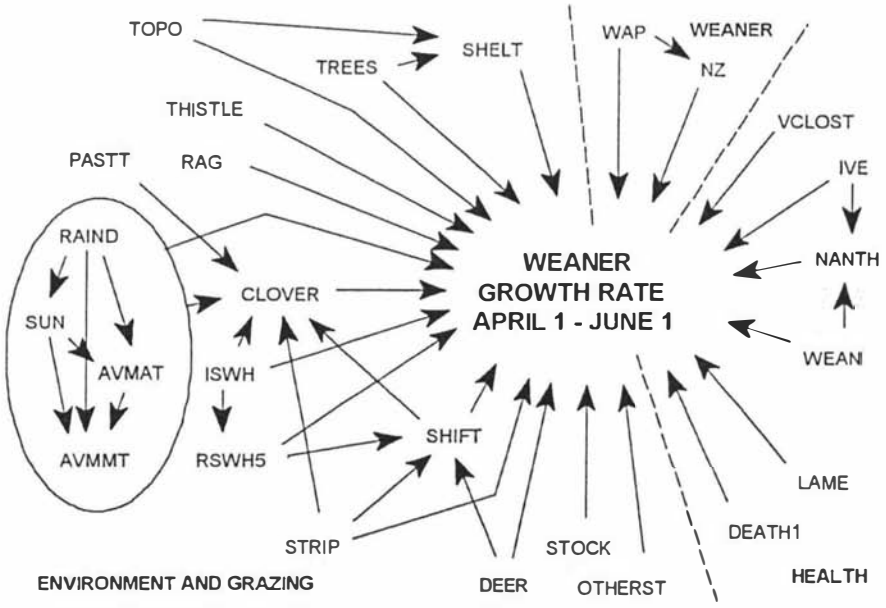
4.4.1.2 Discussion

As deer were not weighed on the same dates, calculation of monthly weaner bodyweights and weaner growth rates was the only appropriate method to allow comparisons between farms. Large variations of weaner growth rates between farms and individual weaners (eg GR46 ranged from -42.9 to 330.8 g/d in weaner stags and from -66.2 to 315.4 g/d in weaner hinds) in this study suggested management factors and/or weaner characteristics could be identified as risk factors.

4.4.1.2.1 Management risk factors

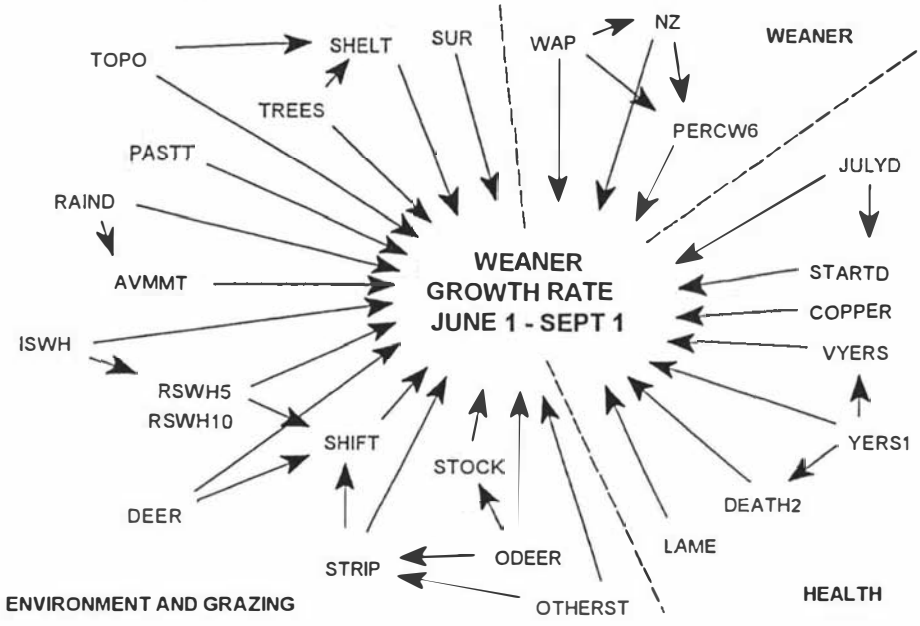
To the author's knowledge, this study is the first investigation of the effects of management practices and environmental factors on the growth rates of weaner deer under commercial farming conditions. Most research on weaner growth has been carried out through experiments indoors or outdoors, and the type of feed on offer varied between research programmes.

Figure 4.33 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between April 1 and June 1.



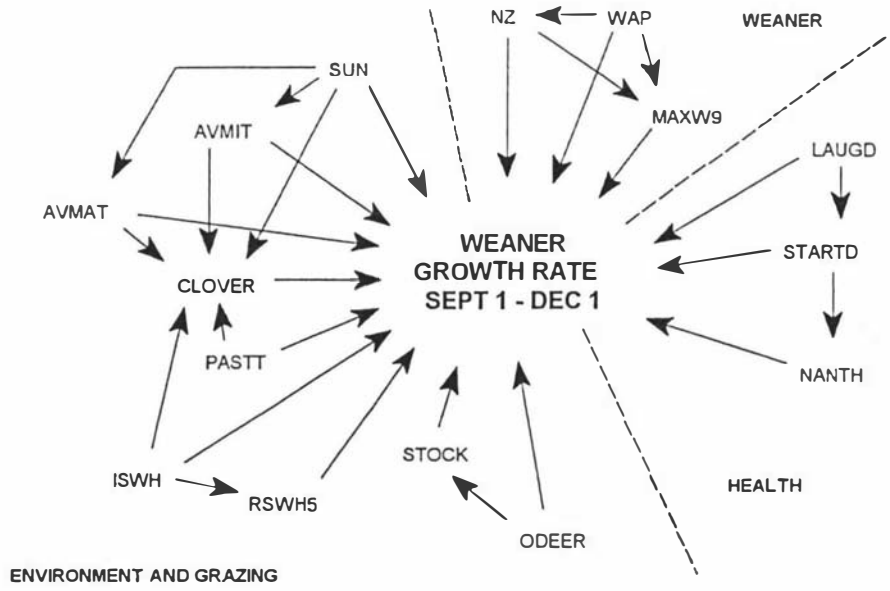
Note : Risk factor codes are described in the glossary and in Table 4.14

Figure 4.34 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between June 1 and September 1.



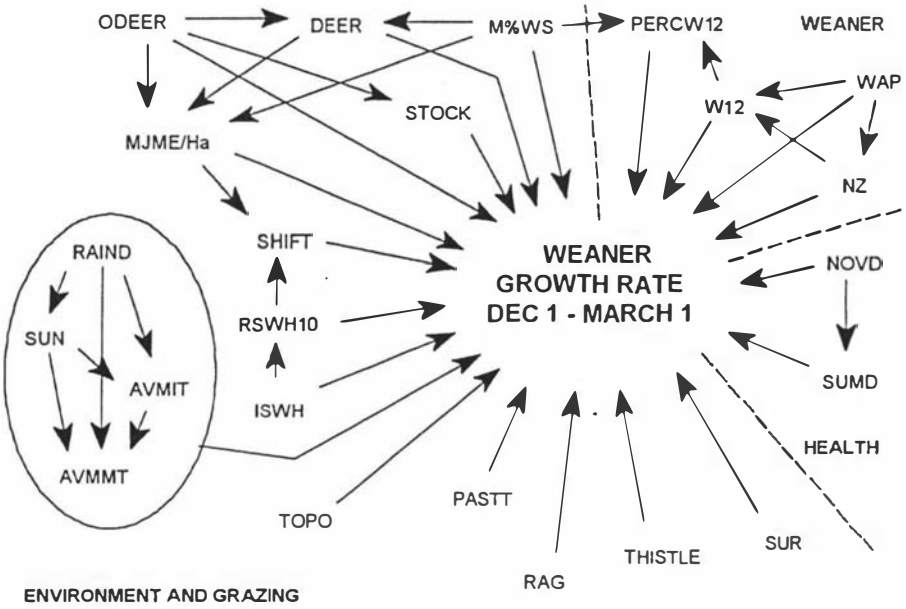
Note : Risk factor codes are described in the glossary and in Table 4.14

Figure 4.35 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between September 1 and December 1.



Note : Risk factor codes are described in the glossary and in Table 4.14

Figure 4.36 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between December 1 and March 1.



Note : Risk factor codes are described in the glossary and in Table 4.14

Table 4.15 : Summary of direct effects of risk factors for weaner stag and hind autumn growth rates with and without the effect of SUN, and winter growth rates.

		WEANER HINDS			WEANER STAGS		
Major risk factors*	Units	Regr. coef.**	SE	p value	Regr. coef.**	SE	p value
Autumn : growth rate from April 1 to June 1							
Final model including the direct effect of SUN							
Model R square				0.53			0.49
Intercept		117.30	13.11	0.000	250.03	20.53	0.000
DEATH1	D	-9.83	3.65	0.007	-0.21	0.05	0.00
ISWH	cm				1.35	0.37	0.000
IVE	D	-13.35	4.21	0.002	-37.44	3.19	0.000
LAME	D				-20.71	4.05	0.000
NANTH					-11.28	2.85	0.000
OSTOCK	D	40.96	6.46	0.000			
RAG	Score 0-3	-7.87	2.87	0.006	-5.74	2.00	0.004
RAIND	mm				-15.81	3.72	0.000
RSWH5	D	-66.39	7.75	0.000	-42.31	9.25	0.000
SHIFT					3.76	0.80	0.000
STOCK		-14.49	2.89	0.000			
STRIP	D	37.08	6.65	0.000	63.68	8.10	0.000
SUN	Score 0-1	-63.40	28.44	0.026	-156.29	17.32	0.000
THISTLE	Score 0-3				-22.73	2.85	0.000
TOPO	Score 1-3	16.15	4.57	0.000	1.85	0.46	0.00
TREES	Score 0-3	15.32	2.16	0.000	12.32	2.21	0.000
VCLOST		34.28	5.09	0.000			
Final model without the direct effect of SUN							
Model R square				0.53			0.50
Intercept		190.53	16.67	0.000	333.17	24.71	0.000
AVMAT	°C				-11.50	1.33	0.000
CLOVER	Score 1-3				17.40	5.08	0.001
DEATH1	D	-33.88	3.40	0.000	-20.10	3.87	0.000
DEER					-0.19	0.04	0.000
IVE	D				-21.84	4.30	0.000
LAME	D	-33.34	4.00	0.000	-77.97	7.19	0.000
NANTH					-20.81	3.00	0.000
PASTT	Score 1-3				14.74	5.58	0.008
RAG	Score 0-3	-14.12	2.37	0.000			
RSWH5	D	-126.56	6.20	0.000	-76.51	8.97	0.000
SHELT		3.35	0.30	0.000			
STRIP	D	41.81	4.90	0.000	65.90	5.50	0.000
THISTLE	Score 0-3				-8.67	3.87	0.025
TREES	Score 1-3	7.24	2.36	0.002	26.91	2.47	0.000
WEAN	days	-1.69	0.26	0.000			
Winter : growth rate from June 1 to September 1							
Model R square				0.51			0.54
Intercept		83.67	10.12	0.000	187.64	17.41	0.000
AVMMT	°C	13.15	0.71	0.000	8.65	1.00	0.000
COPPER	D	36.26	3.78	0.000	43.82	5.80	0.000
DEATH2	D	-13.67	4.33	0.002			
DEER		-0.39	0.05	0.000	-0.93	0.07	0.000
ISWH	cm				6.12	0.84	0.000
JULYD	D				-14.24	3.53	0.000
LAME	D				-19.70	9.29	0.034
NZ	%	-0.27	0.05	0.000	-0.44	0.07	0.000
ODEER	D				-16.97	4.86	0.000
PASTT	Score 1-3	-19.64	2.61	0.000	-28.26	5.51	0.000
PERCW6	%	-0.29	0.04	0.000	-0.21	0.04	0.000
RSWH10	D	41.90	4.59	0.000			
RSWH5	D	-36.08	4.25	0.000	-31.21	8.14	0.000
SHELT					4.11	0.69	0.000
STARTD	days	-0.42	0.06	0.000	-0.57	0.07	0.000
STOCK		3.79	0.66	0.000	8.78	1.13	0.000
SUR	%	-0.23	0.04	0.000	-0.92	0.07	0.000
TOPO	Score 1-3	-12.19	3.10	0.000	-53.34	9.03	0.000
TREES	Score 0-3	-22.19	2.28	0.000	-27.28	5.03	0.000
VYERS	D	-48.87	4.44	0.000	-39.38	4.88	0.000
WAP	%				1.85	0.32	0.000
YERS1	D	37.59	4.13	0.000			

* Risk factor codes are described in the glossary and in Table 4.14

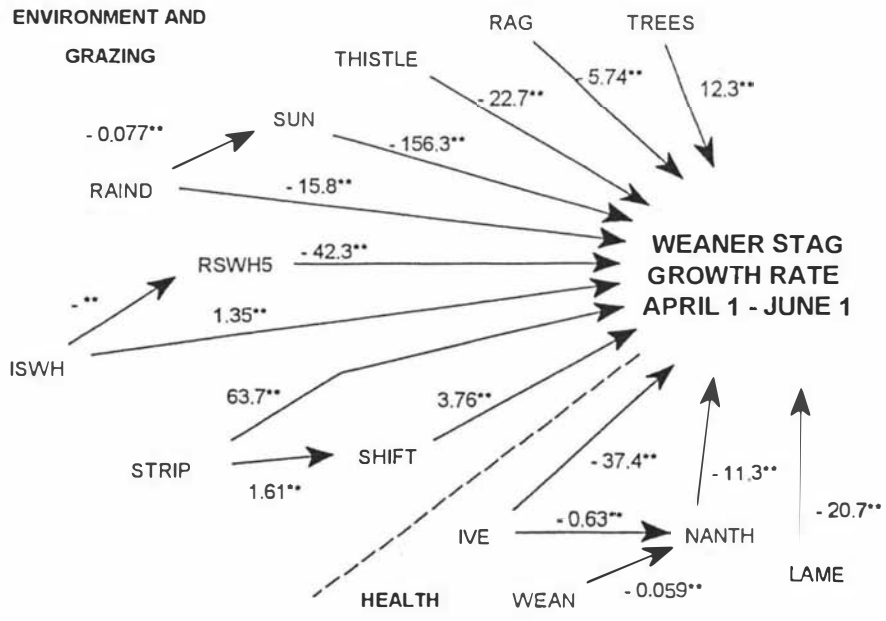
** Regr.Coef. = Regression coefficient = daily gain (g) increase per unit increase of each continuous risk factor, or if dichotomous variables equal to 1, all other factors maintained constant.

SE = Standard error

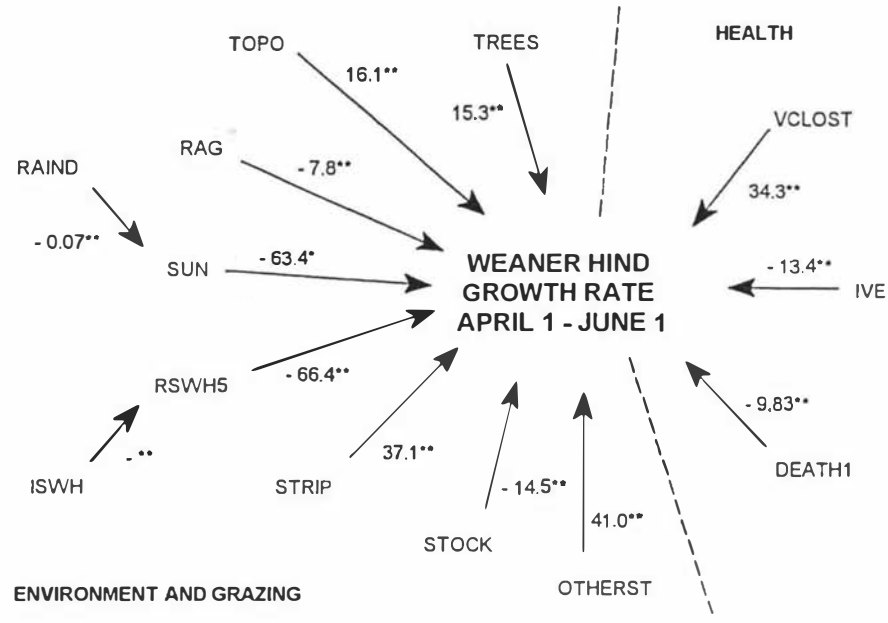
Note on units : "Score 0-1" means "Score ranging from 0 to 1"
D = Dichotomous variable (Yes=1/No=0)

Figure 4.37 : Final path diagrams of risk factors for weaner stag and hind growth rate between April 1 and June 1 (autumn growth).

a. Weaner stags



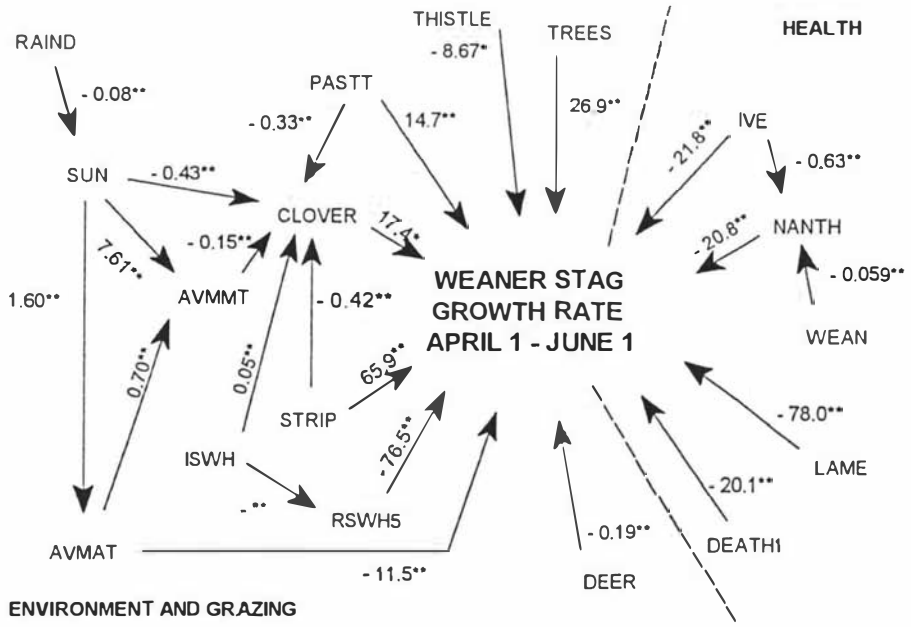
b. Weaner hinds



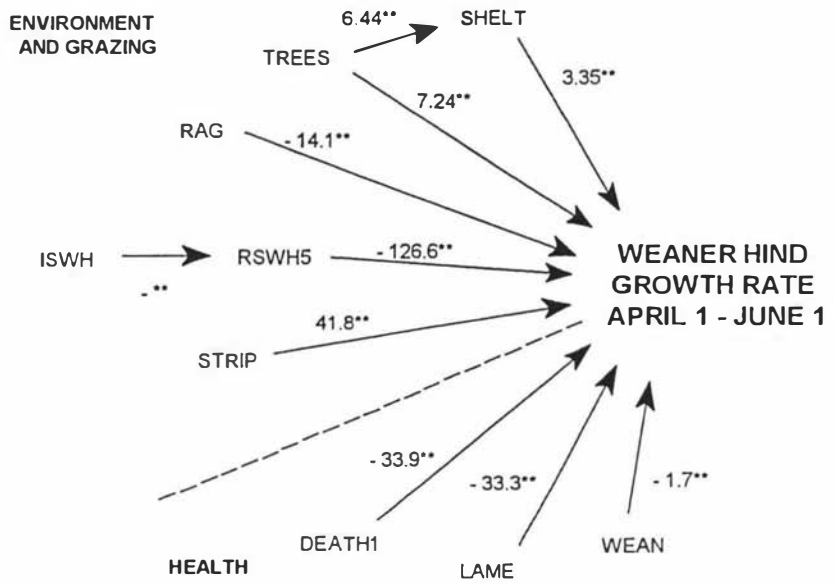
Note : Risk factor codes are described in the glossary and in Table 4.14. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). Model R^2 are presented in Table 4.15.

Figure 4.38 : Final path diagrams of risk factors for weaner stag and hind growth rate between April 1 and June 1 (autumn growth) after withdrawing the direct effect of SUN.

a. Weaner stags



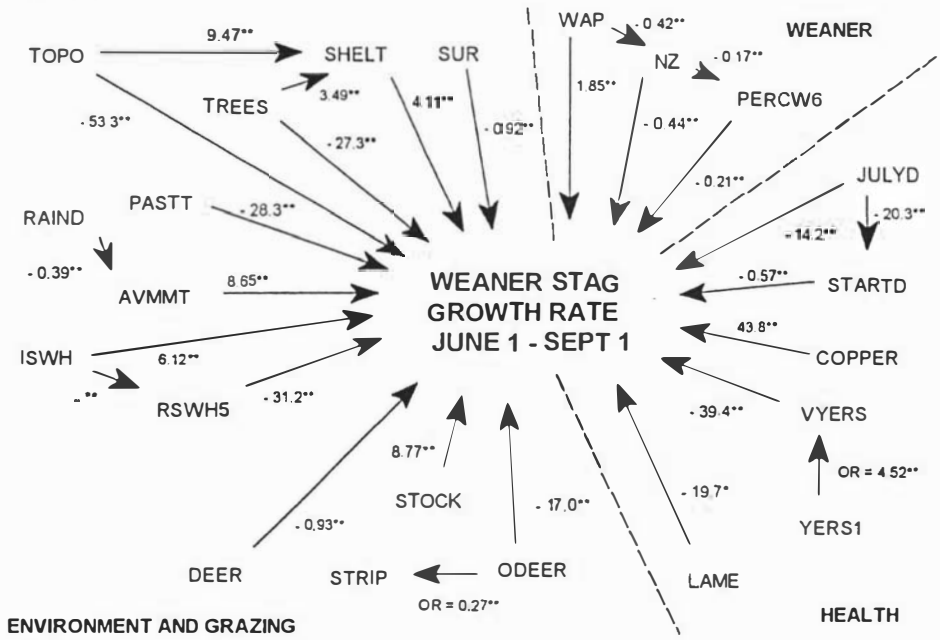
b. Weaner hinds



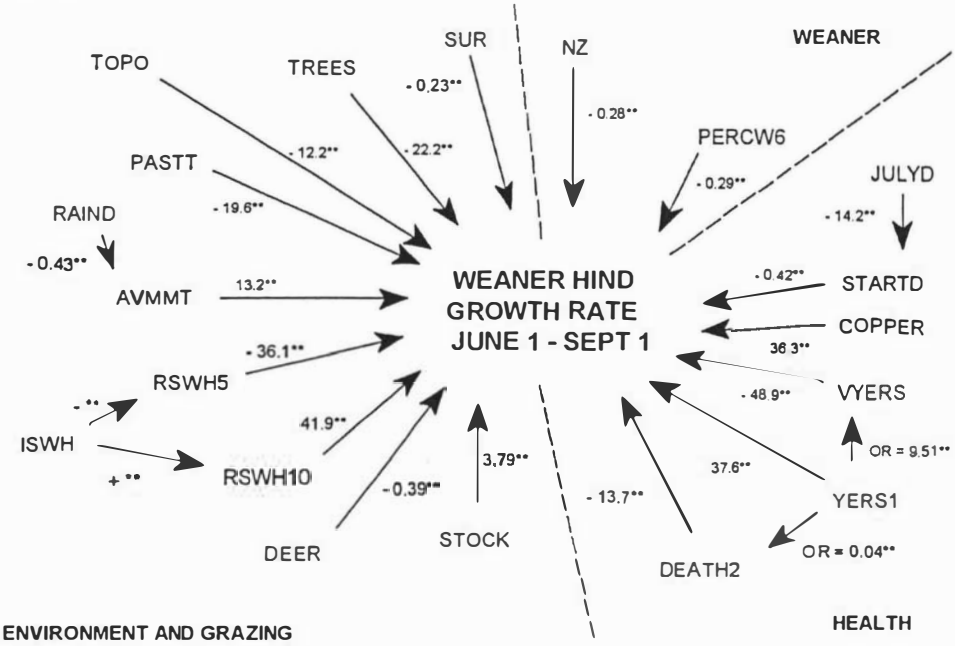
Note : Risk factor codes are described in the glossary and in Table 4.14. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). Model R^2 are presented in Table 4.15.

Figure 4.39 : Final path diagrams of risk factors for weaner stag and hind growth rate between June 1 and September 1.

a. Weaner stags



b. Weaner hinds.



Note : Risk factor codes are described in the glossary and in Table 4.14. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). Model R^2 are presented in Table 4.15. OR = odds ratio

Table 4.16 : Summary of direct effects of risk factors for weaner stag and hind spring growth rates with and without the effect of SUN, and summer growth rates.

		WEANER HINDS			WEANER STAGS		
Major risk factors*	Units	Regr. coef.**	SE	p value	Regr. coef.**	SE	p value
Spring growth rate (September 1 - December 1)							
Final model including the direct effect of SUN							
Model R square				0.37			0.34
Intercept		225.64	11.29	0.000	371.00	17.52	0.00
AVMIT	°C	-9.89	1.13	0.000	-15.22	1.71	0.00
CLOVER	Score 0-1	25.84	2.40	0.000	28.22	3.69	0.00
LAUGD	D	10.23	2.82	0.000	25.86	3.35	0.00
MAXW9	kg	0.25	0.12	0.039			
NZ	%	-0.22	0.05	0.000	-0.41	0.08	0.00
STARTD	days	-0.32	0.03	0.000	-0.37	0.04	0.00
STOCK		-5.41	0.86	0.000	-14.17	1.47	0.00
SUN	Score 0-1	-63.64	11.41	0.000	-79.63	20.95	0.00
Final model without the direct effect of SUN							
Model R square				0.35			0.32
Intercept		223.14	11.90	0.000	327.54	13.10	0.000
AVMIT	°C	-7.05	1.06	0.000	-11.76	1.46	0.000
CLOVER	Score 0-1	19.22	2.37	0.000	21.31	3.26	0.000
LAUGD	D	17.51	3.32	0.000	26.37	3.38	0.000
NZ	%	-0.27	0.04	0.000	-0.52	0.07	0.000
PASTT	Score 1-3	-13.82	3.40	0.000			
STARTD	days	-0.39	0.03	0.000	-0.42	0.04	0.000
STOCK		-3.46	0.78	0.000	-10.56	1.13	0.000
Summer growth rate (December 1 - March 1)							
Model R square				0.62			0.59
Intercept		153.87	40.92	0.000	308.33	41.53	0.00
M%WS	%				-0.92	0.17	0.00
AVMIT	°C	-15.83	3.51	0.000			
DEER					-0.43	0.13	0.00
ISWH	cm	-1.23	0.36	0.001	-4.03	0.51	0.00
MJME/Ha	MJME/ha	0.07	0.01	0.000	0.05	0.01	0.00
NOVD	D				-38.72	6.02	0.00
NZ	%				-0.54	0.13	0.00
ODEER	D	-34.89	5.35	0.000			
PASTT	Score 1-3	49.96	5.27	0.000			
PERCW12	%	0.78	0.11	0.000	-0.62	0.16	0.00
RAG	Score 0-3	-53.81	3.07	0.000			
RAIND	mm	30.73	2.59	0.000			
RSWH10	D	-71.27	6.97	0.000	-25.65	8.79	0.00
STOCK		-35.09	5.53	0.000			
SUMD	D	72.39	5.80	0.000	33.99	9.66	0.00
SUN	Score 0-1	86.11	29.50	0.004			
SUR	%	1.30	0.10	0.000	-0.23	0.10	0.03
THISTLE	Score 0-3	47.97	3.46	0.000			
TOPO	Score 1-3	44.58	4.10	0.000			
W12	kg	-1.99	0.38	0.000	2.07	0.40	0.00

* Risk factor codes are described in the glossary and Table 4.14

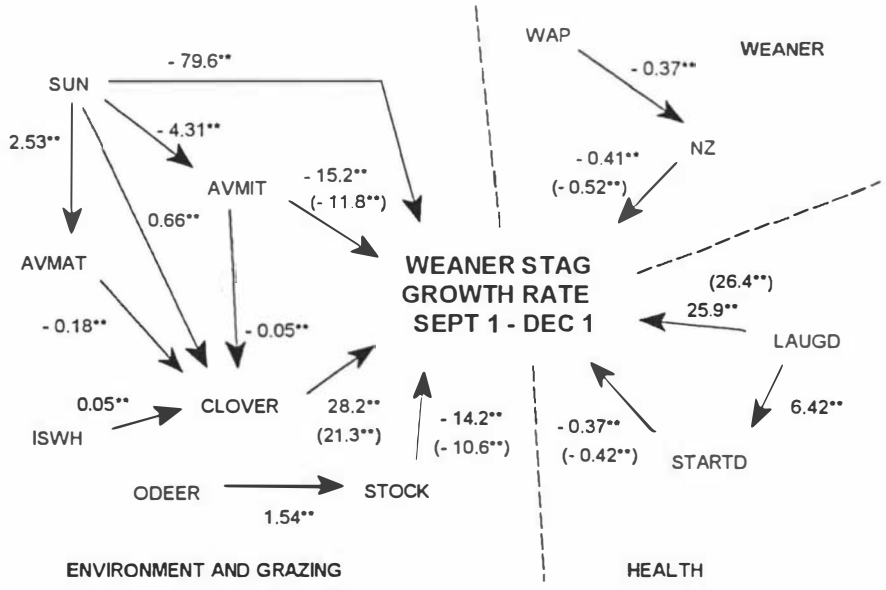
** Regr.Coef. = Regression coefficient = daily gain (g) increase per unit increase of each continuous risk factor, or if dichotomous variables equal to 1, all other factors maintained constant.

SE = standard error

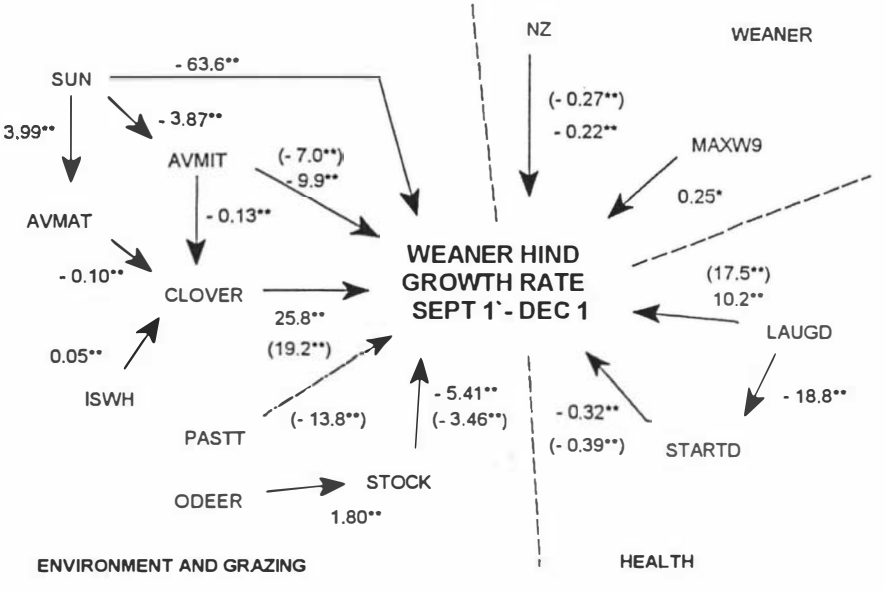
Note on units : "Score 0-1" means "Score ranging from 0 to 1"
D = Dichotomous variable (Yes=1/No=0)

Figure 4.40 : Final path diagrams of risk factors for weaner stag and hind growth rate between September 1 and December 1.

a. Weaner stags.



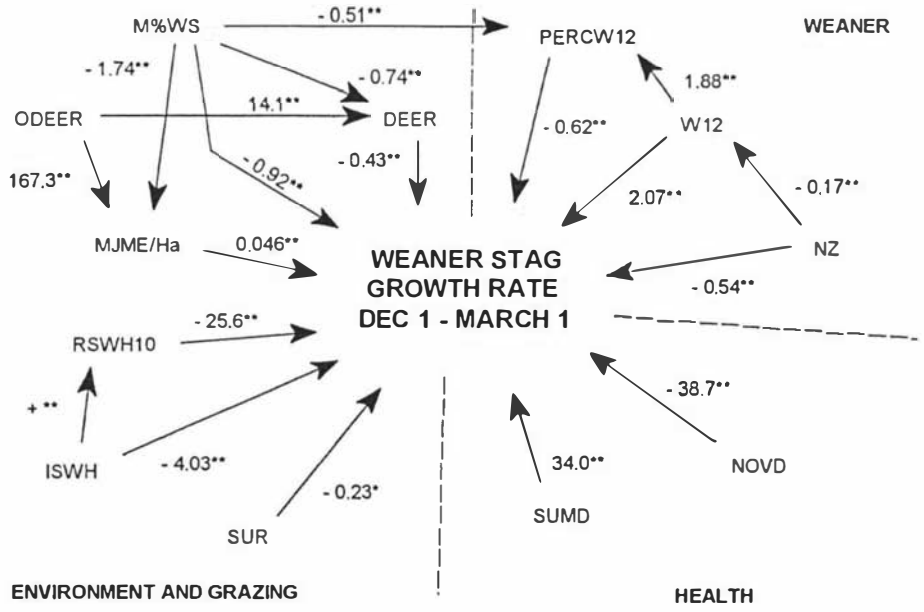
b. Weaner hinds.



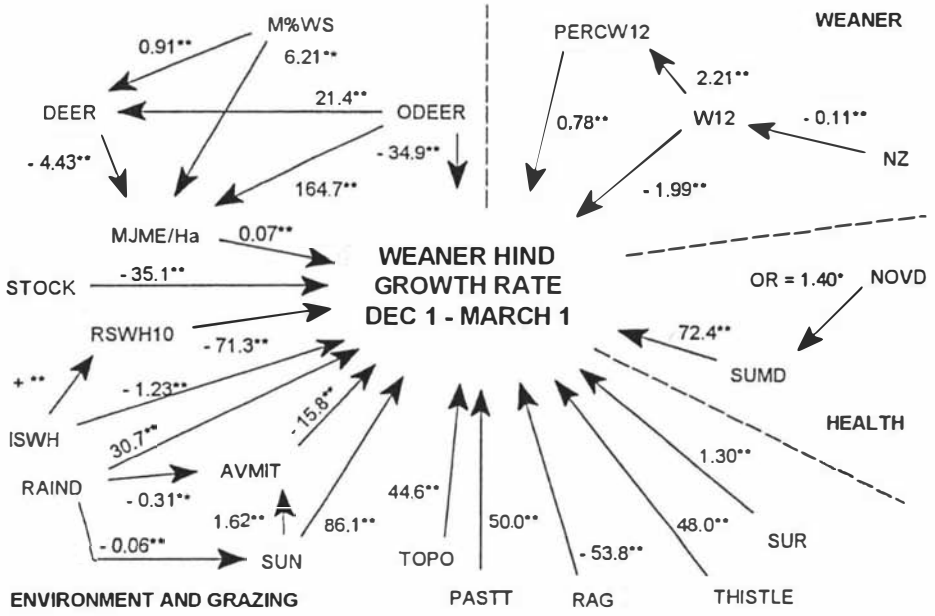
Note : Risk factor codes are described in the glossary and in Table 4.14. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01), those between brackets were obtained by withdrawing SUN from the model as explained in the text. Model R^2 are presented in Table 4.16.

Figure 4.41 : Final path diagrams of risk factors for weaner stag and hind growth rate between December 1 and March 1.

a. Weaner stags.



b. Weaner hinds.



Note : Risk factor codes are described in the glossary and in Table 4.14. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). Model R^2 are presented in Table 4.16. OR = odds ratio

Table 4.17 : Regression coefficients of blood markers significantly associated with individual or mean farm weaner stag and hind growth rates.

Major risk factors	Units	WEANER HINDS Regr. coef.*	SE	p value	WEANER STAGS Regr. coef.*	SE	p value
Autumn growth rate (April 1 - June 1)							
Individual sampling deer characteristics and biological markers							
March visit							
Individual weaner characteristics		No significant risk factor			No significant risk factor		
Biological markers							
Model R square				0.17			
Intercept		127.54	6.31	0.000	No significant risk factor		
Vitamin B12 >= 185 pmol/l	D	-41.64	8.97	0.000			
June visit							
Biological markers							
Model R square				0.25			0.30
Intercept		-2.58	40.04	0.949	67.00	47.98	0.165
Blood urea nitrogen	mmol/l	-6.15	2.44	0.013	-10.39	2.82	0.000
Albumin	g/l	3.87	0.92	0.000	4.20	1.08	0.000
Serum copper	µmol/l	3.83	0.98	0.000	3.20	1.08	0.004
Gamma Glutamyl transferase	IU				-0.32	0.15	0.036
Model R square				0.20			0.29
Intercept		30.15	39.34	0.445	89.86	46.91	0.058
Blood urea nitrogen	mmol/l	-6.69	2.51	0.009	-10.76	2.83	0.000
Albumin	g/l	3.63	0.95	0.000	4.01	1.09	0.000
Serum copper >= 8 µmol/l	D	33.02	11.67	0.006	32.87	11.62	0.006
Gamma Glutamyl transferase	IU				-0.35	0.15	0.023
Farm mean weaner biological markers							
March visit							
Model R square				0.21			
Intercept		143.35	20.42	0.000	No significant risk factor		
Vitamin B12	pmol/l	-0.21	0.10	0.043			
June visit							
Model R square				0.26			0.29
Intercept		24.77	31.81	0.446	26.59	33.41	0.436
Mean serum copper	µmol/l	6.51	2.60	0.022	7.74	2.76	0.011
Model R square				0.20			
Intercept		52.67	24.42	0.045	No significant risk factor		
Mean serum copper >= 8 umol/l	D	55.13	25.74	0.046			
Winter growth rate (June 1 - September 1)							
Individual sampling deer characteristics and biological markers							
June visit							
Individual weaner characteristics							
Model R square				0.11			
Intercept		153.52	27.65	0.000	No significant risk factor		
Length of the upper coat	mm	-1.86	0.52	0.000			
Biological markers							
Model R square				0.05			0.10
Intercept		9.27	19.85	0.641	22.76	26.12	0.386
Phosphorus	mmol/l	15.97	6.87	0.022	28.43	8.99	0.002
Vitamin B12	pmol/l				-0.08	0.04	0.038
September visit							
Biological markers							
Model R square							0.09
Intercept		No significant risk factor			314.98	66.58	0.000
Total protein	g/l				-3.33	1.00	0.001

*Regr. coef. = Linear regression coefficient; SE = standard error; D = dichotomous variables

Note : Individual sampling deer characteristics and biological markers were not subject to path analysis.

Table 4.17 (Cont'd)

Major risk factors	Units	WEANER HINDS Regr. coef.*	SE	P value	WEANER STAGS Regr. coef.*	SE	P value
Winter growth rate (June 1 - September 1) (Cont'd)							
Farm mean weaner biological markers							
June visit							
Biological markers							
Model R square				0.52			0.42
Intercept		-75.21	43.76	0.100	18.62	21.90	0.405
Mean percentage of eosinophils	%				11.86	4.19	0.010
Mean glutathione peroxidase	kIU/l				3.98	1.51	0.016
Mean phosphorus	mmol/l	56.36	14.83	0.001			
SEROYERJ**	%	-0.50	0.17	0.009			
Model R square							0.37
Intercept					6.26	27.82	0.824
Mean percentage of eosinophils	%				9.31	4.39	0.047
Mean glutathione peroxidase >= 3 kIU/l	D				62.94	27.34	0.032
September visit							
Biological markers							
Model R square				0.27			0.30
Intercept		518.54	162.78	0.004	763.10	220.54	0.002
Mean total protein	g/l	-6.97	2.45	0.009	-10.07	3.33	0.006
Spring growth rate (September 1 - December 1)							
Individual sampling deer characteristics and biological markers							
September visit							
Individual weaner characteristics							
Model R square				0.06			0.03
Intercept		-42.96	64.46	0.506	56.32	66.44	0.398
Thoracic girth	cm	1.95	0.67	0.004	1.52	0.67	0.026
Biological markers							
Model R square				0.06			0.07
Intercept		125.95	6.69	0.000	182.84	7.97	0.000
White Cell Count	10E9/l	2.76	0.91	0.003	3.68	1.12	0.001
Model R square				0.10			0.17
Intercept		131.11	6.90	0.000	191.15	7.83	0.000
White Cell Count	10E9/l	2.87	0.90	0.002	4.21	1.07	0.000
Vitamin B12 >= 185 pmol/l	D	-15.98	6.48	0.015	-31.98	7.77	0.000
November visit		No significant risk factor			No significant risk factor		
Farm mean weaner biological markers							
September visit							
Model R square				0.30			0.66
Intercept		421.76	93.65	0.000	530.26	114.59	0.000
Albumin	g/l	-8.65	2.87	0.007	-10.87	3.47	0.007
Vitamin B12	pmol/l				-0.25	0.10	0.022
White cell count	10E9/l				10.83	4.92	0.044
November visit							
Model R square				0.71			
Intercept		200.44	9.70	0.000	No significant risk factor		
Mean vitamin B12 >= 185 pmol/l	D	-60.86	15.83	0.009			
Summer growth rate (December 1 - March 1)							
Individual sampling deer characteristics and biological markers							
November visit							
Individual weaner characteristics							
Model R square		No significant risk factor					0.11
Intercept					59.43	64.74	0.36
Thoracic girth	cm				1.83	0.63	0.01
Biological markers							
Model R square				0.06			0.17
Intercept		93.08	43.40	0.04	224.13	23.53	0.00
Phosphorus	mmol/l	33.80	16.32	0.04	17.17	8.26	0.04
Pepsinogen	mU Tyrosine/l				-0.04	0.01	0.00

*Regr. coef. = Linear regression coefficient; SE = standard error; D = dichotomous variable

**Seroprevalence (increase of 20 Unit OD between March and June) against Yersinia pseudotuberculosis type I, II or III (see Table 4.12)

Note : Individual sampling deer characteristics and biological markers were not subject to path analysis.

Farm mean biological markers recorded in November 1992 were not investigated as risk factors for Summer growth rates because of the limited number of observations.

Table 4.18 : Regression lines of relationships between major individual and mean weaner blood markers for sesonal growth rates presented from Figure 4.41 to Figure 4.49.

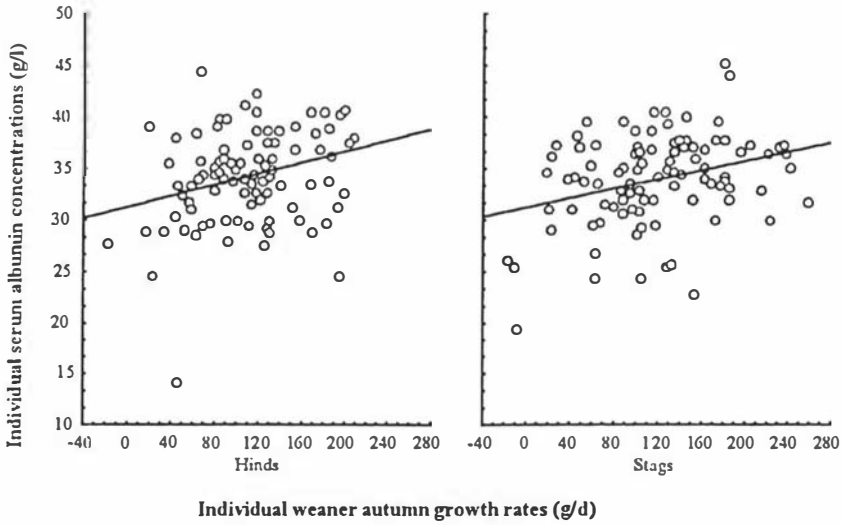
Major blood markers	Units	WEANER HINDS Regr. coef.*	SE	p value		WEANER STAGS Regr. coef.*	SE	p value	
Autumn growth rate (April 1 - June 1)									
June visit (individual and mean blood markers)									
	Model R square				0.09				0.09
	Intercept	-0.02	34.01	1.000		-26.26	41.14	0.524	
Albumin	g/l	3.18	0.99	0.002		4.19	1.21	0.001	
	Model R square				0.10				0.13
	Intercept	-22.44	91.08	0.808		-45.73	96.43	0.641	
Mean serum albumin	g/l	3.65	2.65	0.186		4.80	2.82	0.105	
	Model R square				0.03				0.11
	Intercept	161.88	29.80	0.000		242.17	34.18	0.000	
Blood urea nitrogen	mmol/l	-4.81	2.67	0.075		-11.41	3.05	0.000	
	Model R square				0.03				0.15
	Intercept	158.67	74.83	0.048		260.54	77.56	0.003	
Mean blood urea nitrogen	mmol/l	-5.20	6.85	0.458		-13.12	7.07	0.079	
	Model R square				0.11				0.07
	Intercept	62.02	13.56	0.000		73.16	15.36	0.000	
Serum copper	µmol/l	3.83	1.05	0.000		3.60	1.23	0.000	
	Model R square				0.26				0.29
	Intercept	24.77	31.81	0.446		26.59	33.41	0.436	
Mean serum copper	µmol/l	6.51	2.60	0.022		7.74	2.76	0.011	
Winter growth rate (June 1 - September 1)									
June visit									
Individual sampling deer characteristics and biological markers									
	Model R square				0.05				0.07
	Intercept	9.27	19.85	0.641		16.64	26.36	0.529	
Phosphorus	mmol/l	15.97	6.87	0.022		25.41	9.01	0.006	
Farm mean weaner biological markers									
	Model R square				0.33				0.21
	Intercept	-104.13	49.21	0.046		-79.46	75.85	0.307	
Mean phosphorus	mmol/l	56.04	17.13	0.003		61.07	26.24	0.030	
September visit									
Individual sampling deer characteristics and biological markers									
	Model R square				0.028				0.09
	Intercept	160.79	56.89	0.006		314.98	66.58	0.000	
Total protein	g/l	-1.61	0.86	0.064		-3.33	1.00	0.001	
Farm mean weaner biological markers									
	Model R square				0.27				0.3
	Intercept	518.54	162.78	0.004		763.10	220.54	0.002	
Mean total protein	g/l	-6.97	2.45	0.009		-10.07	3.33	0.006	
	Model R square				0.04				0.01
	Intercept	176.63	126.45	0.176		155.31	174.39	0.383	
Mean albumin	g/l	-3.70	3.86	0.349		-1.82	5.34	0.737	
	Model R square				0.11				0.19
	Intercept	194.10	82.48	0.028		333.67	106.77	0.005	
Mean globulin	g/l	-4.10	2.44	0.107		-7.07	3.17	0.037	
Spring growth rate (September 1 - December 1)									
September visit									
Farm mean weaner biological markers									
	Model R square				0.00				0.08
	Intercept	181.34	163.82	0.281		461.80	215.63	0.047	
Mean total protein	g/l	-0.63	2.47	0.801		-3.93	3.23	0.241	
	Model R square				0.30				0.43
	Intercept	421.76	93.65	0.000		663.44	128.26	0.000	
Mean albumin	g/l	-8.65	2.87	0.007		-14.34	3.96	0.002	
	Model R square				0.10				0.02
	Intercept	32.39	72.24	0.658		136.69	112.27	0.240	
Mean globulin	g/l	3.18	2.13	0.151		1.85	3.26	0.579	
Sununer growth rate (December 1 - March 1)									
November visit									
	Model R square				0.07				0.10
	Intercept	84.52	50.07	0.10		159.25	45.25	0.001	
Serum phosphorus	mmol/l	37.04	18.79	0.05		31.06	16.05	0.061	
	Model R square				0.27				0.45
	Intercept	-111.00	169.86	0.532		-93.81	163.55	0.591	
Mean serum phosphorus	mmol/l	110.36	63.92	0.123		124.27	61.76	0.100	
	Model R square				0.06				0.28
	Intercept	220.02	22.10	0.00		307.15	18.19	0.00	
Serum pepsinogen	mmol/l	-0.06	0.04	0.07		-0.11	0.03	0.00	
	Model R square				0.37				0.34
	Intercept	306.21	60.01	0.001		362.95	82.51	0.007	
Mean serum pepsinogen	mmol/l	-0.23	0.11	0.064		-0.23	0.14	0.167	

*Regr. coef. = Linear regression coefficient, SE = standard error

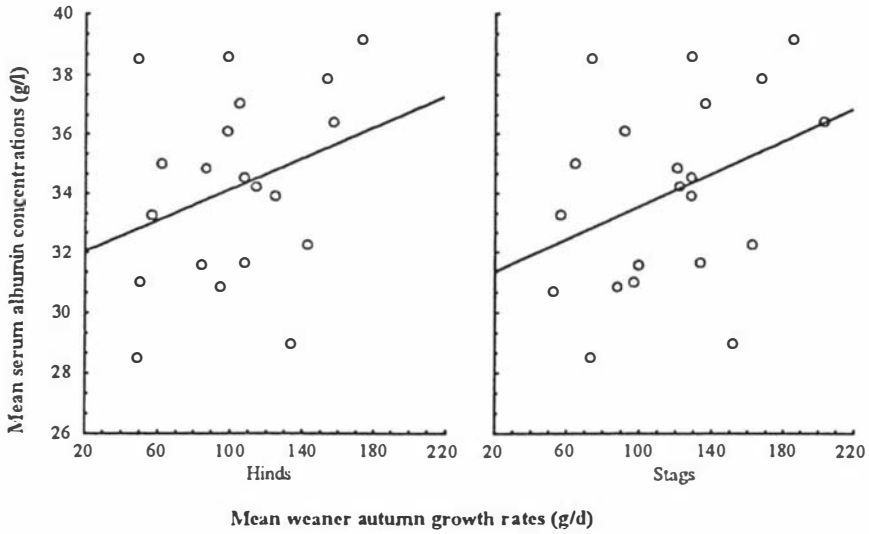
Note : Farm mean biological markers recorded in November 1992 were not investigated as risk factors for Summer growth rates because of the lirtuted number of observations. Mean serum pepsinogen, however, was investigated in a follow-up analysis.

Figure 4.42 : Relationships between individual (a) and mean (b) weaner stag and hind autumn growth rates (g/d) and serum albumin concentrations (g/l) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in June.

a. Individual deer serum albumin concentrations



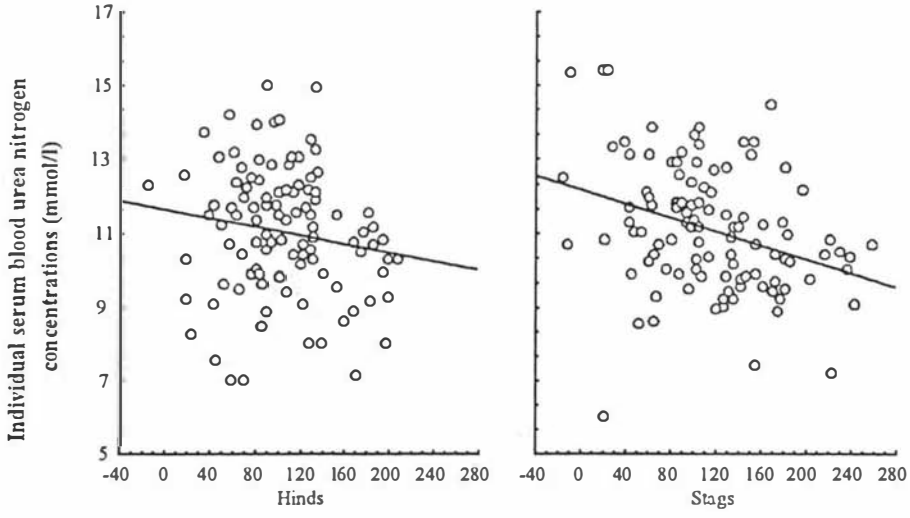
b. Farm mean serum albumin concentrations



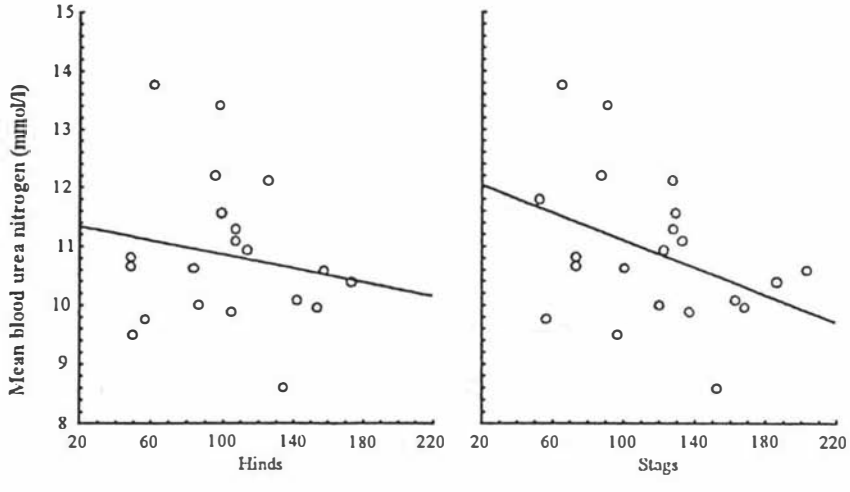
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.43 : Relationships between individual (a) and mean (b) weaner stag and hind autumn growth rates (g/d) and blood urea nitrogen concentrations (mmol/l) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in June.

a. Individual deer serum blood urea nitrogen concentrations



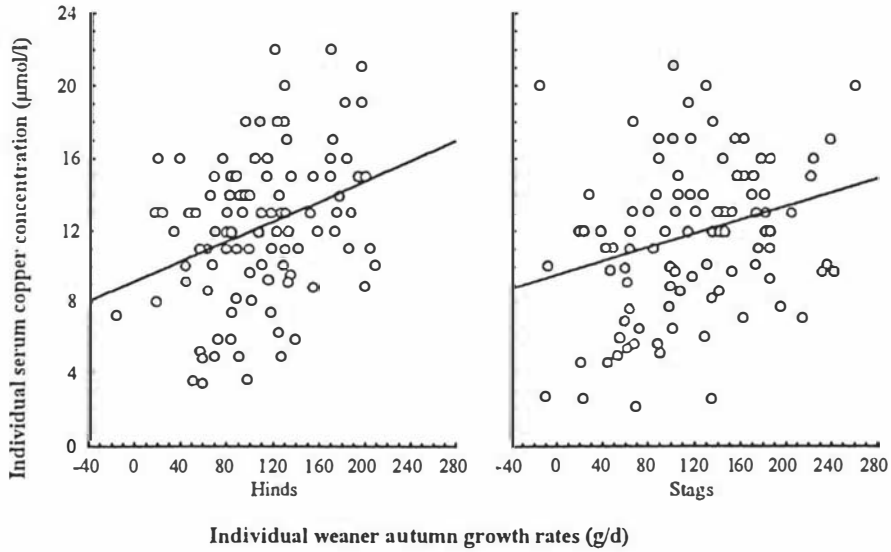
b. Farm mean blood urea nitrogen concentrations.



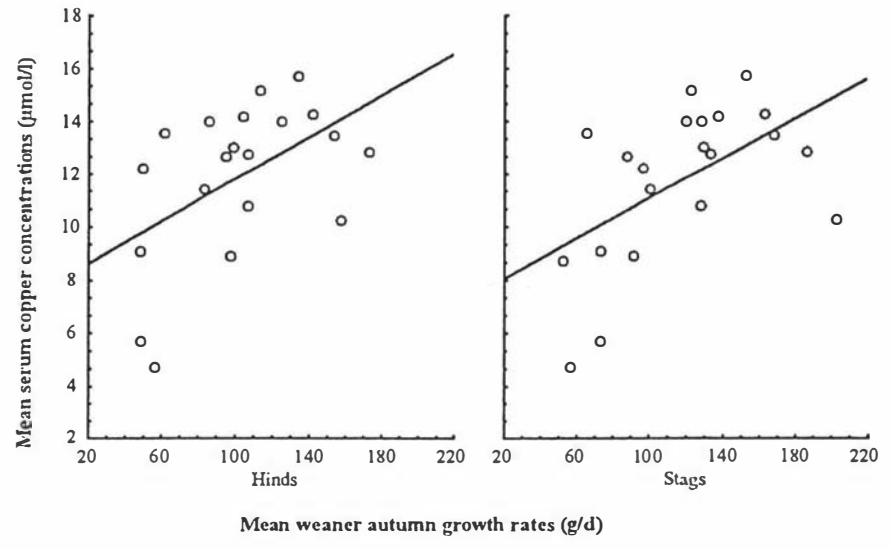
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.44 : Relationships between individual (a) and mean (b) weaner stag and hind autumn growth rates (g/d) and serum copper concentrations (µmol/l) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in June.

a. Individual deer serum copper concentrations



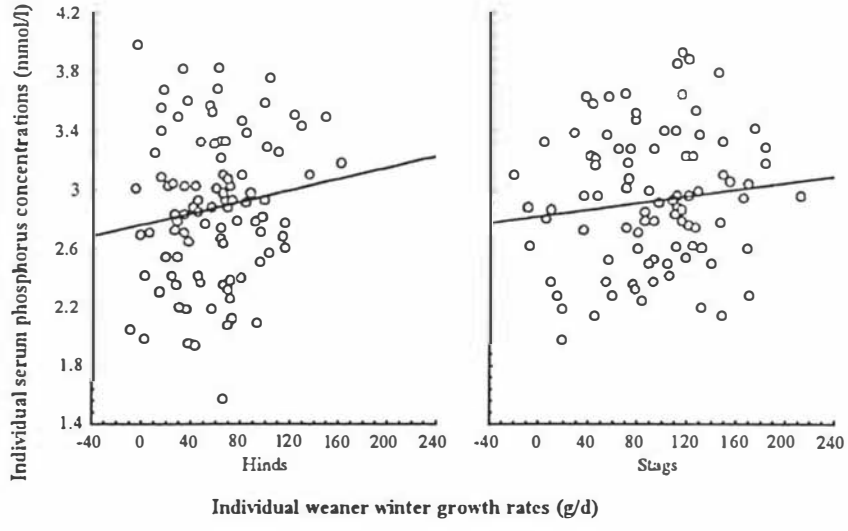
b. Farm mean serum copper concentrations



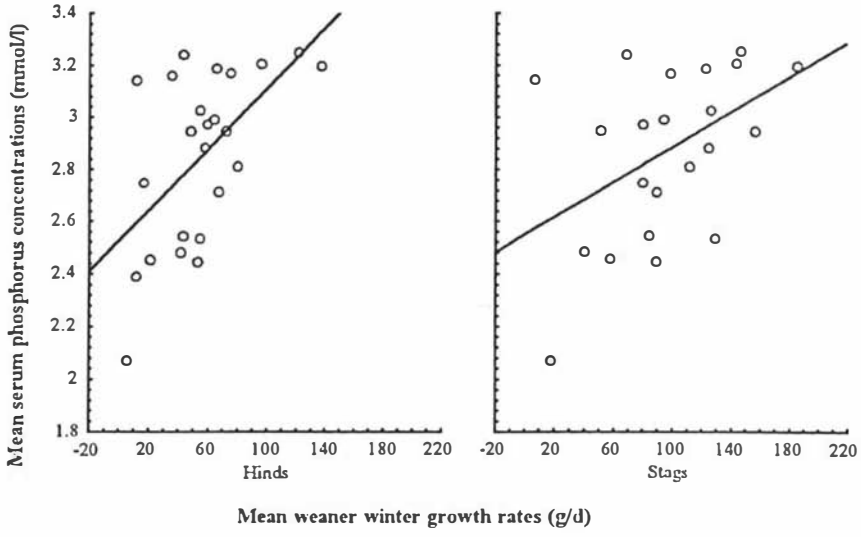
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.45 : Relationships between individual (a) and mean (b) weaner stag and hind winter growth rates (g/d) and serum phosphorus concentrations (mmol/l) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in June.

a. Individual deer serum phosphorus concentrations.



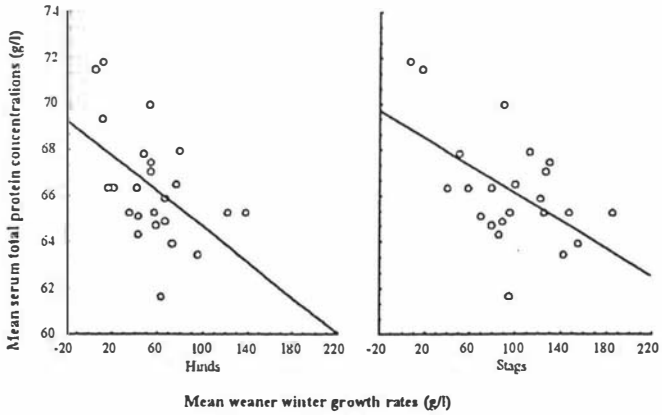
b. Farm mean serum phosphorus concentrations.



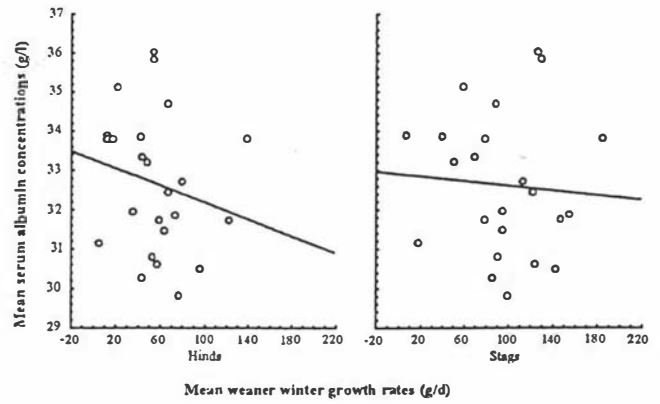
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.46 : Relationships between mean weaner stag and hind winter growth rates (g/d) within farms and mean serum total protein (a), albumin (b) and globulin (c) concentrations (g/l) from 10 weaners randomly selected (5 hinds and 5 stags) and sampled in September.

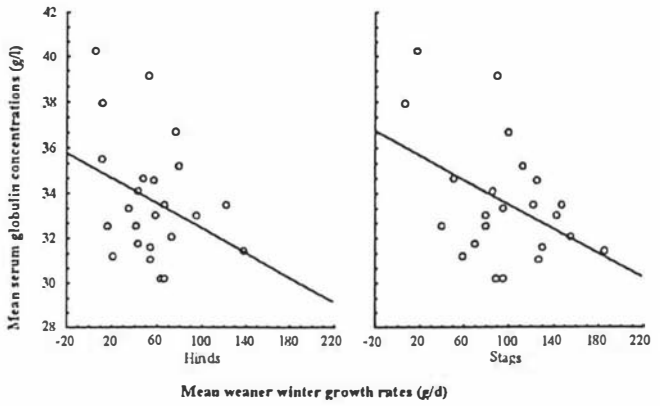
a. Farm mean serum total protein



b. Farm mean serum albumin

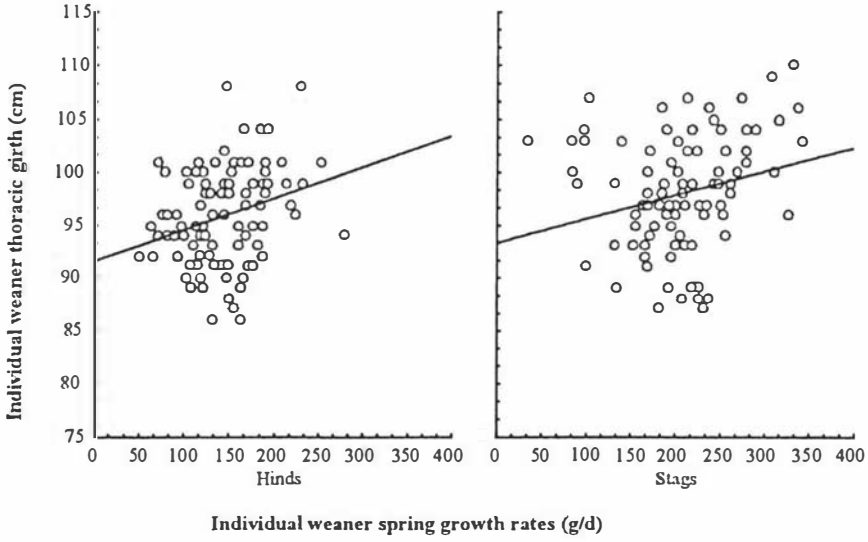


c. Farm mean serum globulin



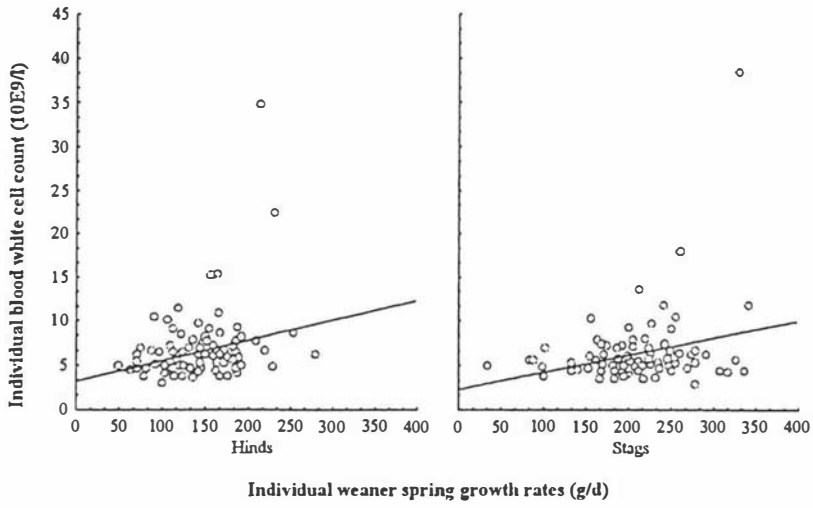
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.47 : Relationships between individual weaner stag and hind spring growth rates (g/d) and individual thoracic girth (cm) recorded in September.



Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

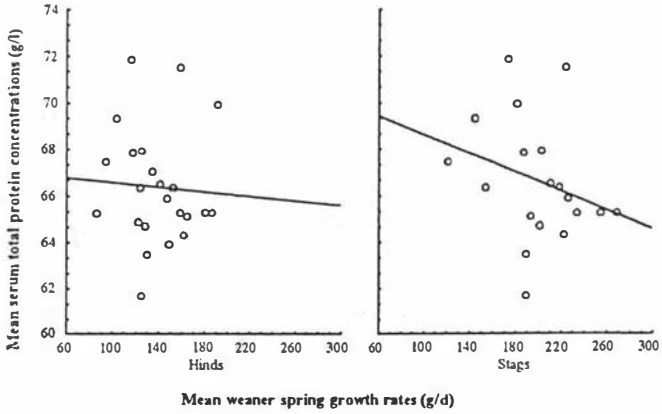
Figure 4.48 : Relationships between individual weaner stag and hind spring growth rates (g/d) and individual blood white cell count (10^9/l) recorded in September.



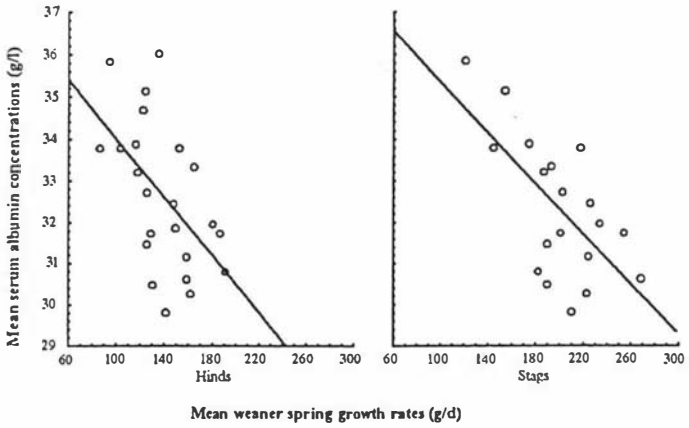
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.49 : Relationships between mean weaner stag and hind spring growth rates (g/d) within farms and mean serum total protein (a), albumin (b) and globulin (c) concentrations (g/l) from 10 weaners randomly selected (5 hinds and 5 stags) and sampled in September.

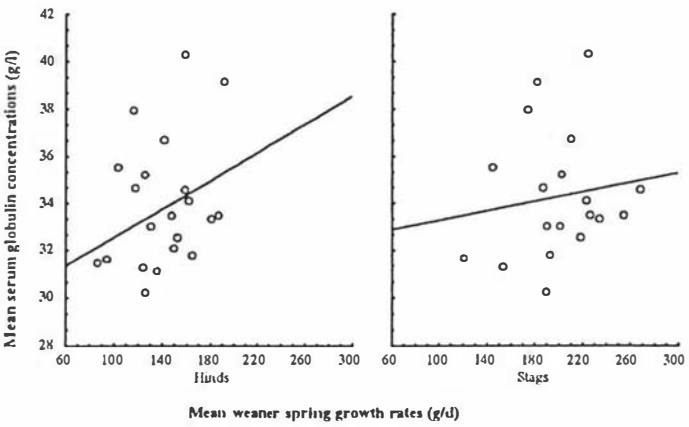
a. Farm mean serum total protein concentrations.



b. Farm mean serum albumin concentrations.



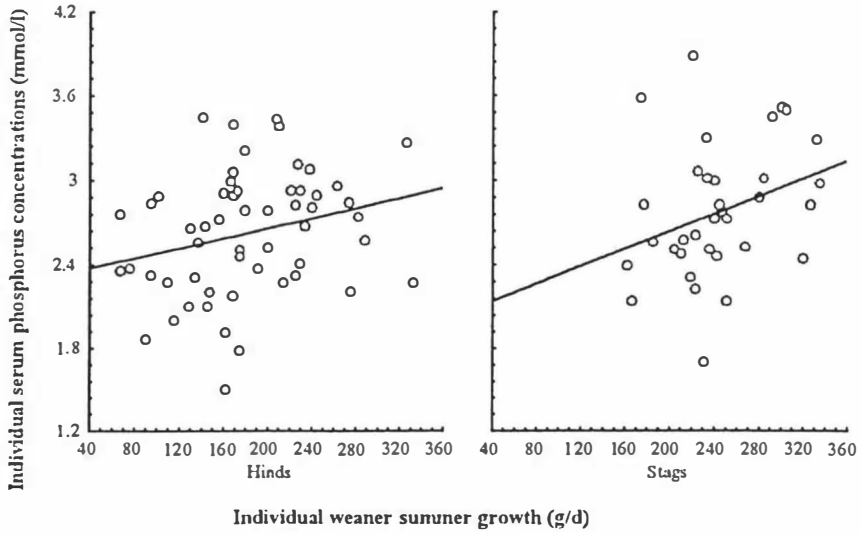
c. Farm mean serum globulin concentrations.



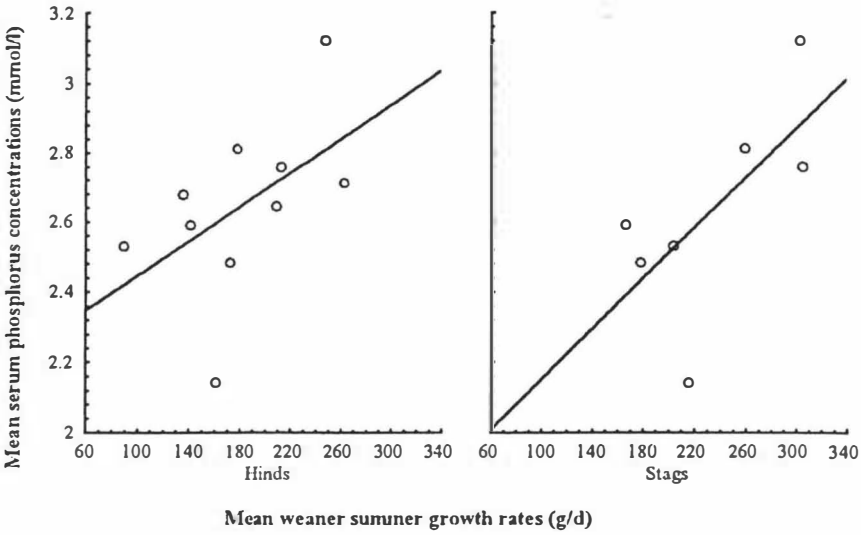
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.50 : Relationships between individual (a) and mean (b) weaner stag and hind summer growth rates (g/d) and serum phosphorus concentrations (mmol/l) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in November.

a. Individual deer serum phosphorus concentrations



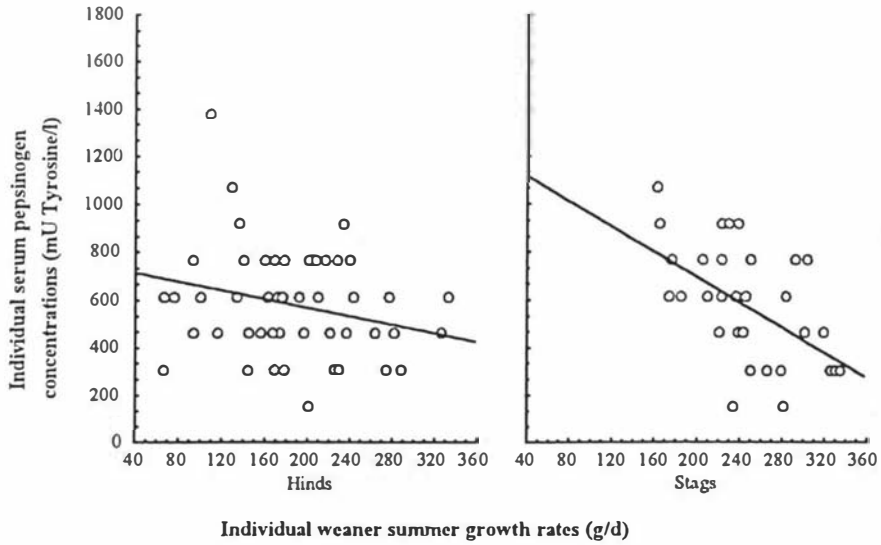
b. Farm mean serum phosphorus concentrations



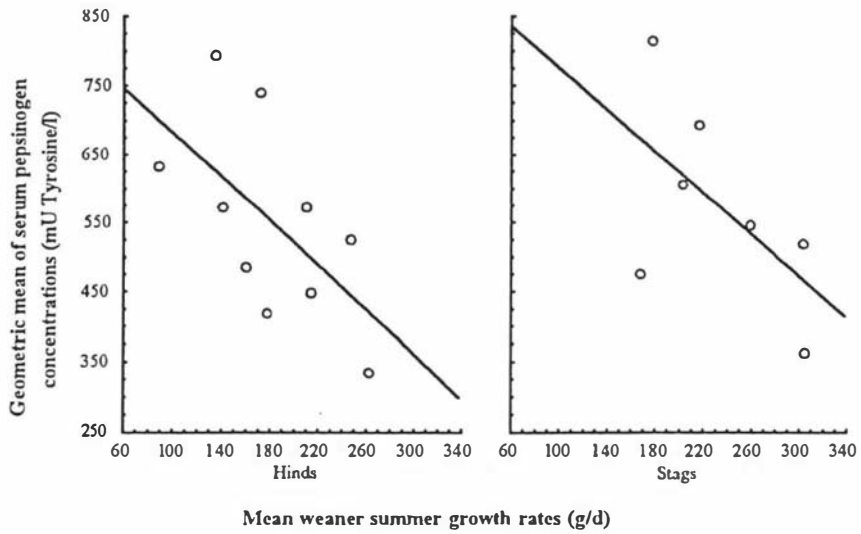
Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Figure 4.51 : Relationships between individual (a) and mean (b) weaner stag and hind summer growth rates (g/d) and serum pepsinogen concentrations (mU Tyrosine/l) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in November.

a. Individual deer serum pepsinogen concentrations



b. Geometric farm mean serum pepsinogen concentrations



Note : Regression lines, beta coefficients and p values are presented in Table 4.18.

Fennessy (1982) stressed the importance of external factors such as quality and quantity of food, and disease, on weaner growth, and concluded that comparisons must be made on a within mob basis. This study, however, compares results between weaners from different mobs between farms, while controlling statistically for the factors outlined by Fennessy (1982) and other potentially important factors. The interpretation of significant associations was sometimes difficult because there was no pre-existing evidence of association or causation to explain the presence of some some factors in the final path models. Discussion is, therefore, only suggestive of plausible explanations in many situations.

4.4.1.2.1.1 Autumn growth

This analysis suggests that management factors and health problems were more important that individual weaner characteristics in explaining differences in individual weaner stag and hind growth rates between April 1 and June 1 (GR46). Significant risk factors explained 49 and 53% (model R^2 x 100) of the variability of weaner stags and hinds GR46, respectively, which was considered high when compared with the variability explained by models elsewhere in this thesis for various outcomes.

It was identified in the first final diagrams (Figure 4.37) that the daily sunshine score (SUN) had a significant negative direct influence on weaner growth rates. It is known solar radiation is often a significant component of the heat load on cattle, and that heat stress can adversely affect growth in 3-14 months weaner cattle (Blackshaw and Blackshaw, 1994), so it may be that heat stress occurs in weaner deer. It was considered, however, that the magnitude of path coefficients (although they may be only indicative) were very high and could not be fully explained on biological grounds. Further investigations showed SUN was statistically correlated with many risk factors (Appendix 4.29) which may have affected growth but were not selected in the final diagram because of their correlation with SUN. Whereas the potential negative influence of SUN cannot be excluded, it was believed other potentially important factors would be identified by running the analysis again after withdrawing the direct effect of SUN in the model.

The percentage of variability explained by final models (model R^2 x 100) with and without the variable SUN changed little for both weaner stag and hind models (Table 4.15). By comparing the two final diagrams for weaner stags, it appeared the substantial apparent effect of SUN may have concealed that of the mean mob size (DEER). The larger the mob, the lower the average growth rate between April 1 and June 1 (GR46), which supports the observation that large mob size after weaning was associated with lower weaner bodyweight on April 1 (see section 4.3). Moreover, the weather was sunnier on farms where at least one lame weaner was observed in weaner mobs (LAME), which may explain the three-fold increase of the path coefficient of LAME in the stag diagram and the significance of LAME in the weaner hind diagram (Figure 4.38). It must be noted at this point that LAME was not observed on farms with low percentage of New Zealand blood lines (NZ), so its adverse effect on GR46 may be related to genetic differences (thus SUN, LAME and NZ may be confounded to some extent). The date of weaning became significant in the hind diagram with a negative effect, which means the later the weaning date, the poorer the growth. This tends to support the potential beneficial effect of weaning early for optimal production (see section 4.3). However, its indirect and marginal positive effect on weaner stag GR46 suggests WEAN (within the range recorded in this study, ie before April 1) was not a critical factor.

In the weaner stag final diagram, the effect of SUN also appeared to be confounded with that of the mean clover (CLOVER) and pasture (PASTT) scores. The higher the amount of clover in the

pasture, the higher the autumn growth rate, which is consistent with previous observations in sheep (Marsh and Laidlaw, 1978) and in deer (Semiadi et al., 1992, 1993). Clover dominant swards have a higher nitrogen content and higher organic matter digestibility than mixed ryegrass/white-clover swards (Niezen et al., 1991; Semiadi et al., 1992, 1993; Niezen et al., 1993). The positive relationship between low clover content and autumn growth was not expected as it is contrary to conventional understanding of the need for high energy feedstuffs to achieve high growth rates. Thus this relationship may be spurious.

In the weaner stag final diagram (Figure 4.38), the substantial negative effect of high daily maximum temperature (AVMAT) suggests warm weather conditions *per se* may have a direct negative effect on weaner growth. This is somewhat contradictory with the common belief that cold rather than warm weather adversely affects growth through higher maintenance energy requirements (Fennessy et al., 1981). However AVMAT in this study ranged from 12.5 to 19.6°C, which may not be considered as "cold". The negative effect of high mean daily rainfall, in the initial analysis may be related to a cold effect. Research into the effect of high environmental temperature on feed intake and grazing patterns could provide an answer to this question.

The difference between the two final diagrams in terms of selected variables and estimated magnitude of association illustrate one limitation inherent in analysing correlated sets of variables and emphasised that the plausibility of associations should be taken into account in interpreting the results.

Nutrition was identified as a major risk factor affecting growth. Consistently, grazing weaners on swards below 5 cm high (RSWH5) was associated with a lack of growth of 40-127 g/d. This was supported by the further positive effect of high pre-grazing sward height on growth rates of weaner stags, either directly or indirectly through the increase of CLOVER. These observations are consistent with pre-existing experimental evidence in sheep (Chestnutt, 1992) and in cattle (Moore et al., 1992). In deer, Ataja et al. (1992) showed winter and spring growth rates of weaner deer to be lower on 5-cm-high than 10-cm-high pasture swards (74 and 147 g/d on 5-cm swards, versus 153 and 234 g/d on 10-cm swards, in winter and spring, respectively). Therefore the effect of RSWH5 is likely to be causal. The beneficial effect of pasture height over 5 cm is attributable to higher intake (Arnold, 1975), because on long leafy pasture, the bite volume and bite weight increases (Betteridge et al., 1991; Hughes et al., 1991; Mitchell et al., 1991), and more efficient food conversion through increased pasture quality. Optimum animal milk production or growth has been achieved when pasture sward height was about 8-10 cm and this has been applied in commercial farms (Stakelum and Dillon, 1990). It must be noted, however, that most experimentation involving sward height did not have a treatment group grazing swards over 11-12 cm. Authors often concluded 9-10 cm to be the optimum heights for production without investigation at higher sward heights. For instance, for sheep, sward height were controlled at 3, 5, 7 and 9 cm (Chestnutt, 1992) or in cattle at 5, 7, and 9 cm (Moore et al., 1992), and between 4 and 11 cm in beef cattle (Wright and Russel, 1986). Hennessy (1973) did not find a significant effect of sward height on the growth of steers, but the short sward was 14-18-cm-long, whereas the long sward was 17-24-cm-long. Both ranges are probably above the heights that should have been investigated to show a sward height effect.

The use of strip grazing (STRIP) was significantly associated with a 37-42 and 64-66 g/d increase in GR46 in weaner hinds and stags, respectively. This positive relationship is substantial and may be related to the better control farmers had over the weaner feed quality and intake. Thus, strip grazing may be worth the extra labour involved to optimise weaner growth in autumn. Although significant

in one final diagram only, the positive effect of shifting weaner stag between paddocks (SHIFT) may also be related to the better control over the feed supply for optimal growth. Moreover, white clover is likely to contribute more to the sward in a rotational than in a continuous grazing situation (Marsh and Laidlaw, 1978).

A unit increase of the mean tree score (TREES) was significantly associated with a 7-to-27 g/d increase in weaner GR46. Further analyses showed there was a significant interaction term between TREES and SUN in the first final diagrams of both hinds and stags, ie the apparent beneficial effect of TREES was higher where SUN was high. Considering the negative effect of SUN on growth (Figure 4.37), it is suggested TREES may have a potential protective effect against sunshine and warm weather in autumn. The positive effect of TREES significantly increased with the amount of sunshine over the farm.

The lower growth rates attributed to the presence of thistles (THISTLE) or ragwort (RAG) in the stag or hind diagram suggests weeds should be thoroughly controlled on deer farms. Whereas THISTLE increases the sward rankness, thus decreasing pasture quality, and may affect the grazing efficiency of deer, ragwort is toxic to deer (Haigh and Hudson, 1993). Further, the toxicity of this weed is maximal from its seeds which abound in autumn. In this study, signs consistent with ragwort poisoning were observed on the liver from an adult hind grazing on a farm heavily infested by ragwort plants. That ragwort affects weaner growth, therefore, is likely. Alternatively, THISTLE and RAG may be surrogate variables for poor pasture management. In this analysis, however, the pasture type (PASTT) was positively associated with GR46 in weaner stags after SUN was withdrawn, but not in other models, thus this may not be a major factor after correcting for sward height and other significant factors.

Health problem variables appeared to have significant negative effects on weaner growth after controlling for pasture variables. Lame weaners have been associated with severe copper deficiency and the occurrence of osteochondrosis on one farm (Audigé et al., 1993), and this was suspected on another. Weaners from these farms, although apparently healthy, may be subclinically affected by a common cause of lameness, which may be copper deficiency, osteochondrosis, or both, resulting in impaired growth rates. This observation is consistent with the apparent beneficial effect of adequate copper status for optimal autumn growth (see biological markers). Weaner mortalities between April 1 and June 1 other than through misadventure (DEATH1) were mainly related to Yersiniosis in this study (see sections 3.3.4.3.2 and 4.6.2), which appeared to develop subclinically in almost all weaners on every farm (see section 3.4.1.4.1). Therefore it was suspected DEATH1 may have exposed apparently healthy weaners to a higher challenge of *Yersinia pseudotuberculosis* in autumn, resulting in transient subclinical Yersiniosis and reduced growth rates. The mean bodyweight loss for each weaner during autumn associated with DEATH1 was estimated around 1 kg. This is consistent with the finding that weaners losing bodyweight during autumn were 25 times more likely to die from Yersiniosis (see section 4.6.1), although the converse sequence of cause-effect was hypothesised in that analysis. Thus a reciprocal relationship may exist. Improving growth may prevent mortality, which may in turn limit the severity of subclinical infection and improve growth. This hypothesis needs to be validated by further research.

The negative relationship of using ivermectin/albemycin-based anthelmintics instead of benzimidazole-based anthelmintics (IVE) on GR46 is intriguing as such anthelmintics have been found very effective to treat internal parasites in weaner deer (Mackintosh et al., 1990). Moreover, that increasing the number of anthelmintic treatments by June 1 was associated with reduced weaner stag GR46 cannot be explained either. However, since IVE and NANTH were not significant in the

weaner hind final diagram and WEAN was identified with the converse effect, as discussed earlier, the importance of health control variables in this analysis may be equivocal.

In this study, there was no evidence of grazing density *per se* being a significant factor affecting autumn growth rates as shown by Adam and Asher (1986).

The paddock wind exposure index (AVWIND) was not included in the null hypothesis path diagram because it was correlated (weaner hind data : r = -0.84) with the mean paddock shelter score (SHELT)(they were calculated from almost the same raw data), thus a potential multicolinearity in the data was avoided (Kleinbaum et al., 1988).

4.4.1.2.1.2 Winter growth

Significant risk factors accounted for 54 and 51% of the variabitity of weaner stag and hind winter growth rates (GR69), respectively.

Final diagrams (Figure 4.39) showed significant risk factors to be consistent between weaner hinds and stags. Nutritional factors appeared once again to be major risk factors. It was known growth rates in winter are dependent on quality and quantity of food supply (Fennessy, 1982). Quantity was measured through sward heights. Grazing pasture swards below 5 cm during winter resulted in lower growth rates by 31-36 g/d on average, which represents a 9-10 kg lower bodyweight at the end of winter. By adding the positive effect of the pre-grazing sward height (ISWH) or grazing sward over 10 cm (RSWH10), pasture height appeared a very important management practice to optimise winter growth. This result is consistent with the experimental results of Ataja et al. (1992), where red deer stags maintained on 5-cm and 10-cm swards of perennial ryegrass/clover pasture grew 74 and 153 g/d, respectively. In sheep, the daily dry matter intake of ewes under rotational grazing increases with pre-grazing green pasture mass (McCall et al., 1986).

Pasture quality was measured through clover content (CLOVER) and pasture type (PASTT), but CLOVER was not significant in univariable analysis. PASTT was associated with reduced growth rates by 20 (hinds) to 30 g/d (stags) on average (Figure 4.39), which highlights the potential benefit in improving pastures and soils to decrease the proportion of low quality pasture such as browntop. The thistle and ragwort scores which were identified as important factors for autumn growth, were not included in the analyses because these scores are yearly averages and not seasonal records (see Table 2.4). In winter, most of these plants had died.

The use of sires with imported red blood lines or wapiti cross-bred sires was beneficial in improving winter growth rates of weaners. At the same percentage of New Zealand blood lines (NZ), wapiti blood (WAP) further boosted weaner stag growth, which may highlight the genetic superiority of heterosis. Hybridisation is known to increase the productive efficiency for venison (Fennessy and Thompson, 1989). There was a significant inverse relationship between the percentile of weaner bodyweight on June 1 within mobs (PERCW6) with the lightest weaners within mobs growing on average 21-29 g more daily than the heaviest weaners, within each sex group. This observation supports previous records of compensatory winter growth in deer (Hamilton and Blaxter, 1981; Blaxter et al., 1981; Fennessy , 1982). Hamilton and Blaxter (1981) identified this relationship with weaner bodyweight at weaning, and attributed their observation to the fact that naturally suckled calves were more reluctant to feed in troughs than artificially reared calves. This cannot be the explanation for this effect in this study. There was, however, a significant interaction between PERCW6 and RSWH5, and between PERCW6 and the average mob size (DEER) in the analysis

of weaner hind GR69. The compensatory growth, as suspected here, was more intense under short grazing conditions (sward height below 5 cm) and within large weaner mobs. The larger the mob of weaners, the more likely weaners at the lower end of the bodyweight scale were "catching up" bodyweight with the heaviest weaners in the mob during winter. Should this result be validated, farmers may expect a 1.5-2 kg "catch up" by the lightest weaners compared to the heaviest weaners in the mob between June and September, which is smaller than the 6 kg reported by Fennessy (1982).

The negative influence of grazing weaner deer in large mobs (DEER) in both final diagrams is consistent with previous observations in this thesis. Its interpretation is not straightforward since compensatory growth by the lightest weaners during winter tended to increase with the average size of the mob. However, there was a significant interaction between RSWH5 and DEER in the analysis of weaner stag GR69, which suggests the negative effect of DEER worsened when swards were grazed below 5 cm. Therefore it may be that competition for food occured more intensively within weaner stags than weaner hinds, and this did not appear to be related to grazing densities. The beneficial effect of changing the mob composition (STOCK) is intriguing, although it may be related to removals of weaners between June 1 and September 1 through live sale or mortalities. Where these occurred, changing mob composition was high, but the weaners that were kept were more likely to be those with the highest growing potential. This introduced a potential bias. The negative influence of grazing weaners with yearling or adult deer (ODEER) was identified only with weaner stags, which suggests it may be a marginal factor. It was also identified that such weaner stags were less likely to strip graze during winter (STRIP in Figure 4.39a), which was identified as a major beneficial factor for autumn growth, thus the effects of ODEER and STRIP may be confounded.

Winter growth was further reduced as weaners grazed on steeper slopes (TOPO), which may be related to an increase of maintenance energy requirements. There was a significant interaction between TOPO and RSWH5 indicating the effect of TOPO worsened when deer grazed swards below 5 cm. Deer spend more energy grazing on rolling to steep paddocks, in particular under tight grazing, as the time spent grazing increases. Paddocks with high topography scores, however, offered more potential shelter against adverse weather condition (SHELT) through hills and gullies. SHELT is further increased by the amount of trees in the paddock (TREES), and shelter belt. The positive relationship of SHELT on GR69 was expected as it is logical that feed energy expenditure for maintenance will decrease as weaners are offered protection against adverse weather conditions. Although the direct effect of SHELT was not statistically significant in the weaner hind final diagram, it may be mediated through TOPO. The total effect of TOPO in the stag diagram approximates that in the hind diagram. The negative effect of TREES is intriguing and will need further investigations and research, as it was contrary to the belief that the use of mature plantations reduces feed energy requirement (Moore et al., 1985). The negative relationship of the time spent grazing close to signs of human presence (eg houses, buildings or road)(SUR) with GR69 is intriguing and will need to be investigated further.

The positive relationship of high mean daily temperature range (AVMMT) with GR69 may highlight the importance of environmental factors for growth. High AVMMT is often related to sunny weather patterns and, in this analysis, was associated with low mean daily rainfall (RAIND). From 6 to 13°C, which is the range of AVMMT recorded in this study (see Appendix 4.19), there was an average increase of GR69 by 60 and 92 g/d in weaner stags and hinds, respectively.

Health variables are more difficult to analyse because of the variety of disease control programmes implemented on each farm and the potential long term effects of these programmes. Health problems also varied in nature and time of occurrence (see section 3.3.4). Consequently, potential risk factors included in these analyses can only be general. This simplistic approach was a compromise to allow a minimum control on the potential benefit of disease control measures and potential negative effect of health problems. Their statistical significance in both final diagrams supports these hypotheses and suggests more research should be carried out to further refine the risk factors under investigation. The later farmers treated their weaners with anthelmintics after June 1 (STARD), the lower the growth, which suggests the drenching programme should have been continued in June on some survey farms in this study. In this respect, the treatment of weaners with anthelmintics in July (JULYD) appeared beneficial to optimise winter growth. Suttie et al. (1983) suggested parasites (ie gastrointestinal nematodes) may be responsible for the reduced appetite noticed in winter. However, the reason of the negative direct effect of JULYD on weaner stag GR69 is not known.

Weaners that received copper supplementation through copper oxide rods (COPPER) prior to or early in winter grew faster than other weaners by 36-44 g/d. It is generally accepted that severe copper deficiency does reduce weight gains in other domestic species (Grace, 1983), and supplementation often produces a positive growth response (Phillippo, 1983). This study supports a potential beneficial effect of copper supplementation on weaner growth, although it is debated (Wilson, 1989; Wilson et al., 1993). A marginally significant growth response to treatment with copper oxide rods in May was observed during June and July by Killorn et al. (1991). In this study, the negative influence of the observation of at least one lame weaner (LAME) was related to osteochondrosis and copper deficiency in the previous section, and further supports their potential distinct or joint subclinical effects on growth.

The occurrence of weaner death other than misadventure during winter (DEATH2) can be related to that of Yersiniosis as explained in the previous section, and therefore its negative influence on GR69 is consistent with that of DEATH1 on GR46. DEATH2 was less likely to occur if Yersiniosis was confirmed on farms during autumn, possibly as a response to the vaccination programme with Yersiniavax (VYERS) following the mortality outbreaks (odds ratio = 9.5). Since VYERS had a negative effect on GR69, however, it is not really known which are the important factors. It is speculated that weaners which experienced subclinical Yersiniosis in autumn, and possibly a lower autumn growth, and subsequently recovered, may be protected against further infection and mortalities, and thus be more likely to grow in winter. Weaners in mobs with mortalities after June 1 may not be immunologically protected against Yersiniosis and thus be further affected by subclinical infections. This strongly supports the need for further research, in particular whether the preventive use of Yersiniavax will minimise weaner mortalities caused by Yersiniosis and the effect of subclinical infections, possibly manifested by growth rate.

4.4.1.2.1.3 Spring growth

Significant risk factors identified in these analyses explained 34 and 37% (model R^2 x 100) of the variability of weaner stag and hind spring growth rates (GR912), respectively.

In univariate statistical analyses, the bodyweight gap between individual weaner stags and the heaviest weaner stag in the mob on September 1 (MAXW9), and the percentile of bodyweight on September 1 within mobs (PERCW9) were both selected but were highly correlated (r=-0.82). Since these weaner individual characteristics were closely related, MAXW9 only was kept in the

null hypothesis path diagram (Figure 4.35). This variable was preferred, since a bodyweight difference would be easier understood by farmers than percentiles and, thus would be easier to interpret.

This analysis has again identified a significant negative direct effect of the mean daily sunshine score (SUN) on weaner growth. It was interesting to note that by withdrawing SUN from the null hypothesis path diagram, as it was done in the analysis of autumn growth, the final models changed only slightly, with significant risk factors still explaining 32.5 and 35% (model R^2) of the variability of weaner stag and hind GR912, respectively. Therefore, revised final diagrams were not drawn up, as done for the autumn analysis, but instead new path coefficients of significant factors were added to the final diagram (Figure 4.40) and put under brackets. The total effect of SUN on weaner stag GR912 was positive (regression coefficient = 65, $p<0.01$), but was not significant on weaner hind GR912. SUN had a direct positive effect on CLOVER, and also a positive effect through mean daily maximum or minimum temperature (AVMIT and AVMAT). It was suggested that the direct negative effect of SUN needs further investigation, although it may be confounded with that of PASTT. The mean pasture type score (PASTT) became significant in the hind diagram (Figure 4.40b). The higher PASTT, the lower GR912, which is consistent with similar observations in the analysis of winter growth rates.

Pasture sward height variables were not identified as major factors influencing spring weaner growth, although Ataja et al. (1992) showed experimentally that weaner stags grazing on 10-cm-high swards grew on average 80 g/d more than on 5-cm-high swards in spring. The univariate statistics, however, supported their observations (see RSWH5 and RSWH10 in Appendix 4.22). The non-significance of RSWH5 in final diagrams may be because of the limited number of weaners that grazed on short pasture in spring. This occurred on one farm only, and it is interesting to note that weaner hinds that grazed on swards below 5 cm in spring on that farm had the lowest conception rate of all yearling hinds after mating the following year. The potential beneficial effect of sward height may be mediated through that of the mean clover score (CLOVER) in this analysis as the higher the pre-grazing sward (ISWH), the higher was CLOVER.

CLOVER was significantly positively associated with weaner hind and stag growth rates. From score 1 (grass-dominant pasture) to score 3 (clover-dominant pasture), weaner hind and stag GR912 increased on average by 50 and 64 g/d. Furthermore, the pasture type score (PASTT) was negatively associated with GR912 when SUN was removed from the diagram (see later in this discussion). These observations further support the importance of pasture quantity and quality for weaner growth. Deer have a high potential for growth in spring following restricted growth in autumn and winter (Fennessy, 1982), but adequate feeding is required to exploit this potential.

The lower genetic potential of New Zealand blood lines (NZ) for growth was further supported in this analysis. NZ was identified with a direct negative effect on GR912. Compensatory spring growth has been described in weaners that were on restricted feed during winter (Suttie and Hamilton, 1983), which may explain the significant positive relationship of the bodyweight gap between individual weaner hinds and the heaviest weaner hind in the mob in September 1 (MAXW9) with GR912. But since the magnitude of this relationship is small, and it was not significant in the stag diagram, and no longer significant in the hind final model after the direct effect of SUN was withdrawn, it was suspected to have been of limited importance for spring growth on these farms. The effect of MAXW9 may be minor because compensatory growth may affect herds rather than individual weaners within herds.

The apparent negative effect of changing the mob composition was in contradiction to the previous analysis (winter growth). On that analyses it was believed the negative effect of STOCK on winter growth was potentially biased. In spring, weaner removals were limited thus reducing this potential bias. On one farm, all weaner stags were sold early November (see Appendix 3.17) and thus were not included in the analyses. Therefore, the effect of STOCK may be more negative than positive as observed in winter. This may be related to social interactions (and social stress) associated with disturbing socially organised mobs. Mixing unfamiliar groups is a stressful experience for deer (Pollard et al., 1993). Mixing weaners with yearling or adult deer (ODEER) appeared, in this context, to be a practice to avoid.

Internal parasite control appeared to be important to optimise weaner growth in spring. Weaner hinds and stags that were treated with anthelmintics in the last 15 days of August (thus implying they should have low burdens of internal parasites in early spring)(LAUGD) grew on average 10 (hinds) and 26 g/d (stags) faster in spring. Whether there is a causal relationship is unknown. The importance of internal parasite control is further supported by the negative influence of delaying the date of drenching after September 1 (STARTD). The relationship between STARTD and LAUGD is inconsistent between weaner hinds and stags, but allows estimation of the total effect of LAUGD, which was 16 and 24.7 g/d in hinds and stags, respectively. It was recognised that the lungworm *D.viviparus* has the potential to affect weaner growth if it is not controlled (Corrigall, 1985). Gastrointestinal nematodes may not have been recognised as important because of difficulties of diagnosis, as proposed by Suttie et al. (1983), and may be responsible for a reduced appetite or digestive efficiency in spring, as in winter. From the observed reduction of egg and lungworm larvae output in the faeces, it is commonly believed weaners develop an immune response against internal parasites and that treatment with anthelmintics may not be necessary in spring (Wilson, personal communication). Should the effect of LAUGD be causal, weaner stags would weigh an extra 2.4 (±0.3) kg in spring compared to weaner stags not treated late August. This would produce an extra 1.4 (±0.2) kg of venison and NZ$7 (±1) return. Although this is a simple direct calculation, it suggests that it may be economically worthwhile to drench weaners late winter and that research should further investigate this possibility.

4.4.1.2.1.4 Summer growth

Significant risk factors identified in this analysis explained 59 and 62% (model R^2 x100) of the variability of weaner stag and hind growth rates between December 1 and March 1 (GR123), which is considered high.

In this analysis, the mean daily maximum temperature (AVMAT) and the mean daily range of temperature (AVMMT), although selected at the univariate statistical level, were not both included in the multivariable analyses because they were highly correlated in the weaner stag dataset ($r = 0.84$). To avoid the problem of multicolinearity in the model, AVMAT was arbitrarily rejected.

The higher the pre-grazing sward height (ISWH), the lower GR123 by 12.3 and 40.3 g/d in weaner hinds and stags, respectively, for each 10 cm pasture height. Further, the higher the ISWH, the more likely weaners grazed sward no shorter than 10 cm (RSWH10), which was identified as adversely affecting GR123 in both sexes. This latter effect appeared substantial, and was attributed to the lower quality of pasture over 10 cm high due to an increased proportion of stems and dead materials and reduced clover content (Stakelum and Dillon, 1990). Height was thought to be a major factor influencing pasture intake and digestibility. The negative relationship identified in this analysis is consistent with other analysis of summer or late summer grazing management practices

as risk factors for conception (see sections 4.1) and weaner bodyweight on April 1 (see section 4.3). Weaner deer can achieve high growth rates during summer providing the pasture growth is controlled and maintained at the vegetative stage as needed for lactating hinds (Moore et al., 1985). In this study, the seed head height records (see Table 2.7 and Figure 2.3) could not be included in the analysis because of inconsistency of recording. However, the range of ISWH was 7.7-32.5 cm and visual observation confirmed most pastures over 10 cm contained stems, seed heads and dead material. No swards were grazed below 5 cm during summer. The positive effects for hinds of high browntop content in the pasture (PASTT) and high mean thistle score (THISTLE), which may lower pasture quality, were not expected, and there is no logical explanation for this relationship. Since these factors were not identified as risk factors for weaner stag GR123, they may be of marginal significance, if any. This also applied to the mean ragwort score (RAG), although its negative effect may be related to its toxicity (see section 4.4.1.2.1.1).

Significant individual weaner characteristics are inconsistent between hinds and stags. The negative direct effect of New Zealand blood lines (NZ) on growth was identified only in the stag diagram. There was agreement between the two diagrams in that weaners with high NZ were lighter on December 1 (W12). Heavy weaner stags in December 1 and the lightest weaner stags within mobs (PERCW12) grew better, whereas weaner hinds showed the converse relationship. The reason for these converse relationships was not clear, although it may be that heavy stags on December 1 may gain more weight because of their larger frame. Stags gain bodyweight late summer through water retention (Fennessy, 1982) which may be proportional to their size. The converse effect of W12 in weaner hinds may be related to the presence of stags as, in this analysis, the average percentage of weaner stags in the mob (M%WS) was significantly negatively correlated with weaner hind W12 ($r = -0.30$). Thus the effect of W12 could be due to the presence of weaner stags, resulting in increased harrassment in the pre-rut period. This effect may be further illustrated by the positive relationship between PERCW12 and GR123 since PERCW12 of hinds was higher if hinds were not mixed with stags on December 1 ($p<0.01$). Conversely PERCW12 of stags was lower as the mean percentage of stags increased (M%WS), which may further indicate that better weaner growth may be achieved by separating weaner stags and hinds in summer. This would be consistent with the analysis of risk factors for conception (see section 4.1) where weaner hinds (15 months old) that were mixed with weaner stags up to the rut were significantly lighter than hinds grazed separately from them. This interpretation, however, is speculative and will need to be validated by further research. The total effect of W12 in weaner stags was small (an extra 7.5 g/d for each 10 kg increase in W12), whereas that in weaner hinds was not significant (the total effect was estimated by withdrawing PERCW12 from the final model).

When weaner hinds and stags were mixed (ie when M%WS was high and low in the weaner hind and stag model, respectively), the average mob size (DEER) was increased. Large DEER were identified as negatively associated with weaner stag and hind GR123, directly or indirectly through the average total energy requirement per grazed hectare (MJME/Ha). This is consistent with previous observations in this section. In summer, however, weaner hinds and stags were often mixed with older deer (ODEER) which were significantly associated with larger DEER. In the univariate statistics (Appendix 4.26), ODEER was apparently positively associated with GR123. Final path diagrams suggest there may be two separate influences, with ODEER having on one hand an adverse influence possibly through social interactions, and on the other hand a stronger beneficial influence through MJME/Ha. The reason for the latter positive influence was not clear, although it may be related to feed levels and pasture quality. In both analyses, MJME/Ha was significantly higher when the mean residual sward height was below 10 cm.

M%WS appeared to have a similar dual effect on weaner hind GR123, with an overall beneficial effect. Should these observations be validated, it seems that pasture management is a key issue for optimal weaner growth during summer and that this should not be carried out by mixing deer together to increase the grazing pressure. This added to the apparent negative influence of changing the weaner hind mob composition (STOCK), and considering the potential influence of stags in triggering puberty and early conception (Fisher and Meikle, 1994), it appears beneficial to separate weaner hinds and stags early summer (or probably before) to optimise growth and mix them back together a few weeks before the rut as is suggested to improve reproductive efficiency (see section 4.1). More research should be targeted on these particular issues.

Weather variables were significant only in the hind final diagram, which may indicate they were not critical factors. The total effect of SUN was not statistically significant. It was unexpected that the mean daily minimum temperature (AVMIT) increased as SUN increased and as the mean daily rainfall (RAIND) decreased, since the converse relationships were observed in the other analyses in this thesis. There was an overall beneficial effect of RAIND, which may be related to the drought and associated dry swards occurring in one of the study area (Hawkes' Bay).

The mean paddock topography score (TOPO) was only significant in the hind final diagram, with an apparent beneficial influence on GR123. This contrast with a negative effect of TOPO on both weaner stags and hinds during winter. It was likely, however, that this positive effect in summer was mediated through other factors (eg shelter variables) not included in the multivariable analysis. The non-significance of TOPO in the stag diagram suggests it is not a major factor in summer. This may also be true for the percentage of time spent on paddocks close to signs of human activities (eg houses, buildings or road)(SUR) which had a marginally significant negative effect and a significant positive effect on weaner stag and hind GR123, respectively.

Growth rates appeared to improve on average by 30 and 70 g/d in weaner stags and hinds, respectively, that were treated with anthelmintics during summer (SUMD). This analysis supports further the belief that parasitism may be a significant production limiting factor in weaner deer over 1 year old, and that trials should be carried out to evaluate the potential economical advantage of drenching these deer in summer. The negative effect associated with drenching stags in November was not considered important since it was not identified as such in the hind final diagram.

4.4.1.2.2 Sentinel weaner characteristics and biological markers

Preliminary analyses showed that there were significant differences in all sentinel deer characteristics and biological markers between farms, and that these differences explained a large proportion of the variability of individual blood markers (see section 3.4). This suggests that management practices and the overall performance of weaners on each farm (eg mean seasonal growth rates) may be associated with biological markers. Consequently, means (or geometric means where appropriate) obtained from the 10 weaners (or the 5 weaner hinds and the 5 weaner stags depending on sex differences as described in Appendix 3.72) were investigated as farm markers in association with optimum seasonal growth. Whereas blood markers recorded at the end of grazing periods may reflect the direct influence of management practices during the grazing periods under study, it was useful to evaluate how these blood markers would be related to growth during the following grazing period, thus allowing a more in-depth exploration of the data. It was acknowledged that the multiplicity of analyses would increase the probability of obtaining statistically significant relationships by chance alone, and this has been taken into account in the discussion. As for the investigation of grazing management variables and environmental factors, it was believed the most

relevant blood markers were those associated positively or negatively with both weaner hind and stag growth rates. Therefore the discussion will mainly focus on these blood markers. Results were also interpreted in relation with significant management practices identified earlier in this section.

Individual autumn growth rates were significantly negatively associated with serum blood urea nitrogen concentrations (BUN), and positively associated with serum albumin (ALB) and copper (CU) concentrations. These blood markers may reflect the nutritional status of the weaners which influences growth. In ruminants, a high BUN is related to a physiological adaptation to inadequate diet, ie decreased renal excretion of urea, increased BUN and increased re-use of urea nitrogen in the rumen (Kay, 1963). In the post-weaning period, it may also indicate that feed proteins were degraded in the rumen but energy was lacking (or the rumen was not fully functional) to convert them into digestible proteins, resulting in a waste of nitrogen and increase of BUN (Alvarez, personal communication). A negative effect of such dietary protein:energy imbalance has been observed in white-tailed deer in autumn (Verme and Ozoga, 1980). Alternatively, an increase of BUN may be caused by dehydratation (Delgiudice et al., 1994), which could be associated with many factors such as nutritional restriction, heat stress or disease, ie yersiniosis. High ALB may be associated with optimum absorption of digestible proteins. In white-tailed deer, high serum protein concentrations were recorded from fawns on high protein diets (Ullrey et al., 1967). In this study, however, many other factors may be involved, such as internal parasites which may be responsible for the disturbance of the protein metabolism (Sykes, 1994). This latter explanation would be consistent with previous observations of the significance of many internal parasite control variables in this section. These speculations, however, need to be further evaluated. Mean BUN and mean ALB were not significantly associated with mean weaner hind and stag autumn growth rates (MGR46), but that may be because of a limited number of farms. Scatterplots do not convincingly suggest they may be useful to monitor the nutritional status of weaners in relation with their growth (Figure 4.42 and Figure 4.43), although it may be because they only represent univariate associations (some regression lines in Table 4.18 are not statistically significant). It may be that these blood markers should be investigated together as shown by the multiple linear regression equations in Table 4.17.

This study suggests serum copper (CU) may also be an important blood marker to routinely investigate on commercial farms. Weaners with a CU over 8 µmol/l, which has been proposed as the threshold minimum value for farmed deer (Clark and Hepburn, 1986; Mackintosh et al., 1986), grew on average an extra 33 g/d compared with other weaners. Moreover there was a significant positive relationship between the mean copper concentration from the 10 sentinel weaners and MGR46 (Figure 4.44). Although the tissu concentration of copper needed to support growth in young deer is debated (Wilson et al., 1993), this result supports the belief that adequate copper supply is needed not only to prevent health problems such as osteochondrosis (Audigé et al., 1993, 1995), but also to optimise growth rates. This hypothesis is supported by the previous observation in this analysis that the pre-winter treatment of weaners with copper oxide rods was positively associated with winter growth rates (see COPPER in Figure 4.39). However this study was not able to provide further data to help the establishment of a treshhold level for this element.

Individual serum phosphorus concentrations (P) recorded in June were positively associated with individual weaner winter growth rates. This relationship is not strong as shown by the scatterplot in Figure 4.45 possibly because many other factors affect winter growth. Mean weaner phosphorus concentrations, however, appeared to be a potential marker for mean weaner hind winter growth rates (MGR69). To the authors' knowledge, phosphorus deficiency has only been suspected as a

cause of health problems associated with spontaneous fractures in deer (Wilson, 1992), whereas it is also the cause of reduced appetite and poor growth in cattle (Grace, 1983). An experimental diet that was deficient in P was found to cause severe inappetence in lambs (Field et al., 1975) and moderate inappetence in stag calves (Kay and Goodall, unpublished result cited by Hyvärinen et al., 1977). In this study, it must be noted that the lowest P was from a farm where 13 weaners died from suspected yersiniosis early June 1992 (farm 13 in Appendix 3.61). The subclinical effect of this health problem on survivors on that farm may thus be confounded with the potential negative effect of low P, if any. Conversely, it could be suggested that low phosphorus levels on some farms may have been partly responsible for the reduced appetite and resulting feed intake observed in weaner deer during winter. Serum P was also positively associated with individual weaner summer growth, which further supports the need to further evaluate the importance of phosphorus as a blood marker and risk factor for growth in weaner deer. Mean blood markers recorded in November were not investigated as potential blood markers for summer growth because of the limited number of observations. However, the scatterplot of mean P against GR123 (Figure 4.49), suggests a potential benefit in routinely monitoring serum phosphorus.

The negative relationship between mean serum total protein concentrations (TP) recorded in September and mean weaner hind and stag winter growth rates (MGR69) was intriguing and required further investigations. By plotting mean serum albumin and mean globulin concentrations against MGR69, it appeared winter growth was maximal where weaners had the lowest serum globulin concentrations (GLOB)(Figure 4.45). This suggests the growth of weaners which are more immunologically reactive, thus those with high GLOB, may be reduced, although this may be speculative. Whether the observed differences between farms was related to the occurrence of health problems such as subclinical yersiniosis was not known and will need to be further investigated.

A few relationships in these investigations were contrary to logical thought and knowledge from other domestic species. The lower GR912 associated with individual serum vitamin B12 over 185 pmol/l was not expected and was not explained (Table 4.17), whereas the positive association of individual blood white cell count (WCC) with GR912 (Figure 4.47) may have been caused by a few outliers. That mean serum albumin concentrations were inversely associated with mean weaner spring growth (MGR912)(Figure 4.48) can not be explained either.

There was a significant inverse relationship between individual serum pepsinogen concentrations (PEPS) of weaner stags and their individual growth rates during summer (Figure 4.51). Although it was not significant with weaner hinds, PEPS was investigated further because of the apparent beneficial effect of drenching weaners during summer identified earlier in the analyses (Figure 4.41). Although the number of farms from which data were available was limited, there was a clear trend that mean weaner hind and stag summer growth rates decreased as geometric means of serum pepsinogen concentrations increased. Whether this relationship was causal was not known, but it strongly warranted that further research be carried out to investigate this possibility. Until then, as PEPS has been related to the occurrence of abomasal parasites, it may be worth treating weaners with appropriate anthelmintics to ensure they reach target weights.

4.4.1.3 Conclusion

This study is the first large scale investigation of many factors potentially affecting weaner growth from 3 to 15 months of age under commercial farming conditions, and many risk factors have been identified. Although some important risk factors may have been omitted (or not adequately coded),

the large R^2 of final models suggest most important factors have been taken into account in the analyses. Most significant associations were consistent with pre-existing evidence and between the various analyses in this study, and therefore their causality is likely.

This study has been effective in identifying individual deer characteristics, management practices and environmental conditions more likely to improve weaner growth rates on farms.

To maximise growth of young stock, it is therefore suggested that farmers :

- Increase the proportion of imported blood lines in their herd through genetically superior hinds and sires.
- Use wapiti x red type sires.
- Feed their deer high pasture allowance and high pasture quality at all times. Swards should not be grazed below 5 cm and be clover-dominant. In summer, pasture should remain at the vegetative stage if grazed over 10 cm high.
- Pastures and soil should be improved to minimise the proportion of low quality pasture such as browntop.
- Weeds such as thistles and ragwort plants should be controlled.
- Strip graze weaners in autumn.
- Keep mobs of reasonable size.
- Prefer flat paddocks, particularly in winter.

Other management practices may result in improved growth rates, but since results were not clear cut and interpretations difficult, they are proposed tentatively until further research proves causality (researcher's advice). They are :

- Wean calves early
- Ensure adequacy of copper status (>8 μmol/l) of hinds during pregnancy and of weaners after weaning.
- Vaccinate weaners in March-early April with two doses of Yersiniavax.
- Keep mob size below 85, which is the average of DEER recorded in winter (Appendix 4.19).
- Strip graze weaners in winter.
- Drench weaners in winter, spring and summer with an anthelmintic effective on abomasal parasites. Pepsinogen concentrations may be used in spring to monitor success or need for drench..

- Monitor serum copper, phosphorus, albumin and blood urea nitrogen concentrations in June as they may act as markers for adequate nutrition for optimal growth in autumn and in winter. Phosphorus also appeared useful to predict summer growth rates.

- Prefer paddocks with trees in autumn and avoid them in winter.

- Prefer paddocks away from houses, buildings or other signs of human activity.

- To separate hinds and stags during summer to ensure optimal growth (note : join them back together a few weeks before the rut to ensure hind fertility as shown in section 4.1).

- To separate weaners from older deer in summer.

This study has shown that, although genetic factors and feed allowance were confirmed as key issues for weaner growth, many other management factors may help meeting target bodyweights. Experimental evidence showed that with high feed allowance on conventional pastures, 50-75% of weaner red deer stags can reach optimum weight of 92kg by 12 month of age (Ataja et al., 1992; Semiadi et al., 1992). This study showed 50% is achievable on commercial farms as it was observed on one farm. This suggests however, that there is considerable scope for improvement on the other farms.

4.4.1.4 Identified areas for further research

This section has highlighted areas which deserve priority in research and development designed to improve the growth of weaner deer.

It is appropriate to further investigate :

- The effect of weaning before March on autumn growth in relation with rumen degradation and nutrient utilisation efficiency.

- The effect of vaccination with Yersiniavax on the intensity of subclinical infections by *Y.pseudotuberculosis*, immunity, mortality rates and growth during autumn and winter.

- The effect of parasitism in weaner deer, in particular abomasal parasites, and the use of pepsinogen to monitor these parasites.

- The use of serum copper, phosphorus, albumin and blood urea nitrogen concentrations from selected weaners in June as blood markers for growth.

- The beneficial effect of trees on weaner autumn growth

- The effect of limiting weaner mob size below 85 in winter

- The effect of separating weaner hinds and stags in spring and summer on growth.

4.5 RISK FACTORS FOR VELVET ANTLER PRODUCTION

In the Cervidae family, males usually grow antlers, which are derived from the frontal bones of the skull. They are used for defense against predators and for access to harems during the rut. Antlers of red deer are regenerated each year with casting occurring late winter or early spring so new sets can fully grow and harden before the onset of the rut (Lincoln, 1971; 1992). Antlers are made of several tines, but the bez tine may not grow as shown in Figure 1.1 (the bez tine is only present on the left velvet).

In New Zealand, antlers from farmed stags are removed before they are fully developed for sale as a medicinal product to the Asian market. When removed, antlers are covered by a velvet-like skin which gives the name "velvet antlers"[2]. The stage of growth is an important criteria for quality and the GIB has provided guidelines for the timing of removal (Appendix 1.1), which is just before the formation of royal tines. Farmers are rewarded for quality as the price they are given for each kilogram of velvet produced principally increases with the circumference of the main beam of the velvet antler. Other grading criteria are the length of the main beam and the presence of a bez tine. Velvet antler is downgraded if overgrown because of calcification. The monetary value of the velvet, therefore, reflects all these attributes.

Velvet weight and grade have a strong genetic component, but antler weight is also considered to be influenced by age, bodyweight and nutrition (Muir and Sykes, 1988) and date of casting of the previous set of hard antlers (or antlers stubs), but these factors are correlated, so it is difficult to evaluate their relative effect on velvet production. For instance, for the same age, hard or "velvet" antler is positively associated with bodyweight. There is a suggestion that stags in poor body condition cast their hard antlers later (Watson, 1971). Experimental evidence showed low nutrition allowance during winter delayed antler casting and produced lower velvet weight (Fennessy, 1981; Muir and Sykes, 1988), and this was related to the bodyweight rather than age (Muir and Sykes, 1988). Thus the range of variables affecting velvet growth that has been subject to research evaluation in a field environment is very limited. There was therefore a need to investigate the relative influence of individual stag characteristics and environmental factors, including nutrition, on velvet antler weight and grade.

4.5.1 Materials and methods

The outcomes under investigation were the combined weight of the left and right velvet antlers (WEIGHT) and the highest velvet antler grade of both sides (GRADE). Farm mean blood markers were investigated as risk factors for the mean velvet antler monetary value corrected for age (MCVEL$), the mean velvet antler grade (MGRADE) and weight (MWEIGHT) and monetary value (VELV$) of velvet antler. These outcomes are described in Table 2.38.

During each of the two years of study, about 500 adult stags and 300 2-year-old[3] stags (see Appendices 3.6 and 3.7 for numbers) were individually monitored for winter growth and velvet antler production. Where possible individual bodyweights were recorded in June, September and at

[2] Velvet antlers will be refered hereafter as "velvet"

[3] For the purpose of this study, stags 15-27 months old were defined as "yearling". At the time of velvet antler removal, "yearling" stags, therefore are at or almost 2 years old. In this section, the terminology "2-year-old" will be used instead of "yearling" as it is commonly used by deer farmers.

the time of velvet antler removal. Date of cutting, total velvet antler weight and grade of each side (according to GIB guidelines (Appendix 1.1)) were recorded. During farm visits in June 1992 and 1993 and in November 1992, 5 randomly selected 2-year-old and 5 randomly selected adult stags were blood sampled, where possible, to define their haematological, biochemical and mineral profiles (see sections 2.4.1.1 and 2.5). Their individual physical characteristics, ie shoulder height, thoracic girth, bodyweight, body condition score, coat length and teeth score were recorded as described in Table 2.21.

Risk factors potentially affecting WEIGHT or GRADE were identified and classified according to the area of data collection they describe. Codes and descriptions of each group of variables are presented in Table 4.19. The first block includes individual stag characteristics. Variables describing grazing management practices, deer internal parasite control and environmental factors during winter (June 1 to September 1) and pre-velvetting (September 1 to date of velvet harvesting) were grouped in the 2nd and 3rd block, respectively. Individual sentinel stag characteristics and blood markers recorded in June or in November make the 4th block, while farm mean blood markers were grouped in the 5th block.

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in section 2.7.

- Data from both years of study were combined for statistical analyses.
- All stags two years old and over at the time of velvet antler removal for which the grazing history and velvet records were recorded were included in the analyses. Stags with damaged velvet antlers were excluded.
- To select potential risk factors for WEIGHT or GRADE at the univariate statistical level, the outcome variable under investigation was VELV$ or MVELV$ as appropriate. VELV$ (and MVELV$) was based from the average prices of the four harvesting seasons from 1990 to 1994 (Isaacs, GIB, personal communication), and therefore is a direct calculation from WEIGHT and GRADE. Prices used for calculations are presented in Table 2.35 and Table 4.19.
- Yearling and adult stag data were analysed separately. During preliminary data analyses (data screening), however, potential risk factors were selected for multivariable analyses if they were statistically significantly, positively or negatively (eg if both Spearman correlation coefficients have the same sign in the screening of continuous risk factors), associated with VELV$ or MVELV$ at the 20% confidence level for both yearling and adult stags (unless risk factors were specific to one age group, eg AGE). Therefore, null hypothesis path diagrams were similar to most respects for both age groups.
- Data screening of categorical risk factors was carried out using SAS, while the rest of the analyses were carried out using Statistica.

- Path analysis was only used for the analysis of blocks 1, 2 and 3.

  Path diagrams were formulated within each block (steps 1 to 3 in Table 4.1), which were analysed separately. However, grazing management risk factors (blocks 2 and 3) were analysed with statistically significantly important individual stag characteristics (from step 1) included, since they may otherwise be important confounding factors.

Table 4.19 : Potential risk factors for velvet antler weight, grade and monetary value of 2-year-old and adult stags.

Risk factor code	Unit	Description

Outcome variable for univariate screening of potential risk factors :

Velvet antler dollar value based on average prices (NZ$/kg) from the last 4 years (Isaacs,GIB, personal communication)

	Velvet harvesting seasons				
Velvet grade	90/91	91/92	92/93	93/94	Average price
A and SA	163	190	127	136	154.00
B	149	181	108	127	141.25
C	126	163	73	100	115.50
D	100	145	59	82	96.50
E	81	120	44	60	76.25

BLOCK 1 : Stag management

Individual stag variables

AGE	year	Age
NZ	%	Percentage of New Zealand blood lines
JUNEW	kg	Pre-winter bodyweight (recorded in June)
CHWJV	kg	Percentage of bodyweight change between June and the time of velvet antler harvesting
GRJS	g/d	Bodyweight gain between June and September

Characteristics of velvet antlers harvested

CUT	day	Number of days between October 1 and the date of velvet harvesting
WEIGHT	kg	Weight of velvet antler harvested
GRADE	Dis. 1-7;1	Highest grade of the left and right velvet anler (7=SA ; 6=A ; 5=B ; 4=C ; 3=D ; 2=E ; 1=Other grade)
TINE	D	Velvet antler with a bez tine on at least one side

BLOCK 2 : Winter grazing management from June 1 to September 1, and
BLOCK 3 : Pre-velvetting grazing management from September 1 to the date of velvet antler removal.

Grazing and food supplementation variables

ISWH	cm	Mean pre-grazing pasture sward height
RSWH5	D	Mean residual (ie post-grazing) pasture height below 5 cm
RSWH10	D	Mean residual (ie post-grazing) pasture height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
PASTT	Score 1-3	Mean pasture type score
RAG	Score 0-3	Mean paddock ragwort score (calculated from observations during farm visits)
THISTLE	Score 0-3	Mean paddock thistle score (calculated from observations during farm visits)
STOCK		Number of times the mob composition was changed
SHIFT		Number of times deer were shifted between paddocks
DEER		Average number of deer in the mob
DEER/Ha	deer/ha	Average number of deer per deer-fenced hectare (grazing density)
OTHERST	D	Paddocks shared with stock other than deer at least one day
STRIP	D	Deer strip grazing at least in one paddock
KALE	D	Deer grazing on a kale crop at least one day
FSUP	D	Food supplementation of stags

Note on units : D = Dichotomous variable : Yes=1 ; No=0
"Score 0-1" means "Score ranging from 0 to 1"
"Dis. 1-7;1" means "discrete variable from 1 to 7 with 1 unit increments"

Table 4.19 (Cont'd)

Risk factor code	Unit	Description
BLOCKS 2 and 3 (Cont'd)		
Environmental variables		
FAREA	Ha	Mean paddock size (deer-fenced area)
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt
Disease control		
Block2		
WINTD	D	Anthelmintic treatment during winter
WINCOP	D	Copper supplementation of stag in winter
Block 3		
SEPTD	D	Anthelmintic treatment in September
BLOCK 4 : Scottish stag and biological markers recorded in June and in November		
Individual deer measurements		
SIZE	cm	Shoulder height
GIRTH	cm	Thoracic girth
BCS	Dis. 1-5;0.5	Body condition score
COATL	mm	Length of the upper coat
TEETH	Dis. 1-3;1	Incisor teeth score
EASES	D	Blood sampling without firm physical restraint
Individual stag blood characteristics		
White cell count (WCC), neutrophil percentage (NP), lymphocyte percentage (LP), eosinophil percentage (EOP), haemoglobin (HB), packed cell volume (PCV); total protein (TP), albumin (ALB), phosphorus (P), gamma glutamyl transferase (GGT), blood urea nitrogen (BUN), copper (CU), vitamin B12 (B12), pepsinogen (PEPS), glutathione peroxidase (GSHPx).		
CU8	D	Serum copper concentration >= 8 µmol/l
B12185	D	Serum vitamin B12 concentration >= 185 pmol/l
GSHPx3	D	Glutathione peroxidase activity >= 3 kIU/l
BLOCK 5 : Farm mean stag blood markers recorded in June and in November.		
Mean values of weaner blood markers (for farm mean blood markers, codes start with "M") plus :		
MB12185	D	Geometric mean vitamin B12 concentration >= 185 pmol/l
MGSHPx3	D	Mean glutathione peroxidase activity >= 3 kIU/l

Note on units : D = Dichotomous variable : Yes=1 ; No=0
"Score 0-1" means "Score ranging from 0 to 1"
"Dis. 1-7;1" means "discrete variable from 1 to 7 with 1 unit increments"

Potential risk factors were regressed on both velvet antler weight (WEIGHT) and grade (GRADE), separately.

- Sentinel stag characteristics, individual and mean biological markers were analysed separately without the use of path analysis.

Each step described in Table 4.2 represents a separate analysis. In adult stags, multivariable regression analyses were used to investigate relationships between individual and mean blood markers, and individual and mean velvet antler monetary value corrected for age (CVELV$ and MCVELV$, respectively), respectively. The variable AGE or MAGE (mean age of adult stags) were included in the multivariable regression analyses of individual and mean blood markers for WEIGHT and GRADE, respectively. Some biological markers were categorised and analysed as discussed in section 2.8.12.3. Scatterplots of significant biological markers against respective outcomes were drawn up where appropriate.

For each final model, the square of the multiple correlation coefficient (r^2) is presented as the proportion of variance in the data "explained" by the variables included in the model (Kleinbaum et al., 1982).

4.5.2 **Results**

Mean and standard deviation of 2-year-old and adult stag velvet antler monetary value at each level of categorical variables and significance level of association are presented in Appendix 4.30. Descriptive statistics, including Spearman correlation coefficients and their statistical significance, of continuous risk factors are presented from Appendix 4.31 to Appendix 4.34.

Null hypothesis and final path diagrams of 2-year-old and adult stag individual characteristics (block 1) are presented in Figure 4.52 and Figure 4.53, respectively. Null hypothesis path diagrams of winter grazing management and environmental variables (block 2), and pre-velvetting grazing management and environmental variables (block 3) are presented in Figure 4.54 and Figure 4.55, respectively. The respective final path diagrams for 2-year-old and adult stags are presented in Figure 4.56 and Figure 4.57. Unstandardised multivariable regression coefficients, standard error of coefficients, p values and model R^2 are presented in Table 4.20.

Sentinel individual stag characteristics and blood markers significantly associated with either velvet value, weight or grade, and farm mean sentinel stag blood markers significantly associated with mean velvet value (corrected for age in adult stags), weight or grade are presented in Table 4.21.

For convenience and clarity, the detailed descriptions of final path diagrams are presented in the discussion

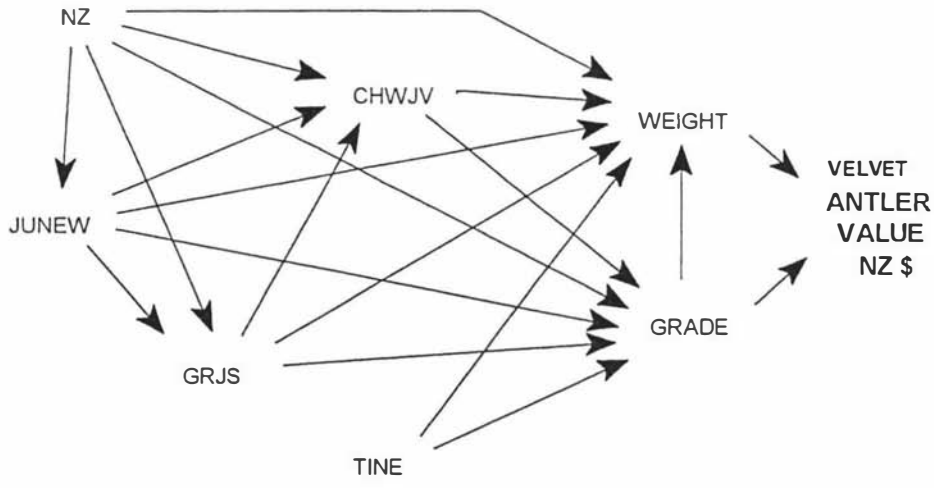
Table 4.20 : Summary of direct effects of risk factors for 2-year-old and adult stags velvet antler weight (WEIGHT) and grade (GRADE).

Major risk factors*	Units	2-YEAR-OLD STAGS Regr. coef.**	SE	p value	ADULT STAGS Regr. coef.**	SE	p value
BLOCK 1 : Stag individual characteristics							
Final model predicting WEIGHT							
Model R square				0.59			0.71
Intercept		0.296	0.117	0.012	-0.503	0.118	0.000
AGE					0.096	0.009	0.000
GRADE	Dis 1-7;1	0.218	0.015	0.000	0.279	0.015	0.000
JUNEW	kg	0.004	0.001	0.000	0.008	0.001	0.000
NZ	%	-0.004	0.000	0.000	-0.003	0.001	0.000
TINE	D	0.184	0.028	0.000	0.196	0.028	0.000
Final model predicting GRADE							
Model R square				0.24			0.43
Intercept		1.815	0.360	0.000	1.528	0.300	0.000
AGE					0.230	0.019	0.000
CHWJV	%				0.011	0.004	0.009
JUNEW	kg	0.023	0.003	0.000	0.020	0.002	0.000
NZ	%	-0.011	0.001	0.000	-0.010	0.001	0.000
TINE	D	0.176	0.087	0.044	0.390	0.063	0.000
BLOCK 2 : Winter grazing management							
Final model predicting WEIGHT							
Model R square				0.66			0.74
Intercept		0.006	0.11	0.952	0.132	0.14	0.330
AGE					0.099	0.01	0.000
AVMIT	°C				-0.046	0.01	0.001
AVMMT	°C	0.036	0.01	0.000			
DEER		-0.002	0.00	0.000			
DEER/Ha	deer/ha				-0.004	0.00	0.002
FSUP	D				-0.108	0.03	0.002
GRADE	Dis. 1-7;1	0.183	0.01	0.000	0.280	0.01	0.000
JUNEW	kg	0.004	0.00	0.000	0.004	0.00	0.000
OSTOCK	D				-0.162	0.03	0.000
RSWHS	D	0.060	0.02	0.003			
STRIP	D	0.227	0.03	0.000	0.611	0.08	0.000
SUN	Score 0-1	-0.530	0.11	0.000			
TINE	D	0.170	0.03	0.000	0.198	0.03	0.000
Final model predicting GRADE							
Model R square				0.34			0.46
Intercept		0.134	0.39	0.733	2.520	0.34	0.000
AGE					0.232	0.02	0.000
CHWJV	%				0.012	0.00	0.004
CLOVER	Score 0-3	1.064	0.25	0.000			
FSUP	D				-0.215	0.08	0.010
GRJS	g/d	0.003	0.00	0.006			
JUNEW	kg	0.021	0.00	0.000	0.018	0.00	0.000
NZ	%				-0.008	0.00	0.000
OSTOCK	D	0.315	0.08	0.000			
SHELT					-0.014	0.00	0.000
STOCK					-0.165	0.03	0.000
STRIP	D	0.548	0.08	0.000			
TINE	D				0.363	0.06	0.000
TREES	Score 0-3	-0.284	0.05	0.000			
BLOCK 3 : Pre-velvetting grazing management							
Final model predicting WEIGHT							
Model R square				0.67			0.73
Intercept		-0.491	0.23	0.03	-0.401	0.11	0.000
AGE					0.101	0.01	0.000
AVMAT	°C	0.040	0.01	0.00			
AVWIND					0.126	0.02	0.000
CUT	day	-0.003	0.00	0.00			
DEER/Ha	deer/ha	0.012	0.00	0.00			
FAREA	ha				-0.015	0.00	0.001
FSUP	D				-0.139	0.03	0.000
GRADE	Dis. 1-7;1	0.193	0.01	0.00	0.278	0.01	0.000
ISWH	cm	-0.027	0.01	0.00			
JUNEW	kg	0.005	0.00	0.00	0.006	0.00	0.000
NZ	%	-0.002	0.00	0.00	-0002	0.00	0.008
OSTOCK	D	0.156	0.03	0.00			
STRIP	D				0.250	0.05	0.000
SUN	Score 0-1	0.458	0.12	0.00			
TINE	D	0.164	0.03	0.00	0.201	0.03	0.000
Final model predicting GRADE							
Model R square				0.34			0.47
Intercept		3.903	0.47	0.000	1.439	0.49	0.004
AGE					0.175	0.02	0.000
AVMAT	°C				0.128	0.03	0.000
AVMMT	°C				-0.084	0.04	0.021
AVWIND					0.179	0.06	0.002
CHWJV	%				0.017	0.00	0.000
CUT	day	-0.016	0.00	0.000	-0.012	0.00	0.000
ISWH	cm	-0.039	0.01	0.001			
JUNEW	kg	0.014	0.00	0.000	0.018	0.00	0.000
NZ	%	-0.005	0.00	0.002	-0.007	0.00	0.000
SEPTD	D				-0.415	0.12	0.001
SHIFT		0.042	0.01	0.000			
SUN	Score 0-1				-1.644	0.33	0.000
TINE	D				0.342	0.06	0.000
TREES	Score 0-3	-0.724	0.11	0.000			

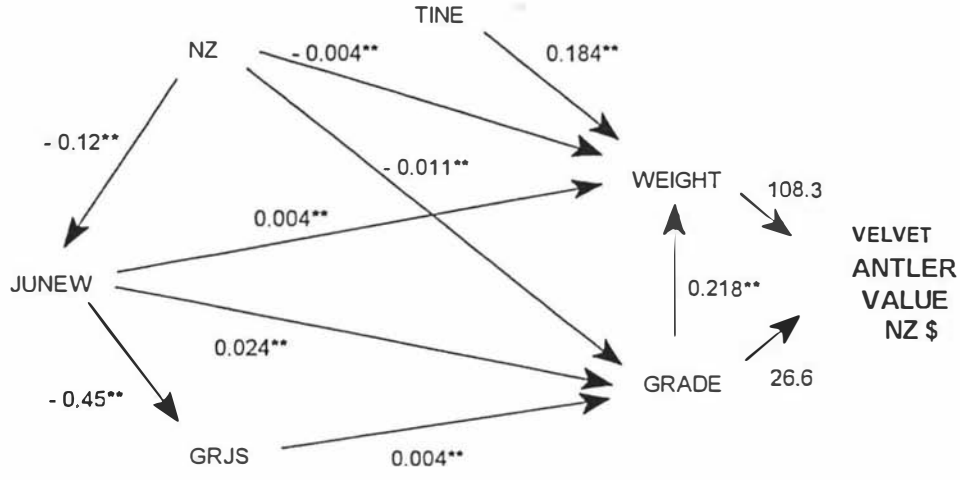
* Risk factor codes are described in the glossary and Table 4.19.
SE = standard error; Regr.Coef. = regression coefficient
** Regression coefficient = Kilogram of velvet WEIGHT or unit of GRADE increase per unit increase of each continuous risk factor, or if dichotomous variables equal to 1, all other factors maintained constant.
Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis. 1-7;1" means "discrete variable from 1 to 7 with 1 unit increments"
D = Dichotomous variable (Yes=1/No=0)

Figure 4.52 : Null hypothesis and final path diagrams of 2-year-old stag individual risk factors for velvet antler weight or grade, or both weight and grade. Data from 1992 and 1993 combined.

1. Null hypothesis path diagram



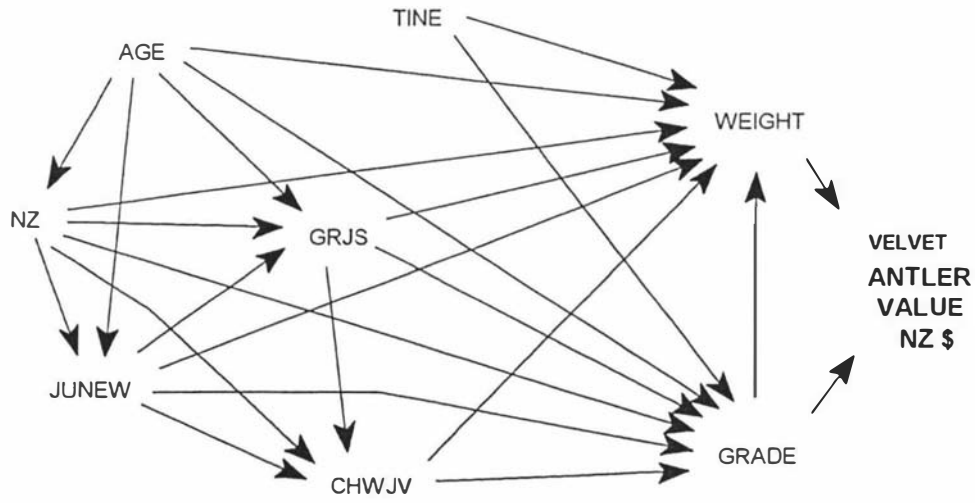
2. Final path diagram



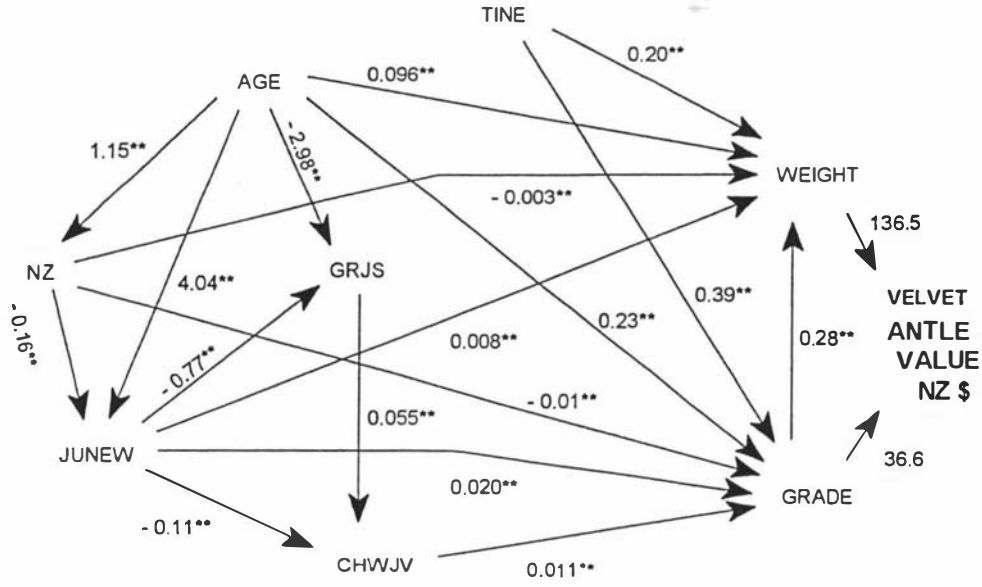
Note : Risk factor codes are described in the glossary and in Table 4.19. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentage of variability of the outcomes explained by these final models are presented in Table 4.20.

Figure 4.53 : Null hypothesis and final path diagrams of adult stag individual risk factors for velvet antler weight or grade, or both weight and grade. Data from 1992 and 1993 combined.

1. Null hypothesis path diagram

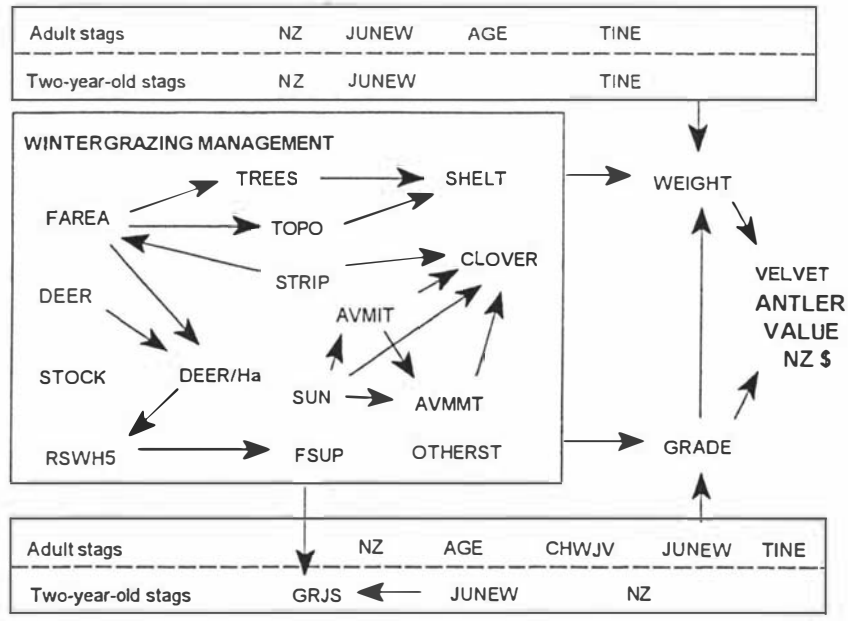


2. Final path diagram



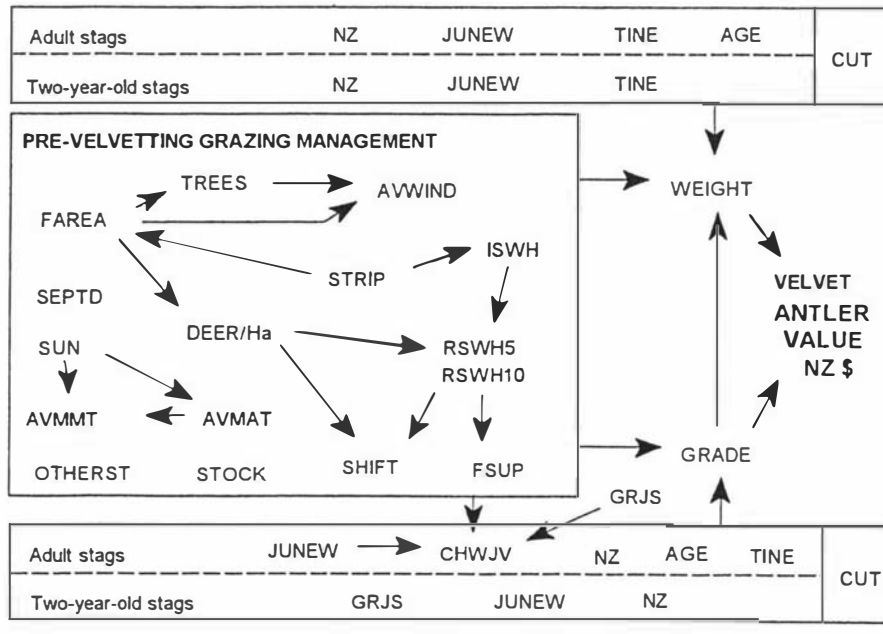
Note : Risk factor codes are described in the glossary and in Table 4.19. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentage of variability of the outcomes explained by these final models are presented in Table 4.20

Figure 4.54 : Null hypothesis path diagram of winter (June 1 - Sept 1) grazing management factors for 2-year-old and adult stag velvet antler weight or grade, or both weight and grade. Data from 1992 and 1993 combined.



Note : Risk factor codes are described in the glossary and in Table 4.19.

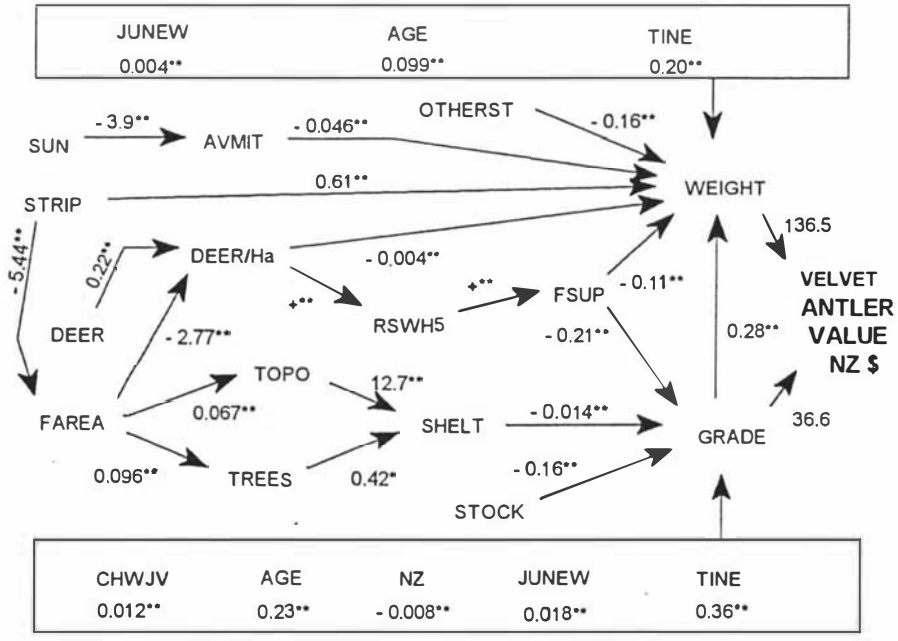
Figure 4.55 : Null hypothesis path diagram of pre-velvetting (Sept 1 - time of velvet antler removal) grazing management factors for 2-year-old and adult stag velvet antler weight or grade, or both weight and grade. Data from 1992 and 1993 combined.



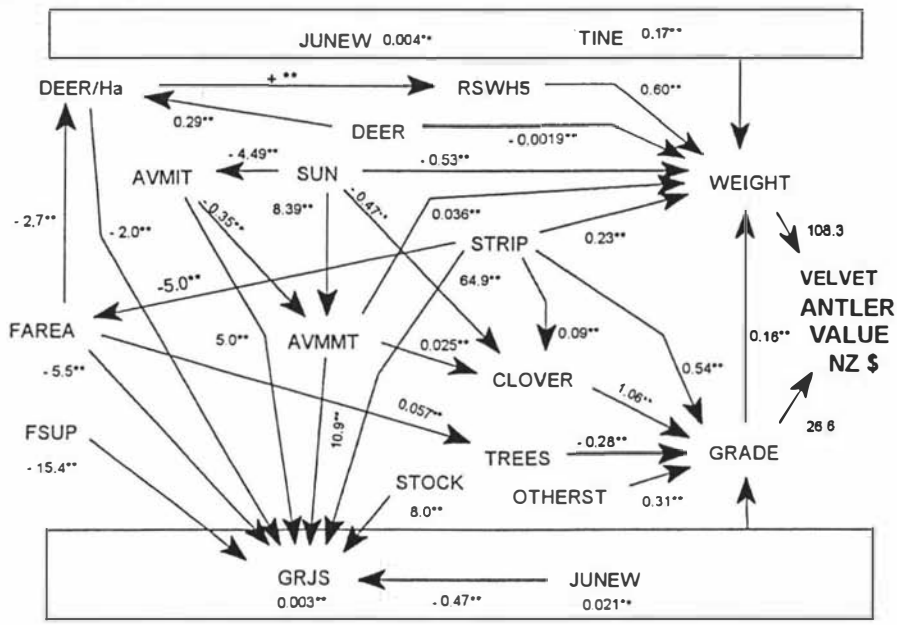
Note : Risk factor codes are described in the glossary and in Table 4.19

Figure 4.56 : Final path diagrams of winter (June 1 - Sept 1) grazing management factors for 2-year-old and adult stag velvet antler weight or grade, or both weight and grade. Data from 1992 and 1993 combined.

1. Adult stags.



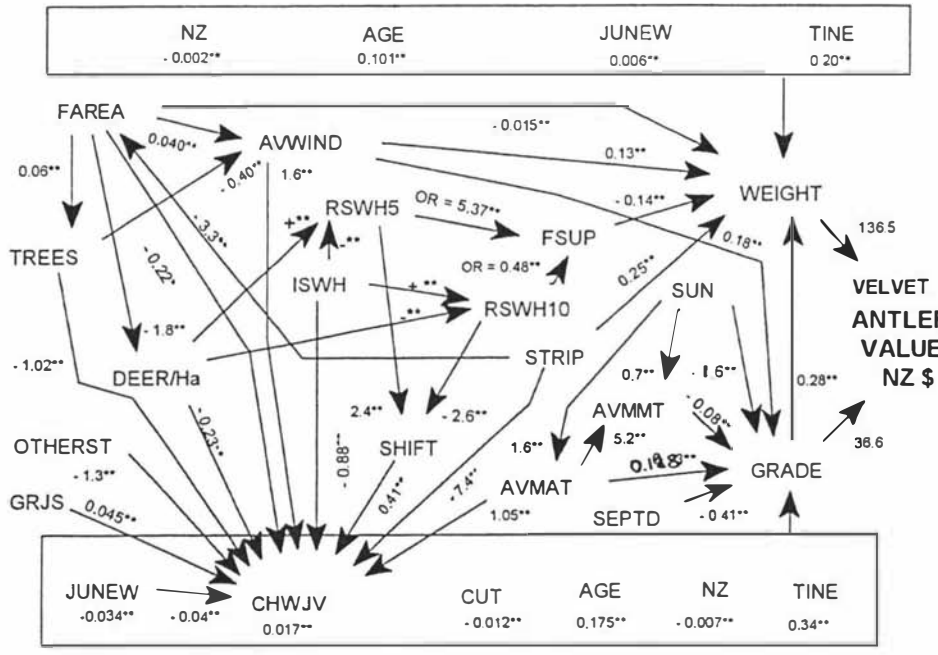
2. Two-year-old stags.



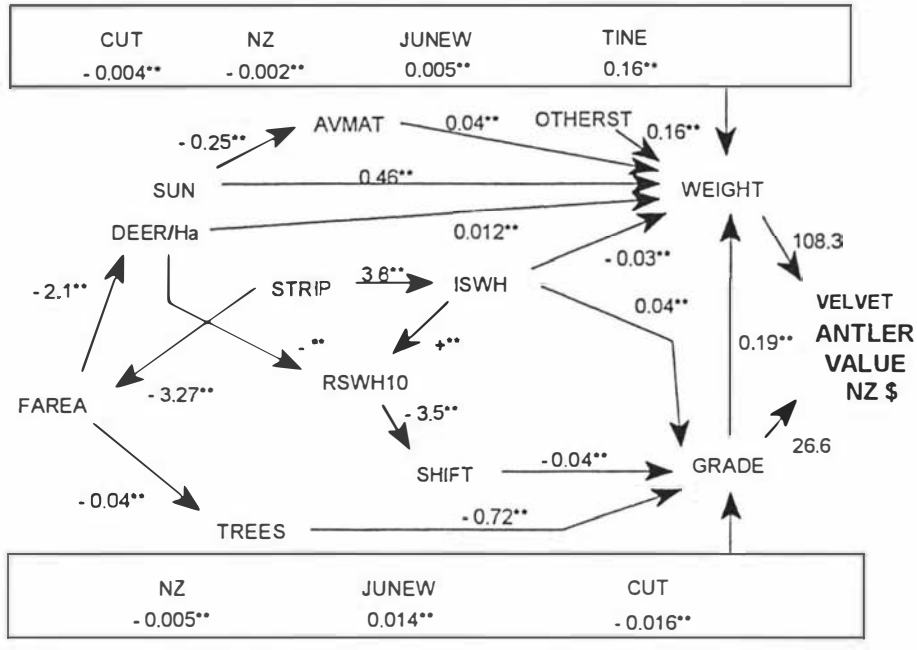
Note : Risk factor codes are described in the glossary and in Table 4.19. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentage of variability of the outcomes explained by these final models are presented in Table 4.20

Figure 4.57 : Final path diagrams of pre-velvetting (Sept 1 - time of velvet antler removal) grazing management factors for 2-year-old and adult stag velvet antler weight or grade, or both weight and grade. Data from 1992 and 1993 combined.

1. Adult stags.



2. Two-year-old stags.



Note : Risk factor codes are described in the glossary and in Table 4.19. Unstandardised regression coefficients are presented on significant paths (*p<0.05; **p<0.01). The percentage of variability of the outcomes explained by these final models are presented in Table 4.20

Table 4.21 : Regression coefficients of sampling stag characteristics and blood markers significantly associated with individual or mean farm 2-year-old and adult stag velvet anlter value (NZ$), weight (kg) or grade.

Farm visit

Velvet outcome	ADULT STAGS			2-YEAR-OLD STAGS		
Major risk factors	Regr. coef.*	SE	p value	Regr. coef.*	SE	p value
BLOCK 4 : Individual stag characteristics and blood markers						
June visit						
Stag individual characteristics	No significant markers			No significant markers		
Blood markers						
Velvet value corrected for age**	No significant markers			No significant markers		
Weight of velvet antler						
Model R square			0.39			
Intercept	1.546	0.178	0.000	No significant markers		
Stag age	0.215	0.049	0.000			
Vitamin B12 >= 185 pmol/l	-0.322	0.121	0.010			
Grade of velvet antler	No significant markers			No significant markers		
November visit						
Stag individual characteristics						
Velvet value corrected for age**	No significant markers			No significant markers		
Weight of velvet antler	No significant markers			No significant markers		
Grade of velvet antler						
Model R square			0.16			0.39
Intercept	-12.751	8.153	0.131	2.183	0.298	0.000
Girth	0.135	0.064	0.046	0.001	0.000	0.015
Blood markers						
Velvet value corrected for age**	No significant markers			No significant markers		
Weight of velvet antler	No significant markers			No significant markers		
Grade of velvet antler	No significant markers			No significant markers		
BLOCK 5 : Farm mean blood markers						
June visit						
Mean velvet value corrected for age***						
Model R square			0.24			0.25
Intercept	62.024	85.662	0.478	52.139	28.797	0.086
Mean haemoglobin concentration	11.797	4.935	0.028			
Mean serum copper concentration				4.996	2.000	0.022
Mean weight of velvet antler						
Model R square						0.22
Intercept	No significant markers			0.760	0.175	0.000
Mean serum copper				0.029	0.012	0.029
Mean grade of velvet antler						
Model R square			0.62			
Intercept	-0.187	0.954	0.847	No significant markers		
Mean age of stags	0.711	0.144	0.000			
Mean haemoglobin concentration	0.134	0.040	0.004			
November visit						
Mean velvet value corrected for age***	No significant markers			No significant markers		
Mean weight of velvet antler	No significant markers			No significant markers		
Mean grade of velvet antler	No significant markers			No significant markers		

*Regr. coef. = regression coefficient; SE = standard error

** Individual velvet antler monetary value divided by AGE (age at the start of the survey year, ie March).

*** Mean velvet antler monetary value divided by the mean AGE of the velvet herd.

4.5.3 Discussion

Both velvet antler weight (WEIGHT) and grade (GRADE) are useful criteria to evaluate stag performance, but the financial return to the farmer was considered more appropriate to investigate since it combines these two velvet measurements. The monetary value per kilogram depends on GRADE which is based essentially on the circumference of the main beam, and to a minor extent the presence of the bez tine and the overall velvet antler length. Important risk factors were those associated with an increased financial return to the farmer through WEIGHT or GRADE or both. This approach, therefore, rejected at the univariate level factors significantly increasing WEIGHT and decreasing GRADE, or *vice versa*, but with no significant effect on the financial outcome. Such factors, however, were suspected unlikely.

Velvet antler prices varied significantly between and within years. However, it was believed the averages that were used for calculation were the only appropriate measurements to compensate for seasonal fluctuations. Despite the recent change in the grading system (Anonymous, 1994b), farmers were still rewarded for quality (grade) and quantity (weight) so unless the relative differences in price between velvet grades change dramatically, the results of these study will remain valid. However, by conducting the multivariable analyses separately on WEIGHT and GRADE it was possible to identify specific risk factors, thus allowing management decisions to be made should WEIGHT or GRADE become the key criteria for selection.

Two-year-old and adult stags were investigated separately because of the known significant age effect on velvet production between them, and because they were often managed separately on the farm. Velvet weight and grade have been controlled for age in adult stags as it is an important potential confounding factor. Variables with significant positive or negative effects on both age groups at the univariate level were selected for multivariable analyses. It was suspected these factors are likely to be the most important, although the magnitude of associations may vary between 2-year-old and adult stags. It was also believed the possibility of factors being significant only by chance was minimised. Furthermore the most important factors were deemed to be those identified in both 2-year-old and adult stag final path diagrams, so this discussion is essentially focused on these factors.

4.5.3.1 Individual stag characteristics

Significant individual stag characteristics explained 24 and 43% of the variability of velvet antler GRADE, and 59 and 71% of the variability of velvet antler WEIGHT in 2-year-old and adult stags, respectively. This may highlight that individual stag characteristics may be more important in adult than in 2-year-old stags for velvet production and that other factors may be critical for 2-year-old velvet antler production.

High velvet antler weights (WEIGHT) were associated with high velvet grade (GRADE), June bodyweight (JUNEW), low percentage of New Zealand blood lines (NZ), the presence of the bez tine on at least one side (TINE) and, for adult stag, increased age (AGE). High GRADE were associated with high JUNEW and low NZ in both age group, with increased AGE, the presence of TINE and high percentage of bodyweight change between June and the time of velvet antler removal (CHWJV) in adult stags, and with high growth rates between June and September (GRJS) in 2-year-old stags. These results are consistent between 2-year-old and adult stags.

For the same JUNEW, NZ, TINE and CHWJV, there was a positive age effect on WEIGHT and GRADE. The effect of AGE on WEIGHT was about 100 g directly and 60 g indirectly through GRADE for each year older, which is less than the 260 g in total reported by Muir and Sykes (1988) between 3- and 4-year-old. AGE also had a positive indirect effect through a 4 kg increase of JUNEW per year of age. Older stags also gained more bodyweight during winter and had a higher NZ, but these latter indirect effects appeared to be of marginal magnitude. Stags with a high percentage of imported blood lines produced thicker and heavier velvet, not only because of their higher pre-winter bodyweight. All other factors considered, a 50% decrease in NZ was associated with an increase of WEIGHT by about 300 g in 2-year-old and adult stags. Since there was no significant interaction between AGE and NZ in adult stags, this effect did not appear age-dependent. It could be concluded therefore that imported blood lines are genetically superior for velvet antler production.

Each unit increase in GRADE was associated with a mean increase of 220 and 280 g of velvet in 2-year-old and adult stags, respectively. About a third of a unit of GRADE was related to TINE in adult stags, while for the same velvet grade, TINE was associated with an extra 180-200 g of velvet in both age groups. TINE therefore appeared to contribute positively to higher velvet grade and weight and thus may be used for selection of velvetting stags. It is the decision of velvet buyers as to whether presence of a bez tine is an undesirable trait or not. Further analysis (Audigé et al., publication in preparation) showed stags presenting a bez tine one year were 12 times more likely to growth a bez tine the following year. There was no significant interaction between AGE and TINE, so the effect of TINE on weight was not age-dependent.

This study further supports the strong relationship between velvet production and stag bodyweight (Moore et al., 1988b), and has further identified the relative influence of JUNEW on GRADE and WEIGHT. There was no significant interaction between AGE and JUNEW on WEIGHT and also on GRADE, so the beneficial effect of JUNEW was not age-dependent in adult stags. This observation contrasts with that of Hyvärinen et al. (1977) that allometric growth of hard antler is age-dependent. A grade unit increase was associated with an extra 40 kg and 50 kg in JUNEW in 2-year-old and adult stags, respectively, while for the same GRADE, an extra 10 kg of JUNEW was associated with a 40 and 80 g velvet antler WEIGHT increase, in 2-year-old and adult stags, respectively. This means that the effect of JUNEW in 2-year-old stags may be proportionally more important on GRADE than in adult stags. However, the total effect of a 10 kg increase of JUNEW on WEIGHT was 90 (95% confidence interval 68-112) and 133 (116-150) g velvet antler in 2-year-old and adult stags, respectively. This is very consistent with the 90 g increase of velvet weight for a 10 kg increase of liveweight recorded by Fennessy (1982) in 2-year-old stags, although bodyweights in that study were recorded pre-rut at 27 months of age. In another study, Moore et al. (1988b) recorded a 68 g increase of WEIGHT for the same change in stag bodyweight. These authors, however, reported a wide variation of effect between stags. As shown by confidence intervals, it seems that this variability is proportionately less in adult stags. The bodyweight effect was also identified in Sika deer (Zhou and Wu, 1985), with 11.4 and 26.4 g increase in velvet weight per kg increase in bodyweight for antlers with and without the bez tine, respectively, but in this study there was no significant interaction between TINE and JUNEW in both 2-year-old and adult stags, so the bodyweight effect was not related to the presence of the bez tine. There is evidence that WEIGHT increases at a faster rate than bodyweight increases (Huxley, 1931 cited by Fennessy, 1982), while a different set of data from Moore et al. (1988b) did not suggest non-linearity in this relationship in stags up to 5-year-old. This was not investigated in this study.

The pre-winter bodyweight has been chosen in this study because most farmers did not weigh their stags in March. It has been reported that antler production in Cervidae was related to body size (Clutton-Brock et al., 1980). It has been argued the frame of the stags may be more reflected by their pre-rut bodyweight, since stags are then in their best body condition (Hyvärinen et al., 1977), but this bodyweight may be affected by water retention (Fennessy, 1982). In contrast, the bodyweight in June is affected by loss of fat tissue during the rut (Drew, 1985). Therefore, it was believed JUNEW reflected both the frame and the body condition of the stag prior to winter. High JUNEW have been associated with low growth rates between June and September (GRJS) and low percentage of bodyweight change between June and the time of velvet removal (CHWJV), which may be related to the change in body condition, although 2-year-old stags may still grow at that time. Muir and Sykes (1988) identified that stags losing body condition during winter may fully recover their bodyweight by the time of velvet antler removal through compensatory growth, which has been shown in 2-year-old wapiti stags (Wairimu et al., 1992), so high GRJS and high CHWJV may have been recorded from stags which were in poor body condition in June. Further research, however, is needed to investigate the specific effect of these two components through the recording of the body condition score of the stags which was not recorded in all stags in this study.

An increase of bodyweight during winter in 2-year-old stags (GRJS) and during winter and spring in adult stags (CHWJV) appeared to positively affect WEIGHT indirectly through GRADE, which is consistent with the observations of Hyvärinen et al. (1977) that antler weights were positively related with bodyweight changes of stags during summer. This suggests nutrition during winter and spring may be important for velvet antler production. Such potential benefit may be particularly important for stags in poor body condition before winter. However, since body condition *per se* was not investigated in this study, more research is needed to verify this hypothesis. A high plane of nutrition has been associated with increased velvet weights (Muir and Sykes, 1988) and these authors suggested this effect was related to the increase of body condition. However, the positive effect of increased plane of nutrition on antler weight was debated. Poor body condition (Watson, 1971) or low plane of nutrition (Fennessy, 1981) was associated with delayed antler-casting. Although stags casting their antlers early usually produce heavier velvet antlers, casting dates may not be related to winter nutrition (Fennessy, 1981). In this study, antler casting dates could not be included in the analyses because it was not recorded on every farm, so this hypothesis could not be investigated. The benefit of advancing the casting date through nutrition was therefore questioned (Fennessy, 1981) and according to the literature did not appear an important factor to consider.

4.5.3.2 Grazing management factors

Significant grazing management factors in final models explained between 2.5 and 17.5% of the variability in WEIGHT or GRADE as detailed in Table 4.22.

For the first time grazing management and environmental factors were investigated as risk factors for velvet production and financial return along with individual stag characteristics. It was essential to include major individual stag risk factors in these analyses as they explained a large proportion of the variability of WEIGHT and GRADE (Table 4.20), and they may otherwise be significant confounding factors. Apart from anecdotal nutrition trials already mentioned in this discussion, there is no published work on environmental factors affecting velvet antler production, so interpretations here are only suggestive of plausible explanations.

Table 4.22 : Part of the variability (multiple r^2) in velvet weight (WEIGHT) and grade (GRADE) explained by winter and pre-velvetting grazing management risk factors after individual stag characteristics have been taken into account.

	Winter grazing management		Pre-velvetting grazing management	
	WEIGHT	GRADE	WEIGHT	GRADE
Adult stags	4.5	2.9	2.5	3.7
Two-year-old stags	12.7	17.5	7.2	6.6

4.5.3.2.1 Winter grazing management

All individual stag characteristics selected by univariate analyses except NZ remained significant in final diagrams (Figure 4.56) with only marginal variations in the magnitude of regression coefficients. It is interesting to note that winter grazing management factors appeared to contribute more to the variability of WEIGHT and GRADE in 2-year-old stags than in adult stags (Table 4.20 and Table 4.22), which may indicate that management factors during winter may be more important for optimum velvet production in 2-year-old stags than in adult stags. Improved feeding during velvet growth may not increase velvet production in adult stags (Fennessy, 1981; Muir and Sykes, 1988). In 1.5-year-old white-tailed bucks, low dietary energy and proteins were associated with reduced velvet production, and there is evidence that adequate supply of these nutritients may be particularly important in the month before the start of antler growth (Ullrey, 1982).

That NZ was negatively associated with GRADE only in adult stags in this analysis (Figure 4.56a) may indicate its beneficial effects identified in the analysis of individual stag characteristics may not be important. The relative importance of NZ and significant winter management factors, however, will need to be further investigated as these factors were apparently confounded in these analyses.

The most important management factors appeared to be nutritional. Strip grazing (STRIP) was associated with higher WEIGHT in adult stags, and with higher WEIGHT and GRADE in 2-year-old stags. Furthermore, it was positively associated with the winter growth rates (GRJS) of 2-year-old stags and with the mean clover score (SCORE) of the swards, which in turn was positively associated with GRADE for 2-year-old stags. These observations are consistent with risk factors for weaner growth (see section 4.4), and emphasised the need for quality pasture to improve performance. CLOVER appeared to have a strong positive effect on GRADE, although the clover score only ranged from 1 to 1.7 in this study. This is expected in winter when clover does not grow much, but may be a good indicator of quality. Farmers that use strip grazing may have more efficiently controlled the pasture supply with regard to energy requirements. The positive effect of grazing swards below 5 cm on WEIGHT in 2-year-old stags was not expected since feed intake by deer is low at this pasture height (Ataja et al., 1992). It must be noted, in this study, that the mean residual pasture sward height was always below 5 cm when 2-year-old stags trip grazed, whereas there was no significant association between STRIP and RSWH5 in adult stags. In this latter age group, RSWH5 was positively associated with the distribution of food supplementation (FSUP) which in turn had a significant negative effect on WEIGHT and GRADE. Therefore, it was believed the positive effect of RSWH5 in 2-year-old stags may be related to that of STRIP and that the negative effect of FSUP in adult stags may actually be related to short grazing conditions. This suggests that despite supplements, the deer were still fed poorer than others on high pasture alone. In 2-year-old stags, although there was no statistical association between RSWH5 and FSUP, it was

believed the negative effect of FSUP on GRJS may be because food supplementation was insufficient where needed. In this study farmers did not go through a feed budgeting exercise before winter. More research needs to be done to evaluate whether the level of supplementation affects WEIGHT or GRADE in supplemented stags, and whether supplementation in the presence of RSWH10 would result in improved velvet antler production.

There was an overall positive effect of warm weather patterns on velvet production of 2-year-old stags, as monitored by the mean daily sunshine score (SUN), the mean daily minimum temperature (AVMIT) and the mean daily temperature range (AVMMT). The effect was either directly on WEIGHT or indirectly on GRADE through CLOVER and GRJS, which can be related to the observations of Watson (1971). A positive effect of low AVMIT (observed with high SUN) was observed on WEIGHT in adult stags. However there was a negative effect of SUN *per se* on WEIGHT in 2-year-old stags after accounting for temperature differences between farms, which could not be explained.

As identified in section 3.1.2.1 , the mean tree score (TREES) increased with the mean paddock size (FAREA) in both analyses and FAREA was also positively associated with the mean paddock topography score (TOPO) of paddocks where adult stags grazed, which contributed positively to the overall mean paddock shelter score (SHELT). In 2-year-old stags, the negative influence of FAREA on GRJS may be partly related to strip grazing as FAREA was reduced by 5 ha under strip grazing, but also to other paddock characteristics such as gullies (which increase TOPO and SHELT). The significant negative influence of SHELT and TREES on GRADE in adult and 2-year-old stags, respectively, is intriguing and will need to be investigated further through the refinement of shelter variables. The negative influence of TREES has also been observed on weaner growth during winter (see section 4.4).

FAREA was also negatively associated with the mean grazing density of stags (DEER/Ha) which had a negative effect on WEIGHT in adult stags. It was not known whether the grazing density *per se* or the average mob size (DEER) was important, as DEER appeared to adversely affect WEIGHT in 2-year-old stags. The apparent negative effect of high DEER/Ha was also partly mediated through grazing swards below 5 cm and food supplementation.

The effects of changing the mob composition (STOCK) or grazing with livestock species other than deer (OTHERST) are inconsistent between 2-year-old and adult stags, and thus may be of little significance for velvet production.

4.5.3.2.2 Spring grazing management

Considering multiple r^2, spring management variables did not appear to contribute largely to WEIGHT or GRADE either in 2-year-old or adult stags (Table 4.22), although multiple-partial F were significant. Pre-velvetting grazing management factors, however, appear more important in 2-year-old stags than in adult stags.

The number of days between September 1 and the date of velvet antler harvesting (CUT) has been included in the analyses because grazing management factors were calculated for each stag between these two dates, thus CUT may be a confounding factor in the analyses (Figure 4.57). For instance, it was logically expected that the mean daily maximum temperature, which is a calculated variable for each stag between September 1 and the time of velvet antler removal, would increase as the date of cutting is delayed through summer. No attempts were made in these analyses to explain how

CUT relates to individual stag characteristics, as it will be the purpose of separate analyses not included in this thesis. Preliminary analyses, however, showed CUT was negatively associated with JUNEW, GRADE and NZ separately in 2-year-old and adult stags, and also with AGE in adult stags (Audigé et al., publication in preparation). CUT was also negatively associated with WEIGHT in 2-year-old stags, but not with WEIGHT in adult stags after accounting for AGE, JUNEW, NZ, and TINE. In this analysis, the non-significance of GRJS in 2-year-old stags suggests CUT, may be related to winter growth rates and thus nutrition. Therefore it is hypothesised that improved nutrition of 2-year-old stags during winter may improve GRADE and advance the date of velvet antler removal.

Strip grazing (STRIP) was identified has positively associated with WEIGHT in adult stags, but it may actually be the same association as that identified within winter management practices. In this study, stags which strip grazed after September, also did during winter. However, STRIP appeared to be important relative to other spring grazing management risk factors in adult stags, but not in 2-year-old stags. STRIP was also associated with low mean paddock size (FAREA), and consequently higher mean grazing densities (DEER/Ha). Therefore it is suggested the apparent beneficial effect of DEER/Ha in 2-year-old stags may actually be related to strip grazing. It must be noted that the mean residual pasture sward height was always below 10 cm and more likely to be below 5 cm due to increased DEER/Ha, so the differentiation of specific effects between strip grazing, sward heights, grazing densities *per se* is difficult.

In these analyses, however, high pre-grazing sward heights (ISWH) and residual sward height over 10 cm (RSWH10) appeared to have inconsistent effects on velvet WEIGHT and GRADE between 2-year-old and adult stags. ISWH and RSWH10 appeared to influence GRADE negatively in adult stags through their bodyweight change (CHWJV), but positively in 2-year-old stags. Stags were more often shifted between paddocks (SHIFT) when the residual pasture sward height was below 10 cm. In contrast, ISWH and RSWH10 appeared to influence WEIGHT negatively in adult stags and positively in 2-year-old stags. It is suspected the negative effect of food supplementation (FSUP) on WEIGHT in adult stags, may actually be related to short grazing conditions, as adult stags grazing swards below 5 cm were more likely, and those grazing over 10 cm were less likely, to be food supplemented. These inconsistencies suggest grazing conditions recorded in this study may not have had a strong influence on velvet production. The total effect of ISWH on WEIGHT in 2-year-old stags, evaluated by withdrawing GRADE from the model, was not statistically significant.

There are no easy explanations of the negative effect of the presence of trees (TREES) on GRADE in 2-year-old stags and on both WEIGHT and GRADE through the paddock wind exposure index (AVWIND) in adult stags. TREES was also negatively associated with the percentage of bodyweight change between June and velvet antler removal (CHWJV). It was not known why paddocks exposed to wind were positively associated with increase velvet financial return in adult stags, although it may be related to the negative effect of specific shelter variables such as gullies for reasons not related to their potential effect as a wind break. It is intriguing that TREES recorded in winter or spring was consistently negatively associated with velvet production in both age groups, and this suggests more research needs to be done on this matter. It was not clearly known either why grazing with other domestic livestock had a positive effect for 2-year-old stags and a negative effect for adult stags. Perhaps these associations are spurious.

There was a consistent positive effect of high mean daily maximum temperature (AVMAT), but the effect of the mean sunshine score (SUN) was not consistent. Furthermore the magnitude of the

regression coefficient between SUN and GRADE in adult stags (Figure 4.57a) was not credible and suggests SUN may be statistically associated with other negative factors. The total effect of SUN on WEIGHT in 2-year-old stags was not significant.

The negative direct effect of a treatment with anthelmintic carried out in September (SEPTD) on GRADE was believed to be purely coincidental and related to other factors not identified in this analyses.

4.5.3.3 Sentinel stag characteristics and blood markers

This study failed to identify significant relationships between body height at shoulder (SIZE), thoracic girth (GIRTH), body condition score (BCS), coat length (COAT) and teeth wear (TEETH) on velvet WEIGHT or GRADE of 2-year-old and adult stags after correcting for age. It must be remembered a number of missing data were replaced by their respective mean value for the purpose of multivariable analyses (see section 2.7.2). SIZE and GIRTH were recorded from about a third of sentinel stags, so the number of observations was limited. Furthermore, pre-winter BCS in stags were often recorded while stags were in the crush system at sampling, which may have changed the scaling and subjective assessment by the researcher compared with stags standing quietly in a pen.

To the author's knowledge, this was the first attempt at investigating the effect of pre-winter BCS on velvet production. Despite the above limitation in the scoring technique used in adult stags, it is suggested pre-winter BCS *per se* may not have had a strong influence on velvet production on survey farms, providing stags recovered their bodyweight (thus body condition) by the time of velvet antler removal, as indicated by the positive influence of CHWJV and GRJS. It may be worth investigating further, however, the relative effects of pre-winter BCS and subsequent body condition change by the time of velvet removal on velvet production to allow a more conclusive outlook of the potential benefit of improved nutrition during winter and spring on velvet financial return.

There was a positive relationship between the thoracic girth of 2-year-old and adult stags in November and the grade of the velvet antler they produced. The relationship in 2-year-old stags is weak (Figure 4.58). From the small number of observations available (Appendix 4.33), however, this relationship appeared marked in adult stags.

No individual blood markers appeared significantly associated with velvet grade and weight, as the negative effect of serum vitamin B12 recorded in June being over 185 pmol/l (B12185) was observed only on the velvet grade of adult stags, and thus was considered of limited significance. In contrast, there was a positive relationship between mean haemoglobin (MHB), packed cell volume (MPCV) and serum copper concentrations (MCU) and mean velvet antler values (VELV$) of 2-year-old and adult stags (corrected for age)(Figure 4.59). MCU and MHB were highly significantly correlated with MPCV as shown in Table 4.23, which explains the variety of associations observed in Table 4.21. MCU was positively associated with mean velvet antler weight in 2-year-old stags, while MHB was positively associated with mean velvet grade in adult stags, but this may be related to the same subclinical/nutritional condition.

Figure 4.58 : Relationship between the thoracic girth (cm) of 2-year-old and adult stags recorded in November and the grade of the velvet antler they produced.

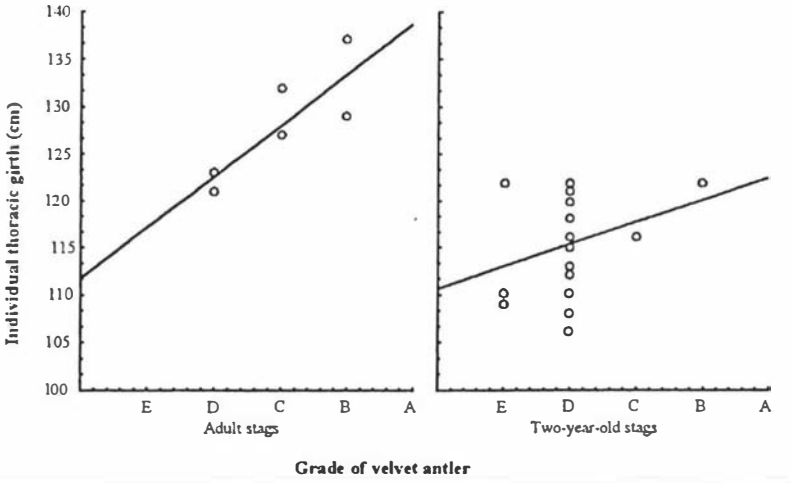


Table 4.23 : Correlation coefficients between farm mean haemoglobin concentration (MHB), mean packed cell volume (MPCV) and mean serum copper concentration (MCU) from 10 stags per farm sampled in June[1].

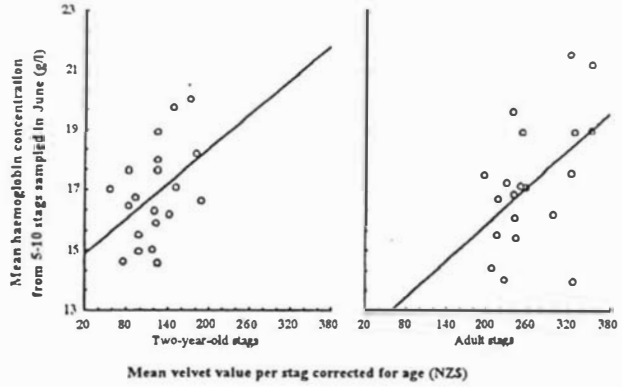
	Adult stags n=20		2-year-old stags n=21	
	Cu	Hb	Cu	Hb
Hb	0.34 p=0.145		0.12 p=0.606	
PCV	0.60 p=0.005	0.61 p=.004	0.60 p=0.004	0.74 p=0.000

[1] Five 2-year-old stags and 5 adult stags were selected. MHB and MPCV were obtained by averaging the 10 values as there were no age differences, while MCU was calculated separately for 2-year-old and adult stags because of age differences. n = number of farm-years

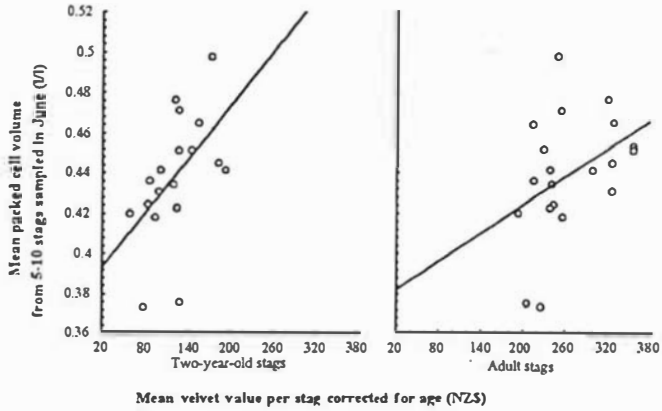
The diet of stags, therefore, appears to be important for optimum velvet production, in particular with regard to copper status and haematological characteristics. These results are consistent with the clinical case investigated by McHugh (1992), who suggested copper deficiency and anaemia may be responsible for low velvet production. The apparent non significance of serum vitamin B12 concentrations in this study is consistent with the failure of McHugh (1992) to show a velvet production response to vitamin B12 supplementation. This suggests MCU, MHB and MPCV can be useful in monitoring the nutritional condition of herds of stags with regard to velvet production. That only blood markers recorded in June were significant may be due to the limited number of farms investigated in November, or because the nutritional status of stags prior to winter is more critical than during antler growth in spring. The analyses of grazing management factors supports this latter hypothesis. From a practical point of view, however, it may allow farmers to correct the diet or treat the stags early enough to avoid production losses.

Figure 4.59 : : Relationships between farm mean haemoglobin (a), packed cell volume (b) and serum copper (c) concentrations with mean velvet antler values (NZ$) of 2-year-old and adult stags (corrected for age in adults) obtained on each survey farm. Data from 1992 and 1993 combined.

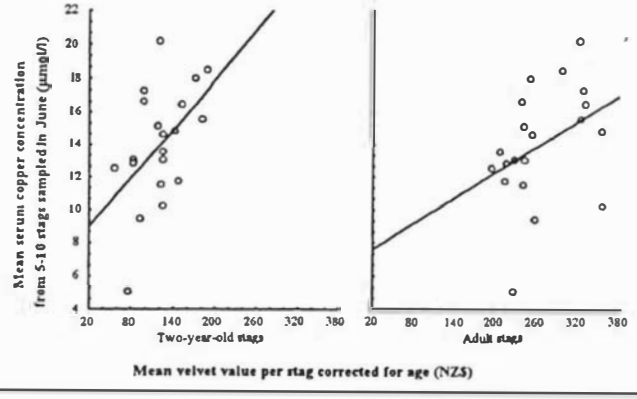
a. Mean haemoglobin concentration (g/l)



b. Mean packed cell volume (l/l)



c. Mean serum copper concentration (µmol/l)



There was no evidence that other blood markers were also associated with velvet production. In particular, this study supports the observation of Grasman and Hellgren (1993) that phosphorus may not be a limiting factor for velvet production. Hyvärinen et al. (1977) and Ullrey (1982) suspected it would, considering the requirement of this mineral for velvet growth, but stags fed on low P diet compensate by physiological adaptation (Grasman and Hellgren, 1993).

4.5.3.4 Conclusion

Individual stag characteristics appear to be the most important factors influencing velvet production. The associations between these characteristics and velvet weight were consistent with other published work, thus they are likely to be causal. This consistency helps validate the technique used in this thesis to study grazing management risk factors that were investigated for the first time (and other outcomes in this section).

This data suggests that high velvet returns can be achieved by :

- Keeping stags to old ages.
- High pre-winter bodyweight. Should stags be too fat for slaughter prior to the rut, farmers can wait until early winter and select their stags from their bodyweight.
- Increased bodyweight during winter and spring.
- Imported blood lines.
- The presence of a bez tine.

In contrast to individual stag characteristics, the final diagrams of grazing management factors (Figure 4.56 and Figure 4.57) show the complexity between potential risk factors and the difficulties that arise in drawing conclusions in the absence of previous experimental or anecdotal evidence. Therefore the following conclusions are only suggestive and must be substantiated by further research before any inference on causality can be made.

Considering the consistency of association of individual stag characteristics with velvet production, there was a lot of confidence in the ability of the technique to identify important factors, should they exist and be analysed. Nutritional factors appeared to be more important during winter than during spring, and to be more important for 2-year-old stags (in particular winter nutrition) than for adult stags. The relative effects of many factors (ie strip grazing, sward heights, mob size and grazing density) could not be distinguished. It may be that optimum nutrition of 2-year-old stags will advance their harvesting date and thus allow them to graze spring pasture during the peak of velvet growth. However, to improve velvet production it is suggested farmers :

- Feed budget prior to winter.
- Have their stags graze swards no shorter than 10 cm in winter, or if so, they should give them adequate food supplementation.
- Strip graze stags in winter.

- Increase the proportion of clover in pastures.

- Minimise mob sizes and grazing densities. It is the researcher's advice mob sizes should be kept below 70 stags and grazing densities below 25 stags/ha during winter, which are the mean values recorded in this thesis.

- Prefer medium to small paddocks with a limited number of trees.

Furthermore, serum copper, haemoglobin and packed cell volume should be routinely monitored during the course of a herd health programme, and copper supplemented where deficient.

4.5.3.5 Identified areas for further research

This section has highlighted areas which deserve priority in research and development designed to improve velvet production management techniques.

It is appropriate to investigate :

- The relative influence of pre-winter bodyweight, pre-winter body condition score and their change by the time of velvet antler removal on velvet antler grade and weight.

- The effect of food supplementation on velvet production of stags grazing at different sward heights during winter and spring.

- The potential beneficial effect of reducing mob sizes and grazing densities below 70 and 25 stags/ha, respectively.

- The apparent negative effect of trees and large paddocks.

- Serum copper, haemoglobin and packed cell volume in the context of nutritional research for velvet antler production.

4.6 RISK FACTORS FOR HEALTH PROBLEMS

4.6.1 Risk factors for yersiniosis

Mortality of weaner deer to 15 months of age has been identified as one major factor affecting the productivity of red deer farms (see section 3.3.4.1.1). Most weaner deaths occurred during autumn and winter, and were essentially related to outbreaks caused by yersiniosis (18.6% of mortalities). Although the cause of a large proportion of deaths (59.6%) could not be or were not confirmed by post-mortem examination or laboratory investigations, clinical reports for many of these deaths suggested yersiniosis was the likely causative factor. Therefore it was worth investigating risk factors potentially associated with this health problem. Other causes of death were not frequent enough to allow risk factor analysis.

This section presents risk factors for the occurrence of weaner death, confirmed or suspected to be due to yersiniosis, the disease associated with *Yersinia pseudotuberculosis*.

4.6.1.1 Materials and methods

For each of the two years of study, about 1400 weaners were monitored for growth and health problems. Where possible, post-mortem examinations and laboratory investigations were carried out to identify the most likely cause of death. All weaners that died in association with at least one confirmed or suspected case of yersiniosis were classified as dying from yersiniosis (YER). Weaners that died from other identified causes such as misadventure, osteochondrosis, malignant catarrhal fever or malformation were included in the analyses as other apparently healthy weaners. No attempts were made to investigate their clinical conditions as individual weaner risk factors for yersiniosis.

Risk factors potentially associated with yersiniosis in weaner deer were identified and grouped per area of data collection as described in Table 4.24. Weaner individual characteristics grouped in block 1 were analysed at the individual animal level. Grazing management, environmental factors and other factors related to handling and disease control, that were calculated between April 1 and June 1, are grouped in block 2. Because the indentity of individuals was not always consistently recorded, the risk factors in this latter block were analysed at the mob level. The outcome for this analysis, therefore, was whether mobs experienced at least one death associated with YER (MYER)

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in section 2.7. Because of the limited number of mobs in the study, however, the Chi-square test was replaced by the Fisher exact test for the univariate screening of block 2 at the mob level.

- Data from both years of study were combined for statistical analyses.
- Weaner hind and stag data were analysed together.
- Weaners that were preventively vaccinated against yersiniosis with the vaccine Yersiniavax were not included in the analyses.
- Statistical analyses were carried out using SAS.

Table 4.24 : Potential risk factors for weaners dying from yersiniosis.

Risk factor code	Unit	Description
BLOCK 1 : Individual weaner characteristics		
NZ	%	Estimated percentage of New Zealand blood lines
WAP	%	Estimated percentage of wapiti (or elk) blood lines
HIND	D	Weaner hind (ie sex = female)
Specific risk factors for the occurrence of yersiniosis after April 1		
W4	kg	Bodyweight standardised to April 1
PERCW4	%	Percentile of W4 within mobs on April 1
MAXW4	kg	Difference W4- maximum W4 within mobs on April 1
Bodyweight analysis		
W40	D	Bodyweight standardised to April 1 below 40 kg
W50	D	Bodyweight standardised to April 1 between 40 and 50 kg
Specific risk factors for the occurrence of yersiniosis after June 1		
W6	kg	Bodyweight standardised to June 1
PERCW6	%	Percentile of W6 within mobs on July 1
MAXW6	kg	Difference W6- maximum W6 within mobs on July 1
GR46	g/d	Growth rate between April 1 and June 1
GR46<0	D	Weaner losing bodyweight between April 1 and June 1
BLOCK 2 : Management practices and environmental factors between April 1 and June 1		
MW4	kg	Mean weaner bodyweight on April 1within mobs
MNZ	%	Mean percentage of New Zealand blood lines within mobs
Grazing management		
ISWH	cm	Mean pre-grazing pasture sward height
RSWH10	D	Mean residual (ie post-grazing) pasture sward height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
PASTT	Score 1-3	Mean pasture type score
RAG	Score 0-3	Mean paddock ragwort score (calculated from observations during farm visits)
THISTLE	Score 0-3	Mean paddock thistle score (calculated from observations during farm visits)
STOCK		Number of times the mob composition was changed
SHIFT		Number of times deer were shifted between paddocks
DEER		Average number of deer in the mob
MJME/Ha	MJME/ha	Mean mob daily energy requirements per grazed hectare (effective paddock area)
OTHERST	D	Paddocks shared with stock other than deer at least one day
ODEER	D	Weaners grazing with deer over 15 months old
M%WS	%	Mean percentage of weaner stags in the weaner mob
FSUP	D	Food supplementation of deer
STRIP	D	Strip grazing weaners at least in one paddock before June 1
Environmental variables		
FAREA	ha	Mean paddock size (deer-fenced area)
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt
Handling and disease control		
NANTH		Number of anthelmintic treatments by June 1
YARDED		Number of times weaners were yarded by June 1
WEAN	day	Number of days between January 1 and weaning

Note on units : D = Dichotomous variable : Yes=1 ; No=0
"Score 0-1" means "Score ranging from 0 to 1"

- Path analysis was only used for the analysis of block 1 and block 2.

Path diagrams were formulated within each block (steps 1 to 3 in Table 4.1), which were analysed separately. Individual weaner characteristics (block 1) were investigated in two separate analyses at the individual deer level. The first analysis (step 1) included all weaners that were present on farms on April 1 and bodyweight variables on April 1 were investigated as risk factors for YER after April 1 (YER4). The second analysis (step 2) included all weaners that were present on farms on June 1 and bodyweight variables on June 1 were investigated as risk factors for YER after June 1 (YER6). All weaners dying from YER were included, but it should be noted that no weaner died after August 8. No attempts were made to correct for removal of weaners from survey farms, nor to evaluate the potential bias associated with it. Moreover, it was suspected the relationship between the growth rate of weaners between April 1 and June 1 (GR46) and the probability of yersiniosis was not likely to be linear, so GR46 was arbitrarily categorised as being positive or negative (GR46<0). Environmental and grazing management variables, and some weaning and disease control variables were analysed at the mob level (step 3). The mean values of significant individual weaner characteristics on April 1 (MNZ and MW4) were included in this analysis, since they may otherwise be important confounding factors.

- Categorised weaner bodyweight variables were analysed separately without the use of path analysis. In the analysis of individual weaner characteristics (step 1), the weaner bodyweight on April 1 (W4) has been included as a continuous variable. To explore the possibility of a threshold bodyweight under which weaners would be more likely to experience clinical yersiniosis, W4 was transformed to several categorical variables as described in Table 4.24 and included together in a multivariable logistic regression analysis.

For each final model, the deviance was reported as a goodness of fit statistic. The proportionate reduction in deviance observed when including significant risk factors in the model compared with an intercept-only model is interpreted as the proportion of variance in the data "explained" by the variables included in the model (Frome and Checkoway, 1985).

4.6.1.2 Results

Summary statistics of continuous risk factors screened for association with the occurrence of yersiniosis in a preliminary univariate analysis, and rank sum test p value are presented in Appendix 4.35. Chi-square test and Fisher exact test p values and unadjusted odds ratios of dichotomous risk factors for the occurrence of yersiniosis in individual weaner or mobs of weaners are presented in Appendix 4.36.

Null hypothesis and final path diagrams for weaner individual risk factors for the occurrence of YER after April 1 and after June 1 are presented in Figure 4.60 and Figure 4.61, respectively. Null hypothesis and final path diagrams for grazing management factors controlled for significant individual weaner risk factors are presented in Figure 4.62. Logistic regression coefficients estimates and adjusted odds ratios of model components, and model deviance are presented in Table 4.25.

The lighter the weaners on April 1, the more likely they were to die from YER after April 1. The analysis of categorical bodyweight variables shows weaners below 40 kg and between 40 and 50 kg on April 1 were 4.2 and 2.7 times more likely to die from YER than heavier weaners, respectively. The lighter the weaners on June 1, the more likely they were to die from YER after June 1, and

weaners that lost bodyweight between April 1 and June 1 were 25 times more likely to die from YER after June 1. The higher the percentage of New Zealand blood lines in weaners, the less likely weaners were to die from YER after April 1 after controlling for W4, but the more likely they were to die from YER after June 1 after controlling for W6 and GR46<0.

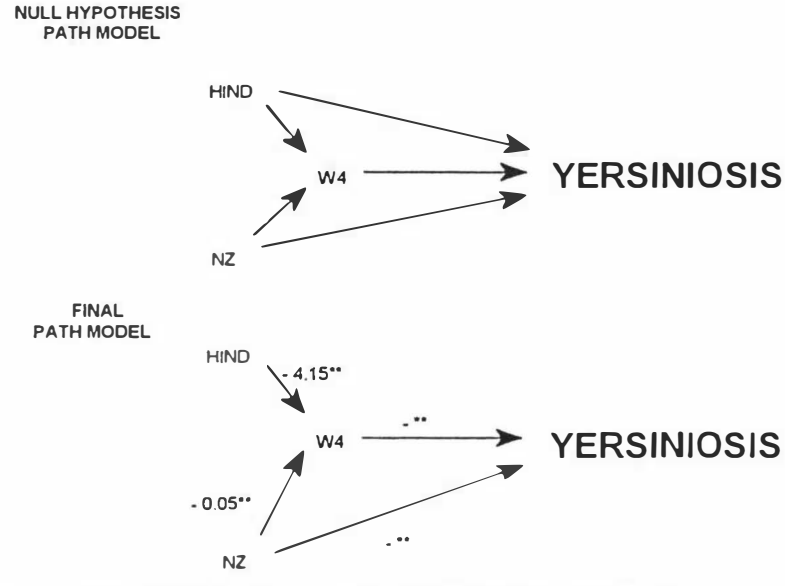
The higher the mean daily minimum temperature, the more likely the mob experienced YER after April 1.

4.6.1.3 Discussion

In this study, yersiniosis was not observed in weaners that were preventively vaccinated with Yersiniavax. Therefore, they were rejected from the analysis as they were not at the same risk of being affected by yersiniosis as non-vaccinated weaners. Weaners that were vaccinated in response to clinical problems (see Appendix 3.61), however, were included, although it is acknowledged that this would have altered the risk of dying from yersiniosis to those animals or mobs after vaccination.

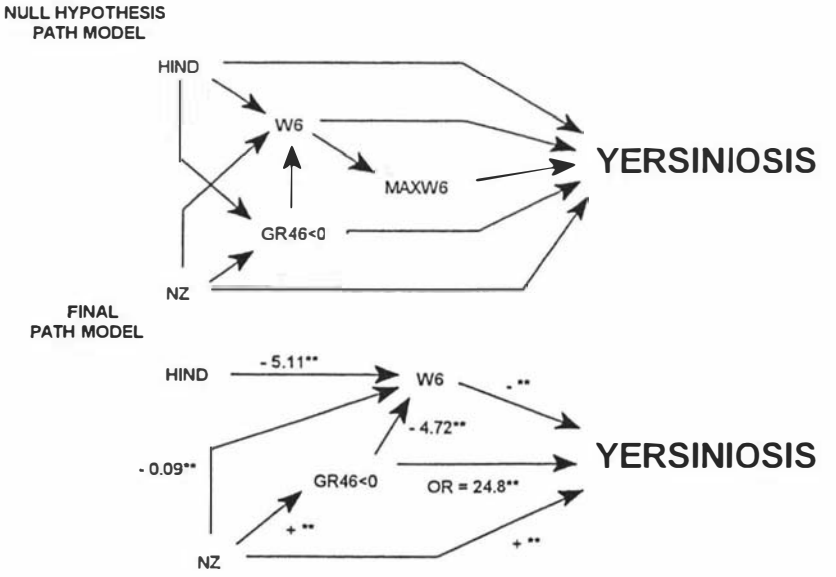
In this investigation, suspected occurrences of yersiniosis from clinical records (clinical examination with or without post-mortem examination) were classified as being caused by *Yersinia pseudotuberculosis (Y.pstb)*. Yersiniosis is a common disease in weaners and is associated with a mild to severe haemorrhagic enteritis and often weaners affected by *Y.pstb* are found dead in paddocks (Beatson 1984). Other agents such as *Salmonella sp* can cause enteritis ressembling yersiniosis in weaners (McAllum et al., 1978; Gill, 1983), but it is quite rare (Henderson and Hemmingsen, 1983). Leptospirosis also can cause mortality outbreaks in weaners but clinical symptoms and post-mortem lesions differ (Fairley, 1984; Fairley et al., 1986) from those of yersiniosis.

Figure 4.60 : Null hypothesis and final path diagrams of risk factors for the occurrence of yersiniosis in individual weaners after April 1.



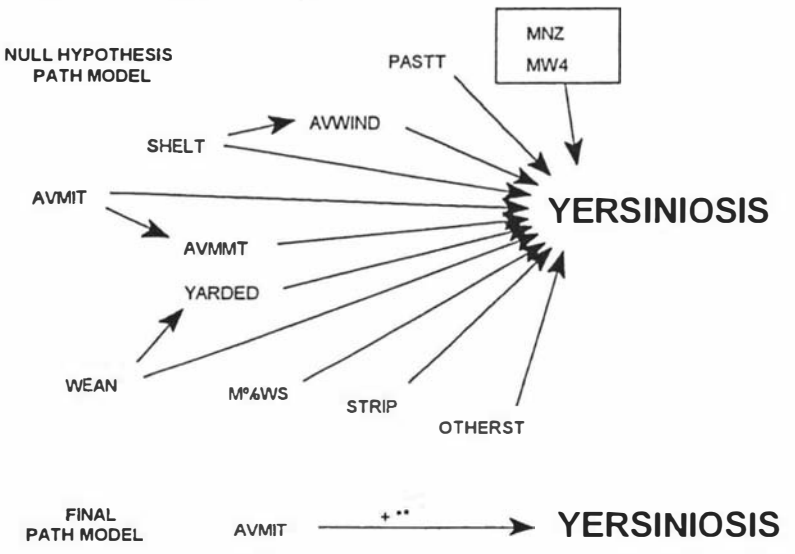
Note : Risk factor codes are described in the glossary and in Table 4.24. Unstandardised linear regression coefficients or the sign of logistic regression coefficient are presented on statistically significant paths (*p<0.05; **p<0.01). The percentage of variability of the outcome explained by this final model is 6.14%.

Figure 4.61 : Null hypothesis and final path diagrams of risk factors for the occurrence of yersiniosis in individual weaners after June 1.



Note : Risk factor codes are described in the glossary. Unstandardised linear regression coefficients or the sign of logistic regression coefficient are presented on statistically significant paths (*p<0.05; **p<0.01). The percentage of variability of the outcome explained by this final model is 16.51%.

Figure 4.62 : Null hypothesis and final path diagrams of risk factors for the occurrence of yersiniosis in weaner mobs after April 1.



Note : Risk factor codes are described in the glossary and in Table 4.24. The sign of the logistic regression coefficient is presented on the statistically significant path (**p<0.01). The percentage of variability of the outcome explained by this final model is 34.55%

Table 4.25 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of risk factors predicting the probability of weaners or mobs of weaners to be affected by yersiniosis.

BLOCK 1 : Weaner characteristics on April 1

Total number of weaners included in the analysis : 2683
Number of weaners dying from confirmed or suspected Yersiniosis = 26

			Deviance		
			Intercept	Model	% of variability explained
			292.85	274.87	6.14
Risk factors*	Coefficient estimates	Std error	p value		
NZ	-0.027	0.01	0.000		
W4	-0.078	0.03	0.002		

Bodyweight variables

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
NZ	-0.025	0.01	0.000		
W40	1.446	0.59	0.015	4.25	1.33 13.57
W50	1.008	0.52	0.054	2.74	0.98 7.65

BLOCK 1 : Weaner characteristics on June 1

Total number of weaners included in the analysis : 2134
Number of weaners dying from confirmed or suspected Yersiniosis = 23

Analysis with autumn growth rate as a continuous variable

			Deviance		
			Intercept	Model	% of variability explained
			261.16	229.58	12.09
Risk factors*	Coefficient estimates	Std error	p value		
NZ	-0.037	0.01	0.000		
W6	-0.067	0.03	0.019		
GR46	-0.015	0.00	0.002		

Analysis with autumn growth rate as a categorical variable GR46<0

			Deviance		
			Intercept	Model	% of variability explained
			254.14	212.19	16.51
Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
NZ	-0.034	0.01	0.000		
W6	-0.067	0.03	0.013		
GR46<0	3.211	0.57	0.000	24.81	8.10 76.00

BLOCK 2 : Mob analysis

Management practices and environmental factors (April 1- June 1)

Total number of mobs included in the analysis : 38
Number of mobs with weaners dying from confirmed or suspected Yersiniosis = 8

			Deviance		
			Intercept	Model	% of variability explained
			37.10	24.28	34.55
Risk factor*	Coefficient estimate	Std error	p value		
AVMIT	1.426	0.51	0.005		

* Risk factor codes are described in the glossary and Table 4.24.
Std error = standard error; OR = odds ratio; 95%CI = 95% confidence interval
Note : Intercept = deviance of an intercept only model; Model = deviance of the model
% variability explained = (Model - Intercept) x 100 / Intercept

The analysis of individual weaner characteristics was difficult and subject to many potential bias one should be aware of before interpreting results. Weaners were considered at risk of dying from yersiniosis if they were present on farms on April 1 (or June 1 depending on the analysis), but a limited number of weaners left the properties sold alive or for slaughter during autumn or winter. Furthermore, as sick deer are presumed to be a major source of *Y.pstb* and contaminate the environment, apparently healthy weaners grazing with affected deer are thought to be more at risk of severe infection due to heavy challenge.

It has been noted that some deer farms have a higher rate of weaners shedding *Y.pstb* from the faeces than other farms (Henderson and Hemmingsen, 1983; Hodges et al., 1984), probably because of increased secretion by diseased deer, although it may also depend on the timing of sampling with regard to the spread of infection within weaner mobs. The analysis of data was further complicated by management practices such as separating diseased weaners from the rest of the mob, which is thought to reduce the risk of apparently healthy weaners of getting infected (Mackintosh, 1984).

Diseased animals not dying from YER were not included in this analysis, as they were identified on only 4 farms (see Appendix 3.61). It was possible, however, they may have died, were they not treated with antibiotics, as the diarrhoea most often causes dehydratation, recumbency and death (Beatson, 1984). Further, treatment of the mob with antibiotics and vaccination with Yersiniavax after initiation of clinical occurrence in 1993 on three farms may have saved some weaners from death.

It was therefore suspected the number of weaners susceptible to death from yersiniosis in this study was underestimated, and consequently, the strengh of the significant associations indentified at the individual level may be underestimated (Rumeau-Rouquette et al., 1989). To avoid this potential bias, grazing management practices and environmental conditions were investigated at the mob level as risk factors for the occurrence of at least one mortality associated with or likely to be yersiniosis.

The lower the weaner weight on April 1 and on June 1, the higher the risk of yersiniosis, which supports the common belief from clinical observations (Wilson, personal communication) that small weaners are more susceptible to yersiniosis. Blaxter et al. (1981) did not find a correlation between weight of calf at weaning and mortality, possibly because they did not identify cause-specific risk factors for yersiniosis. In this study, further analyses of April 1 bodyweights suggest weaners below 40 kg and from 40-to-50 kg are 4.3 and 2.7 times more likely to be clinically affected by yersiniosis than weaners over 50 kg on April 1, respectively. The reason for this highly significant association is not known, although it may be related to the individual immune response to infection. That the percentile bodyweight within mobs (PERCW4) and the difference between W4 and the highest W4 in the mob (MAXW4) were not significant suggests the effect of light bodyweight is not related to chronic social stress. There is evidence that most herds of weaners, if not all (see section 3.4.1.4.), and individual weaners within a herd (Mackintosh and Henderson, 1984) will experience a subclinical infection prior to or during their first winter, resulting in a transient excretion of *Y.pstb*. Calves should be protected against yersiniosis by maternal antibodies up to 3 or 4 months of age, then later develop their own immune response when in contact with the bacterium (Mackintosh et al. 1986). Since, in this study, the bodyweight on April 1 of sentinel weaners was positively associated with their serum total protein concentrations (see section 4.3), it is suggested small weaners may have been of a lower nutritional status resulting in poor immune response to *Y.pstb*

infection, and thus were more susceptible to severe infection. Small calves (usually late-born calves) may also be more parasitised (as shown by the association between MW4 and FLCI in section 4.3), which may be associated with malnourishment. Alternatively, light weaners may have less body fat insulation and thus be more exposed to adverse weather conditions. Consequently, weaners grazing with weaners below 50 kg may be more at risk of death from yersiniosis, but this needs further investigation.

After accounting for bodyweight on April 1 (W4) or on June 1 (W6), weaner hinds were not more susceptible to yersiniosis than weaner stags (as suggested by univariate statistics in Appendix 4.36).

For the same bodyweight on April 1, the higher percentage of New Zealand blood lines (NZ), the lower the risk of dying from yersiniosis. Although this observation has not been reported elsewhere, it suggests there may be difference in susceptibility due to genetics. It was interesting to note that on one farm, 7 of 13 severely clinically affected weaners (including the ones that did not die) came from the same sire, thus supporting the observation of a possible genetic effect (Mackintosh et al., 1990). This sire was of pure New Zealand origin, but whether this observation was related to the individual sire or its origin was not known. The apparent higher susceptibility of New Zealand weaners on that property may actually be related to smaller size and lower ability to grow, since the higher NZ, the lower the bodyweight (W4 or W6) and the higher the risk of losing bodyweight between April 1 and June 1 (GR46<0).

For the same weaner bodyweight on June 1, weaners losing weight between April 1 and June 1 were 25 times more likely to die from yersiniosis, which supports the hypothesis that the nutritional state of the deer may be a major factor, which may be associated with the immune response to infection as discussed previously. These weaners also are more likely to have lacked fat reserve s, albeit minimal in this age of deer anyway, for protection against adverse weather conditions. Factors affecting the growth of weaners such as undernutrition or exposure to adverse weather conditions have been suspected to be major risk factors for yersiniosis for many years (Hutton, 1983). Other potential risk factors for GR46 have been investigated further in section 4.4. It was not known, however, whether the bodyweight loss observed on many weaners was a cause or a consequence of severe yersiniosis infection. As the infection develops, weaners may be more likely to lose bodyweight and consequently be more likely to die from yersiniosis. Such explanation would be consistent with the hypothesis that infection with *Y.pstb* develops slowly over time and that sufficient causes, which may be a group of risk factors, trigger acute infection and fatal yersiniosis, but this hypothesis requires further research. This study, however, supports the observation of Mackintosh and Henderson (1984) that fatal "yersiniosis occurs always with animals in poor condition", although poor condition may have resulted from subclinical infection.

The mean percentage of New Zealand blood lines (MNZ), mean weaner bodyweight on April 1 (MW4) and many grazing management and environmental factors were not significant predictors of yersiniosis outbreaks within mobs. Perhaps they are not important factors, or perhaps there were only 38 mobs included in the analysis, insufficient to achieve statistical significance. It was interesting to note that grazing and environmental conditions appeared to be adequate on 2 farms that experienced a yersiniosis outbreak in 1993 (Appendix 3.61). However, the importance of nutrition levels, shelter and other factors associated with growth and reduced stress should not be underestimated. The significant positive association between the average daily minimum temperature (AVMIT) between April 1 and June 1 and the likelihood of yersiniosis outbreak, suggests the weather pattern may be a major factor. From other analyses in this chapter, high average daily minimum temperature is associated with low amounts of sunshine and high average

daily rainfall. The specific negative effect of storms or heavy rainfall as suggested by Mackintosh and Henderson (1984) could not be investigated in this study, other than through their influence on the calculated average weather variables, but this result supports their view.

Adverse weather conditions such as storms may have a chiller effect on weaners and consequently weaners in poor condition may be more likely to die from yersiniosis, but also weaners exposed to a storm may stop eating during 12-24 hours. Fasting is believed to predispose weaners to the disease (Mackintosh, personal communication), and has been used successfully, in conjunction with other factors, to trigger the disease after experimental challenge with *Y.pstb* (Mackintosh et al., 1990). However, the potential effect of fasting could not be investigated in this study other than through its effect on growth rates.

4.6.1.4 Conclusion

Identified risk factors are in accordance with previous observations of yersiniosis outbreaks in young deer. It must be remembered however that the significant associations identified in this study are not proof for causality (Martin et al., 1987).

To reduce the risk of yersiniosis, this study suggests that farmers :

- Manage their breeding and feeding programmes to avoid light-weight weaners on April 1, particularly those below 40 k g (see section 4.4) or sell weaners below 40 kg.

- Carefully consider the nutrition allowance for weaners so they can grow to their genetic potential during autumn and respond immunologically to subclinical infection by *Y.pstb.* Feed no less than 10 cm green leafy pasture or feed budget to provide feed energy requirements.

- Separate weaners below 50 kg from the rest of the mob after weaning and increase their nutritional allowance.

- Weigh weaners monthly from weaning to June and calculate individual growth rates. If they are significantly below growth targets, in particular if they are negative, alter feeding regime or review factors associated with autumn growth rates (see section 4.4).

- Provide weaners with individual protection, ie shelter and good body condition, from weather patterns associated with high daily minimum temperature.

- Vaccinate their weaners in March and April with two doses of Yersiniavax.

Should these conditions be met, it is probable that mortalities caused by yersiniosis will be prevented as observed in this study. The subclinical effect (suspected to be negative) of yersiniosis infections on growth has not been studied, and may be worth further investigations for scientific purposes. However, the implementation of these management practices may also reduce the subclinical effect substantially.

It is the researcher's advice that the thresholds of 40 and 50 kg bodyweight have been chosen arbitrarily for a more in-depth exploration of the data, and therefore, should be considered as only suggestive. These proposed thresholds apply to weaners with no more than 25% wapiti blood lines

as recorded in this study, and thus may be lower than for weaners with a higher percentage of wapiti genes. This requires further research.

4.6.1.5 Identified areas for further research

This section has identified likely key factors influencing the occurrence of yersiniosis and has highlighted areas which deserve priority in research and development designed to reduce weaner mortality on commercial farms.

It is appropriate to investigate :

- The occurrence of yersiniosis in vaccinated commercial weaner mobs.
- The relationship between nutritional status, bodyweight, growth and immune development in young deer after weaning, in relation with their susceptibility to yersiniosis.
- To investigate the possibility of a threshold bodyweight on April 1 (and the relative difference between breed of deer, eg wapiti) underwhich weaners are more at risk of fatal yersiniosis.
- The potential beneficial effect of splitting weaner herds into bodyweight categories after weaning.
- Potential genetic factors associated with the susceptibility to yersiniosis.
- The most efficient type of shelter to protect weaners from adverse weather conditions, eg trees, shelter belt or gullies.

4.6.2 Risk factors for malignant catarrhal fever in hinds and stags over 15 months of age.

Malignant catarrhal fever has been identified in this study as one of the most frequently confirmed causes of mortality of yearling and adult deer, killing 0.17 and 0.53 hinds and stags, respectively, per 100 deer-years at risk (see section 3.3.4.1.1). Furthermore, it is believed that these figures are an underestimate of mortality rates due to malignant catarrhal fever since the cause of a large proportion of yearling and adult deer mortalities could not be confirmed. This section presents risk factors associated with the occurrence of malignant catarrhal fever in hinds in winter and in stags from winter to summer.

4.6.2.1 Materials and methods

For each of the two years of study, about 1200 stags and 2700 hinds were monitored for performance and health problems as presented in chapter 2. Individual hind or stag characteristics, and environmental factors and grazing management risk factors potentially affecting the occurrence of malignant catarrhal fever are described in Table 4.26. Environmental factors and grazing management variables were calculated between May 1 and July 1, and between June 1 and September 1 for the investigation of malignant catarrhal fever in hinds and stags, respectively.

Summaries of statistical analyses carried out are presented in Table 4.1. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in chapter 2 (section 2.7)

- Data from both years of study were combined for statistical analyses.
- Hind and stag data were analysed separately at all stages.
- All hinds that were present on farms on April 1, and all stags that were present on farms on June 1 were included in the analyses. A small number of deer were removed from farms during the periods of study, but that number was considered insufficient to bias the results. In total, 7 hinds and 11 stags dying from malignant catarrhal fever were included in the analyses.

- Statistical analyses (path analyses) were carried out using SAS in two steps.

  The first step was to investigate potential risk factors at the individual deer level (step 1), ie the outcome was whether an individual hind or stag died from malignant catarrhal fever in winter, or from winter to summer, respectively (MCF). Individual deer characteristics and calculated environmental and grazing management factors were grouped in one single multivariable analysis, and interaction terms were included where appropriate.

  In the analysis of hind risk factors, the pre-mating body condition score (BCSM) was included as a continuous discrete variable, but the relationship between BCSM and the probability of malignant catarrhal fever may not be linear. To explore the possibility of a threshold score under which hinds could be more likely to die from malignant catarrhal fever, BCSM was transformed to two categorical variables as described in Table 4.26. The result of this investigation was used for inclusion in the null hypothesis path diagram of hind risk factors.

Table 4.26 : Potential risk factors for the occurrence of malignant catarrhal fever in hinds in winter and in stags from winter to summer.

Risk factor Code	Unit	Description
Individual deer characteristics		
ADULT	D	Adult deer (at least 2 years old in March)
AGE4	D	Deer over 4 years old in March
NZ100	D	Pure New Zealand type deer
Specific hinds characteristics		
ADVC	D	Hind conceived before May 1 (early conception)
BCSM	Dis. 1-5;0.5	Pre-mating body condition score
BCSS2	D	Pre-mating body condition score below 2.5
BCSS4	D	Pre-mating body condition score over 3.5
MARW	kg	Pre-mating bodyweight (recorded in March)
Specific stags characteristics		
JUNEW	kg	Pre-winter bodyweight (recorded in June)
Environmental factors and grazing management from May 1 to July 1 (for hinds) or from June 1 to September 1 (for stags)		
Grazing variables		
ISWH	cm	Mean pre-grazing pasture sward height
RSWH5	D	Mean residual (ie post-grazing) pasture sward height below 5 cm
RSWH10	D	Mean residual (ie post-grazing) pasture sward height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
SHIFT		Number of times deer were shifted between paddocks
STOCK		Number of times the mob composition was changed
PASTT	Score 1-3	Mean pasture type score
DEER		Average number of deer in the mob
DEER/Ha	Deer/ha	Average number of deer per deer-fenced hectare (grazing density)
OTHERST	D	Paddocks shared with stock other than deer at least one day
OSHEEP	D	Paddocks shared with sheep at least one day
BSHEEP	%	Percentage of time spent in paddocks on deer farm boundary adjacent to paddocks where sheep could be found all year round
FSUP	D	Food supplementation of deer
Environmental variables		
FAREA	ha	Mean paddock size
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt

Note on units : D = dichotomous variable (Yes/No)
"Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments"

In a second step, environmental and grazing management risk factors were investigated at the mob level (step 2), ie the outcome was whether hind or stag mobs (including deer with the same grazing history during the grazing period defined above) included individual hinds or stags that died from malignant catarrhal fever in winter, or from winter to summer, respectively (MMCF).

4.6.2.2 Results

Summary statistics of continuous risk factors screened for association with the occurrence of malignant catarrhal fever in hinds and stags in a preliminary univariate analysis, and t-test p values are presented in Appendix 4.37 and Appendix 4.38, respectively. Fisher exact test p values and unadjusted odds ratios of dichotomous risk factors for the occurrence of malignant catarrhal fever are presented in Appendix 4.39.

Null hypothesis and final path diagrams for hind individual risk factors are presented in Figure 4.63. Logistic regression coefficients estimates, adjusted odds ratio of model components, and model deviance are presented in Table 4.27.

Hinds conceiving before May 1 were less likely to die from malignant catarrhal fever (MCF) and hinds in mobs with high grazing densities were more likely to die from MCF. Heavy stags in June 1 were more likely to die from malignant catarrhal fever. Malignant catarrhal fever was more likely to occur in hind mobs with high grazing densities, in stag mobs that strip grazed in winter and in stag mobs that grazed in large paddocks.

4.6.2.3 Discussion

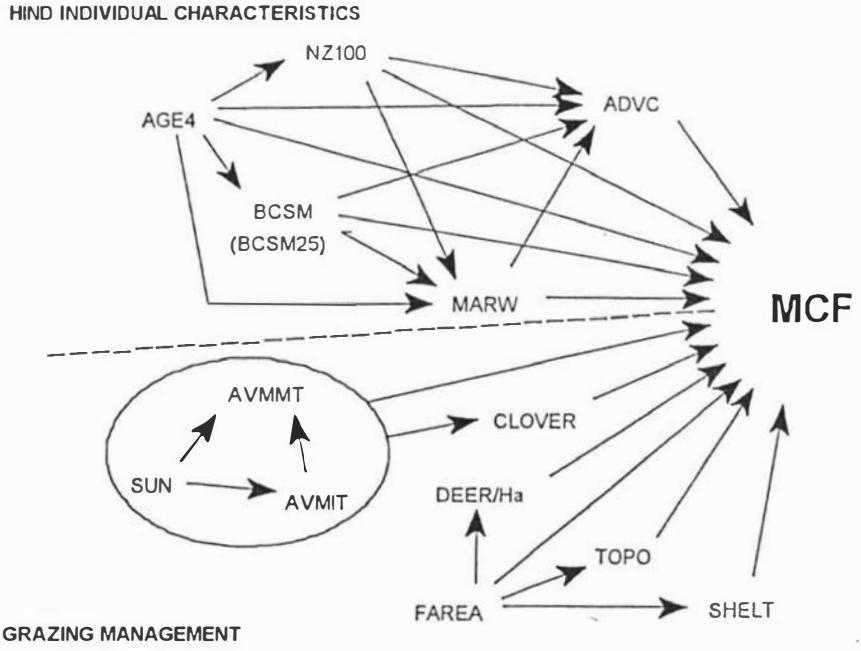
Malignant catarrhal fever is a common fatal disease of red deer in New Zealand and elsewhere (Beatson, 1984; Reid, 1992). This study supports this observation, and further, identifies it as one of the most frequently diagnosed causes of mortality in yearling and adult deer.

Malignant catarrhal fever is known to be caused by a viral agent carried and transmitted by sheep, but little is known about the actual transmission pathways to deer. Rare occurrences of malignant catarrhal fever in deer without association with sheep have been occasionnally reported in red deer (Reid et al., 1986; Fennessy, 1988). Deer are believed to be dead-end hosts for the virus, so it is likely to be a non-contagious disease between deer. Observation of the occurrence of malignant catarrhal fever on two farms in this study where at least the width of a road separated deer from sheep, along with previous reports (Brown and Bloss, 1992), suggests either that close contact with sheep is not mandatory or that infection can be latent for months or years. In the latter case, risk factors may be required to trigger the disease process (Beatson, 1984; Orr, 1986). Grazing management and environmental factors were, therefore, investigated as potential risk factors for this disease.

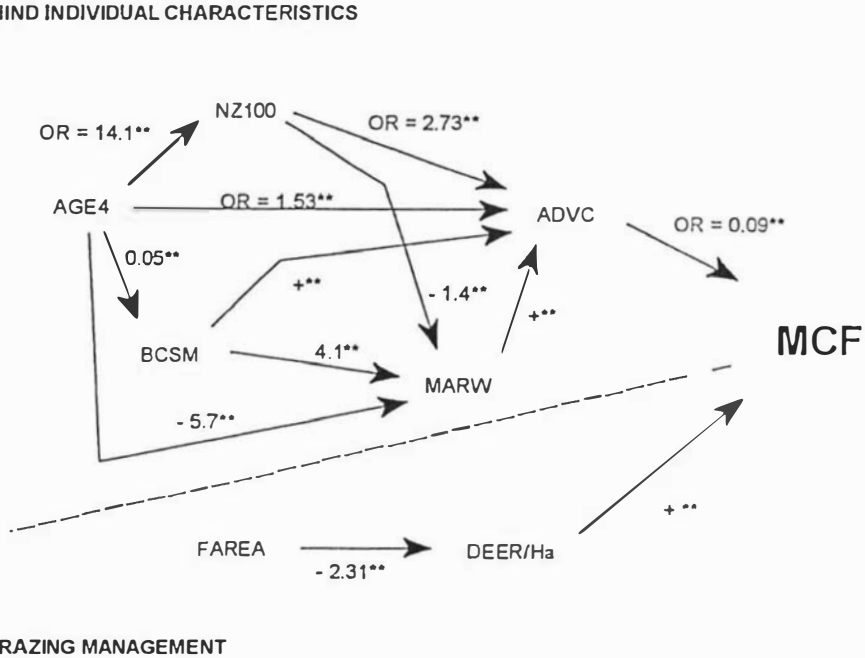
Risk factors for malignant catarrhal fever were investigated separately for hinds and stags because of the higher frequency of this health problem in stags, combined with a different seasonal distribution (Figure 3.38). While most cases in stags developed during winter and early spring, those in hinds occurred early winter. So periods for calculation of grazing management and environmental risk factors were chosen accordingly.

Figure 4.63 : Null hypothesis and final path diagrams of risk factors for the occurrence of malignant catarrhal fever in hinds in winter.

1. Null hypothesis path diagram



2. Final path diagram.



Note : Risk factor codes are described in the glossary and in Table 4.26. Odds ratio (OR), sign of beta logistic regression coefficent or unstandardised linear regression coefficients are presented on significant paths.(*p<0.05; **p<0.01). The percentage of variability of MCF explained by this final model is 13.49%.

Table 4.27 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of animal and grazing management risk factors predicting the probability of hinds and stags dying from malignant catarrhal fever.

HINDS

Total number of hinds included in the analysis of individual risk factors : 4735
Number of hinds diagnosed with malignant catarrhal fever : 7

Hind individual characteristics and grazing management variables from May 1 to July 1
with BCSM as a continuous variable

Deviance		
Intercept only	Model deviance	% of variability explained by the model
105.23	91.04	13.49

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
ADVC	-2.437	0.775	0.002	0.09	0.02 0.40
DEER/Ha	0.032	0.012	0.009		

Mob analysis of grazing management variables from May 1 to July 1
Number of mobs: 86
Number of mobs with MCF : 6

Deviance		
Intercept only	Model deviance	% of variability explained by the model
43.95	38.20	13.09

Risk factor*	Coefficient estimate	Std error	p value
DEER/Ha	0.037	0.015	0.015

STAGS

Total number of stags included in the analysis of individual stag risk factors : 2654
Number of stags diagnosed with malignant catarrhal fever : 11

Stag individual characteristics and grazing management variables from June 1 to September 1

Deviance		
Intercept only	Model deviance	% of variability explained by the model
142.65	138.41	2.97

Risk factor*	Coefficient estimate	Std error	p value
JUNEW	0.028	0.013	0.025

Mob analysis of grazing management variables from June 1 to Sept 1
Number of mobs: 73
Number of mobs with MCF : 10

Deviance		
Intercept only	Model deviance	% of variability explained by the model
43.95	38.20	13.09

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
STRIP	3.318	1.205	0.006	27.60	2.60 292.57
FAREA	0.274	0.103	0.008		

Std error = Standard error; OR = odds ratio; 95%CI = 95% confidence interval
* Risk factor codes are described in the glossary and Table 4.26

However, the drawback of conducting two separate analyses was that a limited number of cases of malignant catarrhal fever were investigated in each sex group (7 hinds and 11 stags), and therefore it was likely only very strong associations would be identified. No differentiation could be made between acute and chronic malignant catarrhal fever because of limited numbers of observations. Chronic malignant catarrhal fever occurring in stags in spring and summer were included in the analysis, as many of these stags were observed fading weeks or months before death. Therefore it was believed common risk factors for MCF may have occurred during winter.

That hinds conceiving before May 1 (ADVC) were 12 times less likely to die from malignant catarrhal fever (MCF) was an interesting observation, and will require further investigation. Although the possibility of a cause and effect relationship between ADVC and MCF cannot be excluded, it was believed this relationship may occur through causes common to ADVC and MCF. Some risk factors increasing the likelihood of early conception (see section 4.1) may have also a protective effect against malignant catarrhal fever, or *vice versa*.

In this analysis, hinds of pure New Zealand origin (NZ100), hinds over 4 years old at mating (AGE4), hinds with high bodyweight in March (MARW) and high pre-mating body condition score (BCSM) were more likely to conceive before May 1. There was a significant interaction between AGE4 and BCSM to explain the variability of ADVC, with a stronger positive effect of BCSM on ADVC in the older group, which was expected since fat yearling hinds were less likely to conceive early (see section 4.1). However, by withdrawing ADVC from the model, none of NZ100, AGE4, MARW or BCSM were identified with a direct significant effect on MCF. Therefore, it is likely the common causes, if any, were not recorded or not properly analysed in this study, or that the association between ADVC and MCF is in itself a spurious result. It must be noted further that 3 of the 7 hinds dying from malignant catarrhal fever were non-pregnant, and one only conceived late (see Appendix 3.62), so the apparent effect of early conception may be that of conception *per se*.

There was no significant incidence differences between yearling and adult deer, but it appeared at the univariate screening (Appendix 4.39) that hinds 1-4 years old may be more at risk of dying from malignant catarrhal fever as observed previously (Beatson, 1984; Orr, 1986). However, this relationship was not significant in the final diagram of hind risk factors, and was not observed for stags.

Univariate statistics suggested hinds with a pre-mating body condition score below 3 (BCSM25) instead of low BCSM *per se* to be at risk of dying from malignant catarrhal fever, so BCSM was replaced by BCSM25 in the null hypothesis path diagram. However there was no significant direct effect of BCSM25 on MCF, which suggests pre-mating hind body condition may not be a major factor influencing the occurrence of malignant catarrhal fever. The pre-winter body condition score of stags was not recorded, so its effect could not be investigated. It may be difficult, therefore, to draw definite conclusions on the likely contribution of body condition. Deer affected by chronic malignant catarrhal fever were fading for weeks before death. It was not known whether the development of chronic MCF caused deer to fade, or loss of condition triggered the development of the disease. Both hypotheses could be correct (Mackintosh, personal communication). In this respect, the development of a diagnostic test to diagnose malignant catarrhal fever before death would help answer this difficult question.

That stags with a high pre-winter bodyweight were more at risk of dying from malignant catarrhal fever was not expected, and cannot be explained logically without pre-winter body condition scores, but suggests these pre-winter stag characteristics should be further investigated.

A high grazing density (DEER/Ha) was significantly associated with a high risk of malignant catarrhal fever in hinds, which supports the observation of Beatson (1984) that the incidence of MCF increase with the intensity of farming conditions. The significance of DEER/Ha in the mob analysis further supports the importance of this risk factor. In this study, the average grazing densities between May 1 and July 1 ranged from 4 to 112 hinds per hectare. Since pasture height variables (which may have been low as a result of high grazing densities) were not significant, social interactions between hinds may have contributed to this relationship. It was recorded on one farm in 1992 that a hind dying from malignant catarrhal fever was newly introduced into the breeding herd and was constantly harrassed by dominant hinds. The average grazing density on that farm was 68 hinds per hectare, which may have indirectly increased the social stress upon that hind. Whether subordonate hinds were more at risk of MCF, however, was not known, although it supports the view of Wilson et al. (1983).

The apparent negative effect of large paddocks in the analysis of risk factors for MCF in mobs of stags, may somewhat contradict the negative effect of DEER/Ha in hinds, although there was no clear explanation for this. Further, stags that strip grazed during winter appeared more at risk of dying from malignant catarrhal fever, which may be related to increased social interactions caused by close proximity at the feeding site. This hypothesis requires further investigation.

There is a common belief in New Zealand that sheep and deer should be managed separately. In this study, whether stags grazed with sheep at least one day (OSHEEP) and the percentage of time grazing deer paddocks next to paddocks (outside the deer farm boundary) where sheep could be found grazing (BSHEEP) were not significant for both hinds and stags. This result therefore does not support that close contact with sheep is a necessary cause for the occurrence of malignant catarrhal fever in farmed red deer.

4.6.2.4 Conclusion

Despite the limited number of hinds or stags affected by MCF in these analyses, some risk factors appeared associated with the occurrence of the disease. Whether they have a causative role is not known, and further research is needed to investigate this possibility.

Whereas more research needs to be done to clarify and identify risk factors for MCF in stags, this study suggests that management practices can help reduce the incidence of the disease in hinds :

- By increasing the number of hinds conceiving early (see section 4.1) and thus the reproductive performance of the breeding herd, farmers may also prevent mortalities through malignant catarrhal fever.

- It may also be beneficial to use modest to low grazing densities for hinds during autumn and early winter, and separate harrassed or victimised hinds from the rest of the group (should social stress be involved).

Malignant catarrhal fever is one of the most commonly confirmed cause of mortality in farmed red deer, but the complexity of its pathogenesis and the fact that no diagnostic test for live deer is available makes epidemiological investigations difficult to carry out. However, it may be necessary to carry out more intense and widespread epidemiological investigations across the country to identify new prevention strategies for malignant catarrhal fever on commercial farms. Such

strategies can be applied along with a vaccine, should it be developed via molecular biology (Reid, 1994).

This analysis, therefore, has identified likely key factors influencing the occurrence of malignant catarrhal fever on commercial farms and has highlighted areas which deserve priority in research. It is appropriate to investigate :

- The nature of the relationship between early conception and the occurrence of malignant catarrhal fever.

- The relative influence of body condition and bodyweight in stags on the occurrence of malignant catarrhal fever.

- The potential beneficial effect of reducing grazing densities to about 40-60 hinds per hectare on farms affected by malignant catarrhal fever.

4.6.3 Risk factors for the occurrence of dystocia

Dystocia has been identified in this study as one of the main identifiable causes of perinatal mortality (see Table 3.28). This section investigates putative causative factors associated with the occurrence of dystocia.

4.6.3.1 Materials and methods

For each of the two years of study, about 2700 hinds were monitored for calving performance. During farm visits in September, the body condition score (BCS) of each hind mated was recorded. The composition of each hind mob from September 1 to December 1, thus the grazing history of each hind, was recorded. During calving, farmers recorded the occurrence of calving difficulties (dystocia) which either needed human assistance or caused the death of the hind.

Potential risk factors for the occurrence of dystocia (DYS) were identified and grouped in 2 blocks as described in Table 4.28. These blocks were individual hind characteristics, and grazing management variables calculated between September 1 and December 1.

Summaries of statistical analyses carried out with and without the use of path analysis are presented in Table 4.1 and Table 4.2, respectively. The general principles of preliminary data analyses (data screening), multivariable analyses and path analysis are presented in chapter 2 (section 2.7)

- Data from both years of study were combined for statistical analyses.
- Yearling and adult hind data were analysed together.
- All yearling and adult hinds diagnosed pregnant in June, present on the farm at calving and which were not identified as having lost its foetus (through bodyweight change or physical appearance consistent with non-pregnancy) were included in the analysis.
- Statistical analyses were carried out using SAS.

- Path analysis was used for the analysis of block 1 and block 2.

  Path diagrams were formulated within each block (steps 1 and 2 in Table 4.1), which were analysed separately. However, environmental factors and grazing management risk factors (block 2) were analysed with important individual hind characteristics included (those identified in step 1), since they may otherwise be important confounding factors. Interaction terms between BCSS4 and CHW9C, BCSS4 and ADULT, CHW9C and ADULT in block 1, and that between BCSS4 and TOPO in block 2, were investigated, where appropriate.

- Categorised body condition score variables were analysed separately without the use of path analysis (Table 4.2).

  In the analysis of block 1, the post-winter hind body condition score (BCSS) has been included as a continuous discrete variable. To explore the possibility of a threshold score over which hinds might be more likely to experience dystocia, BCSS was transformed to several categorical variables as described in Table 4.28 and included together in a multivariable logistic regression analysis. The result of this investigation was used for path analysis of blocks 1 and 2 and final presentation of results.

Table 4.28 : Potential risk factors for the occurrence of hind dystocia

Risk factor Code	Unit	Description
BLOCK 1 : Individual hind variables		
ADULT	D	Adult hind (ie at least 3 years old at calving)
NZ	%	Percentage of New Zealand blood lines
ADVC	D	Hind conceived before May 1 (early conception)
BCSS	Dis. 1-5;0.5	Post-winter body condition score (recorded in September)
BCSD	Dis. 1-5;0.5	Body condition score difference between March (pre-mating) and September (post-winter)
WD6	kg	Post-mating bodyweight on June 1
CHW9C	kg	Bodyweight change between September and calving (late October-November)
GR69	g/d	Growth rate between June 1 and September 1
Categorised body condition score variables		
BCSS2	D	Post-winter body condition score below 2.5
BCSS4	D	Post-winter body condition score over 3.5
BLOCK 2 : Pre-calving environmental factors and grazing management (Sept 1 - Dec 1)		
Grazing variables		
ISWH	cm	Mean pre-grazing pasture sward height
RSWH5	D	Mean residual (ie post-grazing) pasture sward height below 5 cm
RSWH10	D	Mean residual (ie post-grazing) pasture sward height over 10 cm
CLOVER	Score 1-3	Mean pasture clover score
SHIFT		Number of times deer were shifted between paddocks
STOCK		Number of times the mob composition was changed
PASTT	Score 1-3	Average pasture type score
DEER		Average number of deer in the mob
DEER/Ha	Deer/ha	Average number of deer per deer-fenced hectare (grazing density)
M%AH	%	Mean percentage of adult hinds in the hind mob
OTHERST	D	Paddocks shared with other stock than deer at least one day
FSUP	D	Food supplementation of hinds
Environmental variables		
FAREA	ha	Mean paddock size (deer-fenced area)
SUR	%	Percentage of time spent in paddocks close to road, buildings or houses (ie signs of human presence)
TOPO	Score 1-3	Mean paddock topography score
TREES	Score 0-3	Mean paddock tree score
SHELT	Score 0-30	Average paddock shelter score combining scores of trees, hill, gully and shelter belt
BULLR	Score 0-3	Mean paddock bull rushes score
AVMIT	°C	Average of daily minimum temperatures
AVMAT	°C	Average of daily maximum temperatures
AVMMT	°C	Average of daily temperature ranges (maximum-minimum)
RAIND	mm/d	Average daily rainfall
SUN	Score 0-1	Average daily sunshine score
AVWIND		Paddock average wind exposure index = average of wind strength over potential wind protection scores from trees, hill, gully and shelter belt

Note on units : D = dichotomous variable (Yes/No)
"Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

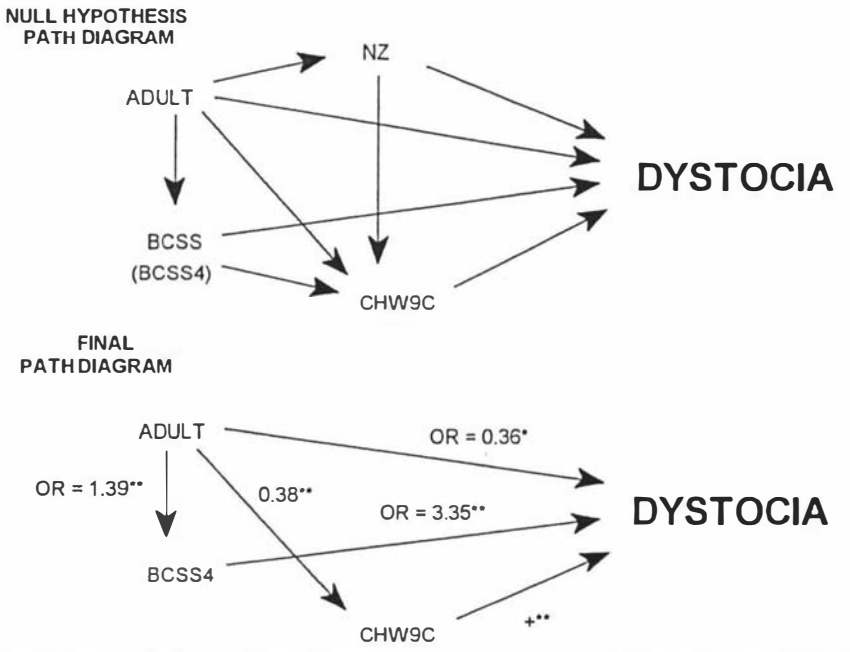
4.6.3.2 Results

Summary statistics of continuous risk factors screened for association with the occurrence of dystocia in a preliminary univariate analysis, and t-test p value are presented in Appendix 4.40. Chi-square test p values and unadjusted odds ratios of dichotomous risk factors for the occurrence of dystocia are presented in Appendix 4.41.

Null hypothesis and final path diagrams for hind individual risk factors and for grazing management factors controlled for significant hind individual risk factors are presented in Figure 4.64 and Figure 4.65, respectively. Regression coefficient estimates, adjusted odds ratios of model components, and model deviances are presented in Table 4.29.

Hinds with a post-winter body condition score over 3.5 (BCSS4) were 2.9 times more likely to experience dystocia than hinds scoring between 2.5 and 3.5. There was no significant difference between this latter group of hinds and thinner hinds. BCSS4 was significant in the analysis of block 1 but not the body condition score as a continuous discrete variable (BCSS). Thus BCSS4 was subsequently included in the analysis of block 2 variables. Given the same class of body condition score, adult hinds (ADULT) were less likely to experience dystocia than yearling hinds, although this observation was marginally significant (p=0.042). High pre-calving bodyweight gain (CHW9C) was associated with an increase risk of dystocia. There was a significant interaction between BCSS4 and CHW9C. At each level of BCSS4, CHW9C remained significant but the risk of experiencing dystocia for the same bodyweight increase was higher in hinds with BCS over 3.5.

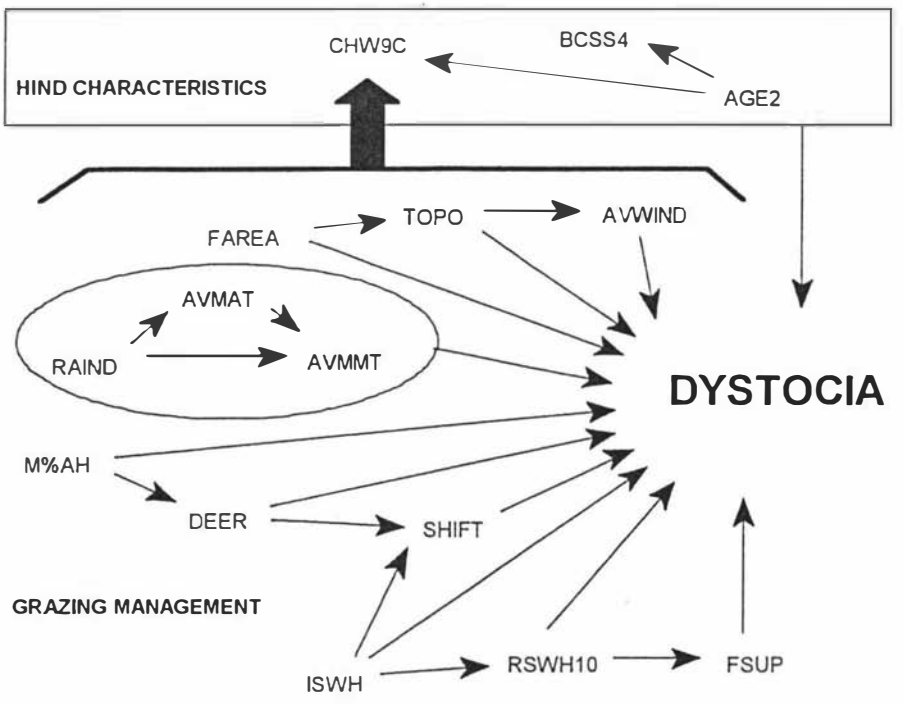
Figure 4.64 : Null hypothesis and final path diagrams of individual hind risk factors for the occurrence of dystocia.



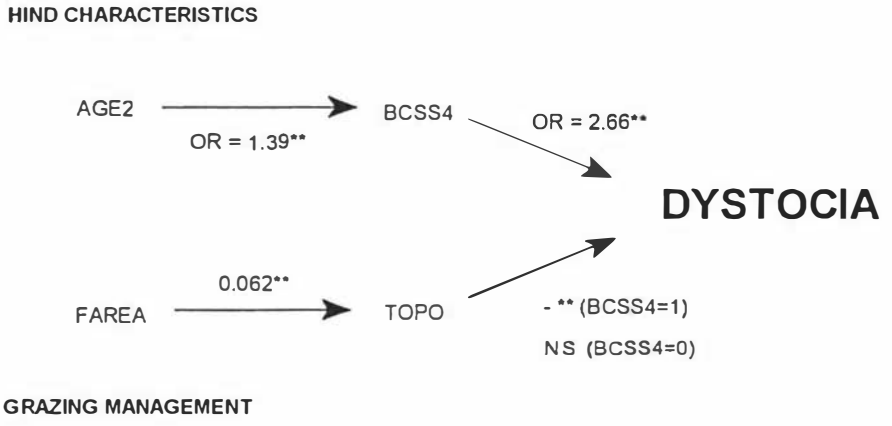
Note : Risk factor codes are described in the glossary and in Table 4.28. Unstandardised linear regression coefficient, odds ratio (OR) or the sign of logistic regression coefficient are presented on statistically significant paths (*p<0.05; **p<0.01). The percentage of variability in the outcome explained by this final model is 9.79%.

Figure 4.65 : Null hypothesis and final path diagrams of individual hind and grazing management risk factors for the occurrence of dystocia.

1. Null hypothesis path diagram



2. Final path diagram



Note : Risk factor codes are described in the glossary and in Table 4.28. Unstandardised linear regression coefficients, odds ratio (OR) or the sign of logistic regression coefficient are presented on statistically significant paths (*p<0.05; **p<0.01). The percentage of variation in the outcome explained by this final model is 9.24%.

Table 4.29 : Logistic regression coefficient estimates and adjusted odds ratios (OR) of animal and grazing management risk factors predicting the probability of hinds being affected by dystocia at calving.

Total number of hinds included in the analysis : 3782
Number of hinds diagnosed with dystocia : 21

BLOCK 1 :
Hind individual characteristics
with BCSS as a continuous variable

Deviance		
Intercept only	Model deviance	% of variability explained by the model
260.01	244.56	5.94

Risk factor*	Coefficient estimate	Std error	p value
CHW9C	0.219	0.045	0.000

Body condition score variables

Deviance		
Intercept	Model	% of variability
260.01	232.73	10.49

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
BCSS2	-0.255	0.759	0.737	0.78	0.18 3.43
BCSS4	1.056	0.450	0.019	2.88	1.19 6.95

Hind individual characteristics
with BCSS transformed as BCSS4

Deviance		
Intercept only	Model deviance	% of variability explained by the model
260.01	234.56	9.79

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
AGE2	-1.014	0.498	0.042	0.36	0.14 0.96
BCSS4	1.210	0.452	0.008	3.35	1.38 8.14
CHW9C	0.239	0.047	0.000		

BLOCK 2 :
Pre-calving grazing management from Sept 1 to Dec 1

Deviance		
Intercept only	Model deviance	% of variability explained by the model
260.01	235.99	9.24

Risk factors*	Coefficient estimates	Std error	p value	Adjusted OR	95%CI
BCSS4	0.977	0.444	0.028	2.66	1.11 6.35
TOPO	-1.965	0.535	0.000		

Logistic regression analysis with interaction term TOPOxBCSS4

Risk factors*	Coefficient estimates	Std error	p value
BCSS4	5.265	1.862	0.005
TOPO	-0.801	0.650	0.218
TOPOxBCSS4	-3.198	1.411	0.024

Variance-Covariance matrix of regression coefficients estimates

	Intercept	BCSS4	TOPO	TOPOxBCSS4
Intercept	1.275	-1.275	-0.702	0.702
BCSS4	-1.275	3.466	0.702	-2.519
TOPO	-0.702	0.702	0.423	-0.423
TOPOxBCSS4	0.702	-2.519	-0.423	1.992

Conditional coefficient estimate (BCSS4=1)

TOPO	-3.999	1.253	0.001

Std error = standard error; OR = odds ratio; 95%CI = 95% confidence interval
Note : risk factor codes are described in the glossary and in Table 4.28.

AGE3 and CHW9C did not remain significant when included in the analysis of grazing management factors. Hinds with BCS over 3.5 were still about 2.7 times more likely to experience dystocia than other hinds, while hinds grazing steep paddocks between September 1 and December 1 (TOPO) were less likely to experience it. However, there was a statistically significant interaction between BCSS4 and TOPO. TOPO was identified as an important factor only if hinds were over 3.5 in BCS, whereas it was no longer significant in the other group of hinds (Table 4.29).

4.6.3.3 Discussion

There is a common belief that hinds should not be in overfat condition at the beginning of spring so calving difficulties can be avoided (Moore, 1985; Moore et al., 1985), thus putting emphasis on monitoring hind body condition scores (BCS). Dystocia was observed as one of the most common cause of perinatal mortality in this study and elsewhere (Gill, 1985), but a large proportion of calves could not be found during the calving season. Whereas calf mortalities through mismothering-starvation or stillbirth may have resulted from dystocia, it was believed the most severe calving difficulties have been recorded since they triggered human intervention or caused the death of the hind. Therefore the relative importance of dystocia as a cause of perinatal mortality may be underestimated in this study. Since dystocia is also a cause of hind mortality, it was justified to investigate preventive management practices.

The non-significance of BCSS in the final model and results from the analysis of categorised body condition variables (Table 4.29) support the hypothesis that the relationship between BCSS and the risk of dystocia is not linear, but may increase substantially after a threshold which may be around 3.5 or 4. Consequently, BCSS4 was included in the analysis of individual hind characteristics. Hinds with a BCS over 3.5 were 3.4 times more likely to experience calving difficulties than thinner hinds, and this effect was of the same magnitude for yearlings and adults, considering the non-significance of the interaction term ADULTxBCSS4.

Whereas fetal oversize and abnormalities of presentation occurred in this study, most affected hinds were in good body condition in September (Appendix 3.63), which supports the view of Haigh and Hudson (1993) that maternal overweight and unfitness are common causes of calving difficulties. By overweight, it was believed these authors referred to the body condition of the hind though that was not stated. The significant negative effect of high pre-calving BCS has also been reported in sheep (Thomas, 1990). Only 3% of cases of dystocia were attributed to feto-maternal disproportion in that study.

The significant negative effect of high hind bodyweight changes prior to calving was consistent with these observations, although it may be related to both fetal growth and dam body condition change. In an earlier analysis, it was found that CHW9C was related to the dam weight, her percentage of New Zealand blood and her body condition score in September (see section 4.3). This analysis showed CHW9C was also on average higher in adult hinds than in yearling hinds. However, the two interaction terms ADULTxCHW9C and BCSS4xCHW9C were not significant, which shows that the negative effect of high CHW9C did not vary between yearling and adult hinds, and between thin and fat hinds, thus suggesting fetal and uterine gowth may explain most of pre-calving bodyweight changes. Therefore genetic factors from the dam, and more likely from the sire may be important factors for the occurrence of dystocia.

Yearling hinds were about 3 times more likely to experience dystocia than adult hinds, although the apparent relationship was lowered because they had a lower BCSS. Adult hinds were 1.4 times more likely to be over 3.5 in BCSS than yearling hinds.

In this study, the positive influence of grazing hinds on steep paddocks (see Table 2.4 and Table 2.31 for the description of this risk factor) prior to calving is consistent with the common observation than unfitness and overweight (through overfatness) are predisposing factors for calving difficulties (Haigh and Hudson, 1993). In wapiti farms in Canada, calving problems (or dystocia) were mainly reported in tame overweight hinds (Hudson et al., 1991). By grazing steep paddocks, hinds are kept in good general fitness, in particular if food supplement was not distributed, as hinds are encouraged to graze. The distribution of food supplementation appeared to increase the risk of dystocia (Appendix 4.41) but it was not significant in the final analysis. Further analyses of the data showed grazing steep paddocks may significantly reduce the risk of dystocia only for hinds with a BCSS over 3.5. Therefore, it appeared beneficial to keep fat hinds on steep paddocks to increase their fitness and prevent them getting fatter prior to calving, whereas allowing hinds that were in moderate to poor condition in September to graze on flat paddocks did not significantly increase their risk of dystocia.

4.6.3.4 Conclusion

To the authors' knowledge, this study was the first multivariable investigation of risk factors for dystocia of red hinds on commercial farms including both individual hind characteristics and mob management factors. Results somewhat supported the common beliefs that resulted from experience. Although this research does not prove that each significant risk factor has a causative role, it suggests the risk of dystocia can be alleviated through appropriate management practices:

- Pregnant hinds should be in body condition score 3-3.5 after winter to maximise their chance of rearing a heavy calf up to weaning, but should be below 4.

- Should hinds be overfat (BCS over 3.5) in September, minimise their nutritive allowance and let them graze on steep slopes. Controlled break grazing hinds in late pregnancy is another option (Moore et al., 1985).

- Large terminal sires should not be used with yearling hinds (and small adult hinds) to avoid feto-maternal disproportion at calving.

Providing these conditions are met and they are causal, it is possible to substantially reduce the risk of dystocia as observed on some farms in this study.

This analysis, therefore, has identified likely key factors influencing the occurrence of dystocia on commercial farms and has highlighted areas which deserve priority in research. It is appropriate to investigate :

- Whether the body condition score in September for optimum reproductive performance is indeed 3.5, and management strategies during winter to achieve this target.

- The optimum pre-mating sire bodyweight/hind weight to avoid feto-maternal disproportion at calving.

Future trials should aim to examine a higher proportion of dead calves to determine causes of death more accurately and thus also include in the analysis the dam of calves that died from dystocia. This would require more intense monitoring on survey farms, including the identification of all dam-offspring pairs at birth.


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Jan. 95

CHAPTER 5
GENERAL DISCUSSION AND CONCLUSIONS

This study has investigated a range of risk factors associated with the major outcomes on commercial deer farms. It is the first such epidemiological study of deer farming systems. It has contributed substantially to knowledge and understanding of deer production in terms of providing reference data and examining associations between risk factors and outcomes. It has provided the basis for proposals on possible management models to achieve optimum production, and has identified a significant number of areas requiring future research.

This chapter brings together discussion of the methods used, results, conclusions and suggestions as to the use of this data and future research priorities. It also proposes in brief the opportunities that are presented to the deer industry for improving production and profitability of the individual farm, which would have substantial financial implications for all sectors of the deer industry.

It should be noted that discussion, conclusions and recommendations relate only to the range of data recorded for this project, and may not be extrapolated reliably to other situations or beyond the scope of the set of factors considered here.

5.1 STUDY DESIGN AND ANALYSIS

As discussed in section 1.3.2.1, "health and production profiling" is a powerful tool for on-farm investigation of complex systems, and, in the context of this study, is applied to a limited number of farms. These farms were selected as "typical" within the deer industry, rather than truly randomly selected, because the consent of farmers to participate was essential to ensure completeness and accuracy of the data.

5.1.1 Data recording

Seventeen farmers have been involved in recording data although only 15 and 14 were monitored all year round in 1992 and 1993, respectively. It was important to limit the amount of data collected to the most relevant information and facilitate farmers' recording as much as possible. In this context, it is recommended that data collection and analysis should be carefully considered at the design stage of the study, and that a pilot trial precede the main study (Martin et al., 1987; Ganière et al., 1991). This was not carried out in this study because of time and financial considerations. To compensate, farms were selected with great care and recording systems were flexible to suit the needs of each participant. Frequent visits at the start of recording allowed necessary changes to occur rapidly after initial adaptation to recording techniques. Furthermore only a limited number of farms and only one investigator, ie the researcher, were involved, so changes could be implemented with a minimum of time and costs. The meeting prior to the start of the study, gathering all participants at Massey University, and personal visits to farmers were essential to ensure farmers remained motivated and involved, and the information was complete and accurate. Even with that,

record keeping and accuracy varied between farms. The use of templates for recording, eg listing of animal tag identification, was very useful for cross-checking by farmers.

5.1.2 Data analysis

Path analysis is becoming a commonly used multivariable statistical technique in veterinary epidemiology. This technique has been chosen as the main analytical method for this thesis rather than alternative analytical techniques, such as principal components analysis, discriminant analysis or standard multivariable linear and logistic regression, because it is the most satisfactory technique to investigate both the structure of possible causal webs within the production system, and quantify in real terms direct and indirect effects of risk factors. Other techniques do not combine these two attributes. Path models provide a comprehensive view of the causal webs under study, through visual representations of the complex interrelationships that exist within the system as a whole (Pfeiffer and Morris, 1994).

However, in this study, path analysis was used only when a sufficient number of variables were selected at the univariate screening level and hypothesised interrelationships between them allowed the construction of a causal web (see Table 4.1 and Table 4.2).

In this study, the multitude of risk factors under investigation was substantial and the numerous correlations between them resulted in somewhat complex path diagrams. Furthermore, the inclusion of a large number of explanatory variables in multivariable models may result in instability of regression coefficients (Cox and Hinkley, 1974 cited by McDermott et al., 1994). Where possible, scores and indices, such as the creation of a shelter score (SHELT) and a paddock wind exposure index (AVWIND) have been created to limit this problem, and to avoid the inclusion of a number of variables which were really representing different facets of the same environmental influence. A limitation of this approach is that the potential effects of individual observations used to compute these indices may not be identified, eg that SHELT was not associated with weaner spring growth may be because trees and gullies (which are both used to calculate SHELT) have a positive and negative effect, respectively, when analysed as individual variables. The associations between such indices and outcomes, therefore, were more difficult to interpret. Alternative statistical approaches to reduce the number of correlated variables to be included in the analysis could have been used. These are, for instance, factor analysis which computes uncorrelated scores as a combination of initial correlated risk factors. This technique has been used to identify farm management practices affecting respiratory disease of swine in Canada (Hurnik et al., 1994b). Another technique could have been the construction of synthesised common risk factors (SCRFs) through the use of principal components analysis (Lafi and Kaneene, 1992). However, factor scores or SCRFs are more difficult to interpret and these techniques do not allow the quantification of the effect of specific risk factors. Their disadvantages were considered greater than the limitations of path analysis used in this study.

It was appropriate to analyse some data either as continuous or as categorical variables where biological responses may be associated with attainment of threshold values or where effects may have been non-linear, eg the effect of body condition score (BCS) on conception. The major limitation of these transformations, however, is that results and their interpretation are influenced by the choice of cut-off points for the categories. For instance, it was concluded adult hinds over 2.5 in body condition, which was chosen from the distribution of the data, may have a higher probability of conceiving than thinner hinds, but it does not mean that the actual biological threshold is 2.5. Had the researcher chosen 3 for the lower BCS category,

conclusions may have been similar. The same limitation applies when cut-off points were chosen from the existing literature, because the minimum threshold values published for deer or other domestic species may not be valid in deer with regard to the particular outcome under investigation under the circumstances of the study. MGSHPx3 is significantly associated with the probability of yearling hinds conceiving before May 1, which suggests there may be a minimum threshold value of MGSHPx around 3 kIU/l. This latter value, however, has been proposed as the marginal GSHPx in sheep (MAF Optigrow Animal Health profile) and may not apply to deer. The observation of the scatterplot of MGSHPx against early conception rates in yearling hinds within farms (Figure 4.13) led to the conclusion that the minimum required blood level for GSHPx may be around 5-6 kIU/l. While it is important to be aware of these limitations, the transformation of some variables into categories and the dual analysis of both continuous and categorical variables allows a better interpretation of the data. In many instances, however, the determination of the exact nature of identified relationships (ie linear, non-linear or spurious) in this thesis is a matter for further research.

5.1.2.1 Selection of outcomes

Outcomes chosen for multivariable analyses were those that affect both the farmers' income, and the success of the industry as a whole as follows :

- Reproductive performance defined as conception (and conception before May 1) and survival of progeny to weaning, as these contribute to economic viability of breeding herds but also influence the number of deer available for slaughter, or retention in the national breeding or velvet herds.
- Growth to weaning (as bodyweight standardised on April 1) was chosen because weaners are sold on a dollars per kilogram basis, and because it is associated with future growth potential and attainment of target bodyweights.
- Seasonal growth rates were chosen because they are critical for attainment of target bodyweight for slaughter (thus carcass weight) or for reproduction (to increase the risk of hind conception at 15 months of age). Achieving target carcass weight to meet market demand improves financial return through added value to the product. Furthermore, the slaughter of weaners by one year of age is the most profitable management option for venison production units (Fraser, 1993). High bodyweight is also associated with increased velvet antler production.
- Health problems are important outcomes because of the direct loss on farms, and because of the threat they impose upon the sanitary status and image of deer production, and consequently on market access for deer products. The health outcomes under investigation are those identified as the most important, ie those being the most prevalent and occurring on many farms, relatively to other health problems.
- Velvet production outcomes were chosen because they relate directly to market demand.

5.1.2.2 Multivariable analysis using path analysis

The technique of path analysis has been adapted for each risk factor analysis (Chapter 4) depending on the outcome under investigation and the structure of the data. Typically, where there was a large number of potential risk factors selected at the univariate level, these risk factors were split into two blocks, namely animal management factors (eg block 1 : deer characteristics and mating management for analysis of conception) and other factors (eg block 2 : environmental conditions and nutrition management). These blocks were initially analysed separately but were subsequently

merged to allow the identification of the most important risk factors and remove confounding effects. This was carried out for the analysis of hind conception status (early conception or conception *per se*)(section 4.1) and hind lactational status at weaning (section 4.2). By doing so it was possible to merge :

- risk factors that were significantly associated with the outcome in respective analysis of block 1 and block 2 (ie to merge both final path diagrams)
- risk factors of block 1 with those of block 2 (ie to merge both null hypothesis path diagrams)
- risk factors of block 2 significantly associated with the outcome with those of block 1 (ie to merge the final path diagram from block 2 with the null hypothesis path diagram of block 1)
- risk factors of block 1 significantly associated with the outcome with those of block 2 (ie to merge the final path diagram from block 1 with the null hypothesis path diagram of block 2)

There were no published guidelines on the most appropriate approach to handle data in this manner. However, the last option was chosen because of the belief that animal management risk factors in these analyses were likely to be the most important and that those identified with a direct effect on the outcome in the analysis of block 1 alone were more likely to remain in the overall final diagram. This hypothesis was subsequently confirmed. This approach also simplified the drawing of path diagrams. Although it is probable that the stepwise selection procedure used in this thesis may have led to slightly different final path models by following each of these 4 approaches, it is believed the most important associations have been identified by the method chosen. Further investigations of alternative final models obtained from each of these four approaches could assess the validity of this hypothesis.

The grouping of explanatory variables per block has been previously used (Salman et al., 1984a), but all blocks were not analysed separately. Those authors presented a simplified null hypothesis path diagram where arrows were drawn only between blocks and not between individual risk factors. In another study (Lafi and Kaneene, 1992), path analysis was used to investigate the interrelationships between synthesised risk factors calculated from groups of variables related to common areas of recording (which are equivalent to blocks). In both studies, however, the structures of causal webs between specific risk factors were not thoroughly investigated. Therefore this study has developed an innovative approach to the use of path analysis to investigate plausible causal webs when a large number of explanatory variables are taken into consideration. It is believed the series of path diagrams generated provided useful visual support for a better understanding of the system under investigation.

A similar approach has been used for the analysis of velvet antler production and dystocia. However, environmental and grazing management factors were not analysed separately from individual stag or hind characteristics, as this was deemed inappropriate. The influence of individual stag characteristics on velvet production and that of individual hind characteristics on dystocia were already known (or believed) to be important and, therefore, there was a need to control for their potential confounding effects.

In other path analyses, such as analyses of weaner bodyweight standardised on April 1, weaner seasonal growth rates, and the occurrence of malignant catarrhal fever in hinds and stags, potential risk factors were grouped in a single path analysis because the number of individual deer characteristics was limited and the splitting of other risk factors in 2 blocks was not justified.

Within each risk factor analysis, it was not possible to merge risk factor blocks for which the number of observations differed (ie dam characteristics, lactation management and post-weaning

management risk factors for weaner bodyweight on April 1 (W4)) because it would have required selection of observations only from the smallest block. Consequently, the distribution of explanatory variables from the larger blocks would change and, should inferences change, it would be difficult to conclude whether the change was due to the reduced number of observations (in particular for mob data) or the effect of other risk factors. For the analysis of risk factors for W4, however, it may be informative to include significant lactation, weaning and post-weaning management factors in the analysis of dam-offspring characteristics to test for the significance of these characteristics, but this is considered as a follow-up analysis.

It was also deemed inappropriate to merge risk factor blocks which related to different time periods, such as merging winter grazing management factors (calculated from June 1 to September 1) and pre-velvetting grazing management factors (calculated from September 1 to the time of velvet antler removal) for the investigation of risk factors for velvet production (Morris, personal communication).

Other specific issues on statistical methods have been addressed within each section in Chapter 4, and are further discussed with regard to the percentage of variability in outcomes explained by their respective final model (see section 5.1.4).

5.1.2.3 Multivariable analysis without the use of path analysis

Path analysis was of limited value for minor follow-up analyses, such as analyses of categorical body condition score and bodyweight variables, those of individual sampling hind characteristics and that of back-up sire management risk factors.

Path analysis was not used for the investigation of biological markers because of the limited number of markers selected at the univariate level, and the limited knowledge of biologically plausible relationships between them. It is believed that the approach used in this thesis allows a first insight into the data and that other statistical techniques may be necessary to explore interrelationships further. For instance multivariable techniques such as the principal components analysis and discriminant analysis may be useful to identify "blood profiles" (ie the intercorrelations between blood markers) and investigate relationships between such profiles and health and production outcomes. This is a matter for further research.

Biological markers were analysed primarily at the individual level. For all blood markers, there was highly significant variation due to farm factors (climatic conditions, nutrition levels, genetic factors, etc). This illustrates that sampling deer are not independent with regard to their blood characteristics, but are clustered within farms (blood markers are correlated within farms). This also illustrates that the mean of blood characteristics from sampling deer within farms may be used to evaluate the value of blood markers of the other deer (not sampled) in the same farm. This justified the analyses of biological markers at the farm level. Furthermore, analysing means of continuous individual markers at the farm level (eg mean growth rates) reduces the cluster effect further. The limitation of this approach in this study is that, because of the limited number of farms, data from both years were combined for analyses and thus most farms were used twice in the dataset. Therefore, observations at the farm level are still not statistically independent. Although it is acknowledged this is not truly statistically valid, this allowed the identification of relationships that, otherwise, may not have been significant because of limited number of observations. In the context of this study, it is believed that it is more productive to use techniques which can identify

associations, albeit crudely, which may later be validated, rather than risk generating no hypotheses about the data at all merely because of poor statistical power in the analyses.

The analyses of farm mean blood markers were carried out for the investigation of continuous outcomes, ie bodyweight on April 1, seasonal growth rates and velvet production outcomes, for which means have been calculated for each farm. Individual and mean values of these production parameters are, to some extent, measuring the same outcome. This is quite different for the investigation of dichotomous outcomes, although rates (ie conception and weaning rates) have been calculated to allow analyses at the farm level. These latter analyses were considered to be of a different type, in particular since linear instead of logistic regression analyses were used. Investigation of mean blood markers as risk factors for conception rates has been carried out only as follow-up analyses of relationships that were significant at the individual level. Investigations of all mean blood markers as risk factors for weaning rates, however, were carried out because there were not enough sentinel adult hinds that were non-lactating at weaning. Although analyses at the individual animal level could be carried out in yearling hinds, farm-level analyses in this age group were carried out for comparison with adult hinds (see section 4.2).

The multiple stepwise linear regression approach allowed the identification of blood markers that "explained" most of the variability of the outcome under investigation. Furthermore, results from analyses in both age or sex groups, and both at the individual and mob level (where carried out) are useful to identify the most important blood markers to be included in further research. Other blood markers associated with the outcome at the univariate level (step 1 in the analysis process as in section 2.7.4.1) may have been rejected at the multivariate stage because of intercorrelation between blood markers. For instance, the mean phosphorus concentration (MP) of weaners was not included in the regression equation showing the relationship between mean blood markers and the mean weaner stag growth rate during winter (GR69)(Table 4.15), after the mean percentage of eosinophil (MEO) and the mean glutathione peroxidase (MGSHPx) had been taken into account. It is believed, however, phosphorus may be the most important blood marker because it was also identified at the individual deer level (Table 4.15), but it may be that the effects of glutathione peroxidase and the percentage of eosinophils, if any, are confounded with that of phosphorus. In this respect, the use of other multivariable techniques such as principal components analysis which identifies "blood profiles" may help understand the intercorrelation between blood markers.

The use of multivariable regression analysis also allowed the identification of associations which otherwise may not have been significant and not considered for further investigation. For instance, the negative relationship between the blood urea nitrogen (BUN) in individual weaner hinds sampled in June and their autumn growth rate (GR46) was significant only after the serum copper (CU) and serum albumin concentrations (ALB) had been taken into account, but not at the univariate level (Table 4.16). This suggests that BUN, CU and ALB should be considered together in future investigations of blood markers for weaner growth.

5.1.3 The control for herd effect

The decision not to control for herd effects as discussed in section 2.8.13.2 was carefully considered as it is an important issue when investigating mob-level risk factors for individual animal level outcomes (Curtis et al., 1988a; Curtis et al., 1993b; McDermott and Schukken, 1994). However, this was not considered essential because this study was exploratory and had broad objectives related to identification of major effects on productivity applicable to the national deer herd. Controlling for herd effect would be appropriate in a second phase study

based on the major effects identified in this study. McDermott et al. (1994b) have presented the various techniques available to adjust for herd effects. One of them is to use farms or groups of animals as statistical units to investigate management practices on farm or mob outcome variables (eg Dargent-Molina et al., 1988, Chesterton et al., 1989) which are transformed into a high/low or absent/present classification. The limitations of this technique are that individual animal characteristics and mob variables cannot be investigated simultaneously, and the classification of the outcome variable may result in a loss of information. It is proposed, however, that such an approach can be used for further studies where a large number of herds are used to investigate a smaller range of mob variables.

In a recent paper, McDermott and Schukken (1994) reviewed explanatory studies in the veterinary epidemiology literature in which herds were sampled and individual responses were measured. Thirty one papers of 67 reviewed did not adjust for cluster effects, 26 of which were considered to have lead to incorrect inferences, while only 6 of the 36 for which adjustments were used may have made incorrect inferences. The main consequence of not adjusting for herd effect is an underestimation of variances and an inflation of the statistical significance of risk factors. Consequently, it is recognised that risk factors that were identified at the 5% confidence level may not have been selected should herd effects have been controlled for. In the context of this study, however, it is considered these risk factors, although of marginal significance, may be more important than factors rejected from the final diagram. Most risk factors in final models were significant at less than the 1% confidence level, which suggests they would still have been selected into the final model (at least at the 5% confidence level) should adjustment for herd effect be used. This assumption may need to be tested by further analysis, but it is believed the major conclusions in this thesis would not be altered.

5.1.4 Variability explained by path models

The percentages of variability of the outcome under investigation explained by each final model (%VAR) can be used to evaluate the overall importance of significant risk factors with regard to respective outcomes. This discussion focuses only on final models generated by path analyses, ie the analyses summarised in Table 4.1.

Apart from the one analysis which did not identify significant risk factors (yearling hind WET), %VAR recorded across all multivariable analyses ranged from 2.3 to 74%. Differences of %VAR depend on the statistical technique used (ie logistic or linear regression), the number of statistical units (ie mainly whether analyses were carried out at the individual or mob level) and the nature of the risk factors selected in final models.

Logistic regression analyses give lower %VAR (ranging for individual-level analyses from 2.3 to 16.5%) than linear regression analyses (%VAR ranged for individual-level analyses from 24 to 74%). This may be because the outcome variables under investigation are different in nature (dichotomous or continuous) or because the computations of %VAR differ, or both. %VAR is the square of the multiple regression coefficient (r^2) when using linear regression (Kleinbaum et al., 1988), whereas it is the proportionate reduction in deviance when using logistic regression (Frome and Checkoway, 1985), although Frome and Checkoway (1985) reported that these two computations were equivalent. A direct comparison of %VAR to evaluate model fit (ie to assess whether important risk factors have been considered) when these two analytical techniques have been used is difficult.

Using logistic regression, the overall final models of hind conception explained less than 16% of the individual hind variability in conception status (early conception or conception *per se*), which is considered low. This means that other factors not included in the analyses may be important in explaining differences in conception status in individual hinds. These factors may be related to farm characteristics or other individual hind characteristics, or management practices which cannot be measured or were not measured. Some factors may not have been measured because the current knowledge of the biological process involved (which allow the building of the null hypothesis path diagrams) is limited, or because these factors are costly and time-consuming to record or have no direct practical and useful application for management decisions.

Alternatively, it may be that the outcome under investigation (eg conception before May 1 in adult hinds) is not the most sensitive outcome in identifying important management risk factors because there may be a loss of information in categorising outcomes. For instance, the bodyweight of adult hinds may be associated with the time of conception *per se* rather than whether hinds conceived before or after May 1 (see section 4.1). If timing of conception was the outcome variable, other statistical techniques such as survival methods, eg the Cox regression model, may have been used (Bugnard et al., 1994). However, in this example, although the investigation of the time of conception *per se* is achievable in deer through ultrasound diagnosis (Revol and Wilson, 1991), this recording was very time-consuming and the workload already involved did not allow such investigation. This factor should be considered for further research into factors affecting conception in farmed deer.

The %VAR was also low (below 5% when both years data were analysed together) for the analysis of whether hinds were lactating at weaning. The extreme situation was found in the analysis of yearling hind data for which only one significant management factor (which may be a surrogate variable) was identified (section 4.2). This means that the underlying biological process explaining differences in lactational status at weaning is currently not fully understood in yearling hinds (and may be to some respects in adult hinds too), or alternatively, that the outcome under investigation is too general. The analysis of more refined outcomes, eg whether calves died from difficult calving or from mismothering, may lead to the identification of more specific significant risk factors.

Consequently, whereas most risk factors identified in these analyses are statistically highly significantly associated with categorical outcomes, the current findings suggests that manipulating known reproductive management risk factors (provided they are causal factors) may not result in a dramatic improvement in reproductive performance within the range of performance observed in this study.

The %VAR recorded from final models of continuous outcomes are close to or above 30% (see Appendix 1, sections 4.3 to 4.5), which suggests most of the important risk factors have been taken into account in these analyses. Where only 30% of the outcome variability has been explained, however, some other important factors may have been omitted. Alternatively, such %VAR may result from the analytical approach used, eg for that of risk factors for individual bodyweights standardised on April 1 (W4). It is acknowledged that this outcome was related to a multitude of factors, which may not have been all recorded in this study. Further, those variables that were recorded were analysed within three different blocks. No attempt was made to merge these factors into one single multivariable analysis so the total variability explained by an overall final model could be calculated, because there was not the same number of weaners in each block. To do so would have required selection from the three datasets only those weaners for which dam-offspring pairs were recorded. Because this data was available from only 6 farms, the variability in the mob or

farm data (block 2 and 3) would be reduced, eg on 5 of these farms calves were weaned late February-early March so the potential effect of weaning date may not be identified.

In contrast to the above analysis, the high %VAR recorded from final models of risk factors for velvet WEIGHT (close to or above 60% with a maximum of 74%) suggests a large proportion of important factors have been recorded and analysed. The relative importance of %VAR between yearling and adult stags and groups of risk factors has been discussed previously (see section 4.5). That %VAR is higher for WEIGHT than for GRADE is because GRADE is an important factor influencing WEIGHT. The stage of antler growth may be a critical factor for WEIGHT and GRADE (Suttie, personal communication), but that variable was not analysed because it was not recorded on every farm.

There were a large number of variables recorded in this study. Had all of them been included for risk factor analyses, higher %VAR may have been achieved. However, it is a limitation of observational studies, which rely on farmers to record the data, that complete information is not collected on every farm. Consequently some potentially important risk factors could not be analysed. Furthermore, for those variables for which limited data was missing, the replacement procedure used (see section 2.7.2) allowed these variables to be included in the analyses, but missing values led to a reduced sensitivity of the analysis and thus likely reduced %VAR. In this thesis, therefore, it is believed a compromise has been reached.

It is accepted that other researchers may have chosen slightly different approaches, eg by selecting, recording, and analysing some risk factors differently. The list of risk factors and outcomes under investigation, and the statistical technique used in this thesis were considered the most appropriate by the researcher within the context of this study.

5.2 WHAT THIS STUDY HAS SHOWN

The amount of data collected is substantial covering reproduction, bodyweight and growth, velvet production, health problems and biological markers. This thesis is the most comprehensive data available on commercial deer farm characteristics, management practices, and health and production parameters.

An important conclusion from this study is that there is considerable potential on many deer farms to improve production efficiency and therefore profitability. Data has shown a large range of productivity levels and, for the first time, potential productivity levels on commercial farms has been demonstrated. There were wide variations of all parameters between farms, which suggests some management practices are better than others for optimum farm profitability. It is therefore believed that improvement of profitability is achievable for almost all farms within the deer industry.

5.2.1 The most important associations

Many risk factors have been identified in association with the most important health and production outcomes. A few associations remained unexplained in biological terms and were suspected to be spurious or due to confounding factors not included in the analysis, or that other interpretations need to be considered.

This study has confirmed and strengthened understanding of relationships that were known prior to the study from other observation or experimental evidence, eg :

- The positive effect of yearling hind bodyweights on conception
- The lower mothering ability of yearling hinds (first calvers) compared to mature hinds
- The beneficial effect of imported blood lines or wapiti for weaner production.
- The negative effect of grazing swards below 5 or 10 cm on weaner growth.
- The positive relationship between stag age (and stag bodyweight) and velvet production.

It is particularly notable that the regression coefficient for the relationship between yearling stag bodyweight and velvet weight, in this study, was similar to that from already published work (see section 4.5). These observations support the validity of the epidemiological techniques used in this study.

However, many risk factors have not been investigated previously and this study proposes their importance for the first time. Inferences made in this context, therefore, are only suggestive and should be targeted for further research. The most striking associations were as follows :

- The apparent need for different mating management strategies for yearling hinds according to reproductive performance objectives, ie whether farmers prioritise early conception (before May 1) or conception *per se*.
- The presence of SUN and TREES in many final path diagrams. SUN was negatively associated with hind early conception, weaner weight on April 1, weaner autumn and spring growth rates. TREES was positively associated with hind early conception, weaner weight on April 1 and weaner autumn growth rates, but negatively associated with weaner winter growth rates and stag velvet weight and grade. This suggests environmental conditions, ie climate and shelter, may be critical for deer welfare and production, and that paddock requirements may differ between seasons and overall weather conditions.
- The significant negative association between health problem variables and growth in weaners which illustrates the potential loss associated with some health problems other than through mortalities.
- The significant positive association between internal parasite control variables and growth in weaners, which highlights the need for thorough internal parasite control on deer farms and the potential negative effect on production of not doing so.
- The positive association of STRIP (strip grazing) with weaner autumn growth and 2-year-old and adult velvet production, and the negative relationship of FSUP (food supplementation) with many production outcomes. This suggests that nutrition allowances are not budgeted on many farms. Further education of feed requirements and how to meet them would improve production on many farms.
- The associations of some biological markers, such as a farm faecal lungworm larvae index, serum albumin, copper, phosphorus and vitamin B 12 concentrations, and blood packed cell volume, haemoglobin and glutathione peroxidase activities, with various production outcomes as detailed in Chapter 4.

One of the most important risk factors which may have practical application for deer management is body condition score (BCS). This study has consistently identified hind BCS or its change in association with key reproduction outcomes, ie :

- adult hinds in moderate to good body condition, with a BCS over the threshold 2.5, were more likely to conceive early or to conceive *per se*.
- fat yearling hinds, with a BCS over the threshold 3.5, were less likely to conceive early.
- yearling and adult hinds gaining body condition during pregnancy (and thus more likely to be in good post-winter body condition) were less likely to lose their progeny up to weaning.

- hinds over BCS 3.5 were more prone to dystocia.
- adult hinds losing body condition during the last third pregnancy and lactation produced lighter calves on April 1 (weaning).

These associations have led to a putative management plan for breeding hinds from target body condition scores as presented in a later section in this chapter.

5.2.2 The most important areas for potential improvement of productivity

This study has shown the main areas for potential improvement of productivity for the deer industry are :

- The reproductive efficiency of yearling hinds, combining conception and calf rearing.
- The advancement of conception dates of adult hinds (since the percentage of adult hinds not conceiving on each farm is commonly around only 3-4%, it is believed limited improvement can be expected from conception rates *per se* of adult hinds).
- The weaning rate of adult hinds.
- The bodyweight of weaners standardised on April 1 (as a measure of weaning bodyweight)
- The bodyweight of weaners at 12-15 months of age through improved seasonal growth rates.
- The percentage of weaner stags that reach 92 kg bodyweight, and therefore optimum 50 kg carcass weight, by one year of age.
- The velvet production from 2-year-old stags, which may partly result from improved growth rates.
- The velvet production from adult stags. Mean velvet antler weights are expected to increase with the age of the velvetting herd, but also through management decisions as shown by the velvet weight index.
- Mortalities in weaner deer.

The current mean values of these performance parameters within farms and the proposed targets (their 75th percentiles) are summarised in Table 5.1.

Improvement of productivity, however, is subject to the identification of risk factors statistically significantly associated with the outcome under investigation, that can be manipulated on farms, that are causal, and that have a substantial effect on the outcome in question. This study has identified many management risk factors that may have important practical application on farms for improvement of performance, but such improvement cannot be totally guaranteed because cause-and-effect has not been proven for all factors.

Furthermore, the percentages of variability of outcomes explained by each final model, discussed in a previous section, provided an insight into which productivity parameters could be reasonably improved by employing current knowledge of the deer production process. For instance, it is believed there is scope for improvement of the reproductive efficiency of breeding herds because of the range of results recorded across all farms. However, because the %VAR was low for those outcomes, manipulation of management risk factors that were identified significantly associated with reproductive outcomes (conception or lactational status at weaning), should they be causal, may not be sufficient on some low producing farms to meet the proposed performance targets. Inherent limiting factors associated with farms or districts, such as farmer ability, topography or climate, may preclude improvement.

Table 5.1 : Current mean values and proposed targets of farm-level major health and production outcomes

Outcomes	Unit	Mean†	Proposed target‡	Mean†	Proposed target‡
Reproduction		Yearling hinds		Adult hinds	
Conception rates	%	85.0	94.7	96.7	98.4
Early conception rates	%	65.5	83.1	91.0	95.5
Weaning rates	%	84.0	87.8	91.8	95.7
Reproductive efficiency	%	68.6	81.2	83.6	87.3
Weaner production		Weaner stags		Weaner hinds	
Bodyweight on April 1	kg	50.6	53.2	46.3	48.8
Bodyweight on June 1	kg	56.4	61.4	52.0	55.6
Bodyweight on Sept 1	kg	65.2	70.6	58.5	62.7
Bodyweight on Dec 1	kg	82.3	86.5	71.0	75.2
% > 92 kg BW by Dec 1	%	15.4 (median: 7.5)	29.5		
Bodyweight on Mar 1	kg	95.4	100.3	80.7	87.9
Velvet production		2-year-old stags		Adult stags	
Mean velvet weight	kg	1.18	1.25		
Mean velvet weight index§	kg			0.84	1.12
Weaner mortality rates		Weaner stags and hinds combined			
		25th percentile	median	75th percentile	
number / 100 weaner-years		2.15	2.61	5.24	

% > 92 kg BW by Dec 1 = percentage of weaner stags reaching 92 kg bodyweight by December 1
† Means of study farm data
‡ The 75th percentile of study farm data
§ This index is presented in Table 2.37

The same limitations apply to other productivity outcomes such as weaner bodyweight, weaner growth rates and velvet production, although the percentages of variability of these outcomes explained by respective final models were significantly higher. Furthermore, some associations related to these outcomes are believed to be causal-and-effect relationships because they have been studied previously. It is believed, therefore, there is considerable scope for improvement of these production outcomes.

Some health problems in weaners, such as yersiniosis and osteochondrosis (copper deficiency), may be preventable, as they did not occur on every farm. Clinical health problems in deer over 15 months old were limited, although dystocia in hinds and malignant catarrhal fever in both hinds and stags were, in relative terms, the most important causes of mortalities. While it is believed dystocia could be prevented, this is more uncertain for malignant catarrhal fever because its epidemiology is not fully understood. Misadventure, eg injuries, occurred on every farm with a variety of identified causes. The occurrence of broken necks or legs in young deer around weaning was notable but this study is inconclusive as to whether these could be a prevented. This health problem is believed to be a herd rather than an individual animal problem and, thus, should be investigated across a larger number of farms to identify potential management factors associated with it.

This study has shown progeny loss in yearling hinds may be an important factor limiting the reproductive efficiency of the New Zealand breeding herd. The lack of significant management risk factors for this outcome is a striking finding and suggests a different research approach should be used to further investigate this production limiting factor. The range of results recorded between farms suggests improvement may be achievable. It is therefore believed reproductive performance

of yearling hinds from conception to weaning, ie pregnancy, calving and lactation, should be prioritised for further research.

5.3 IMMEDIATE APPLICATIONS OF THESE DATA AND ANALYSES

5.3.1 At the farm level

5.3.1.1 Deer farmers' self evaluation of management options

Risk factor analyses allow the design of putative epidemiological models for a year round management plan likely to increase the productivity of many commercial deer farms. These conclusions are presented at the end of each section in Chapter 4. Body condition score (BCS) will be chosen to illustrate the usefulness of this approach.

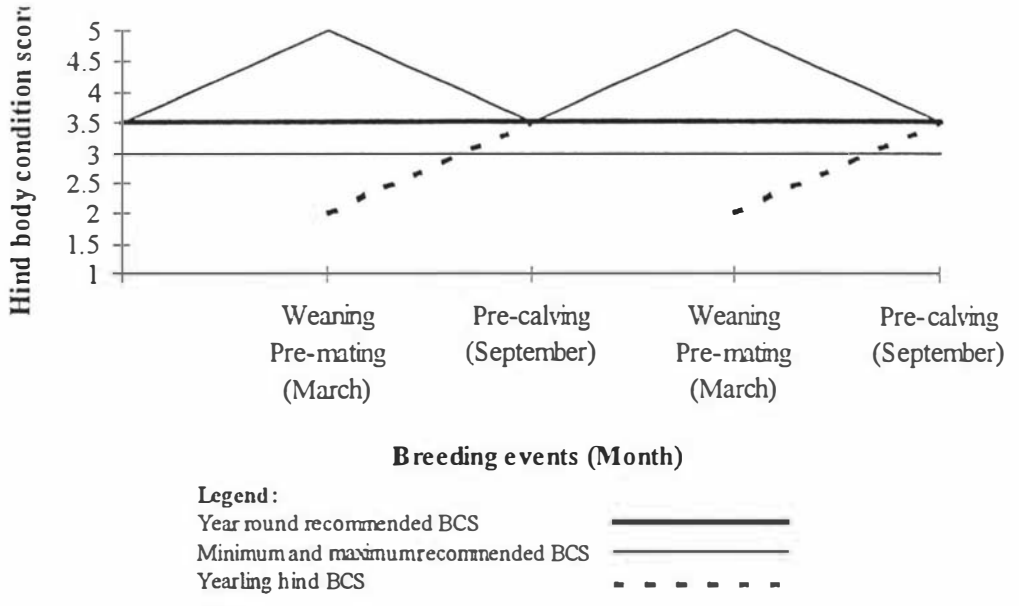
This study has defined a practical body condition scoring chart for use in red deer (see Appendix 2.21) which should be adopted industry-wide for farm management. Deer farmers should routinely assess the nutritional status of breeding hinds through BCS. It is proposed farmers should achieve BCS presented in Figure 5.1.

Yearling hinds should have a pre-mating BCS between 2 and 3.5 and gain body condition by September (post-winter). Adult hinds should have a pre-mating BCS over 2.5. Yearling and adult hind BCS in September should be 3.5 but not over, and if they are, should be restricted in feed or they should be grazed on steep paddocks before calving. Hinds should not lose body condition during lactation. It is critical that hind BCS be over 2.5 at weaning. Hinds losing condition during lactation should be separated from their calves early (late February) and preferentially fed after weaning so they can recover their body condition by the following calving season. Since loss of body condition in hinds during early pregnancy and late pregnancy/lactation is associated with progeny loss and reduced weaner weight on April 1, respectively, hinds should ideally maintain a BCS of 3.5 all year round.

While primarily studied in relation to health and reproduction outcomes on farms, it was anticipated that BCS in deer could be used to predict the GR measurement (measure of carcass fatness at DSP) of the deer before slaughter. If the estimated GR is high, the farmer could withhold the deer from slaughter and avoid downgrading of the carcass for over-fatness with its substantial financial penalty. This should be investigated in a future study.

It should be noted that putative management proposals in Chapter 4 are related to respective outcomes under study. Some management proposal to achieve productivity related to one outcome may be contradictory when considering the overall production objectives. For instance, increasing the size of hinds by the use of imported blood lines or wapiti to produce heavy weaners may be at the expense of having a lower proportion of hinds conceiving early. Risk factors identified in this thesis, therefore, should not be taken in isolation and potential effects must be investigated beyond only those on the production parameters one may wish to improve. When designing a putative management plan based on data in this thesis for multi-faceted farms, eg those with breeding, venison and velvet operations, some compromises may be required.

Figure 5.1 : Proposed year-round body condition scores (BCS) of yearling and adult hinds to optimise reproductive performance.



Farmers should consider the lifetime performance of their deer and not only the immediate apparent benefits. Since hinds lactating at weaning were more likely to conceive early, and hinds conceiving early were more likely to rear a calf up to weaning, there is limited benefit from a prolonged mating season. Farmers who wish to increase the size of their breeding herd, for instance, may be better to select yearling hinds more likely to conceive rather than allowing all to enter the breeding herd. Late conception appears to be a self continuing process if not controlled.

5.3.1.2 Whole-farm investigations

Information provided in this thesis, ie productivity parameters, biological markers and risk factors, will allow whole-farm investigations by veterinarians and farm advisers to help management decisions on commercial farms.

Descriptive data provide the baseline information on health and production parameters, ie standards for evaluation of farm performance as a whole and to set up reasonable performance targets adapted to the individual farm. The productivity targets (as the 75th percentile of farm productivity parameters) proposed in Table 5.1 should be considered as overall industry targets, and it is conceded these may be set differently for individual farms. While the quarter of farms that are above these targets may have higher performance expectations, these targets may not be currently reasonable for low producing farms and it may be wiser to set lower objectives for performance for those farms, which can be reviewed later.

Risk factor investigations provide the elements for the diagnosis of the likely causes associated with productivity failure or success. The most important risk factors outlined in Chapter 4 should be investigated on any farms identified with poor performance results. Furthermore, this study has

identified blood markers associated with various production levels. Some may be used for diagnostic purposes (eg using the faecal lungworm index or serum albumin concentrations in calves at weaning) or for the prediction of reduced productivity (eg using serum phosphorus concentrations in weaners for winter growth or using serum copper and haemoglobin concentrations in stags for velvet production), and thus, in this latter case, lead to cost-effective preventive programmes.

In a second stage of research and development, there is scope for the development of a computer model of deer farming as an aid for making management decisions on farms. This is presented in a later section.

The list of productivity parameters produced in this thesis is substantial, and many have been measured or calculated for the first time (eg the stag velvet weight index). These parameters were chosen because they can be easily recorded on commercial farms and thus be the most useful for whole-farm investigations. For instance, it is believed calving rates (number of calves born alive per hind mated), which has been used in cattle (McDermott et al., 1991b) and published from research farms (Kelly and Moore, 1977; Hamilton and Blaxter, 1980; Hamilton, 1988), may not be appropriate as the sole measure of reproductive performance on commercial deer farms since a large proportion of calves may not be found (see section 3.3.4.1.2).

It is accepted however that the list of farm productivity parameters studied here may not be exhaustive and entirely appropriate to most on-farm situations. The identification of such parameters that can be calculated and be useful for monitoring and interpreting herd health is not easy, as in cattle (Dohoo, 1993). Future research and field experience of whole-herd investigations may highlight where productivity parameters are useful, where they should be refined or where other parameters need to be investigated.

5.3.2 At the industry level

If risk factors affecting the health and production outcomes investigated in this study are addressed by all deer farmers in New Zealand, it is likely that productivity gains would achieve returns of millions of dollars to the deer industry. In the event, the outcome would be both improved volume as well as quality of product, ie attainment of higher reproductive performance providing a greater number of carcasses of premium bodyweight, hence adding value and volume to export efforts. As illustrated in Table 5.2, given the current farmed deer population, it is calculated that the potential financial gain from venison exports due to an improvement of the reproductive efficiency alone of yearling and adult hinds by 11.2 and 3.7%, respectively, can reach NZ$ 6.5 million; that due to an improvement of the percentage of weaner stags reaching 92 kg by December 1 by 5-15% can reach NZ$ 1.9 million; and that from both improvements can reach NZ$ 8.5 million per annum. Similar calculations could be made to evaluate potential gains by improvement of velvet production and reduced weaner mortality rates. These figures are simple direct calculations. A full evaluation involving, for instance, altered costs and management implications (eg stocking rates), is beyond the scope of this thesis.

Table 5.1 : Potential financial gain to the deer industry by improvement to proposed targets of hind reproductive efficiency alone, the percentage of weaner stag reaching 92 kg by December 1 alone, and both improvements combined.

	Unit	Yearling hinds		Adult hinds		All hinds
Potential gain from an improvement of the reproductive efficiency of the breeding herd alone						
Number of hinds bred in New Zealand		121,800	17.4†	578,200		700,000
Overall reproductive efficiency (REPEFF)	%	70.0		83.6		
Proposed acheivable REPEFF target	%	81.2	11.2‡	87.3	3.7‡	
Estimate of actual number of calves weaned		85,260		483,375		568,635
Potential extra number of calves		13,642		21,186		34,828
Venison from weaner stags						
Extra number of stag calves weaned		6,821		10,593		17,414
Percentage of weaner stags reaching 92 kg by Dec 1	%	15.0		15.0		
Number reaching 92 kg by Dec 1		1,023		1,589		2,612
Average schedule price per kg carcass	NZ$	5		5		
Potential gain based on 50 kg carcasses	NZ$	255,780		397,240		653,020
Percentage of weaner stags reaching 92 kg after Dec 1	%	80.0		80.0		
Number reaching 92 kg by Dec 1		5,457		8,474		13,931
Average schedule price per kg carcass	NZ$	4		4		
Potential gain based on 50 kg carcasses	NZ$	1,091,328		1,694,890		2,786,218
Venison from weaner hinds						
Extra number of hind calves weaned		6,821		10,593		17,414
Percentage of weaner hinds killed at 15 months	%	95.0		95.0		
Number of weaner hinds killed		6,480		10,063		16,543
Average schedule price per kg carcass	NZ$	4		4		
Potential gain based on 80 kg liveweight	NZ$	1,222,287		1,898,276		3,120,564
	Total improved venison return				NZ$	6,559,801
Potential gain from an improvement of the percentage of weaner stags reaching 92 kg by December 1 alone						
Estimate of actual number of stag calves weaned		42,630		241,688		284,318
Proposed achievable target of the % > 92 kg by Dec 1		20.0	5.0§	30.0	15.0§	
Extra number reaching 92 kg by Dec 1		2,132		36,253		38,385
Added value per kg carcass	NZ$	1		1		
Potential gain based on 50 kg carcasses	NZ$	106,575		1,812,657		
	Total improved venison return				NZ$	1,919,232
Potential gain from an improvement of both the reproductive efficiency of the breeding herd and the percentage of weaner stags reaching 92 kg by December 1						
Venison from weaner stags						
Potential gain from actual weaner stags	NZ$					1,919,232
Potential gain from extra weaner stags						
Percentage of weaner stags reaching 92 kg by Dec 1	%	20.0		30.0		
Number reaching 92 kg by Dec 1		1,364		3,178		4,542
Potential gain based on 50 kg carcasses	NZ$	341,040		794,480		1,135,520
Percentage of weaner stags reaching 92 kg after Dec 1	%	75.0		65.0		
Number reaching 92 kg by Dec 1		5,116		6,885		12,001
Potential gain based on 50 kg carcasses	NZ$	1,023,120		1,377,098		2,400,218
Venison from weaner hinds						
Potential gain from extra weaner hinds	NZ$					3,120,564
	Total improved venison return				NZ$	8,575,533

† Percentage of yearling hinds in the breeding herd recorded in this study

‡ Proposed achievable improvement of hind reproductive efficiency (%). The proposed target are the 75th percentile of reproductive efficiency of yearling and adult hinds within farms recorded in this study, both years combined

§ Proposed achievable improvement of the percentage of weaner stags reaching 92 kg bodyweight by December 1 (%). Improvement from yearling hinds has been arbitrarily set to a lower target as their calves are lighter at weaning. The proposed target for adult hinds is that calculated in this thesis without reference to the age of the dam.

Note : Calculations were based on a 50:50 stag:hind ratio as recorded in this study; a 5% mortality rate was allowed; bodyweights chosen for calculations were actual mean bodyweights of 15-month-old stags and hinds, ie 94 and 80 kg, respectively (see Appendix 3.45); a dressing percentage of 56% has been used; all extra weaner hinds here are considered to be farmed for venison, the replacement hinds being already selected from other hinds

5.4 FURTHER RESEARCH

5.4.1 Validation of putative epidemiological models

A major benefit from this study has been identification of those factors which appear statistically to be most important in affecting productivity. Most associations have biological validity. Because of the paucity of information on the relative success of various management practices on productivity, it may be tempting for individual farmers to apply the proposed management options like a recipe in attempts to improve their own productivity and performance. Improvement cannot be guaranteed - although it is likely - because one cannot claim at this stage causal effects of proposed measures. Putative epidemiological models presented in Chapter 4 must be validated by different research methods, eg intervention studies.

This study has cost-effectively identified areas for future research and has identified where future research should yield the greatest economic benefit to the deer farmer and industry. It is proposed that deer research institutions in New Zealand and elsewhere use these models for determining priorities for production research.

A long term monitoring program of sentinel farms within the deer industry would be useful to evaluate changes that may occur over time following the implementation of key management options identified in this study.

5.4.2 Farm modelling

A future application of these research results is in farm modelling, which allows prediction of production outputs given a set of individual animal and farm characteristics, and management options.

Once models have been validated and regression coefficients have been accurately estimated, a computer model of deer production may be produced. To illustrate the potential, a simple model to predict weaner bodyweight on April 1, given two scenarios, using the path models described in section 4.3, is presented in Table 5.3.

Table 5.3 : Application of modelling technique to predict weaner hind and stag bodyweights on April 1 (W4) with two hinds conforming to a different set of characteristics.

	Dam characteristics						Predicted W4	
Age	WD6 kg	ADVC	BCSS	CHW9C kg	Birth date	BCSL	Weaner stag kg	Weaner hind kg
Yearling	86	No	2	16	Dec 20	-2	28.9	28.3
Adult	100	Yes	4	24	Nov 20	0	53.1	50.1

Note : risk factor codes are described in the glossary

5.4.3 Further analysis of the database

The outcome variables that were investigated in this study have been chosen because of their relevance to deer production. It is unquestioned that many risk factors can be subsequently treated as outcomes in follow-up risk factor analyses from the database, but this is the matter for future analyses and publications, which are beyond the feasibility for this PhD project.

It is proposed that the outcomes and their potential risk factors listed in Table 5.4 should be investigated.

Table 5.4 : Proposed further risk factor analyses from the database

Outcomes	Potential risk factors
Pre-calving hind body condition score (recorded in September) as a continuous (BCSS) or categorical outcome (BCSS4)	• Pre-winter individual hind characteristics • Winter environmental factors and grazing management risk factors
Pre-mating body condition score (recorded in March) as a continuous (BCSM) or categorical outcome (BCSM2)	• Pre-lactating individual hind characteristics • Environmental conditions and grazing management factors during lactation
Farm calf lungworm larvae index (FLCI)	• Internal parasite control on the farm • Individual dam characteristics • Environmental conditions and grazing management factors during lactation
Weaner stag bodyweight at 12 months	• Weaning weight and seasonal growth rates
Weaner hind bodyweight at 15 months	• Weaning weight and seasonal growth rates
Date of velvet antler harvesting (CUT)	• Individual stag characteristics • Winter grazing management • Pre-velvetting grazing management (September 1 to the date of harvesting)
Velvet antler grade and weight	• Individual stag characteristics including the velvet production of the previous year
Velvet antler weight corrected for the number of days of antler growth for the limited number of farms with that data recorded.	• Individual stag characteristics including the date of hard antler casting • Winter grazing management • Pre-velvetting grazing management (September 1 to the date of harvesting)
Unconfirmed stag deaths from winter to early spring taken as caused by malignant catarrhal fever (MCF) and confirmed cases of MCF	• Individual stag characteristics • Winter grazing management

Note : this list of proposed analyses is not exhaustive and the researcher welcomes any suggestion that may come from readers.

5.4.4 Serum bank

From each sampling deer, 6 ml of serum has been frozen to -18°C. This is the first extensive bank of deer serum created from commercial farms in New Zealand. This bank is currently being used for the investigation of leptospirosis serology, but it is possible to further analyse these sera for a wide range of other blood markers not recorded in this study, eg iodine or hormones, and relate them to productivity parameters without the need to monitor and sample other deer. The use of this serum bank will facilitate future investigations.

5.5 CONCLUSION

This study has been motivated by the need of a growing industry to establish a sound basis of knowledge and understanding of farmed deer health and production and identify areas for future research and development. The enthusiasm of the farmers involved in recording the data has been a key component of the success of this study, and their contribution is once more acknowledged. Although more analyses are yet to be carried out from the large amount of data collected, the results presented here are sufficient to claim that objectives have been met.

This research has been innovative in many ways and to many people: to deer farmers because their production system had not been so intensively investigated before and new management options (ie body condition score) have been evaluated to allow methods for improvement of productivity; to deer veterinarians and farm advisers because this study will provide them with a new opportunity to increase their involvement in whole-farm investigation and improvement through health and productivity profiles; to veterinary epidemiologists because this study has extended the use of multivariable statistical methods, ie path analysis, as a screening tool for multiple risk factor investigations; and to the deer industry and research sector because it has provided a baseline for on-farm productivity in 1992 and 1993, and has cost-effectively identified production research priorities. The multiplicity of path diagrams allows generation of hypotheses on the relative influence of management options and, therefore, has direct practical application to many sectors of the deer industry.

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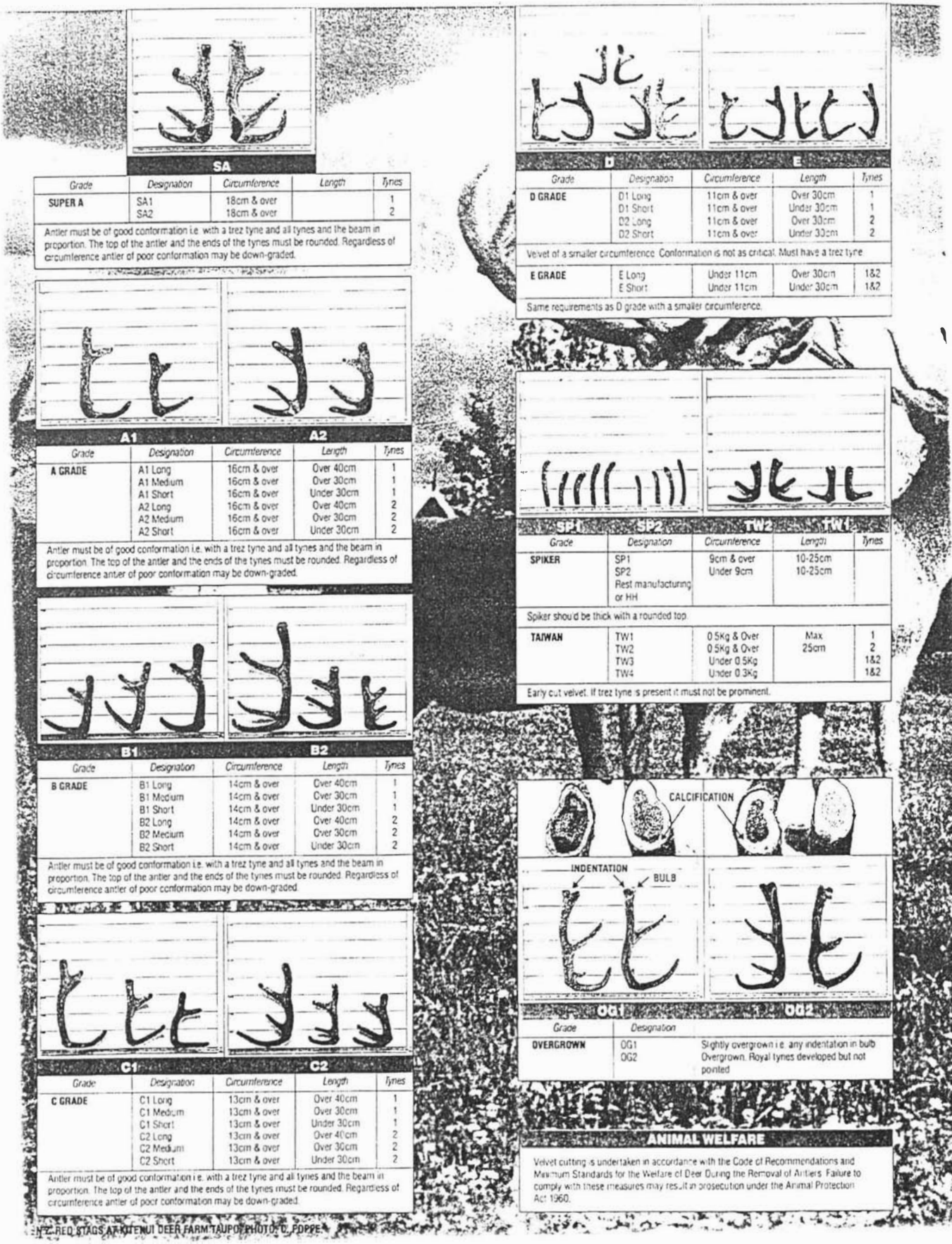
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APPENDICES

CHAPTERS 1 & 2

Appendix 1.1 : New Zealand game industry board guidelines for the removal of velvet antler.



SA

Grade	Designation	Circumference	Length	Tynes
SUPER A	SA1	18cm & over		1
	SA2	18cm & over		2

Antler must be of good conformation i.e. with a trez tyne and all tynes and the beam in proportion. The top of the antler and the ends of the tynes must be rounded. Regardless of circumference antler of poor conformation may be down-graded.

A1 **A2**

Grade	Designation	Circumference	Length	Tynes
A GRADE	A1 Long	16cm & over	Over 40cm	1
	A1 Medium	16cm & over	Over 30cm	1
	A1 Short	16cm & over	Under 30cm	1
	A2 Long	16cm & over	Over 40cm	2
	A2 Medium	16cm & over	Over 30cm	2
	A2 Short	16cm & over	Under 30cm	2

Antler must be of good conformation i.e. with a trez tyne and all tynes and the beam in proportion. The top of the antler and the ends of the tynes must be rounded. Regardless of circumference antler of poor conformation may be down-graded.

B1 **B2**

Grade	Designation	Circumference	Length	Tynes
B GRADE	B1 Long	14cm & over	Over 40cm	1
	B1 Medium	14cm & over	Over 30cm	1
	B1 Short	14cm & over	Under 30cm	1
	B2 Long	14cm & over	Over 40cm	2
	B2 Medium	14cm & over	Over 30cm	2
	B2 Short	14cm & over	Under 30cm	2

Antler must be of good conformation i.e. with a trez tyne and all tynes and the beam in proportion. The top of the antler and the ends of the tynes must be rounded. Regardless of circumference antler of poor conformation may be down-graded.

C1 **C2**

Grade	Designation	Circumference	Length	Tynes
C GRADE	C1 Long	13cm & over	Over 40cm	1
	C1 Medium	13cm & over	Over 30cm	1
	C1 Short	13cm & over	Under 30cm	1
	C2 Long	13cm & over	Over 40cm	2
	C2 Medium	13cm & over	Over 30cm	2
	C2 Short	13cm & over	Under 30cm	2

Antler must be of good conformation i.e. with a trez tyne and all tynes and the beam in proportion. The top of the antler and the ends of the tynes must be rounded. Regardless of circumference antler of poor conformation may be down-graded.

D **E**

Grade	Designation	Circumference	Length	Tynes
D GRADE	D1 Long	11cm & over	Over 30cm	1
	D1 Short	11cm & over	Under 30cm	1
	D2 Long	11cm & over	Over 30cm	2
	D2 Short	11cm & over	Under 30cm	2

Velvet of a smaller circumference. Conformation is not as critical. Must have a trez tyne.

E GRADE	E Long	Under 11cm	Over 30cm	1&2
	E Short	Under 11cm	Under 30cm	1&2

Same requirements as D grade with a smaller circumference.

SP1 **SP2** **TW2** **TW1**

Grade	Designation	Circumference	Length	Tynes
SPIKER	SP1	9cm & over	10-25cm	
	SP2	Under 9cm	10-25cm	
	Rest manufacturing or HH			

Spiker should be thick with a rounded top.

TAIWAN	TW1	0.5Kg & Over	Max	1
	TW2	0.5Kg & Over	25cm	2
	TW3	Under 0.5Kg		1&2
	TW4	Under 0.3Kg		1&2

Early cut velvet. If trez tyne is present it must not be prominent.

CALCIFICATION

INDENTATION

BULB

OG1 **OG2**

Grade	Designation	
OVERGROWN	OG1	Slightly overgrown i.e. any indentation in bulb
	OG2	Overgrown. Royal tynes developed but not pointed

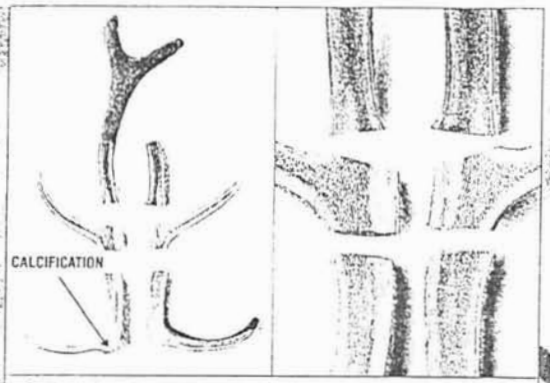
ANIMAL WELFARE

Velvet cutting is undertaken in accordance with the Code of Recommendations and Minimum Standards for the Welfare of Deer During the Removal of Antlers. Failure to comply with these measures may result in prosecution under the Animal Protection Act 1960.

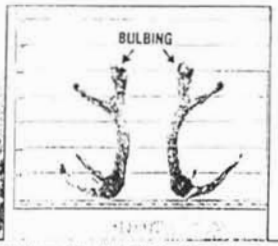
NZ RED STAGS AT KOTENUI DEER FARM TAUPO PHOTO C. FOPPE

ANDARD GUIDELINES

NEW ZEALAND GAME INDUSTRY BOARD



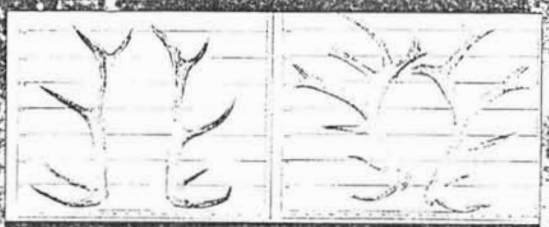
Calcification is readily apparent as a white line on the edge of the cut pieces in the above photographs. It is also seen as a white ring in the photographs of the overgrown velvet cut ends shown below left. Calcification should be avoided by cutting velvet at an earlier stage.



Do not hang velvet. Until frozen it should be placed with cut end uppermost on an angle which is sufficient to prevent blood loss from the cut end. This eliminates the excessive bulbing shown.



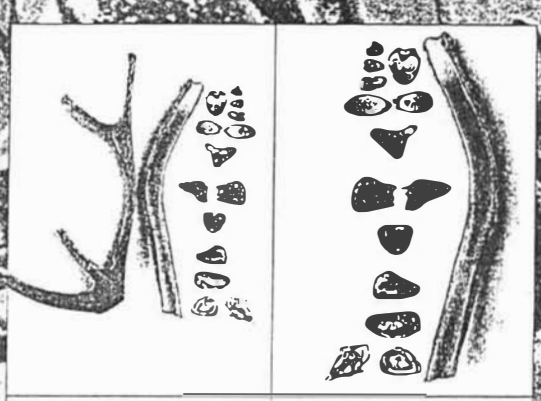
HH1	HH2-SP	MAN-SP
Grade	*Designation*	
HARDHORN	HH1	Fully developed with pointing royals. Velvet still attached.
	HH2	As above with the velvet starting to shed.
MANUFACTURING	Man	As specified and including all severely damaged velvet.

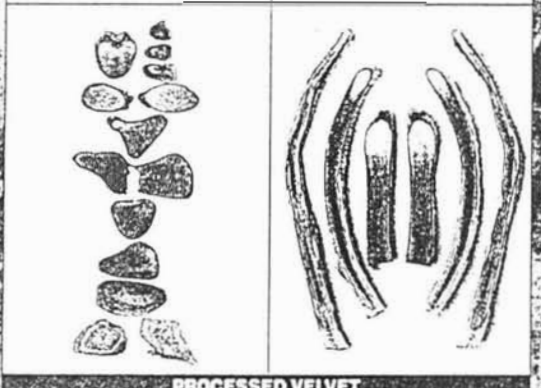


HA1	HA2
Grade	*Designation*
HARD ANTLER	HA1	Fully developed hard antler that is not bleached.
	HA2	All other hard antler.



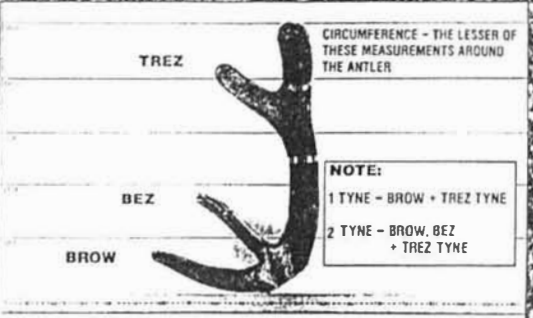
RG1	RG2	RG3	MAN
Grade	*Designation*		
REGROWTH OR 2ND CUT	RG1	As for Taiwanese 1 with minimal calcification	
	RG2	Other RG showing little calcification (min 15cm length)	
	RG3	(Some calcification (min 15cm length)	
	Pest Manufacturing or HH	There is to be no regrowth on any other grades	





PROCESSED VELVET

The stick sliced lengthwise illustrates an absence of calcification. The cross-sectional slices show the variation in the porosity and colour in different parts of the stick. The inner two halves of the dried spiker show the velvet cut at the correct stage. The outer sticks show increasing calcification as the velvet becomes progressively overgrown.



MEASUREMENT

The circumference is the lesser of the measurements taken around the clear beam immediately above the trez tyne and around the mid point of the beam below the trez tyne. Measurement is taken with the velvet fur compressed.

Appendix 2.1 : Participation questionnaire sent to 370 deer farmers

DEER HERD HEALTH AND PRODUCTION PROFILING

PARTICIPATION QUESTIONNAIRE

NOTE : COMPLETE THIS ONLY IF YOU ARE WILLING TO PARTICIPATE IF YOUR FARM IS SELECTED.
THIS INFORMATION WILL REMAIN CONFIDENTIAL.

FARMER NAME :_____

Phone : (___)_____ Fax : (___)_____

FARM LOCATION

ROAD : _____

DISTRICT : _____

POSTAL ADDRESS : _____

FARM CHARACTERISTICS

NUMBER OF DEER		RED	WAPITI	WAPITI X RED	FALLOW
0-1 year	FEMALE				
	MALE				
1-2 years	FEMALE				
	MALE				
> 2 years	FEMALE				
	MALE				
TOTAL NUMBER					
FENCED AREA (Ha)					
WEIGHING MACHINE *		YES		NO	
DEER CRUSH *		YES		NO	

* Circle

Appendix 2.2 : Farmer direct questionnaire

FARMER PROFILE

Your age (years) [ ]
Number of children [ ]
Were your parents farmers before ?
(If more than one answer, add the response scores.)
0 = no; 1 = deer farmers; 2 = sheep farmers; 4 = beef cattle farmers; 8 = dairy cattle farmers [ ]
Your training ?
0 = no degree or diploma; 1 = Agriculture diploma or degree; 2 = other type of degree [ ]
Number of years of farming [ ]
Number of years of farming deer [ ]
Number of labour units working on the farm [ ]
(one person full time = 1, half time = 0.5, one third time = 0.3, one quarter time = 0.25)
Nature of the manpower on the farm
1 = family; 2 = casual employee; 4 = manager [ ]
Farmer commitments within the deer industry other than just farming deer
1 = yes; 0 = No [ ]
Farmer commitments in business other than farming
1 = yes; 0 = No [ ]
Objective for production
(If more than one answer, add the response scores.)
1 = one year old venison production; 2 = two years old venison production
4 = velvet production; 8 = live weaner production & selection for velvet; 16 = breeding animals [ ]
Farmer motivation to farm
1 = Mainly for the income; 2 = Mainly for the life style (Enjoy deer, country life, independent job,..) [ ]
Motivation to farm particularly deer ?
1 = Mainly for the income ; 2 = Diversification, ; 4 = Enjoy deer [ ]
Farmer holidays
0 = no holidays; 1 = 1-2 weeks / year; 2 = > 2 weeks / year [ ]
Average percentage of income generated by deer farming [ ]

FARM PROFILE

TFAREA	Farm total area (Ha)	[ ]
TDAREA	Total deer fenced area (Ha)	[ ]
LALT	Lowest altitude of the deer farm (m)	[ ]
HALT	Highest altitude of the deer farm (m)	[ ]

Appendix 2.3 : Questionnaire of deer stock, health problems and disease control programme related to the year 1991

QUESTIONNAIRE HEALTH MANAGEMENT 1991

This questionnaire refers to the period from March 1991 to March 1992.

DEER STOCK

Total number of adult hinds at mating in 1991	
Total number of yearling hinds at mating in 1991	
Number of fawns weaner in 1991	
Number of stags velvetted in 1991	

HEALTH PROBLEMS : Please, indicate number of occurrences

	Weaner	YH	AH	YS	AS
Broken legs					
Broken neck					
Other misadventure					
Yersiniosis					
Malignant catarrhal fever					
Enzootic ataxia (copper deficiency)					
Leptospirosis					
Internal parasite (lungworm)					
Death					

FAWNING PROBLEMS

	Yearling Hinds	Adult Hinds
Known abortion		
Dystocia		
Calf victimised		
Calf lost over the fence		
Calf mismothered		
Calf death		

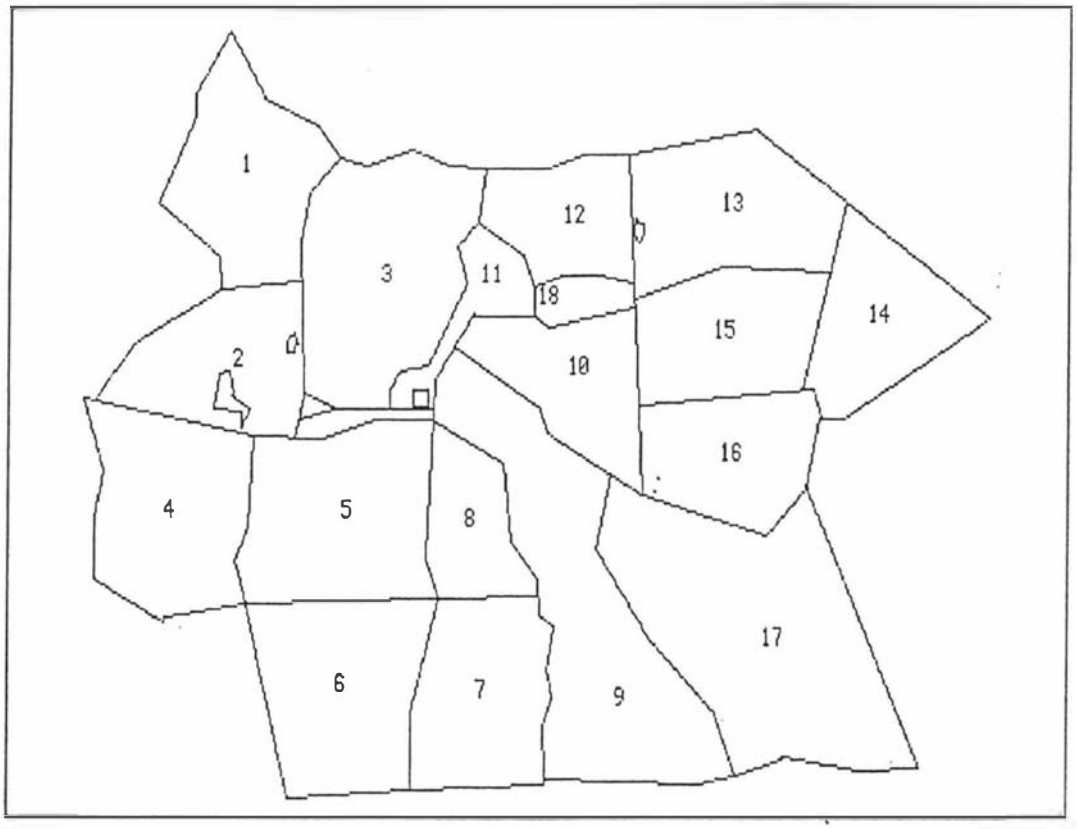
Appendix 2.3 (Cont'd)

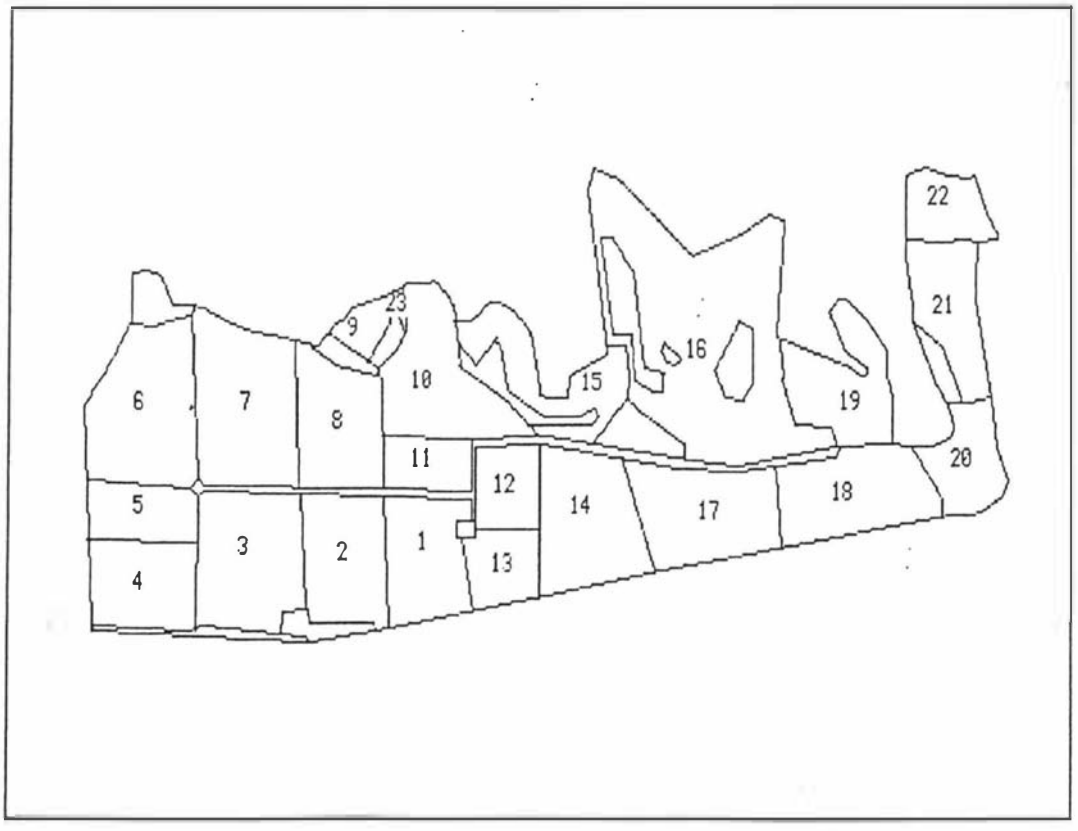
DISEASE CONTROL

	Weaners	YH and AH[1]	YS and AS[1]
Did you **monitor** parasites or trace elements ? Indicate period of the year if yes.			
Vaccination programme • Type of vaccine used • Months of injection			
Internal parasite control • Types of drench used • Number of drenches • Months of administration			
Trace element supplementation • Mineral supplemented • Method of supplementation • Months of supplementation			

[1] Indicate age groups concerned if yearlings and adults had different disease control programmes.

Appendix 2.4 : Examples of computerised farm maps





Appendix 2.5 : Pasture height and stock report

PASTURE HEIGHT AND STOCK

Farm identification : PADDOCK or MOB ID :

MOB or PADDOCK ID	DATE ENTRY	INITIAL SWARD HEIGHT	G M C	L M H	DATE LEAVE	FINAL SWARD HEIGHT	DEER STOCK						OTHER STOCK	INFO
							WH	WS	YH	AH	YS	AS		

Appendix 2.6 : Food supplementation reports

FOOD SUPPLEMENTATION

Farm identification :
Mob identification : Weaners / Hinds / Stags
JUNE 1993

Date	Food supplement No1			Food supplement No2		
	Nature	Quantity	Waste (%)	Nature	Quantity	Waste (%)
01/06						
02/06						
03/06						
04/06						
05/06						
06/06						
07/06						
08/06						
09/06						
10/06						
11/06						
12/06						
13/06						
14/06						
15/06						
16/06						
17/06						
18/06						
.....						
28/06						
29/06						
30/06						

Appendix 2.6 (Cont'd)

FOOD SUPPLEMENTATION

Farm identification :

MOB ID	DATE START	DATE END	FREQUENCY	NATURE	QUANTITY (kg)	WASTAGE (%)	LABOUR
				Cost :			Labour units : Time (hours) : Cost assistant :
				Cost :			Labour units : Time (hours) : Cost assistant :
				Cost :			Labour units : Time (hours) : Cost assistant :
				Cost :			Labour units : Time (hours) : Cost assistant :
				Cost :			Labour units : Time (hours) : Cost assistant :
				Cost :			Labour units : Time (hours) : Cost assistant :

Appendix 2.7 : Deer work in yard report

DEER WORK IN YARD REPORT

Farm identification :

MOB ID	DATE	EVENT	INFORMATION ABOUT DRUGS	LABOUR	VET FEE
			Drugs : Dose : Cost drugs :	Labour units : Time (hours) : Cost assistant :	
			Drugs : Dose : Cost drugs :	Labour units : Time (hours) : Cost assistant :	
			Drugs : Dose : Cost drugs :	Labour units : Time (hours) : Cost assistant :	
			Drugs : Dose : Cost drugs :	Labour units : Time (hours) : Cost assistant :	
			Drugs : Dose : Cost drugs :	Labour units : Time (hours) : Cost assistant :	

Appendix 2.8 : Reproduction management

REPRODUCTION MANAGEMENT
MATING MOBS

Farm identification :

Mating mob ID						
Date of joining						
Number of hinds	Adults (>2 years)					
	Yearlings					
Number of sires						
Sire tag ID						
Blood line						
Sire age						
Number of years of experience as sire						
Pre-mating weight (kg)						
Date sire back-up						
Back-up mob ID (use a new column for information)						
Date removal of sire(s)						

CALVING MANAGEMENT QUESTIONNAIRE

Farm identification :

How often did you visit the hinds per week during calving ? ..... :
Did you visit by foot or by motorbike ?

☐ *By foot* ☐ *By motorbike*

Did you enter into the calving paddocks when visiting hinds ?

☐ *Always* ☐ *Most of the time (>50% of the time)*
☐ *Never* ☐ *Rarely (<50% of the time)*

Why did you enter into the paddock ?

☐ *Just to observe hinds from a distance without going around the paddock*
☐ *To go around the paddock and check hinds and fawns*

Did you tag fawns at birth ? ☐ *No* , ☐ *Yes*

Appendix 2.9 : Deer handling questionnaire

HANDLING QUESTIONNAIRE

Farm identification :

Responses were given for each of the three classes of stock hinds, stags and weaner deer.

DEER WORK IN THE PADDOCK

Method used to shift deer herds on the farm

☐ *by foot* ☐ *by small 4 X 4 or motorbike*

Give the percentage of the time you use motorbike.....:

Number of people to shift deer between paddock .....:

Number of people to shift deer to the yard .....:

Use of dogs to manipulate deer	☐ *no*	☐ *yes*
Give the percentage of the time you are using dogs .....:		
Is the dog(s) barking ?	☐ *no*	☐ *yes*
Do(es) the dog(s) respond well to your commands ?	☐ *no*	☐ *yes*
Do you shout or speak loudly when shifting deer ?	☐ *no*	☐ *yes*

Behaviour of deer mob when shifting to the yard :

☐ *Very calm, the deer almost follow the farmer when opening the gate.*

☐ *Deer calm, but need to be pushed through the gate.*

☐ *Deer restless, running around the paddock before getting through the gate, need more time to be shifted*

DEER WORK IN THE YARD

Number of people to handle deer in the yard ..... :

Do you shout or speak loudly when handling deer	☐ *no*	☐ *yes*

How would you qualify the way your deer are entering the deer-yard in general ?

☐ *They enter quickly*

☐ *They enter easily without rush*

☐ *They don't enter easily even when you are pushing them*

How would you qualify the way your deer are moving inside the deer-yard in general ?

☐ *They move quickly as soon as you open a gate*

☐ *They move easily after slight push*

☐ *They don't move easily even when you are pushing them*

How would you qualify the behaviour of your deer during individual handling ?

☐ *Calm, easily to handle*

☐ *Deer slightly stressed, need firm handling*

☐ *Deer stressed and restless, ie they try to escape*

Have you got some aggressive deer ?	☐ *no*	☐ *yes*
Are you culling aggressive animals ?	☐ *no*	☐ *yes*

Appendix 2.10 : Paddock management report

PADDOCK MANAGEMENT REPORT

Farm identification :

PADDOCK ID	DATE	EVENT	INFORMATION	LABOUR
			Chemicals : Dose : Cost :	Labour units : Time (hours) : Cost assistant :
			Chemicals : Dose : Cost :	Labour units : Time (hours) : Cost assistant :
			Chemicals : Dose : Cost :	Labour units : Time (hours) : Cost assistant :
			Chemicals : Dose : Cost :	Labour units : Time (hours) : Cost assistant :
			Chemicals : Dose : Cost :	Labour units : Time (hours) : Cost assistant :

Appendix 2.11 : Weather report

WEATHER DATA

MAY 1992

Farm identification :

Date	Min Temp. °C	Max Temp. °C	Rain mm	Wind Beaufort scale		Average weather condition	
				Strength score	Direction W N E S	Sun	Cloud
01/05							
02/05							
03/05							
04/05							
05/05							
06/05							
07/05							
08/05							
09/05							
10/05							
11/05							
12/05							
13/05							
14/05							
15/05							
.....							
27/05							
28/05							
29/05							
30/05							
31/05							

Appendix 2.12 : Stock reconciliation report

STOCK RECONCILIATION REPORT

Please indicate the livestock reconciliation on the whole farm (not only the deer farm).

JUNE 1992

Farm identification :

Deer stock		Cattle stock		Sheep and Goats	
Class	Number	Class	Number	Class	Number
Weaner stags		Dairy cows		Ewes	
Weaner hinds		Beef cows		Two tooth	
Yearling stags		Calves		Rams	
Yearling hinds		R1 heifers		Ewe lambs	
Adult hinds		R2 heifers		Wether lambs	
Adult stags		R1 steers		Hoggets	
		R2 steers			
Fallow does		MA steers		Goats	
Fallow bucks		R1 bulls			
Fallow weaners		R2 bulls			
		MA bulls			

Note : R1 : Rising-one-year-old animals
R2 : Rising-2-year-old animals
MA : Mixed-aged animals (>2 years)

Appendix 2.13 : Health problem sheet

HEALTH PROBLEMS

Farm identification :

DATE	PADDOCK ID	MOB ID	DEER IDENTIFICATION Age - Sex - Tag No	HEALTH PROBLEMS OBSERVATIONS

Appendix 2.14 : Disease reports

INDIVIDUAL DISEASE REPORT

Farm identification :

MOB or SUB-GROUP identification :

DEER IDENTIFICATION :

SEX : Male / Female AGE (year): Tag No :

DATE OF FIRST OBSERVATION :

Please, fill the back of this sheet to list the observed clinical signs.

DIAGNOSIS :

Veterinary Diagnosis : Yes / No On the farm / By phone

LABORATORY ANALYSIS : Yes / No (If Yes, keep laboratory reports)

TREATMENT OF THE DISEASED ANIMAL : Yes / No

PRESCRIPTION : Drugs :

Dose :
Duration :

OUTCOME : Chronic illness / Recovery / Death

If the clinical signs changed during the course of the disease, please specify at the end of this report !!

POST-MORTEM EXAMINATION : Yes / No
(If yes, fill out the post-mortem report)

SUPPLEMENTARY INFORMATION :

Deer removed from the herd : Yes / No Date :
Deer returned in the herd : Yes / No Date :

Preventive treatment of the other deer of the same herd : Yes / No
If Yes, give protocol

COST OF INTERVENTION : Veterinary fees :
Drug costs :

Appendix 2.14 (cont'd)

DISEASE OUTBREAK REPORT

Farm identification :

MOB or SUB-GROUP identification : Weaners / Yearling / Adult
DISEASED DEER Please list Deer Tag ID (or number of deer if tag ID unknown)
Stags :

Hinds :

DATE OF FIRST OBSERVATION :

Please fill the back of this sheet to list the observed clinical signs.

DIAGNOSIS :
Veterinary Diagnosis : Yes / No On farm / By phone
LABORATORY ANALYSIS : Yes / No (If Yes, keep laboratory reports)

TREATMENT OF THE DISEASED ANIMALS : Yes / No
Please list tag ID of treated deer (if not all) :

PRESCRIPTION : Drugs :
Dose :
How often :

OUTCOME :
Tag ID (or number) of deer that recovered :
Tag ID (or number) of deer that died :

POST-MORTEM EXAMINATION : Yes / No (If yes, fill out the post-mortem reports)
SUPPLEMENTARY INFORMATION :

Deer removed from the herd : Yes / No Date :
Number of deer removed:
Number of diseased deer among them :
Deer returned in the herd : Yes / No Date :
Number of deer :
Preventive treatment of the other deer of the same herd : Yes / No
If Yes, give protocol and ID of treated animals :
PRESCRIPTION : Drugs :
Dose :
How often :

COST OF INTERVENTION : Veterinary fees : Drug costs :

Appendix 2.14 (cont'd)

DISEASED DEER - CLINICAL SIGN IDENTIFICATION

(printed at the back of disease reports)

HISTORY : Explain briefly how the disease occurred: weather condition, diet, contact with other deer, manipulation,...

Please circle the observations on the following list of clinical signs :

SIGNS OBSERVED :

Deer on its own
Loss of condition
Lean deer
Hair losses on the head
Hair losses on the back

Fence pacing
Loss of appetite
Depression
Dull coat

Light colored coat

Skin lesion
Lameness
Loss of balance
Tremor of the head
Tremor of the back
Deer hit obstacles

Abscess (except on foot)
Unsteadiness back legs
Recumbency
Jaw champing
Deer prone to excitation
Aimless walking

HEAD :

Swelling of the face
Rubbing lesion

Colour of the white of the eye :
Pink White
Red Yellow

Ticks

Head shaking
Scabby lesion
Pus under the scab
Nasal discharge
Crust around muzzle
Ocular discharge
Salivation

THORAX - ABDOMEN :

Coughing
Abdominal pain at palpation
Swollen belly
Physical aspect of faeces :
Normal Pasty liquid

Smelly diarrhoea

Panting
Hunched back

Colour of the faeces :
Red Very red (evenly)
Black Normal
Faeces on the hocks

LEGS :

Injury
Fracture

Foot abscess
Swelling joint

ALL OTHER OBSERVATIONS (or change of clinical signs):

Appendix 2.15 : Post-mortem report

POST-MORTEM EXAMINATION

Farmer identification :
Date of the post-mortem examination :

To answer, please write the proper code in the box or cross the wrong answer and circle the right answer !!

Deer identification : **Tag ID :**

Sex	*1 = Male 2 = Female*	[ ]
Class of stock	Young born calf - Weaner - Yearling - Adult	
Mob identification		[ ]
Paddock identification where the deer died		[ ]

HISTORY :
1 = Deer found dead
2 = Following a disease < 48 hours long
3 = Following a disease > 48 hours long
4 = Misadventure (You have seen the event) [ ]

OBSERVATIONS :

The deer has been found :
1 = along the fence *2 = in bushes, trees,...*
3 = in the water *4 = other (please specify):* [ ]

Damage to the vegetation around the deer :
0 = no *1 = yes* [ ]

EXAMINATION OF THE DEER

Lesion on the head : *1 = scabby lesions* *2 = rubbing lesions* [ ]

Colour of the white of the eye :
1 = white *2 = yellow*
3 = pink/red [ ]

Swollen belly (bloat) : *1 = yes* *0 = no* [ ]

Area on the back without hair : *0 = no lesion*
1 = yes, pink skin *2 = yes, dark skin* [ ]

Dull coat : *1 = yes* *0 = no* [ ]

Body condition score (see scoring chart in Appendix 2.21) [ ]

Discharge from :
1 = nostrils *2 = mouth*
3 = vulva *4 = eyes*
5 = anus [ ]

Appendix 2.15 (cont'd)

Appearance of the discharge : *1 = liquid*
2 = thick *3 = frothy*
4 = crusty *5 = bloody* [ ]

Presence of faeces around the anus or on the hocks
1 = yes *0 = no* [ ]

External parasites : *0 = no* *1 = ticks (mainly in the ears)*
2 = lice [ ]

Signs of trauma : *0 = no* *2 = fracture*
1 = bruise *3 = injury* [ ]

Sign of infection (pus, abscess,..) : *0 = no* *1 = yes* [ ]

WHEN OPENING THE VARIOUS CAVITIES

Fluid in the cavities : *0 = no* *1 = liquid over 1 ml*
2 = blood *3 = pus*
4 = thready material [ ]

found in the : Thorax (chest) [ ]
Abdomen (belly) [ ]

LUNGS Are lungs ... *1 = inflated (spongy) ?*
2 = collapsed (firm/hard) ? [ ]

The lungs stick on the ribs : *1 = yes* *0 = no* [ ]

Colour : *1 = pink* *2 = evenly red* *3 = unevenly red (patches)*
right lung : [ ]
left lung : [ ]

Abscess (creamy patches) : *1 = yes* *0 = no* [ ]

TRACHEA Froth in the windpipe : *1 = yes* *0 = no* [ ]

Lungworm in the trachea : *1 = no* *2 = a few*
3 = full [ ]

KIDNEYS Give the approximate size (cm) : [ ]

Consistency : *1 = firm* *2 = pasty*
3 = almost liquid [ ]

When cut in two parts :
0 = see nothing *1 = red spots*
2 = pus *3 = other :* [ ]

BLADDER Colour of urine in the bladder : *0 = red*
1 = yellow *2 = clear* [ ]

Red spots on the inner surface of the bladder
1 = yes *0 = no* [ ]

LIVER Consistency : *1 = firm*
2 = soft (easily crushed between the fingers) [ ]

Appendix 2.15 (Cont'd)

Colour & aspect :

1 = white spots *2 = small red spots*
3 = very red *4 = pale, yellowish*
5 = abscess [ ]

GUTS Answer the next group of questions after identifying :

the abomasum (4th stomach) A [ ]
the small intestine ..... B [ ]
the large intestine ..... C [ ]

		A	B	C
Outer surface of the guts :	*1 = pink* *2 = red spots* *3 = very red*	[ ]	[ ]	[ ]
Contents :	*1 = no contents* *2 = pasty contents* *3 = liquid contents*	[ ]	[ ]	[ ]
Bloody contents :	*0 = no* *1 = yes, even/uniform* *2 = yes, flecked*	[ ]	[ ]	[ ]
Parasites : (Worms)	*0 = no* *1 = a few parasites* *2 = a lot (guts almost full)*	[ ]	[ ]	[ ]
Inner surface of the guts :	*1 = pink* *2 = red spots* *3 = very red*	[ ]	[ ]	[ ]
Do the guts have any of the following :	*1 = thickened wall* *2 = erosion of the inner surface* *3 = perforation*	[ ]	[ ]	[ ]

OTHER OBSERVATIONS :

CONCLUSION (Diagnosis) :

POST-MORTEM SAMPLES : Take a piece from the following organ.
LUNG, LIVER, KIDNEY, BRAIN, SMALL INTESTINES

- Samples must be no larger than a 50 c coin and 5 mm thick. Half the sample should include the observed lesion (if observed).
- Never wash the samples !!!
- Kidney should be cut in half lengthways and then across
- When fresh death, take 2 or 3 inches of small intestine cut open lengthways and put directly in the formalin without washing.
- If fresh samples can be sent to the Massey veterinary clinic soon, just put them in the fridge.
- Any gross lesion can be frozen, after sections have been taken, for later identification.

Appendix 2.16 : Calving problem report

CALVING PROBLEM REPORT

Farmer identification : DATE :
CALVING MOB : **HIND ID :**

CALF : Male / Female Weight (kg) :

DYSTOCIA : Live calf Dead calf
Front legs first Back legs first Head back
Describe calf posture :

Veterinary Diagnosis : Yes / No At the phone / On the farm

INTERVENTION : Veterinary intervention Farmer intervention
Drugs restraint :
Other treatment :

OUTCOME : Hind : Survived and healthy / Survived but diseased / Died
Calf : Survived and mothered / Survived but hand reared / Died

Appendix 2.17 : Calf mortality report

CALF MORTALITY REPORT

Farm identification : Date of observation :

Calving mob ID: Calving paddock ID: Hind ID:

Suspected problem :
Dystocia / Mismothered / Victimised / Found dead / Other

Sex of the calf : Male Female
Approximate age (days) :
Calf bodyweight (kg) if freshly dead:

Please, answer by "yes" or "no" the following questions ?

Has the calf been found through the fence ?
Is there any sign of trauma on the calf ?
Specify your observation :

Are the hooves worn ?
Are lungs spongy ?
Is there any milk in the stomach ?
Is there any signs of diarrhoea (liquid faeces in the gut) ?
Specify any other observations :

Appendix 2.18 : MAF slaughter report

SLAUGHTER REPORT

MAF VETERINARIAN

Deer slaughter plant :

FARMER NAME : **DISTRICT:** **IDENTIFICATION** :
DATE OF SLAUGHTER :

DEER IDENTIFICATION

Number of	Age < 1 year	Age 1-2 years	Age > 2 years
Male			
Female			

OBSERVATIONS :

Deer Ident.	Gross pathology - Defect	Outcome Carcass		
		OK	Retained	Rejected

Appendix 2.19 : Example of computer deer listing

Year	Farm Id.		Weaner identification				Blood lines	Individual weight records	
	No	NAME	CLASS	COL	ID	Birth	% Bl	W MAR	W4
92	1	MERC	WH		184	30-Nov-91	25 EN	42	42.2
92	1	MERC	WH		186	02-Dec-91	100 NZ	38	38.1
92	1	MERC	WH		187	19-Dec-91	75 EN	38	38.1
92	1	MERC	WH		188	27-Nov-91	25 EN	38	38.1
92	1	MERC	WH		189	11-Dec-91	87.5 EN	38	38.1
92	1	MERC	WH		190	14-Dec-91	100 NZ	36	36.2
92	1	MERC	WH		192	15-Dec-91	75 EN	38	38.1
92	1	MERC	WS		136	19-Dec-91	75 EN	42	42.1
92	1	MERC	WS		137	07-Dec-91	100 NZ	42	42.2
92	1	MERC	WS		138	13-Dec-91	100 NZ	39	39.1
92	1	MERC	WS		139	14-Dec-91	100 NZ	39	39.1
92	1	MERC	WS		140	09-Dec-91	75 EN	38	38.2
92	3	COWI	WH	O	114		100 NZ	37	41.1
92	3	COWI	WH	O	116		100 NZ	44	46.4
92	3	COWI	WH	O	121		100 NZ	39	40.0
92	3	COWI	WH	O	122		100 NZ	42.5	45.8
92	3	COWI	WH	O	125		100 NZ	40	42.1
92	3	COWI	WS	O	134		100 NZ	44	46.2
92	3	COWI	WS	O	135		100 NZ	39.5	43.0
92	3	COWI	WS	O	150		50 EN	40.5	43.8
92	4	HAWK	WH	G	42	15-Dec-91	100 NZ	40.3	47.2
92	4	HAWK	WH	G	43	04-Dec-91	100 NZ	38.1	45.1
92	4	HAWK	WH	Y	61	25-Nov-91	25 SW	45	48.6
92	4	HAWK	WH	Y	63	09-Dec-91	25 SW	41.5	46.8
92	4	HAWK	WH	Y	71	01-Jan-92	25 SW	39	43.0
92	4	HAWK	WH	Y	127	06-Dec-91	12 SW	35.7	42.1
92	4	HAWK	WS	Y	163	10-Dec-91	25 SW	38.1	44.6
92	4	HAWK	WS	Y	166	05-Dec-91	25 SW	40.7	47.1
92	4	HAWK	WS	YJ	1	16-Dec-91	100 NZ	40	44.6
92	4	HAWK	WS	YJ	2	16-Dec-91	100 NZ	41.3	48.1
92	4	HAWK	WS	YJ	5	12-Dec-91	12 SW	41	46.5

Note : NAME = Farmer name code made of the first letters of his name
CLASS = Class of deer (WS=Weaner stags; WH=Weaners hinds)
Identification : COL= Colour of the eartag and ID= the tag number
Birth = Birth date (if provided)
Blood lines = % : percentage and Bl = blood line category
(eg EN=English; NZ=New Zealand; SW=Swedish)
Individual weight records = W MAR= Weight in March (usually weaning)
W4= weight calculated on April 1

Appendix 2.20 : Velvetting diary

VELVETTING DIARY

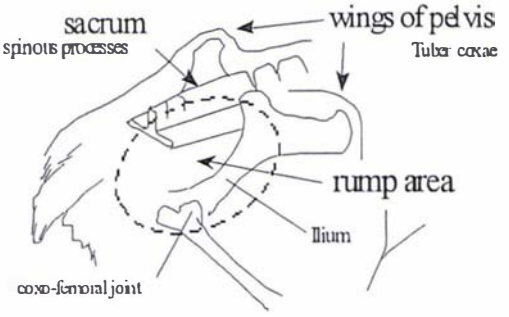
Farm identification :

Date	Action Circle	Previous Mob	Next Mob	Tag identification of the stags Velvet weights and grades
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			
	Shift Velvet			

Appendix 2.21 : Body condition chart

BODY CONDITION SCORE CHART FOR RED DEER

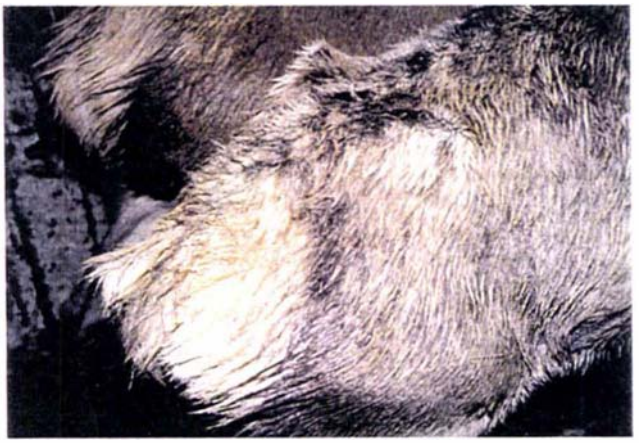




Ideally, deer should be standing straight and quiet. The three landmarks used for body condition scoring are :
- wings of pelvis : estimation of the depth of tissue over tuber coxae,
- sacrum : appraisal of the sharpness of spinous process
- rump areas : appraisal of muscle mass and fat cover beside the sacrum

If deer bend their back legs under the palpation pressure, the assessment of the wings of pelvis should be ignored.
Scores range from 1 to 5 as described below with half unit increments.

SCORE 1 : VERY POOR CONDITION (CACHEXIA)





Wings of pelvis are extremely prominent and sharp. Sacral spinous processes are very sharp. There is little muscle in the rump and no fat cover, the rump areas are very concave at palpation.

SCORE 2 : POOR CONDITION (LEANNESS)





Wings of pelvis are prominent and very easily felt by palpation without finger pressure. Sacral spinous processes are also prominent. The rump areas are slightly concave.

Appendix 2.21 (cont'd)

SCORE 3 : MODERATE CONDITION

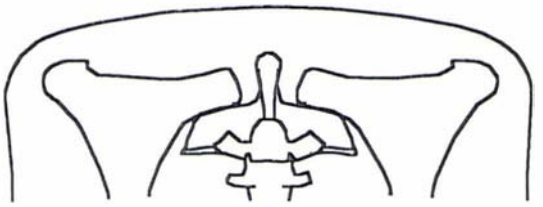




Wings of pelvis are prominent, but rounded and can be easily felt by palpation with slight finger pressure. Sacral spinous processes are slightly enveloped and not prominent. The rump areas are flat.

SCORE 4 : GOOD CONDITION

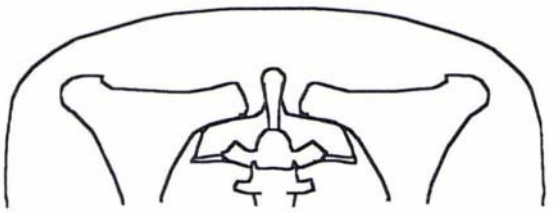




Wings of pelvis are rounded and can be felt by palpation under a thin layer of fat. Sacral spinous processes are enveloped and are felt by palpation only with firm finger pressure. The rump areas are slightly convex.

SCORE 5 : VERY GOOD CONDITION (FAT)





Wings of pelvis are concealed under a thick layer of fat and cannot be felt by palpation with firm finger pressure. Sacral spinous processes are well enveloped and not felt at palpation. The rump areas are convex.

Appendix 2.22 : Variables to describe deer-farmer relationships and deer behavioural characteristics

BEHAVIOUR CHARACTERISTICS OF FARMED RED DEER
DEER-FARMER RELATIONSHIPS

Deer-farmer relationships in the paddock

Behaviour of the farmer behind deer during shifting to the yard ?
1 = calm & patient; the farmer rides his motorcycle rather slowly, stays at a distance from the mob and waits for them to go through the gate
2 = slightly pushing (attitude between score 1 and 3)
3 = very pushing; the farmer rides his motorcycle fast to catch up with the running mob, stays close to the mob to have deer go through the gate, makes noise,...

Behaviour of the mob when shifted to the yard for sampling :
1 = Deer calm, moving easily through paddock gates with or without a slight push by just one person.
2 = Deer slightly restless, need time to go through gates (need several people to muster them).
3 = Deer on the move, running around the paddock and jumping between people to escape, very hard to muster

Level of incentive to have deer enter the yard :
1 = Deer run or rush into the yard with almost no push from the farmer
2 = Deer walk into the yard with farmer slightly pushing,
3 = Deer don't move easily even with farmer pushing behind (several people needed, noise, raise arms or object and work with small groups to help pushing them).

Deer-man relationship when working in the yard

Farmer making noise (shouting, clapping hands, ...) to have deer move from one pen to the other
0 = No; 1 = Yes

Farmer raising arms to have deer move from one pen to the other
0 = No; 1 = Yes

Way deer move inside the deer-yard
1 = They move quickly as soon as you open a gate.
2 = They move easily after slight push.
3 = They don't move easily even when you are pushing them.

Level of deer stress during yarding (mob behaviour as the researcher enter the pen):
1 = Deer very quiet, don't move when the researcher enters the pen, relax, not jumping at each other or fighting.
2 = Alert deer, tense attitude, very little jumping or aggressive behaviour towards each other.
3 = Deer slightly restless and tense, occasionally jump or aggressive behaviour towards each other.
4 = Deer stressed and tense, high flight response to the researcher, jump a lot over each other or have an aggressive behaviour towards each other.
5 = Deer very stressed and restless, jump over each other intensively, climb the wall, fight and show aggressiveness towards each other.

Appendix 2.22 (Cont'd)

Occurrence of upset or aggressive deer during handling of mob in the deer-yards.
(Deer aggressiveness can be expressed by threat such as a straight look at people, grinding teeth, hanging the tongue in one side of the mouth or salivation, or by attack such as bite, or kick with front or back legs)
0 = No, 1 = Yes

Behaviour of individual deer during handling
1 = Calm, easy to handle
2 = Deer slightly stressed, need firm handling
3 = Deer stressed and restless, ie. they try to escape or show aggressiveness

Farmer fighting to have deer handled the way it was expected.
0 = No; 1 = Yes

Farmer seen by the researcher hitting or kicking deer
0 = No; 1 = Yes

Ability to handle stags during the rut (yearling and adult)
1 = quiet, can be handled by hand
2 = a bit aggressive, need careful handling by the use of personal protection such as a board
3 = very aggressive, handling only through doors and gates

APPENDICES

CHAPTER 3

Appendix 3.1 : Farmer individual characteristics : response to direct questionnaire.

		FARM CODE																		
Questions	Category	1	2	3	4	5	6	7	8	9 P	9 P	10	11	13	14 O	14 M	15 O	15 M	16	Number of farmers*
Age		38	36	48	53	58	36	49	25	61	30	62	48	45	38	34	47	43	50	Mean : 44.5
	<30								X											1
	>50				X	X				X		X								3
Number of children		2	3	4	4	4	2	2	0	3	0	8	3	3	3	2	3	3	2	
Were you parents farming ?																				
	Deer								X						X					1
	Sheep		X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	12
	Beef		X	X			X	X	X	X	X	X		X	X		X	X	X	10
	Dairy				X	X														2
Training																				
	Agriculture					X	X		X				X		X					4
	Other	X									X									2
Number of years																				
	Farming	13	14	33	30	32	14	33	3	44	6	35	30	24	18	17	30	26	40	Mean : 24.6
	In deer	13	7	7	7	23	6	7	3	9	5	8	6	6	14	12	5	6	7	Mean : 8.4
Manpower																				
	Labour Units	1	1.3	2.5	1.5	1.1	3	1.5	1.5	2		1.25	2	2	2.25		2.5		1.25	
	Family	X		X	X	X		X	X	X		X	X	X	X		X		X	13
	Emloyee		X	X			X						X	X	X		X			7
Other commitment in deer		X						X	X		X	X			X				X	7
Other business than farming		X				X	X							X	X		X			6
Production objectives																				
	One year venison		X		X		X	X	X											5
	Two year venison					X		X		X		X	X	X	X		X		X	9
	Velvet	X		X		X	X	X		X		X	X	X	X		X		X	12
	Breeding	X		X			X		X								X			5
	Stud	X								X		X			X		X		X	6
Motivation for farming																				
	Mainly income		X				X					X	X	X		X	X		X	8
	Lifestyle	X		X	X	X		X	X	X					X	X		X	X	11
Motivation for farming deer																				
	Mainly income		X					X	X		X				X	X	X		X	7
	Diversification		X	X	X		X			X	X	X	X	X			X	X	X	12
	Enjoy deer	X				X		X	X		X	X			X		X	X	X	10
Holidays																				
	1-2 weeks		X	X			X				X	X			X	X	X	X		9
	>2 weeks				X	X			X	X			X	X					X	7
Deer income																				
	%	90	15	10	40	35	13	12	30	1	6	15	10	15	100		2		17	Mean : 25.7

X = Yes ; P = in partnership; O = owner of the deer farm; M = manager

* or mean where appropriate

Note : the actual questionnaire is presented in the Appendix 2.2

Appendix 3.2 : Farm characteristics : farm areas and altitude, lane, holding paddocks and holding pens.

Questions		Unit	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	Mean values*
Farm areas		Ha																
Total Farm Area			61.4	360	516	180	57	445	24.5	230	450	38.8	404	611	274.8	791.6	168.4	307.5
Total Deer Paddock Area			61.4	55.4	45	20	41.65	48.7	24.1	62	53.5	38.8	55	70.2	274.8	453.3	79.16	92.2
Deer farm altitude		m																
minimum			150	250	150	210	0	180	70	550	580	300	340	200	0	340	240	237.3
maximum			150	270	360	210	0	250	70	550	700	310	340	370	0	400	270	283.3
Lane characteristics		m																
Width between paddocks			5	8.7	8.9	3.7	5.2	4	6	5.3	3.8	5.7	4.7	5	7.1	12	4.8	6.0
Width close to yards			5	8.7	3.5	2.2	3.3	3.7	1.8	5.3	3.8	4.8	2.5	3	3.7	4.3	3.7	4.0
Shade (or wood) on the fence					X							X	X	X				
Holding paddocks that were used																		
No1	Length	m		30	12			12		50‡	50‡		Lane†				12	16.5
	Width	m		14	7.6			12		50‡	50‡						7	10.2
	Area	m2		420	91.2			144									84	184.8
No2	Length	m		29.5	20.2													24.9
	Width	m		24	11.5													17.8
	Area	m2		708	232.3													470.2
Holding pens that were used																		
No1	length	m	27.5			8.8		10.8	14.5	12.5	11.9	9.3	14.1	21.1	18	14.5		14.8
	Width	m	5			6.6		9.9	6.7	12	4.7	4.6	9.5	7.8	7.1	12.5		7.9
	Area	m2	137.5			58.1		106.9	97.2	150.0	55.9	42.8	134.0	164.6	127.8	181.3		114.2
No2	length	m							13.4	9	15.2	14.1	18.7		14.8	10		13.6
	Width	m							9.5	7.2	5.4	9.1	16		9	9.2		9.3
	Area	m2							127.3	64.8	82.1	128.3	299.2		133.2	92.0		132.4

X = Yes

† This farmer used the lane to hold deer mobs and split them in small groups before yarding.

‡ Very rough visual estimates, these holding paddocks were not measured.

Note : the description of deer-yard characteristics is presented in Table 2.5.

Appendix 3.3 : Deer-yard characteristics.

Deer-yard characteristics	Unit	FARM CODE															
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	Mean values*
Yard measurements	m																
(covered area)																	
Length	m	31.2	12.4	11.3	8.9	10.2	6.7	9.6	13	11.7	13.8	9	14	13	12.5	15.5	12.9
Width	m	4.2	7.2	7.5	6.2	8.6	6.4	8.3	8.9	10.8	9.5	7.5	8.5	13	9	10.3	8.4
Area	m2	131.0	89.3	84.8	55.2	87.7	42.9	79.7	115.7	126.4	131.1	67.5	119.0	169.0	112.5	159.7	104.8
Yard doors																	
Width entry door	m	1.2	2.5	1.7	1.1	2.3	1.9	1.5	2.5	2.4	2.5	1.4	1.8	2.3	2.6	2.3	2.0
Width inside door	m	1.3	1.4	1.1	1.2	1.15	1.15	0.6	1.4	1.4	1.2	1	1.3	1.2	1	1.3	1.2
Sorting pens	Number	3	8	4	7	7	4	6	6	9	7	5	6	9	6	8	6.3
Larger size	m2	13.3	9.9	13.7	8.1	9.3	11.6	9.8	56.3	22.4	28.0	10.5	14.7	23.1	11.0	19.7	17.4
Smaller size	m2	6.3	6.2	10.5	2.9		6.3	5.0	19.1	10.5	8.8		5.9	17.2	8.0	8.1	8.8
Handling pens	Number	3	1	2	2			1	1	2	1	2	1	1	1	1	1.5
Size	m2	2.9	2.5	4.0	4.5			4.6	3.5	2.4	5.3	3.2	3.4	5.6	2.0	3.5	3.6
Circular room																	
Diameter	m	4†				2.8	4	4.2	4	3.2			4.4	4.3	4.5		3.9
Circular door		X					X	X				X	X	X	X		7
Light																	
Yard fully closed		X		X		X				X	X	X		X	X	X	9
Electric light		X		X	X	X		X	X	X	X	X		X			10
Solid pen walls and doors			X			X	X	X		X				X	X	X	8
Brick or concrete floor		X						X	X	X	X		X	X	X		8
Crush																	
Drop-floor crush		X				X		X	X	X		X		X	X	X	9
Work-room crush				X							X						2
Loading ramp	m																
Length		3.3	5.7	0	5.1	4.1	3.3	2.3	3.1	3	3.8	2	5.2	6.3	4.2	3.5	3.7
Width		1	0.9	0.8	0.95	0.75	1	0.5	1	1	0.75	0.75	0.55	1.2	1	1	0.9

* The number of "X" (yes) are reported instead of means where appropriate

Note : the description of deer-yard characteristics is presented in Table 2.5.

† esrimate given by the farmer - diameter not actually measured

Appendix 3.4 : Paddock characteristics of each survey farm in 1992 and 1993

Paddock characteristics	Score or unit	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	ALL FARMS number	%
Number of paddocks																		
Year 1992	All time	28	12	10	19	12	16	10	17	9	22	13	12	44	27	10	261	
	New **	0	0	1	0	3	0	2	0	2	0	0	1	0	0	3	12	
Year 1993	All time	28	12	11	19	15	16	12	17	11	22	13	13		21	13	223	
	New **	0	0	0	0	0	0	1	1	0	0	2	0		2	3	9	
Mean paddock size	Ha	1.77	4.53	3.93	0.92	2.70	2.51	2.20	3.63	7.30	1.68	4.93	5.38	6.23	16.79	3.27	4.85	
Number of paddocks described (Including paddock open part of the year)		33	12	12	19	15	16	16	19	12	22	15	14	44	27	16	292	
Topography and shelter (number of paddocks within each farm for each category)																		
Topography	<1.5	24	6	4	19	15	11	16	1	3	18	7	1	43	10	9	187	64.0
	>2.5	0	1	6	0	0	0	0	3	4	1	0	4	0	5	1	25	8.6
Gully	1	3	0	6	2	0	0	3	2	0	4	0	1	11	2	1	35	12.0
	2	2	9	0	1	0	5	9	5	3	1	10	7	17	2	3	74	25.3
	3	7	2	5	0	0	3	0	6	6	0	4	3	2	12	2	52	17.8
Hill	1	4	5	3	0	2	1	0	11	3	2	2	3	1	11	1	49	16.8
Shelter belt	1	0	1	1	2	1	2	2	2	0	4	0	3	0	0	4	22	7.5
	2	7	5	3	8	1	5	5	0	0	1	0	1	15	0	1	52	17.8
	3	9	2	1	6	1	7	5	4	3	14	14	7	16	11	6	106	36.3
Trees	1	7	2	4	0	1	2	2	3	6	3	7	2	3	7	0	49	16.8
	2	2	0	1	0	1	2	2	0	1	1	2	0	2	1	1	16	5.5
	3	4	0	0	7	2	0	2	9	2	5	1	4	0	14	2	52	17.8
Macrocarpa tree	1	1	0	0	5	0	0	3	0	0	0	0	2	0	0	1	12	4.1
Stump	1	4	1	8	4	4	7	9	7	7	8	7	10		14	5	95	32.5
Bull rushes	1	4	4	1	0	2	1	2	3	1	0	6	1	0	0	0	25	8.6
	2	7	4	10	0	2	4	6	5	1	0	7	1	0	0	0	47	16.1
	3	0	0	0	0	0	0	0	1	2	0	1	0	0	0	0	4	1.4

The description of paddock characteristics is presented in Table 2.4.

* Year 1992 : Farm 1 used electric fences to split 2 paddocks during Winter; Farm 3, 7 and 13 split 1, 2 and 1 paddock during 1992, respectively; Farm 8 reduced the size of one paddock

Year 1993 : Farm 15 sold part of the deer fenced area; Farm 7 split one paddock in two.

** Newly fenced or subdivided paddock available during the year.

Appendix 3.4 : Cont'd

Paddock characteristics	Category	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	ALL FARMS number	%
Potential wind protection																		
Potential protection from westerly wind																		
Shelter belt	1	0	0	2	3	4	4	0	0	0	3	0	0	0	0	2	18	6.2
	2	6	3	1	4	2	0	3	1	0	3	2	2	9	0	1	37	12.7
	3	8	1	6	4	1	4	7	1	4	7	7	7	5	11	5	78	26.7
Hill	1	6	2	1	0	3	2	0	1	0	1	1	2	2	1	1	23	7.9
	2	1	0	3	0	6	3	0	4	3	0	1	0	0	0	2	23	7.9
	3	2	6	4	0	0	1	0	13	8	5	2	7	0	16	2	66	22.6
Gully	1	3	0	6	1	0	0	2	2	0	4	0	1	0	2	1	22	7.5
	2	3	9	0	1	0	5	8	4	3	1	11	5	0	2	2	54	18.5
	3	6	0	5	0	0	1	0	6	6	0	2	3	1	12	2	44	15.1
Potential protection from easterly wind																		
Shelter belt	1	0	1	0	3	1	0	0	0	0	1	1	2	0	0	2	11	3.8
	2	8	4	1	3	5	0	2	1	0	7	1	6	0	0	6	44	15.1
	3	1	3	5	0	2	1	3	4	7	8	7	8	8	1	0	58	19.9
Hill	1	2	1	3	4	2	0	0	1	2	0	1	0	1	0	1	18	6.2
	2	4	4	2	0	0	2	0	3	2	2	1	2	0	1	2	25	8.6
	3	7	0	5	0	0	5	7	13	8	5	1	8	0	16	1	76	26.0
Gully	1	2	0	6	2	0	0	2	2	0	4	0	1	0	2	0	21	7.2
	2	2	9	0	1	0	5	8	4	3	1	11	4	1	2	3	54	18.5
	3	7	1	5	0	0	2	0	6	6	0	2	3	1	12	2	47	16.1
Potential protection from southerly wind																		
Shelter belt	1	0	1	1	3	0	2	1	0	0	0	3	2	0	0	0	13	4.5
	2	7	3	3	3	2	4	1	1	0	3	4	1	10	0	1	43	14.7
	3	13	0	1	1	1	6	2	1	3	7	4	2	8	13	5	67	22.9
Hill	1	5	1	2	2	3	3	0	2	4	3	2	1	1	2	0	31	10.6
	2	2	3	2	0	5	0	0	1	1	2	2	1	0	2	1	22	7.5
	3	8	4	3	0	0	2	7	14	7	5	2	6	0	12	1	71	24.3
Gully	1	1	1	2	0	1	3	0	3	0	0	1	1	0	0	1	14	4.8
	2	4	2	1	3	3	4	0	1	1	2	4	1	4	1	0	31	10.6
	3	1	0	4	4	0	3	8	4	2	14	8	7	11	9	3	78	26.7
Potential protection from northerly wind																		
Shelter belt	1	4	1	1	1	3	1	0	1	1	1	1	1	2	0	2	20	6.8
	2	5	1	2	0	0	0	0	6	2	1	2	2	0	1	0	22	7.5
	3	4	4	7	0	0	4	0	12	8	3	3	4	0	14	5	68	23.3
Hill	1	4	1	1	1	3	1	0	1	1	1	1	1	2	0	2	20	6.8
	2	5	1	2	0	0	0	0	6	2	1	2	2	0	1	0	22	7.5
	3	4	4	7	0	0	4	0	12	8	3	3	4	0	14	5	68	23.3
Gully	1	2	0	6	1	0	0	3	2	0	2	0	1	0	2	1	20	6.8
	2	0	6	1	1	0	5	9	6	3	1	10	6	4	1	3	56	19.2
	3	5	2	4	0	0	3	0	4	6	0	2	3	2	10	0	41	14.0

The description of paddock characteristics is presented in Table 2.4.

Note : Farm 14 : Stumps were not recorded on this farm

Appendix 3.4 : Cont'd

Paddock characteristics		Category	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	ALL FARMS number	%
Water supply																			
Dam		1	7	3	2	2	7	2	3	6	0	5	0	10	5	5	4	61	20.9
River		1	7	8	8	1	3	6	10	8	3	0	11	4	14	5	1	89	30.5
Trough		1	19	1	2	16	10	10	2	8	9	17	4	5	30	18	15	166	56.8
Pasture characteristics																			
Pasture type	1992	1	5	1	0	17	6	7	3	7	5	2	1	3	19	4	1	81	27.7
		3	10	1	5	0	1	2	0	0	0	5	2	2	5	9	2	44	15.1
	1993	1	4	1	0	15	8	8	4	7	5	4	3	4	19	9	1	92	31.5
		3	10	1	6	0	2	3	9	0	0	7	7	5	5	3	0	58	19.9
Thistle score	1992	0	18	3	1	11	9	7	6	4	2	8	1	4	45	3	5	127	43.5
		>1.5	2	1	3	3	2	3	1	8	7	4	8	2	0	18	6	68	23.3
	1993	0	11	13	1	19	10	13	8	18	13	11	1	14		6	1	139	47.6
		>1.5	5	0	9	0	2	0	1	1	0	0	11	0		9	9	47	16.1
Ragwort score	1992	0	6	1	5	8	8	7	8	0	1	11	0	2	0	6	1	64	21.9
		>1.5	8	6	0	3	1	2	0	14	8	3	6	4	0	10	12	77	26.4
	1993	0	11	12	0	18	3	3	6	15	11	19	2	13		9	2	124	42.5
		>1.5	3	0	9	0	3	1	1	0	0	0	10	0		10	5	42	14.4
Fence pacing score																			
Fence pacing	1992	<1	6	0	5	8	3	2	2	4	2	5	1	3	9	3	1	54	18.5
		>2	1	4	1	0	6	4	2	6	0	5	1	1	10	4	6	51	17.5
Fence pacing	1993	<1	9	1	1	8	4	2	3	3	3	8	4	0		12	2	60	20.5
		>2	1	3	2	0	3	4	0	1	0	2	2	1		1	6	26	8.9
Miscellaneous																			
Fence																			
Use of netting fence		0%	16	13	1	7	7	8	13	20	11	15	3	3	1	26	15	159	54.5
		100%	18	0	12	13	9	9	0	0	2	8	5	2	44	2	0	124	42.5
Potential contact with other domestic livestock outside deer farm boundaries																			
Sheep		1	19	8	10	3	0	5	14	12	11	9	7	4	4	17	12	135	46.2
Cattle		1	16	2	2	12	7	9	14	12	9	6	8	3	4	17	3	124	42.5
Paddock location																			
Close to road, houses or buildings		1	16	1	7	7	6	10	5	7	3	11	5	2	4	9	2	95	32.5

The description of paddock characteristics is presented in Table 2.4.
Note : Farm 14 was not monitored in 1993

Appendix 3.5 : Mean paddock characteristics on each survey farm over 1992 and 1993

Paddock characteristics		Code*	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
Paddock areas																	
Number of paddocks		NPAD	28.3	12.0	11.2	19.0	14.1	16.0	11.5	17.4	10.5	22.0	13.7	13.0	44.0	24.3	13.0
Mean paddock area		PFAREA	1.9	4.5	4.1	0.9	2.7	2.5	2.0	3.6	6.9	1.7	4.4	5.2	6.2	16.7	2.9
Paddock mean topographical characteristics																	
Mean topography score		FTOPO	1.5	1.8	2.6	1.0	1.0	1.7	1.1	2.3	2.3	1.4	1.6	2.2	1.0	2.2	1.3
Mean gully score		FGULLY	0.8	2.0	1.7	0.2	0.0	1.2	1.0	1.4	1.6	0.3	1.9	1.6	1.2	1.3	0.6
Mean hill score		FHILL	0.1	0.4	0.2	0.0	0.1	0.1	0.0	0.5	0.2	0.1	0.1	0.2	0.0	0.3	0.1
Paddock water supply																	
Percentage with a dam		FDAM	21.2	25.0	16.7	10.5	44.7	12.5	12.5	22.9	0.0	22.7	0.0	64.3	11.4	18.5	19.4
Percentage with a stream		FSTREAM	0.0	0.0	0.0	0.0	36.1	0.0	6.3	0.0	12.5	0.0	2.5	0.0	27.3	11.1	1.7
Percentage with a river		FRIVER	21.2	66.7	60.3	5.3	20.0	37.5	48.0	36.8	16.7	0.0	69.0	28.6	31.8	15.9	6.3
Percentage with a trough		FTROUGH	43.4	8.3	16.7	84.2	60.9	62.5	10.5	42.1	70.8	77.3	22.5	35.7	68.2	59.3	74.7
Mean paddock shelter scores																	
Mean shelter belt score		FBELT	1.0	1.4	0.8	1.9	0.4	2.1	1.2	0.7	0.8	2.2	2.5	1.8	1.8	1.2	1.4
Mean tree score		FTREES	0.7	0.2	0.5	1.1	0.5	0.4	0.5	1.5	1.0	0.9	0.8	0.8	0.2	1.7	0.2
Mean overall shelter score		FSHELTW	10.0	14.4	18.2	5.1	4.6	11.8	9.1	17.6	21.1	10.4	16.9	18.1	4.2	17.3	7.8
Percentage with stumps,...		FSTUMP	12.1	8.3	66.7	21.1	22.8	43.8	39.5	36.8	45.8	36.4	46.7	64.3	0.0	47.4	18.3
Mean paddock pasture characteristics																	
Mean bull rushes score		FBULLR	0.5	1.0	1.6	0.0	0.4	0.8	0.6	0.6	0.6	0.0	1.3	0.2	0.0	0.0	0.0
Percentage with chicory		FCHICO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0
Mean pasture score	1992	FPAST	2.47	1.91	2.76	1.13	1.91	1.99	1.90	1.43	1.64	2.20	2.15	1.93		1.68	2.37
	1993		2.38	2.06	2.72	1.16	1.46	1.86	2.18	1.58	1.69	2.11	2.49	1.70		1.79	2.18
Mean thistle score	1992	FTHIS	0.49	1.07	1.29	0.63	0.69	1.25	0.51	1.57	1.95	1.02	1.80	1.54		0.00	2.05
	1993		1.00	1.72	0.83	0.71	0.49	0.90	0.28	2.16	2.35	0.56	1.52	1.18		1.49	2.11
Mean ragwort score	1992	FRAG	0.99	0.00	2.23	0.03	0.44	0.32	0.46	0.08	0.00	0.49	2.03	0.04		0.19	1.55
	1993		0.72	0.00	2.33	0.02	0.81	0.85	0.59	0.02	0.00	0.02	1.66	0.00		1.54	1.32
Miscellaneous																	
Percentage of wire-and-baton fence		FWIRE	41.4	100.0	0.0	33.0	49.7	75.6	95.6	100.0	68.0	66.4	47.2	71.7	0.0	98.7	98.6
Percentage with macrocarpa tree		FMACRO	3.0	0.0	0.0	26.3	0.0	0.0	12.5	0.0	0.0	0.0	0.0	13.5	0.0	0.0	4.4
Percentage close to road, buildings,...		FSUR	39.4	8.3	52.0	36.8	34.2	62.5	19.7	31.6	25.0	50.0	33.3	14.3	9.1	33.3	12.5
Mean fence pacing score		FFP	1.0	1.8	1.1	0.9	1.8	1.7	0.9	1.4	1.0	1.5	1.2	1.4	1.6	1.3	1.5
Mean contact with sheep paddocks		FSHEEP	0.5	0.7	0.8	0.2	0.0	0.3	0.6	0.6	0.8	0.4	0.4	0.2	0.1	0.5	0.6
Mean contact with cattle paddocks		FCATTLE	0.4	0.2	0.2	0.6	0.4	0.6	0.6	0.6	0.6	0.3	0.4	0.2	0.1	0.5	0.2

* The description of variable codes and calculation formula are presented in Table 2.25.

Appendix 3.6 : Farm stock reconciliation in June 1992 and 1993.

Type of stock		FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	All farms
Year 1992																	
Deer																	
Weaner	Stags	62	54	33	39	41	35	32	85	34	30	68	33		465	46	1057
	Hinds	58	75	44	33	35	35	8	55	60	35	61	79		533	51	1162
Hinds	Yearling	36	22	4	14	10	47	28	33	36	22	0	49		237	42	580
	Adult	141	224	150	62	83	135	53	227	86	151	155	205		695	130	2497
Stags	Yearling	55	12	1	0	21	25	23	13	37	24	59	13		73	37	393
	Adult	64	9	47	3	65	61	23	10	32	26	96	75		222	51	784
Cattle																	
Cows	Dairy	-	-	-	-	-	280	-	27	-	-	-	-	106	52	-	465
	Beef	-	118	-	8	-	166	-	58	160	-	-	127	-	-	8	645
Heifers	Rising 1 year	-	87	-	-	50	90	-	76	62	-	6	5	-	338	3	717
	Yearling	-	-	-	12	-	-	-	16	-	-	-	-	-	134	2	164
Bulls	Rising 1 year	-	46	-	-	-	45	-	-	22	-	153	183	-	6	-	455
	Yearling	-	8	-	-	-	-	6	1	9	-	47	85	-	-	12	168
	Adult	-	1	-	-	-	-	-	3	3	-	-	3	266	2	-	278
Steers	Rising 1 year	-	-	106	32	-	6	-	-	145	-	-	-	-	-	15	304
	Yearling	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	21
	Adult	-	-	-	-	-	15	-	2	-	-	-	-	-	105	2	124
Sheep																	
	Ewes	3	1270	2347	345	-	3500	-	692	1530	-	1400	2100	42	1700	770	15699
	2 Tooth	-	470	-	-	-	1300	3	250	720	-	500	1000	-	-	450	4693
	Lambs / Hoggets	2	705	2430	90	0	1390	6	360	850	0	430	1630	28	2630	430	10981
	Rams	-	20	34	3	-	65	-	12	22	-	25	40	4	22	20	267
Goats		2	-	-	-	-	185	19	-	-	-	1	-	-	1000	-	1207
Horses		-	-	-	-	-	8	5	-	1	-	2	-	-	-	1	17
Year 1993																	
Deer																	
Weaner	Stags	62	62	35	27	42	55	34	101	38	39	52	24		64	66	701
	Hinds	60	97	32	40	30	32	19	40	64	39	47	46		77	61	684
Hinds	Yearling	43	20	23	12	11	26	12	58	60	35	4	46		76	52	478
	Adult	136	185	134	63	64	118	53	190	105	155	107	171		127	157	1765
Stags	Yearling	47	9	27	-	21	20	28	24	34	30	68	29		78	46	461
	Adult	64	9	49	4	105	55	27	8	45	37	144	80		210	87	924
Cattle																	
Cows	Dairy	-	-	-	-	-	240	-	-	-	-	-	-		81	-	321
	Beef	-	118	-	4	-	200	-	61	99	-	-	114		-	6	602
Heifers	Rising 1 year	-	60	-	-	-	70	-	101	178	-	43	6		374	2	834
	Yearling	-	-	-	25	-	60	-	31	30	-	5	2		50	3	206
	Adult	-	-	-	-	-	-	-	-	-	-	-	-		296	-	296
Bulls	Rising 1 year	-	48	-	-	-	20	8	-	24	-	102	169		-	-	371
	Yearling	-	21	-	-	-	20	3	-	14	-	41	127		-	1	227
	Adult	-	-	-	-	-	4	-	3	5	-	-	3		3	-	18
Steers	Rising 1 year	-	-	30	5	-	10	-	-	32	-	-	15		32	-	124
	Yearling	-	-	144	-	-	5	-	-	-	-	-	-		101	-	250
	Adult	-	-	-	-	-	-	-	-	-	-	-	-		17	-	17
Sheep																	
	Ewes	-	1250	1860	217	-	3306	-	-	1600	-	1800	2100		1496	460	14089
	2 Tooth	-	460	600	70	-	1260	-	-	675	-	-	950		584	380	4979
	Lambs / Hoggets	-	680	2105	74	-	1750	-	225	800	-	570	1755		1408	395	8007
	Rams	-	20	32	3	-	80	-	10	26	-	25	33		27	20	276
Goats		-	-	-	-	-	200	17	-	-	-	-	-		210	-	427
Horses		-	-	-	-	-	4	4	-	-	-	-	-		-	1	9

Note : Farm 14 kept the deer stock reconciliation confidential in 1992 and was not monitored in 1993

Appendix 3.7 : Age distribution of hinds and stags on each survey farm in 1992 and 1993.

Farm	Age at the start of the year												
code	1	2	3	4	5	6	7	8	9	10	>10	Unkown	Total
STAGS													
Year 1992													
1	59	19	13	9	7	8	7	2	1		1	1	127
2	27	2		2	5							1	37
3	2	26	16	5	1								50
4		1	1	1									3
5	37	19	28	20	4	6						1	115
6	48	15	15	12	10	1					1	12	114
7	33	9	3	11	1								57
8	12		5	1	1	2		1					22
9	46	3	27	2									78
10	25	13	7	5			1	1	1				53
11	60	48	55	6	1	1						3	174
13	13	7	20	33	9	2		3				1	88
14	0	77											77
15	69	47	25										141
16	37	30	8	4	4	4	1						88
All farms	468	316	223	111	43	24	9	7	2	0	2	19	1224
Year 1993													
1	49	20	10	12	8	7	3	5			1		115
2	89	12	2		2	5							110
3	29	2	26	16	5	1							79
4		1	1	1	1								4
5	21	38	18	27	42	2	9					1	158
6	34	9	10	11	7	7	1				1	11	91
7	32	15	10	3	9	1							70
8	26	4		2		1	1		1			1	36
9	34	32	4	14	3								87
10	30	15	9	7	4	1				1		1	68
11	68	47	44	43	3	1	1					4	211
13	32	10	6	21	32	8	2		3			1	115
15	79	70	53	26								8	236
16	45	37	28	8	4	4	4	1					131
All farms	568	312	221	191	120	38	21	6	4	1	2	27	1511
						HINDS							
Year 1992													
1	40	29	46	26	14	9	10	3	6	2	7	2	194
2	51	35	127	0	27	16	8	3	3	1	1	2	274
3	4	80	16	16	15	6	10	6	3			1	157
4	29	16	20	17	11	5						8	106
5	12	6	6	12	14	1	3	7	1	1	2	46	111
6	47	1	8	0	38	1						91	186
7	31	15	1	8	3	1	1	1	1			22	84
8	36	30	72	24	20	6	15	31				31	265
9	34	49	32	6									121
10	22	24	27	17	22	5	18	22	16	49			222
11	13	38	29	4	55	5	13					35	192
13	48	87	28	21	10	7	6	6	3	4	1	55	276
14				31	48	8	5	12	45	4	5	6	164
15	48											182	230
16	42	38	18	42	23	4		4					171
All farms	457	448	430	224	300	74	89	95	78	61	16	481	2753
Year 1993													
1	43	22	23	38	20	12	9	9	3	5	5		189
2	54	20	31	118		26	16	6	4	3	1	1	280
3	30	2	72	16	15	15	5	9	2	3			169
4	33	14	16	15	14	8	4					5	109
5	11	12	4	4	10	11	1	2	6	1	1	30	93
6	26	37		8		31	1					71	174
7	12	18	13	1	8	2	1	1				21	77
8	57	25	32	63	28	25	6	22	22			14	294
9	60	31	45	26	6								168
10	35	22	24	25	12	16	4	12	18	8	29		205
11	5		11	22	1	43	4	7				20	113
13	46	43	49	45	21	15	6	3	4	1	3	37	273
15	99	47										121	267
16	51	39	36	16	38	20	4		4				208
All farms	562	332	356	397	173	224	61	71	63	21	39	320	2619

Note : were included all deer that were present on each farm at least part of the time.

Appendix 3.8 : Blood line distribution of weaners (< 15 months), hinds and stags within each survey farm in 1992 and 1993.

	Code	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	All farms
HINDS																	
Year 1992																	
Total number of hinds		194	274	157	106	111	186	84	265	121	222	192	277	164	230	171	2754
Pure New Zealand	NZ	46.9	100.0	85.4	73.6	87.4	100.0	100.0	92.8	71.9	100.0	99.5	98.9	79.3	100.0	63.7	78.4
English blood	EN	44.3	-	8.9	-	3.6	-	-	6.4	16.5	-	-	-	-	-	12.9	5.9
European blood	EU	0.5	-	4.5	26.4	1.8	-	-	0.8	11.6	-	-	-	-	-	23.4	3.4
Wapiti or elk	WAP	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-	0.1
Unknown	?	8.2	-	1.3	-	7.2	-	-	-	-	-	0.5	0.4	20.7	-	-	12.2
Year 1993																	
Total number of hinds		189	281	169	109	93	174	77	294	168	205	113	273		269	208	2622
Pure New Zealand	NZ	45.5	99.6	85.8	52.3	93.5	100.0	100.0	93.9	50.6	97.6	99.1	98.9		90.7	54.3	84.1
English blood	EN	53.4	-	10.7	-	4.3	-	-	5.8	20.8	-	-	-		-	16.8	8.0
European blood	EU	1.1	0.4	-	-	-	-	-	0.3	-	-	0.9	0.4		0.7	-	0.3
Wapiti or elk	WAP	-	-	3.6	47.7	2.2	-	-	-	28.6	2.4	-	-		-	28.8	6.6
Unknown	?	-	-	-	-	-	-	-	-	-	-	-	0.7		8.6	-	1.0
STAGS																	
Year 1992																	
Total number of stags		127	37	50	3	115	114	57	22	78	52	174	89	77	141	88	1224
Pure New Zealand	NZ	34.6	91.9	94.0	33.3	74.8	99.1	96.5	77.3	32.1	94.2	86.8	98.9	100.0	100.0	53.4	79.7
English blood	EN	55.9	5.4	4.0	-	3.5	0.9	1.8	-	30.8	3.8	-	-	-	-	15.9	9.9
European blood	EU	7.9	2.7	2.0	66.7	4.3	-	1.8	22.7	37.2	-	-	-	-	-	30.7	6.6
Wapiti or elk	WAP	0.8	-	-	-	17.4	-	-	-	-	-	13.2	1.1	-	-	-	3.7
Unknown	?	0.8	-	-	-	-	-	-	-	-	1.9	-	-	-	-	-	0.2
Year 1993																	
Total number of stags		115	110	79	4	158	91	70	36	87	68	211	115		235	131	1510
Pure New Zealand	NZ	30.4	96.4	87.3	-	81.0	96.7	97.1	80.6	23.0	76.5	89.1	98.3		97.4	38.9	77.9
English blood	EN	65.2	1.8	11.4	25.0	2.5	1.1	1.4	5.6	25.3	22.1	-	-		-	19.8	10.5
European blood	EU	3.5	0.9	1.3	75.0	3.2	-	1.4	11.1	51.7	-	-	-		1.3	41.2	8.0
Wapiti or elk	WAP	0.9	-	-	-	13.3	2.2	-	-	-	-	10.0	1.7		-	-	3.1
Unknown	?	-	0.9	-	-	-	-	-	2.8	-	1.5	0.9	-		1.3	-	0.5
WEANERS																	
Year 1992																	
Total number of stags		128	189	103	72	76	125	78	181	94	177	129	170	262	162	102	2048
Pure New Zealand	NZ	14.8	100.0	87.4	15.3	100.0	100.0	100.0	100.0	18.1	83.1	100.0	100.0	100.0	100.0	21.6	81.9
English blood	EN	60.2	-	12.6	-	-	-	-	-	18.1	14.7	-	-	-	-	27.5	7.9
European blood	EU	22.7	-	-	84.7	-	-	-	-	63.8	2.3	-	-	-	-	51.0	10.1
Wapiti or elk	WAP	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1
Year 1993																	
Total number of stags		173	205	120	68	73	131	66		128	157	104	188		138	131	1682
Pure New Zealand	NZ	67.6	-	17.5	-	-	-	47.0		35.9	39.5	-	-		-	28.2	18.7
English blood	EN	-	-	-	100.0	-	-	15.2		64.1	-	-	-		-	54.2	13.7
European blood	EU	19.1	100.0	82.5	-	-	100.0	37.9		-	60.5	-	100.0		100.0	17.6	55.7
Wapiti or elk	WAP	13.3	-	-	-	100.0	-	-		-	-	100.0	-		-	-	11.9

NZ = Deer 100% of New Zealand blood origin; EN = Deer with some English but not European blood; EU = Deer with European blood; WAP = Deer with wapiti blood

Appendix 3.9 : Deer stock, disease control programme and health problems on survey farms in 1991.

	FARM CODE														
	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
Deer stock															
Number of adult hinds mated	82		84	61	81	122	41	200	34	151	100	113		1146	84
Number of yearling hinds mated	27		92	20	5	20	0	36	43	18	40	45		0	39
Number of calves weaned	89		99	72	47	112	36	183	32	183	119	98		127	84
Number of stags velvetted	82	11	48	3	77	79	24	15	29	38	83	73		200	50
Disease control programme															
Monitoring of internal paraistes†	-	-	-	-	-	W	-	-	-	-	-	-		-	-
Monitoring copper status ‡	-	-	-	W	-	H, S	-	W	-	-	-	-		-	-
Vaccination 5-in-1 §	W, H	-	-	W, H	-	W, H	H	-	-	W	-	H		-	-
Weaners															
Anthelmintic used	IO	IPO	IO	OXF	IO	VMD	IO	OXF	OXF	RL	RL	RL		SLC	IO
Number of drench	4	6	9	5	3	5	5	3	7	5	7	3		3	4
Starting date Weaners	FEB	MAR	FEB	FEB	MAR	MAR	MAR	MAR	MAR	FEB	MAR	MAY		APR	MAR
Ending date	JUN	JUL	OCT	JUN	JUL	AUG	JUN	-	SEP	JUL	SEP	JUN		-	AUG
Spring drench #	SEP	SEP	AUG	-	-	-	-	-	-	-	-	SEP		OCT	
Copper oxide rods supplementation	-	-	-	MAR	JUN	-	JUN	WIN	-	-	-	-		-	-
Hinds															
Anthelmintic used	-	-	-	OXF	-	VMD	IO	-	-	-	-	-		-	IO
Number of drench	-	-	-	1	-	1	1	-	-	-	-	-		-	1
Month	-	-	-	NOV	-	OCT	OCT	JUL	-	-	AUG	-		MAY	AUG
Copper oxide rods supplementation	-	-	-	-	MAR	-	JUN	WIN	JUN	-	-	-		-	-
Stags															
Anthelmintic used	-	IPO	-	-	-	VMD	IO	-	-	-	-	-		-	IO
Number of drench	-	1	-	-	-	1	2	-	-	-	-	-		-	1
Month	-	JUN	-	-	-	SEP	MAY	-	-	-	-	-		-	AUG
Copper oxide rods supplementation	-	-	-	-	VELV	-	JUN	WIN	-	-	-	-		-	-
Health problems															
Brokenneck	-	S	-	-	W	W	W	-	-	W	-	-		2W	-
Broken leg	-	-	-	-	-	W	-	-	-	-	-	-		-	W
Other misadventure	S	-	-	2W	-	-	-	-	-	-	-	-		4S	-
Yersiniosis	-	-	-	-	-	9W	-	-	2W	-	-	-		-	2W
Maligiant catarrhal fever	-	S	-	-	-	H	S	-	2S	-	-	-		-	-
Enzootic ataxia	-	-	-	-	H	-	-	-	-	-	-	-		-	-
Leptospirosis	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Lungworm problems	-	-	-	-	-	-	-	-	-	-	-	-		-	-
Death	S	2S	2S	3W	W	11W, H	S	4H	2W,2S	W,H,S	W,H,S	4H,3S		6S	W,2H
Calving problems															
Known abortion	-	-	-	-	-	-	-	Y	-	2A	-	-		-	Y
Dystocia	A	Y, A	3Y	A	-	A	-	-	3Y	6Y ,2A	3Y ,2A	-		-	Y, 4A
Calves victimised	2Y, 2A	-	-	-	-	Y	-	-	-	Y ,A	-	-		-	4Y
Calves lost through fences	Y	Y	-	-	-	A	-	Y ,5A	-	Y ,2A	-	Y ,2A		A	Y ,3A
Mismothering	-	A	-	-	-	-	-	Y ,5A	2Y	A	Y ,2A	-		A	-
Dead calves found	3Y ,3A	2Y ,2A	-	-	-	Y ,2A	2A	3Y, 1'-A	-	-	-	Y ,2A		A	3Y ,5A

W = weaner, H = hind, S = stag; IO = Ivomec oral; IPO = Ivomec pour on; OXF = Oxfen; VMD =Valbazen mini dose; SLC Synanthic low dose cattle
RL = Red label (benzimidazole drench marketed by local veterinarians)
FEB = February, MAR = March; JUN = June; JUL = July; Aug = August; SEP = September; OCT =October; NOV = November; WIN = Winter; VELV = at velvetting
† through faecal egg and larval count; ‡ through serum or liver copper concentrations, or both; § against clostridial disease
# if farmers stopped anthelmintic treatment during winter.
hyphen = none

Appendix 3.10 : Monthly mean minimum and maximum temperatures (°C), total rainfall (mm) and mean percentage of daily sunshine on each survey farm from March 1 1992 to March 1 1993

		FARM CODES														
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
March 1992																
Min Temp	°C	8.2	8.1	6.9	8.7	8.8	8.8	9.9	6.2	8.3	NR	7.7	5.4	5.1	8.9	NR
Max Temp	°C	18.8	18.7	17.5	17.3	21.9	22.8	21.0	16.2	17.2	NR	20.6	21.4	20.7	23.7	NR
Rainfall	mm	217	265	135	236	72	103	74	57	121	NR	55	33	50	73	NR
Sunshine	%	35	36	45	27	33	55	55	42	39	NR	80	72	69	74	NR
April 1992																
Min Temp	°C	4.7	4.7	4.3	5.5	5.2	6.4	7.6	4.9	5.2	NR	5.5	3.5	2.8	5.5	NR
Max Temp	°C	16.6	16.6	14.2	14.8	18.4	17.8	16.3	14.5	13.8	NR	16.3	17.1	16.5	18.9	NR
Rainfall	mm	118	107	80	106	24	83	55	84	70	NR	70	56	61	99	NR
Sunshine	%	52	52	45	35	48	47	47	50	42	NR	63	59	41	43	NR
May 1992																
Min Temp	°C	3.7	3.9	3.9	4.1	4.1	5.1	6.4	4.6	5.0	NR	3.9	3.1	MD	4.0	NR
Max Temp	°C	13.0	13.1	11.6	11.9	15.2	14.5	12.4	10.6	11.8	NR	13.0	12.3	MD	14.3	NR
Rainfall	mm	60	66	73	65	17	47	23	87	77	NR	116	114	MD	143	NR
Sunshine	%	24	26	27	21	60	27	27	26	23	NR	35	48	MD	24	NR
June 1992																
Min Temp	°C	3.5	3.4	4.9	4.2	4.5	4.5	5.0	2.9	3.6	1.3	2.8	2.1	1.3	3.2	5.7
Max Temp	°C	12.1	12.0	11.7	11.0	13.4	13.1	11.9	8.7	10.2	12.8	10.9	11.5	12.4	15.0	13.2
Rainfall	mm	98	109	112	178	59	98	102	83	92	106	95	114	128	119	112
Sunshine	%	18	18	38	18	47	27	27	38	25	50	58	55	37	43	33
July 1992																
Min Temp	°C	5.2	5.2	5.0	4.6	3.7	5.0	5.7	2.9	4.1	2.2	4.3	3.4	1.0	4.5	4.8
Max Temp	°C	11.6	11.6	11.4	10.7	13.1	13.3	11.9	8.9	10.3	11.9	11.5	12.3	12.2	14.3	13.9
Rainfall	mm	255	348	211	338	90	286	112	217	190	313	229	238	269	236	289
Sunshine	%	8	8	22	18	48	21	21	16	18	27	56	39	60	29	32
August 1992																
Min Temp	°C	4.5	4.5	4.5	3.8	4.1	5.0	5.0	3.7	3.3	1.7	2.9	3.0	2.2	2.8	4.8
Max Temp	°C	11.7	11.7	11.7	10.8	14.2	12.7	12.8	9.2	9.8	12.2	11.9	12.1	11.9	14.3	13.6
Rainfall	mm	205	206	168	255	74	150	90	132	208	97	50	57	120	61	209
Sunshine	%	13	13	32	31	37	27	26	15	5	24	37	44	32	23	16
September 1992																
Min Temp	°C	5.8	6.0	5.0	4.5	5.0	6.2	6.1	4.8	3.8	2.5	3.6	3.5	3.1	3.0	5.1
Max Temp	°C	13.6	13.5	13.5	13.2	16.8	15.4	14.3	11.4	11.7	14.6	12.9	14.0	12.1	15.7	15.8
Rainfall	mm	187	272	203	289	86	121	67	109	100	110	123	152	73	144	114
Sunshine	%	27	24	35	27	44	44	43	28	30	47	47	50	48	40	22
October 1992																
Min Temp	°C	7.2	7.2	6.3	6.2	6.5	6.9	7.5	5.6	6.2	4.2	5.2	4.7	4.0	5.4	6.7
Max Temp	°C	16.5	16.5	16.0	15.9	18.4	20.2	17.5	15.0	15.4	17.3	16.5	16.8	13.9	16.3	18.1
Rainfall	mm	126	132	154	146	66	132	83	119	124	215	138	167	66	261	115
Sunshine	%	40	40	48	23	33	52	52	45	43	50	58	63	61	43	34
November 1992																
Min Temp	°C	10.9	10.9	9.6	9.9	10.4	10.8	10.4	9.6	9.1	8.5	8.8	8.3	MD	8.4	9.3
Max Temp	°C	19.3	19.3	19.3	18.3	21.4	23.2	20.0	19.7	18.2	20.6	19.8	20.8	MD	19.3	21.6
Rainfall	mm	121	161	59	78	47	92	49	52	56	73	133	123	MD	147	85
Sunshine	%	33	33	42	35	12	48	48	47	42	50	47	57	MD	47	27
December 1992																
Min Temp	°C	10.1	10.1	9.5	9.5	11.0	10.4	8.7	10.8	9.5	8.4	9.3	9.1	MD	9.0	10.1
Max Temp	°C	20.6	20.6	19.7	17.9	21.5	21.7	20.5	19.7	18.0	20.2	20.5	20.7	MD	21.7	22.6
Rainfall	mm	226	149	135	206	126	181	106	138	116	175	154	178	MD	164	157
Sunshine	%	26	26	29	24	21	35	35	37	27	47	43	40	MD	19	19
January 1993																
Min Temp	°C	11.8	11.8	10.7	11.0	11.9	10.5	10.5	9.6	9.8	9.1	10.3	10.4	11.9	9.2	10.8
Max Temp	°C	20.4	20.4	20.0	18.3	23.9	23.0	24.0	21.2	19.9	21.9	23.9	25.0	22.0	26.3	24.6
Rainfall	mm	124	129	101	123	35	64	89	65	48	75	65	51	50	76	75
Sunshine	%	39	39	32	27	26	62	60	66	56	82	62	76	55	71	47
February 1993																
Min Temp	°C	10.9	10.9	8.4	10.6	9.3	10.4	10.9	9.4	10.0	8.9	9.9	10.2	11.0	10.4	10.1
Max Temp	°C	20.7	20.7	21.5	18.6	24.2	24.4	22.7	20.9	20.1	20.5	20.4	21.7	19.8	22.7	25.2
Rainfall	mm	82	101	64	112	35	62	44	51	39	147	227	215	97	245	49
Sunshine	%	45	45	54	32	48	59	59	66	36	39	45	57	63	31	57

NR = Data not recorded as farms were selected in May 1992

MD = Missing data

Note : Farm 2 did not record daily temperature, sunshine and wind so data were obtained from farm 1 and from farm 3 in August 1992 as the thermometer broke in farm 1 during that month.

Farm 6 did not record sunshine and wind so data were obtained from farm 7

Min Temp = minimum temperature; Max Temp = maximum temperature

Appendix 3.11 : Monthly mean minimum and maximum temperatures (°C), total rainfall (mm) and mean percentage of daily sunshine on each survey farm from March 1 1993 to March 31 1994

		FARM CODES													
		1	2	3	4	5	6	7	8	9	10	11	13	15	16
March 1993															
Min Temp	°C	9.2	9.2	8.4	8.8	9.3	10.1	9.3	7.8	8.1	7.1	8.5	7.8	7.3	9.8
Max Temp	°C	19.0	19.0	19.1	17.0	23.1	20.5	21.3	19.3	18.4	19.8	19.6	20.3	23.7	24.4
Rainfall	mm	148	137	125	107	73	111	92	39	89	98	119	76	121	114
Sunshine	%	48	48	63	42	47	74	74	53	45	58	65	67	32	34
April 1993															
Min Temp	°C	7.9	7.9	7.1	7.9	7.8	9.0	7.8	6.8	7.1	4.9	6.5	6.9	5.4	8.1
Max Temp	°C	16.5	16.5	16.4	14.4	20.2	18.7	16.9	15.0	14.6	16.7	16.5	17.8	19.4	20.1
Rainfall	mm	96	112	93	121	68	56	53	66	56	60	62	56	57	105
Sunshine	%	25	25	37	23	42	60	60	38	33	52	52	44	33	38
May 1993															
Min Temp	°C	7.6	7.6	6.5	6.2	6.1	7.2	7.1	5.2	7.0	4.1	5.5	4.4	4.4	7.5
Max Temp	°C	14.3	14.3	15.2	13.2	19.1	16.8	16.0	12.6	13.4	15.2	14.6	15.5	19.4	18.0
Rainfall	mm	172	177	119	162	90	61	66	73	85	64	58	89	76	78
Sunshine	%	21	21	50	29	25	46	46	39	13	58	65	82	52	26
June 1993															
Min Temp	°C	7.1	7.1	6.4	5.7	6.6	6.0	6.4	2.9	5.4	2.7	4.5	3.0	4.5	6.6
Max Temp	°C	13.1	13.1	13.3	12.2	16.2	15.0	13.8	10.5	11.6	13.0	12.6	13.2	17.0	14.8
Rainfall	mm	231	263	194	254	166	111	91	88	129	56	71	55	175	128
Sunshine	%	2	2	18	13	23	28	28	23	5	52	70	55	60	22
July 1993															
Min Temp	°C	5.0	5.0	4.2	2.5	2.6	3.8	4.4	1.3	2.3	0.6	2.3	1.3	1.6	4.4
Max Temp	°C	12.4	12.4	12.6	10.8	14.5	14.1	13.3	9.0	11.7	11.8	11.1	11.7	15.0	15.7
Rainfall	mm	37	39	18	32	17	16	8	44	17	19	20	19	70	11
Sunshine	%	39	39	37	26	35	45	45	55	47	50	74	42	71	45
August 1993															
Min Temp	°C	4.5	4.5	2.6	1.9	2.7	4.1	4.0	1.9	2.0	1.2	2.4	1.9	2.0	4.1
Max Temp	°C	12.4	12.4	13.1	11.1	17.0	14.0	13.1	9.7	10.6	11.9	11.5	12.6	15.7	16.3
Rainfall	mm	101	117	74	109	45	68	47	54	35	80	73	99	95	57
Sunshine	%	13	13	56	35	60	52	55	15	21	56	66	55	45	48
September 1993															
Min Temp	°C	5.6	5.6	5.0	3.6	5.6	4.9	5.2	4.7	4.8	0.9	3.1	3.5	2.9	5.2
Max Temp	°C	13.1	13.1	13.9	12.6	16.9	15.5	14.8	11.0	12.6	13.7	13.1	14.2	15.2	16.2
Rainfall	mm	124	113	92	145	53	126	68	87	87	99	61	91	69	93
Sunshine	%	27	27	37	20	22	37	37	35	17	47	55	41	46	35
October 1993															
Min Temp	°C	9.1	9.1	7.7	6.8	7.1	7.7	8.8	7.3	7.5	5.7	6.6	6.5	7.1	8.0
Max Temp	°C	17.8	17.8	18.4	16.5	21.2	19.3	19.8	17.0	16.6	18.6	19.0	19.5	20.4	21.0
Rainfall	mm	119	179	151	221	25	57	39	27	52	38	37	17	24	79
Sunshine	%	61	61	53	40	65	56	56	71	24	81	85	75	59	63
November 1993															
Min Temp	°C	8.0	8.0	6.7	6.1	6.7	7.6	7.4	8.0	6.6	5.6	6.0	6.4	5.6	7.2
Max Temp	°C	18.0	18.0	18.0	16.0	21.3	19.7	18.8	18.1	16.0	18.4	18.5	17.9	19.2	21.0
Rainfall	mm	196	170	185	231	176	152	77	108	122	89	78	103	122	149
Sunshine	%	48	48	53	32	29	63	63	42	20	58	48	62	40	38
December 1993															
Min Temp	°C	11.7	11.7	9.8	9.6	10.4	10.2	10.0	10.7	9.7	10.4	8.8	8.9	8.8	10.0
Max Temp	°C	19.9	19.9	20.3	18.3	23.4	22.1	21.2	21.6	18.6	21.8	22.2	22.8	22.2	24.0
Rainfall	mm	126	126	128	160	77	100	101	58	89	87	52	76	52	108
Sunshine	%	58	58	61	28	37	46	46	65	37	66	50	86	50	40
January 1994															
Min Temp	°C	13.2	13.2	12.4	12.3	12.6	13.6	14.8	10.2	12.1	10.6	11.6	11.6	12.4	12.4
Max Temp	°C	23.6	23.6	23.6	21.4	27.2	25.9	25.4	23.2	22.1	25.6	26.4	26.3	27.8	28.0
Rainfall	mm	73	73	65	95	61	55	14	94	90	60	98	55	91	57
Sunshine	%	63	63	74	37	62	71	71	65	72	77	68	82	69	79
February 1994															
Min Temp	°C	13.4	13.4	11.4	12.0	12.3	13.0	13.4	12.7	12.1	10.5	11.2	11.7	11.1	12.9
Max Temp	°C	24.8	24.8	25.9	23.7	28.9	28.0	26.1	23.8	22.6	24.1	24.0	26.3	25.0	30.0
Rainfall	mm	32	32	37	24	15	39	20	73	51	29	27	27	64	42
Sunshine	%	66	66	71	66	75	77	77	68	73	86	64	95	66	73
March 1994															
Min Temp	°C	10.1	10.1	8.9	7.8	8.9	10.1	9.6	8.9	8.9	7.5	8.8	8.8	9.0	9.7
Max Temp	°C	20.5	20.5	19.8	19.3	25.3	23.1	22.5	18.1	18.1	20.5	21.3	21.8	22.3	24.7
Rainfall	mm	53	53	54	71	44	119	65	67	67	57	35	58	38	93
Sunshine	%	42	42	65	45	50	66	66	55	55	65	69	77	73	47

Note : Farm 2 did not record daily temperature, sunshine and wind so data were obtained from farm 1
Farm 6 did not record sunshine and wind so data were obtained from farm 7
Min Temp = minimum temperature; Max Temp = maximum temperature

Appendix 3.12 : Farmer's deer handling practices and perception of deer behaviour.

Questions	Category	FARM CODE 1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
DEER WORK IN PADDOCKS																
% Use of motorbike	All deer	100	100	50	0	70	100	100	50	90	70	100	100	100	100	100
to shift deer	excepted* :							W=0			H=100					
Number of person to shift deer																
Between paddocks	All deer	1	1	2	1	1	1.5	1	1	1.5	1	1	2	1	3	1
	excepted* :														S=2	
To the yards	All deer	1	1	2	1	1	1.5	1	1	1.5	2	2	2	2	4	1
	excepted* :														H=3-S=2	
Use of dog to handle deer																
% of time	All deer	100	0	50	0	0	0	100	50	80	0	10	20	0	0	0
	excepted* :							H=50-S=0	H=75- S=100	H=90- S=100		S=20	W=0			
Barking dog		X	X						X (H- S)	X		X				
Well trained dog		X	X	X (W)					X			X	X			
Farmer behaviour																
Farmer shouting when shifting deer		Xd	Xd	X	X	X (H-S)			X	Xd		Xd	X(W)		X(W-H)	X
Deer behaviour when shifted between paddocks																
	Very calm	W	H		W-S				H		W-H-S		S			
	Restless					W-H-S			W			W	W		W	
DEER WORK IN THE YARDS																
Number of person to handle deer																
	All deer	1	1	2	1.5	1	1.5	2	2	2	1	2	2	2	2	1
	excepted* :						W=1	H=1								
Farmer behaviour																
Farmer shouting or speaking loudly				X(S)			X		X	X					X	
Deer behaviour when :																
entering the yards	Rushing through door								W			W-H-S	W		W-H	
	Needs pushing					W	W-H-S									W
inside the yards	Rushing through door	W									W-H	W				
	Needs pushing						W-H-S			W-H-S			W			
individually handled	Calm		H-S		S	W-H-S		W-H	H	W-H-S	W-H-S	W-H-S	W-H-S		H-S	W-H-S
	Stressed															
Aggressive deer																
	Presence	H-S	S			H-S	H-S	S	H-S			H	H-S	H		W-H-S
Culling on the basis of aggression			X	X	X	X		X	X	X	X			X	X	X

X = Yes; Xd = Yes to command the dog; X(S) = Yes for Stags; X(H-S) = Yes for hinds and stags; X(W) = Yes for weaners

* Response applying to particular class of deer as specified, ie S = Stags; H = Hinds; W = Weaners

Note : the actual questionnaire is presented in Appendix 2.9.

Appendix 3.13 : Mating management strategies on each survey farm in 1992.

Farm code	Mating mob	Weaning date*	Commencement of mating (Mating mob)											Mating mob after change of sire (Back-up mob)										Date second Back-up†	Date sire removal
			Joining with stag	Number of hinds		Number of sire(s)	Sire 1			Sire 2			Date first Back-up	Number of hinds		Number of sire(s)	Back-up sire 1			Back-up sire 2				
				AH	YH		Age	Blood lines	Exp**	Age	Blood lines	Exp		AH	YH		Age	Blood lines	Exp	Age	Blood lines	Exp		
1	2A	02-Mar	23-Mar	33		1	7	100 EN	5																04-May
	2B			25		1	4	50 EN	3																
	2C			31		1	2	100 EN	1																
	2D			28		1	5	100 NZ	1																
	2E		25-Mar	11	40	1	7	100 EN	5																
	5T			24		1	3	50 WA	2																
2	2		25-Mar		41	2	2	100 NZ	0	2	50 HU	0	22-Apr		41	1	4	75 EN	2						23-May
	4A	24-Mar	24-Mar	78		1	6	100 NZ	4			)	22-Apr	78		4	2	100 NZ	0	4	100 NZ	2			
	4B			60		1	4	75 EN	2			)	22-Apr	85	5	1	5	100 NZ	2				03-May		
	4C			63		1	5	100 NZ	2			)	03-May	148	5	5	5	100 NZ	2						
	4D			25	5	2	5	100 NZ	1	5	100 NZ	)	22-Apr	85	5	1	5	100 NZ	2				03-May		
3	3A	03-Mar	24-Mar	44		2	4	100 NZ	0	4	100 NZ	2													18-May
	3B			34		1	5	100 NZ	2																
	3C		23-Mar	24	2	1	3	50 EN	1																
	3D			38		1	6	100 NZ	2																
	3E		01-Apr	6	2	1	3	100 NZ	0																
4	2	29-Feb	09-Mar	41		1	4	50 SW	3																19-May
	2A			5	10	1	3	100 NZ	2																
	2B			16	4	1	2	25 SW	1																
5	2	18-Mar	15-Feb		12	21	1	25 EN	0	1	25 EN	0													20-May
	3		21-Mar	82		1	6	25 WA	3																
6	3A	27-Mar	27-Mar	4	47	1	3	50 EN	1			)													
	3A			44		1	12	100 NZ	5			)	11-May	136	38	1	12	100 NZ	5						18-Jun
	5B			44		1	6	100 NZ	3			)													
	5C			45		1	5	100 NZ	0			)													
7	2X	09-Mar	24-Mar	33	22	1	5	50 EN	3				20-Apr	31	15	1	4	100 NZ	2						10-May
	3X		09-Mar	30	2	1	2	100 HU	0				20-Apr	32		1	4	100 NZ	2						
8	3		01-Feb		33	10	1	100 NZ	0																11-May
	4A	16-Mar		53		1	3	50 HU	1				09-Apr	53		1	8	100 NZ	7						
	4B			56		1	5	50 SW	4				09-Apr	56		1	6	100 NZ	5						
	4C			54		1	8	100 NZ	7				09-Apr	54		1	3	50 HU	1						
	4D			56		1	6	100 NZ	5				09-Apr	56		1	5	50 SW	4						
	4E		18-Mar	20	3	2	1	100 NZ	0																28-Apr
9	2A		11-Mar		17	2	1	25 EN	0	1	25 EN	0													11-May
	5A	10-Mar		42		1	4	75 HU	2																
	5B			38		1	2	50 HU	1				16-Apr	38		1	2	50 DA	1						
	5C			6	17	1	1	100 EN	0																
10	1	06-Mar	13-Mar	67		1	3	100 NZ	1			)	27-Apr	98		2	9	100 NZ	7	4	100 NZ	2			18-May
	4			31		1	2	50 EN	0			)													
	2			25	22	1	3	50 EN	1				27-Apr	25	22	1	8	100 NZ	6						
	3			54		1	5	100 NZ	3				27-Apr	54		1	7	100 NZ	5						
11	2A	11-Mar	23-Mar	46		1	4	50 WA	1																20-May
	2B			46		1	4	50 WA	1																
	2C			37		1	3	25 WA	0																
13	1	10-Mar	20-Mar	9	48	2	3	100 NZ	1	6	100 NZ	3													15-May
	3			82		2	4	100 NZ	2	2	50 WA	0	) 15-May	123		1	2	50 WA	0						01-Jun
	3A			43		1	8	100 NZ	5			)													
	8			35		1	4	100 NZ	2																30-Jun
14	4A	24-Mar	13-Mar	56		1	7	100 NZ	3			)	23-Apr	110		1	7	100 NZ	3						11-May
	4B			54		1	7	100 NZ	5			)													
	4C			56		1	8	100 NZ	6			)													
15	10	30-Apr	02-Mar	150		6‡	6	100 NZ	3	2	100 NZ	0					5	100 NZ	0	5	100 NZ	0			30-Apr
	4		18-Feb		196	7	5	100 NZ	0																02-May
	5				48	2	3	100 NZ	0	3	100 NZ	1													30-Apr
16	All***	30-Mar		29	10	1	3	50 HU	1			)	14-May	66	21	3									30-May
	O			12	10	1	3	50 HU	1			)													
	B		28-Mar	37	11	1	4	50 EN	1				02-Apr	37	11	1	2	25 SW	0				14-May		
	R		01-Apr	32	11	1	7	100 NZ	5			)	14-May	55	21	2	7	100 NZ	3	5	50 SW	2			
	S			23	10	1	5	50 SW	2			)													

Note : Single sire mating was carried out when there is no Sire 2 (see Number of sire(s))
The number of hinds in back-up mobs increased when mating mobs were joined together. The brackets ")" identify mating mobs that were joined with one or more other mating mobs for back-up, eg on farm 6 all mating mobs were joined together as one back-up mob on May 11

* Weaning of adult hinds (>2 years) ** Number of years of experience as sire *** Hinds artificially inseminated prior to joining with mating sire

† These backup mobs were mixed with one mating mob until sire removal

‡ The 4 other sires were 5 years old, 100 New Zealand origin and with 1 year experience as sire

AH = Adult hinds; YH = Yearling hinds; EN = English; NZ = New Zealand; WA = Wapiti; SW = Swedish; HU = Hungarian

Appendix 3.14 : Mating management strategies on each survey farm in 1993.

Farm code	Mating mob	Weaning date*	Commencement of mating (Mating mob)											Mating mob after change of sire (Back-up mob)										Date sire removal
			Joining with ring	Number of hinds		Number of sire(s)	Sire 1			Sire 2			Date first Back-up	Number of hinds		Number of sire(s)	Back-up sire 1			Back-up sire 2			Date second Back-up	
				AH	YH		Age	Blood lines	Exp**	Age	Blood lines	Exp		AH	YH		Age	Blood lines	Exp	Age	Blood lines	Exp		
1	15	07-Mar	24-Mar	24		1	4	50 WA	3															30-Apr
	23			42		1	2	100 EN	0															
	24			24		1	6	100 NZ	2															
	25			20		1	1	75 GE	0															
	26			16		1	8	100 EN	6															
	17		13-Mar		43	1	6	100 EN	4															03-May
2	13A	03-Mar	19-Mar	45		1	5	75 EN	3				) 11-May	182		4								29-May
	13B			45		1	8	100 NZ	4				)											
	13C			47		1	6	50 EN					)											
	13D			45		1	3	50 HU	1				)											
	13E			20	27	1	3	100 NZ	0				11-May	20	25	2								
3	7A	17-Mar	17-Mar	25	6	1	2	50 EN	1															11-May
	7B			30	5	1	3	50 YU	1															
	7C			31	6	1	4	50 EN	3															
	7D			31		1	6	100 NZ	4															
	7E			17	13	1	4	100 NZ	1															
4	16	25-Feb	09-Mar	9	7	1	4	50 DA	2				05-May	63	12	1	2	50 EN	0					20-May
	17		15-Mar	30		1	5	50 SW	4				) 26-Apr	54	5	1	2	50 EN	0				05-May	
	18			13		1	3	25 SW	2				)											
	19			9	5	1	2	50 EN	0				)											
5	3B	10-Mar	20-Mar	66	5	1	3	50 EN	0				30-Apr	66	5	1	3	50 DA	0					29-May
6	11		18-Mar		26	1	13	100 NZ	10				10-May		26	1	7	100 NZ	4				29-May	02-Jun
	13	01-Apr		37		1	4	50 EN	2				10-May	37		1	13	100 NZ	10				23-May	
	14			41		1	7	100 NZ	0				) 10-May	71		1	6	100 NZ	1				29-May	
	16			31		1	7	100 NZ	4				)			1								
	15			38		1	6	100 NZ	1				10-May	38		1	4	50 EN	2					
7	2	22-Mar	22-Mar	53		1	3	100 HU	1															06-Jun
	2A				11	1	6	100 NZ	3															
8	2A	10-Mar	01-Feb		32	1	2	50 DA	0				28-Apr		32	4	2	50 DA	0	2	100 NZ	0		10-May
	7A		15-Mar	66		1	6	100 NZ	4				) 28-Apr	99		1	4	50 HU	2					
	7C		17-Mar	33		2	2	100 NZ	0	2	50 HU	0	)											
	7B			66		1	4	50 HU	2				) 28-Apr	95		1	6	100 NZ	4					
	7D			29		1	2	50 EN	0															
9	11***	04-Mar	16-Apr	24		1	3	50 DA	1															15-May
	12		13-Mar	61		41	1	87.5 EN	0	1	75 YU	0												
	13			21	21	1	2	100 EN	1															
	14				28	1	8	75 YU	3															
10	21	03-Mar	15-Mar	40		1	7	100 NZ	5				22-Apr	41		1	3	100 NZ	0					05-May
	22			44		1	4	100 NZ	2				22-Apr	42		1	4	100 NZ	0					
	23			37		1	4	50 EN	2				22-Apr	39		1	5	100 NZ	1					
	24			26		1	2	87 EN	0				22-Apr	26		1	12	100 NZ	9					
	25			8	35	1	3	50 EN	1				22-Apr	8	35	1	2	100 NZ	0					
11	13A	18-Mar	23-Mar	52		1	5	50 WA	3															04-May
	13B			55	1	1	5	50 WA	3															
13	12A	15-Mar	12-Feb	66		2	3	50 WA	1	2	50 WA	0												01-May
	12B			28		1	5	100 NZ	2															
	12C			44		1	4	100 NZ	3															
	12D			44		1	7	100 NZ	4															
	6		01-Feb		46	29	1	100 NZ	0															30-Apr
15	10B	06-Apr	16-Feb	111		4	8	100 NZ	6	3	100 NZ	3												25-May
	2A				52	2	2	50 DA	0	2	50 DA	0												11-May
	2B				24	1	3	50 GE	0															
16	21	23-Mar	24-Mar	24		1	9	100 NZ	6				) 26-May	111	7	4	9	100 NZ	6	6	50 SW	3		11-Jun
	27			28		1	6	50 SW	3				) 26-May	111	7	4	9	100 NZ	6					
	28			29	7	1	4	50 HU	2				)											
	29			30		1	6	50 EN	2				)											06-Jun
	26				33	1	2	25 SW	0															
	30***		14-Apr	13		1	1	50 YH	0															
	31***			11		1	1	50 YH	0															

Note : Single sire mating was carried out when there is no Sire 2 (see Number of sire(s))

The number of hinds in back-up mobs increased when mating mobs were joined together. The brackets ")" identify mating mobs that were joined with one or more other mating mobs for back-up, eg on farm 2 mating mobs 13A, 13B, 13C and 13D were joined together as one back-up mob on May 11

* Weaning of adult hinds (>2 years) ** Number of years of experience as sire *** Hinds artificially inseminated prior to joining with mating sire

1 The 2 other sires were 1 year old, 22.5% of New Zealand origin and were not experienced as sire

AH = Adult hinds; YH = Yearling hinds; EN = English; NZ = New Zealand; WA = Wapiti; SW = Swedish; HU = Hungarian; DA = Danish; GE = German; YU = Yugoslave.

Appendix 3.15 : Culling of yearling and adult hinds (number of hinds and culling percentage) on each survey farm in 1992 and 1993.

	ADULT HINDS									YEARLING HINDS								
		Number of hinds culled										Number of hinds culled						
		during Winter			Summer	after weaning		Total				during Winter			after weaning		Total	
Farm	Number of hinds	Culled after PD*				hinds	after	hinds	Culling	Number of hinds	Replacement†	Culled after PD*			hinds	after	hinds	Culling
code	at mating	A	L	MT		not mated	mating	culled	%	at mating	%	A	L	MT	not mated	mating	culled	%
Year 1992																		
1	154			9	3		9	21	13.6	36	18.9			13		1	14	38.9
2	226			3			18	21	9.3	46	16.9			2			2	4.3
3	146	1		3			4	8	5.5	4	2.7			2			2	50.0
4	62	4	4			12	1	21	33.9	14	18.4						0	0.0
5	82		5	3		18		26	31.7	12	12.8						0	0.0
6	137						28	28	20.4	47	25.5		5	3			8	17.0
7	40			1		12		13	32.5	16	28.6			1		4	5	31.3
8	219	2		3		43	3	51	23.3	34	13.4			7	1		8	23.5
9	87	6	2	2		2	2	14	16.1	34	28.1			3	2		5	14.7
10	165		6	6		15		27	16.4	22	11.8						0	0.0
11	129	16		2	3			21	16.3	1	0.8	1					1	100.0
13	180		1	2		19	27	49	27.2	48	21.1	2	3	1	6		12	25.0
14	166						34	34	20.5									
15	150					22		22	14.7	48	24.2	12		2		15	29	60.4
16	122							0	0.0	42	25.6				7		7	16.7
All farm	2065	29	18	34	6	143	126	356	17.2	404	16.4	15	8	34	16	20	93	23.0
Year 1993																		
1	136			4		15		19	14.0	43	24.0			8	4		12	27.9
2	184						26	26	14.1	20	9.8						0	0.0
3	135					5		5	3.7	17	11.2				6		6	35.3
4	63			1		8		9	14.3	12	16.0				1		1	8.3
5	66		1	2			14	17	25.8	7	9.6					4	4	57.1
6	119							0	0.0	26	17.9						0	0.0
7	53			2		5		7	13.2	12	18.5		3	4	1		8	66.7
8	191					22		22	11.5	29	13.2			2	2		4	13.8
9	106					6		6	5.7	47	30.7			3	10		13	27.7
10	155	5	2	1		19		27	17.4	35	18.4						0	0.0
11	107			3				3	2.8	1	0.9						0	0.0
13	155			3		8		11	7.1	34	18.0			3	3		6	17.6
15	136	2				27		29	21.3	76	35.8	1			16		17	22.4
16	135			3		13		16	11.9	40	22.9				1		1	2.5
All farm	1741	7	3	19	0	128	40	197	11.3	399	18.6	1	3	20	44	4	72	18.0
Total	3806	36	21	53	6	271	166	553	14.5	803	17.4	16	11	54	60	24	165	20.5

Note : Farm 10 in 1992 : 4 were not pregnant and 2 were suspected not pregnant

† Percentage of hind mated that were yearling hinds

* PD = Pregnancy diagnosis by ultrasound (A = advanced; L =late; MT = not pregnant (or empty)

Appendix 3.16 : Calving management practices on each farm in 1992 and 1993.

Farm code	Dates of set-stocking in calving paddocks		Number of calving mobs	Number of hinds per mob						Percentage of adult hinds (%)*		Paddock size (Ha)		Stocking rate (hind/ha)		Farmer interference during calving**			
				Yearling hinds		Adult hinds		All hinds											
	the earliest	the latest		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	VISITAW	ENTERP	VISITCP	TAGB
Year 1992																			
1	11-Nov	14-Nov	7	0	23	2	29	2	32	28	100	0.8	3.8	0.6	26.8	7	4	Y	Y
2	17-Nov		7	0	20	11	50	11	50	35	100	3.0	6.1	3.7	10.3	0	3	Y	N
3	07-Nov		5	0	2	6	42	6	42	92	100	0.7	15.6	2.7	8.2	0	1	N	N
4	15-Oct	24-Nov	6	0	9	5	16	6	18	36	100	0.9	1.2	5.6	18.6	14	3	Y	Y
5	08-Nov		1	11	11	89	89	100	100	89	89	4.6	4.6	21.6	21.6	1	2	Y	N
6	09-Nov		4	0	37	3	80	16	80	8	100	0.5	11.3	7.1	33.3	0	0	N	N
7	07-Nov	12-Nov	3	0	13	2	14	6	15	13	100	1.1	2.5	5.6	10.6	7	4	Y	N
8	23-Oct	19-Nov	7	0	22	0	55	20	55	0	100	2.8	7.5	6.3	11.6	1	3	Y	N
9†	09-Nov		3	0	17	12	36	29	43	41	100	4.6	7.2	6.0	6.4	1	4	Y	N
10	03-Nov	20-Nov	5	1	10	11	39	21	43	52	97	1.5	2.0	14.2	27.0	2	2	N	N
11	27-Oct		3	0	0	14	75	14	75	100	100	2.1	9.3	6.7	8.1	1	3	N	N
13†	24-Sep	19-Nov	4	0	39	0	128	15	128	0	100	2.3	9.5	6.6	13.4	1	3	N	N
14	05-Nov		3	0	0	37	64	37	64	100	100	6.4	12.1	5.3	8.0	2	4	Y	N
15	30-Oct		1	48	48	121	121	169	169	72	72	24.3	24.3	7.0	7.0	0	0	N	N
16	09-Nov	25-Nov	8	0	23	0	36	2	36	0	100	2.0	4.7	0.5	10.5	7	4	Y	Y
All farms	24-Sep	25-Nov	67	0	48	0	128	2	169	0	100	0.5	24.3	0.5	33.3				
Year 1993																			
1	11-Nov	14-Nov	6	0	35	0	41	17	41	0	100	0.9	4.1	4.9	25.0	1	3	Y	N
2	01-Sep	16-Nov	6	0	19	17	54	18	54	47	100	3.3	6.1	4.6	9.8	0	4	Y	N
3	02-Nov		3	5	6	25	77	31	83	81	93	4.8	15.6	4.1	6.5	0	0	Y	N
4	10-Nov	26-Nov	6	0	12	0	15	9	15	0	100	0.9	1.2	10.0	14.7	7	3	Y	Y
5	27-Oct		1	7	7	57	57	64	64	89	89	4.0	4.0	15.9	15.9	2	2	N	N
6	18-Nov		2	0	26	1	119	27	119	4	100	3.6	11.3	7.5	10.5	0	0	N	N
7	07-Nov	14-Nov	2	1	2	22	29	23	31	94	96	2.4	2.5	9.3	12.8	7	4	Y	N
8	01-Nov	02-Nov	8	0	28	0	39	21	39	0	100	2.6	5.0	6.2	8.3	0	0	Y	N
9†	05-Nov	19-Nov	4	0	25	0	67	14	67	0	100	3.4	12.9	4.1	5.5	7	2	Y	N
10	01-Nov	19-Nov	7	0	13	9	48	17	48	41	100	0.7	2.5	7.8	32.8	7	2	Y	N
11	05-Nov		2	0	1	42	61	43	61	98	100	6.0	9.3	6.6	7.1	1	2	N	N
13	01-Sep	21-Nov	3	0	24	0	138	24	138	0	100	2.3	17.4	7.9	10.6	1	4	Y	N
15	07-Oct	29-Oct	2	0	98	0	126	98	126	0	100	20.2	24.3	4.0	6.2	0	0	N	N
16†	17-Nov		5	0	34	0	48	24	48	0	100	2.0	4.4	7.7	24.0	2	3	Y	N
All farms	11-Nov	26-Nov	57	0	98	0	138	9	138	0	100	0.7	24.3	4.0	32.8				

* Percentage of adult hinds within calving mobs

** Codes are described in Table 2.11

Y = yes; N = no; Min = minimum; Max = Maximum

† Farm 9 : In 1992, hinds artificially inseminated calving in one mob were visited by the farmer every day
In 1993, one calving mob was visited only once a week and the farmer monitor closely the paddock

Farm 13 : In 1992, one group of hinds stayed on the same paddock from Winter through Summer

Farm 16: In 1993, only hinds artificially inseminated were visited every day and their calves were tagged at birth

Appendix 3.17 : Calendar of purchase and culling, liveweights (kg), carcass weights (kg) and GR measurements (mm) of weaner stags and hinds on each survey farm in 1992 and 1993.

		PURCHASE		CULLING			WEANER STAGS							WEANER HINDS						
								Weight*				GR measurements			Weight*				GR measurements	
Farm code	Year	Date of arrival	Number and sex class	Date of culling	Cause	Number of deer culled	Number of deer	Mean	Min	Max	SD	Mean	SD	Number of deer	Mean	Min	Max	SD	Mean	SD
1	1992			24-Aug	LS	2								NR						
				20-Sep	WO	4	NR							NR						
	1993	29-Jan	1 WS																	
		22-Nov	17 WH																	
				07-Dec	WO	15	NR							NR						
				30-Jan	LS	1	NR													
2	1992			24-Apr	WO	14								14	21.9	20.6	23.8	1.0	2.0	0.0
				03-Aug	LS	1	NR													
3	1992			01-Jun	LS	20	20	47.0†												
				10-Jun	WO	12								12	22.0	19.9	24.4	1.5	2.0	0.0
				11-Jun	WO	2								2	19.6	19.3	19.9	0.3	2.0	
				21-Jul	LS	2	2	42.0†												
	1993			16-Apr	LS	50	32	47.1	40.4	53.9	3.6			18	44.5	39.2	49.4	3.2		
4	1992			01-Nov	WO	20	17	54.4	49.0	59.2	2.8	4.4	1.1	1	33.1				5.0	
				03-Nov	LS	20	20	86.2	72.3	104.8	6.7									
	1993			05-Nov	LS	1	1	107.1												
				05-Nov	WO	12	12	54.6	51.6	59.0	1.7	4.9	0.9							
				17-Nov	LS	12	12	90.9	83.9	93.4	3.6									
	1994			15-Mar	LS	25								25	91.3	86.4	104.6	4.1		
5	1992			18-Jul	WO	3	NR							NR						
				28-Aug	LS	43	19	51.0	41.0	57.0	4.7			24	49.3	41.0	57.0	4.1		
	1993			15-Jul	LS	32	18	57.6	50.5	63.0	4.0			12	54.9	50.0	57.5	2.3		
6	1992			18-May	LS	54	34	47.6†						20	46.0†					
				11-Jul	WO	6								6	24.1	22.0	26.9	1.9	2.0	0.0
	1993			28-Apr	LS	12	12	49.0	46.3	53.5	1.9									
				20-May	LS	31								31	42.5	38.0	47.0	3.0		
7	1992	18-May	12 WS																	
				28-May	WO	12								10	22.9	20.9	24.9	1.4		
	1993	03-Apr	10 WS																	
		28-Apr	12 WS																	
				11-Jun	LS	11								11	48.6	39.5	54.0	4.8		
8	1992			04-Apr	WO	10								10	24.1	23.1	25.1	0.7	2.0	0.0
				08-Apr	WO	30								28	26.3	23.1	28.3	1.2	3.1	0.5
				29-Nov	WO	15	15	53.1	50.0	58.6	2.2	2.7	0.8							
	1993			09-Jun	WO	18	18	52.8	50.3	55.4	1.8	2.7	1.1							
				24-Feb	WO	24	24	53.7	50.4	57.9	1.9	3.7	0.6							
				15-Mar	WO	24	24	54.6†												
				02-May	LS	58								58	48.1	42.5	54.0	3.6		
9	1992	03-May	20 WH																	
	1993			02-Apr	LS	10	10	60.0	58.0	62.0	1.6									
		23-Apr	19 WH																	
		07-Jun	12 WH																	
	1994			21-Feb	WO	15	15	59.3	50.6	73.3	6.5	3.0	1.2							
10	1992			11-May	LS	87	39	53.5	48.0	67.5	5.7			29	52.7	43.5	56.5	2.6		
				13-May	LS	5	4	51.1	46.5	54.5	3.6			1	47.5	47.5	47.5			
				14-May	WO	19								19	22.4	20.2	25.3	1.5	2.4	0.5
	1992			28-Apr	LS	77	30	60.5	53.5	66.0	3.0			47	51.7	45.0	57.5	3.1		
				16-Jun	LS	14	6	49.1	46.6	50.6	1.5			8	46.5	41.1	50.1	2.7		
	1994			08-Feb	WO	8	8	60.9	55.0	65.8	3.0	4.9	1.2							
11	1992			15-Jun	LS	53								53	52.7	44.2	60.9	3.3		
13	1992			01-Jun	LS	49	49	55.9	36.0	60.5	4.0									
				03-Jul	WO	29								28	26.0	22.7	29.0	1.7	2.5	1.3
	1993			25-May	LS	38								38	50.7	47.0	55.8	2.2		
				31-May	LS	43	43	50.9	45.0	60.5	4.0									
				22-Jun	LS	39								39	41.7	34.0	47.0	3.7		

LS = live sell; WO = deer sent to the works; WS = weaner stag; WH = weaner hind

Min = minimum; Max = maximum; SD = standard deviation; GR measurement = tissu depth over the 12th ribs at DSPs; NR = not recorded

* Bodyweights are reported when deer were sold alive, carcass weights and GR measurements are reported when deer were slaughtered at DSPs

† the farmer recorded only the average weight

Appendix 3.18 : Entry and removal calendar of yearling hinds on each survey farm in 1992 and 1993. Carcass weights (kg) and GR measurements (mm)

		Entry		Removal			Carcass characteristics*						
Farm			Number			Number	Number	Weight				GR measurements	
code	Year	Date	of hinds	Date	Reason	of hinds	of deer	Mean	Min	Max	SD	Mean	SD
1	1992			28-May	TO	4							
				17-Oct	WO	3	3	52.5	50.7	55.5	2.1	4.0	0.0
				08-Nov	WO	10	10	48.6	40.7	52.1	3.3	3.0	0.4
				15-Dec	DE	1							
	1993			15-Aug	WO	1	1	55.7				5.0	
				20-Oct	LS†	6	6	83.8	74	91	6.5		
				01-Nov	SV	1							
				01-Jan	DE	1							
				26-Mar	EI	1							
2	1992			03-May	TO	5							
				24-May	WO	24	24	43.3	35.5	55	4.9	7.8	1.9
				18-Jul	WO	2	2	49.7	49.4	49.9	0.2	3.5	0.5
	1993			16-Mar	WO	29	NR						
				02-Jun	TO	5							
3	1992			22-Aug	WO	2	NR						
	1993			16-May	WO	7	7	37.8	36.2	39.3	1.1		
				10-Jun	SV	5							
4	1992			01-Apr	WO	5	5	56.1	51.6	61.4	3.6	6.8	1.7
				05-Apr	WO	10	10	47.0	42.4	51.6	2.9	6.5	2.5
	1993			30-Mar	WO	21	21	48.6	44.8	54.5	2.7	4.7	3.1
6	1992			09-Nov	DE	1							
				20-Nov	WO	8	8	39.3	34.7	47	3.8	2.6	0.7
				28-Dec	SV	1							
7	1992			07-Mar	DE	1							
				30-Jun	DE	1							
				09-Aug	TO	4							
				20-Sep	WO	7	7	39.1	34	44.4	3.4	3.7	1.2
				07-Nov	TO	2							
	1993	25-Mar	4										
				14-Jun	SV	2							
				14-Jun	WO	4	4	42.3	38.9	44.7	2.2	3.3	1.9
				06-Sep	WO	3	3	45.1	43.4	46.8	1.4	4.7	0.9
				15-Jan	DE	1							
8	1992			25-Apr	WO	1	1	45.9				2.0	
				28-Apr	SV	1							
				19-Jun	EI	1							
				22-Sep	WO	7	7	48.9	47.2	50.7	1.1	3.7	1.6
	1993			15-Aug	WO	21	21	44.3	40	48	2.0	3.0	0.2
				14-Sep	WO	3	3	43.6	32.3	49.4	8.0	2.3	1.2
				24-Jan	SV	1							
	1994			15-Mar	WO	4	NR						
9	1992			06-Jul	WO	3	3	44.0	41.4	45.6	1.8	3.7	1.2
	1993			09-Jun	WO	12	NR						
10	1993			05-Jul	WO	3	3	47.6	42.9	50.7	3.4		
11	1992			04-May	WO	11	11	36.5	31.2	40	2.7	5.6	1.8
				11-Aug	WO	1	1	45.2				3.0	
	1993			20-May	SV	1							
13	1992			27-Jul	WO	1	1	53.4				4.0	
				19-Nov	WO	6	6	41.3	38.1	43.8	2.0	3.2	1.1
	1993			17-Jun	LS†	12	11	77.7	72	84	3.4		
				05-Oct	WO	3	NR						
	1994			17-Mar	WO	3	NR						
15	1993			17-Aug	WO	1	NR						
		29-Oct	23										
16	1992			01-Aug	DE	1							
				03-Aug	WO	1	NR						
				14-Nov	DE	1							
	1993			12-Jul	WO	11	11	37.4	33.8	40.5	2.0	3.0	0.0
				17-Dec	ED	1							
				31-Dec	ED	1							

† Yearling hinds from farm 1 on Oct 20 1993 and from farm 13 on June 17 1993 were sold alive so liveweights are reported

Min = minimum, Max = maximum; SD = standard deviation; GR measurement = tissu depth over the 12th rib at DSPs; NR = not recorded

Reason : TO = Taken away from the farm by the owner; WO = Sent to the works; SV = Slaughtered by the farmer for self venison supply; ED = Euthanased because of disease; EI = Euthanased because of injury; DE = Death; LS = Live sell

Appendix 3.19 : Entry and removal calendar of adult hinds on each survey farm in 1992 and 1993. Carcass weights (kg) and GR measurements (mm)

Farm code	Year	Entry		Removal			Carcass characteristics*						
		Date	Number of hinds	Date	Reason	Number of hinds	Number of deer	Weight				GR measurements	
								Mean	Min	Max	SD	Mean	SD
1	1992	02-Mar	17										
				04-May	TO	2							
				13-May	TO	12							
				27-Jun	DE	1							
				27-Jun	ED	1							
				01-Jul	ES	2							
				17-Oct	WO	9	9	52.2	49.0	58.0	2.6	4.1	0.9
				20-Nov	WO	1	1	55.2				3.0	
				31-Dec	WO	1	1	48.4				2.0	
	1993			14-Jan	WO	1	1	45.5				1.0	
				03-Mar	DE	1							
				14-Apr	WO	9	3	49.3	41.6	63.3	9.9	3.0	1.0
				15-Aug	WO	4	3	48.8	45.4	51.3	2.5	3.0	0.0
				29-Aug	DE	1							
				06-Sep	ED	1							
				12-Mar	TO	19							
2	1992			24-May	WO	7	7	49.6	41.9	58.9	6.8	7.9	3.4
				18-Jul	WO	3	3	46.0	43.5	50.4	3.1	3.7	0.5
				24-Jul	DE	1							
				06-Aug	DE	1							
				01-Sep	DE	2							
				13-Sep	DE	1							
				01-Oct	DE	1							
				05-Oct	DE	1							
				25-Oct	DE	1							
				15-Dec	DE	1							
	1993			15-Mar	TO	23							
				02-Jun	TO	17							
				15-Dec	DE	1							
				30-Mar	DE	1							
3	1992			02-Apr	WO	7	7	44.0	37.5	46.3	2.8	5.4	3.7
				22-Aug	WO	5	4	43.3	39.9	46.2	2.2	3.0	0.0
				20-Oct	DE	1							
				25-Nov	DE	1							
				19-Dec	DE	1							
				16-Feb	DE	1							
	1993			16-May	ED	2							
				16-May	WO	3	3	45.3	44.0	46.0	0.9		
				16-Oct	DE	1							
4	1992			03-Mar	DE	1							
				01-Apr	WO	3	3	56.7	55.2	58.7	1.5	7.7	2.1
				05-Apr	WO	11	11	49.5	41.6	63.4	5.8	6.4	3.1
	1993			30-Mar	WO	13	13	54.5	48.3	63.1	4.4	10.4	4.4
				11-Jun	SV	1							
5	1992			09-Aug	WO	8	8	49.3	42.9	53.6	3.9	5.5	3.0
				09-Sep	MI	1							
	1993			20-Mar	WO	16	NR						
				24-Jun	DE	1							
				01-Jul	DE	1							
				15-Jul	DE	1							
				08-Sep	WO	3	3	49.5	43.0	56.4	5.5	5.0	1.6
6	1992			27-Apr	DE	1							
				22-Jul	DE	7							
				30-Aug	DE	2							
				16-Oct	DE	1							
				20-Nov	WO	8	8	47.7	39.2	58.5	5.3	2.6	0.5
	1993			19-May	WO	28	28	49.2	41.2	58.9	4.7	6.2	3.1

Min = minimum; Max = maximum; SD = standard deviation; GR measurement = tissu depth over the 12th ribs at DSPs; NR = not recorded

Reason : TO = Taken away from the farm by the owner; WO = Sent to the works; SV = Slaughtered by the farmer for self venison supply; ED = Euthanased because of disease; DE = Death; MI = hind missing; ES = escaped from the deer farm

Appendix 3.19 (Cont'd)

Farm code	Year	Entry			Removal			Carcass characteristics*						
		Date	Number of hinds		Date	Reason	Number of hinds	Number of deer	Weight				GR measurements	
									Mean	Min	Max	SD	Mean	SD
7	1992			#	11-May	DE	1							
					09-Aug	TO	1							
					29-Aug	TO	1							
					20-Sep	WO	1	1	41.5				2.0	
					27-Sep	DE	1							
					07-Nov	TO	13							
	1993	25-Mar	14											
					28-Mar	WO	12	12	44.8	39.4	52.2	3.8	3.4	1.7
					14-Jun	WO	2	2	44.6	44.0	45.1	0.6	5.0	1.0
					24-Mar	DE	1							
					24-Mar	TO	2							
8	1992				03-Apr	DE	1							
					15-Jul	DE	1							
					21-Jul	WO	11	11	52.0	43.8	60.3	4.2	5.0	1.9
					03-Aug	WO	1	1	100.4				7.0	
					04-Aug	DE	1							
					08-Sep	ED	1							
					01-Oct	DE	1							
					15-Dec	DE	1							
					24-Dec	DE	1							
	1993				21-Apr	WO	43	43	50.8	40.0	66.7	6.9	7.0	4.3
					18-May	DE	1							
					14-Sep	WO	3	3	50.0	46.8	53.7	2.8	3.3	0.9
9	1992				06-Jul	WO	10	10	48.2	41.1	60.1	5.4	4.7	2.7
		30-Jul	1											
	1993				09-Jun	WO	3	3	44.5	43.0	46.5	1.5	4.3	0.5
					15-Jun	DE	1							
					15-Jun	WO	1	NR						
10	1992				13-Apr	WO	20	20	52.7	44.6	63.6	5.7	5.5	4.0
					01-Jun	WO	20	20	55.6	47.8	62.5	3.3	7.0	3.2
					02-Sep	WO	12	12	52.6	42.8	61.4	5.8		
	1993				13-Apr	WO	15	15	55.9	42.7	65.8	6.4	8.0	6.2
					05-Jul	WO	8	8	53.2	46.7	69.2	7.0	5.4	2.1
					01-Aug	DE	1							
11	1992				04-May	WO	12	12	41.8	36.9	46.6	2.9	6.5	1.0
					11-May	WO	13	13	53.1	45.6	62.1	4.0	10.4	4.6
					11-Aug	WO	44	44	45.3	38.6	58.7	4.1	4.6	1.9
					16-Feb	SV	3							
	1993				07-May	DE	1							
					06-Jul	WO	3	3	48.5	46.7	51.9	2.4	3.0	0.0
					21-Aug	DE	1							
13	1992				27-Jul	WO	25	23	50.9	45.7	65.3	4.4	5.3	2.0
					28-Jul	WO	3	3	50.7	46.7	53.4	2.9	4.3	1.2
					01-Aug	DE	1							
					10-Aug	ES	2							
					10-Aug	WO	20	19	44.1	35.3	48.1	2.8	7.7	1.0
	1993				12-Apr	WO	19	14	50.7	36.1	63.3	5.8	5.1	3.8
					17-Jun	TO	27							
					05-Jul	DE	1	NR						
		10-Jul	21											
					18-Jul	DE	1							
					05-Oct	WO	4							
					17-Mar	WO	8							
14	1992				15-Dec	DE	1	NR						
15	1992				30-Jul	WO	18	NR						
					18-Oct	DE	2							
	1993				08-Apr	WO	32	NR						
					05-Jul	DE	1							
					17-Aug	WO	2	2	51.2	50.7	51.7	0.5	3.0	1.0
16	1992				15-Jul	DE	1							
					03-Aug	WO	7	NR						
					22-Sep	DE	1							
					25-Sep	DE	1							
					03-Dec	DE	1							
	1993				12-Jul	SV	1							
					12-Jul	WO	24	23	45.9	37.1	59.3	5.3	3.1	0.4
					17-Nov	ED	1							

Min = minimum; Max = maximum; SD = standard deviation; GR measurement = tissu depth over the 12th ribs at DSPs; NR = not recorded

Reason : TO = Taken away from the farm by the owner; WO = Sent to the works; SV = Slaughtered by the farmer for self venison supply; ED = Euthanased because of disease; DE = Death; MI = hind missing; ES = escaped from the deer farm

Appendix 3.20 : Entry and removal calendar of yearling stags on each survey farm in 1992 and 1993. Carcass weights (kg) and GR measurements (mm).

Farm code	Year	Entry		Removal			Bodyweights or carcass characteristics*					
							Number of deer	Weight				GR measurements
		Date	Number of stags	Date	Reason	Number of stags		Mean	Min	Max	SD	Mean	SD
1	1992			07-Apr	DE	1							
				29-May	DE	1							
		21-Aug	1										
				08-Nov	WO	1	1	51.9				2.0	
		17-Dec	1										
				28-Dec	WO	14	NR						
	1993			07-Jan	LS	1	NR						
				14-Jan	LS	1	NR						
				14-Jan	WO	3	3	77.5	75.9	79.4	1.5		
				18-Jan	LS	1	NR						
				26-Dec	DE	1							
	1994	08-Jan	1										
				30-Jan	LS	8	NR						
		22-Feb	1										
				23-Feb	WO	1	NR						
				10-Mar	LS	1	NR						
				23-Mar	WO	1	NR						
2	1992			23-May	WO	1	NR						
3	1993	07-Jan	1										
				20-Mar	SV	2							
				28-Nov	WO	6	6	52.9	50.1	56.6	1.9	2.3	0.7
5	1992				WO	1	NR						
		04-Sep	15										
6	1992			18-May	LS	2	NR						
				17-Sep	DE	1							
				25-Nov	WO	11	10	53.8	44.4	59.6	5.0	6.4	13.5
	1993			11-Jan	WO	1	NR						
		18-Mar	1										
				23-May	LS	10	10	89.6	80.0	100.0	6.5		
				16-Aug	DE	1							
				06-Sep	DE	1							
				06-Sep	WO	10	10	57.2	52.3	63.1	3.5	4.0	0.0
7	1992	20-Apr	1										
				28-May	WO	4	4	49.1	48.4	50.2	0.7	3.0	0.0
				02-Aug	WO	5	5	49.9	48.1	51.8	1.3	3.2	0.4
				30-Oct	WO	4	4	52.2	51.0	53.8	1.0	2.5	0.5
		07-Nov	8										
				01-Dec	WO	5	5	53.1	44.0	62.6	6.1		
	1993			15-Feb	WO	1	NR						
				05-Apr	WO	3	NR						
				14-Jun	WO	5	5	52.5	50.2	56.3	2.4	1.4	0.8
				06-Sep	WO	2	2	57.0	56.8	57.2	0.2	3.5	0.5
8	1992			21-Jun	WO	4	4	60.6	59.0	61.5	1.0	3.8	0.8
				21-Jun	MI	1							
				23-Sep	WO	6	6	57.2	52.0	75.2	8.2	2.0	0.0
	1993			24-Aug	WO	24	NR						
				21-Sep	WO	1	NR						
9	1992	05-Jun	9										
				20-Aug	SV	1							
				02-Nov	DE	1							
	1993			13-Jan	LS	1	NR						
				13-Jan	OU	1							
				13-Jan	WO	13	13	63.0	49.3	71.6	6.2	5.1	1.5
				09-Jun	WO	1	NR						
				02-Jul	DE	1							
				29-Nov	DE	1							
10	1992			02-Sep	WO	5	5	64.3	62.6	66.8	1.5		
				29-Nov	WO	5	5	74.4	67.0	81.4	5.4	9.4	4.3
	1993			05-Jul	WO	6	6	58.7	49.7	64.0	5.1		
11	1992			26-Aug	WO	1	NR						
	1993			17-Feb	WO	13	NR						
				05-Oct	WO	6	6	59.4	54.1	65.4	4.2	2.2	0.9
				05-Nov	WO	37	37	56.9	46.1	64.4	4.4	3.6	0.8
13	1992			22-Jul	DE	1							
				27-Jul	WO	3	1	57.1				4.0	
				10-Mar	MI	3							
				07-Sep	DE	1							
	1993			05-Oct	WO	10	9	54.0†					
15	1992			14-Dec	DE	1							
				31-Dec	WO	9	0						
	1993			18-Aug	WO	1	1	42.0				2.0	
16	1993			25-Oct	WO	21	1	56.1				2.0	
				26-Oct	WO	1	1	49.7				2.0	

† the farmer recorded only the average weight

* Bodyweights are reported when deer were sold alive, Carcass weights and GR measurements are reported when deer were slaughtered

Min = minimum, Max = maximum; SD = standard deviation; GR measurement = tissu depth over the 12th ribs at DSPs; NR = Not recorded

Reason : OU = Leased out for mating; WO = Sent to the Works SV = Slaughtered by the farmer for self veruson supply; DE = Death; LS = Live sell; MI = Deer missing at handling

Appendix 3.21 : Entry and removal calendar of adult stags on each survey farm in 1992 and 1993. Carcass weights (kg) and GR measurements (mm).

Farm code	Year	Entry		Removal			Bodyweights or carcass characteristics*						
		Date	Number of stags	Date	Reason	Number of stags	Number of deer	Weight				GR measurements	
								Mean	Min	Max	SD	Mean	SD
1	1992			08-Apr	LS	1	NR						
				13-May	TO	1							
				08-Nov	WO	2	2	92.3	90.6	94.0	1.7	7.0	1.0
				20-Nov	WO	1	1	80.1				12.0	
				28-Dec	WO	1	NR						
				31-Dec	WO	2	2	79.6	72.9	86.2	6.6		
	1993			14-Jan	LS	1	NR						
				25-Jan	LS	8	8	179.8	157.0	197.5	14.2		
				30-Mar	OU	1							
				09-Nov	ED	1							
				17-Nov	ED	1							
	1994	22-Feb	1										
				09-Mar	TO	1							
				11-Mar	OU	2							
2	1992			22-Apr	DE	1							
				23-May	WO	1	NR						
3	1992	17-Dec	1										
	1993			01-Jun	DE	1							
				28-Jun	WO	18	NR						
				22-Aug	DE	1							
4	1992			05-Jun	WO	1	1	94.9				4.0	
	1993	09-Mar	1										
		19-Mar	1										
5	1992	24-Aug	14										
		27-Aug	22										
	1993			30-Jul	DE	1							
				01-Aug	ES	2							
				08-Sep	WO	1	NR						
6	1992			09-May	DE	1							
				18-May	DE	3							
				09-Sep	DE	1							
				10-Sep	DE	1							
				20-Sep	DE	1							
				05-Oct	DE	1							
				25-Oct	DE	2							
				11-Dec	WO	5	5	78.5	63.0	96.0	10.6	9.3	5.2
	1993			11-Jan	WO	1	NR						
				16-Aug	DE	1							
	1994	16-Feb	1										
7	1992	31-May	4										
				08-Jun	ES	1							
				20-Jun	DE	1							
		07-Nov	1										
				01-Dec	WO	1	1	66.3					
	1993			15-Feb	WO	1	NR						
				16-Feb	WO	2	2	51.4	48.7	54.1	2.7		
				05-Jun	WO	1	NR						
				25-Oct	DE	1							
8	1992			02-Aug	WO	2	1	107.4				8.0	
	1993	17-Mar	3										
				21-Sep	WO	2	2	87.7	78.3	97.0	9.3	5.0	
	1994	07-Feb	1										
				24-Feb	OU	1							
9	1992			03-Aug	DE	1							
				27-Nov	WO	11	11	89.6	80.1	104.1	7.3	16.5	5.4
	1993			13-Jan	WO	1	1	96.9				14.0	
	1994			23-Feb	OU	1							
10	1992			13-Sep	DE	1							
				08-Feb	LS	1	NR						
				24-Feb	LS	1	NR						
	1993			19-Jul	WO	7	7	87.7	82.3	94.7	3.8	5.3	1.0
				07-Nov	DE	1							
	1994	17-Jan	1										
11	1992			11-May	WO	4	4	62.2	55.0	66.0	4.2	5.8	2.2
				16-Aug	DE	1							
				26-Aug	WO	1	1	47.9					
				20-Nov	WO	10	10	80.6	65.7	91.9	6.5	13.9	4.6
	1993			11-Aug	WO	22	22	62.0	55.0	70.1	4.1	2.5	0.9
				03-Sep	DE	1							
				05-Oct	WO	17	17	61.3	51.2	72.4	5.8	2.2	0.8
				05-Nov	WO	2	2	52.7	51.3	54.1	1.4	4.0	0.0
				20-Nov	WO	1	NR						
	1994			19-Jan	DE	2							
13	1992			27-Jul	WO	2	2	84.5	75.0	93.9	9.4	3.5	0.5
	1993			20-Jul	DE	1							
				29-Jul	DE	1							
15	1992			12-Sep	DE	1							
				09-Nov	WO	1	NR						
				18-Nov	WO	1	NR						
				04-Dec	DE	1							
				21-Dec	WO	7	6	69.8	58.7	83.3	8.1		
	1993			15-Jun	DE	1							
				18-Aug	DE	2							
				18-Aug	WO	2	2	77.2	76.0	78.3	1.1	2.0	0.0
				18-Aug	WO	2							
				04-Oct	DE	1							
	1994			07-Feb	ED	1							
16	1992			01-Aug	DE	1							
				02-Aug	DE	1							
	1993			18-Jul	WO	23	23	59.7	42.6	76.6	7.7	3.8	0.6

* Bodyweights are reported when deer were sold alive, carcass weights and GR measurements are reported when deer were slaughtered
Min = minimum; Max = maximum; SD = standard deviation; GR measurement = tissu depth over the 12th ribs at DSPs; NR= not recorded
TO = Taken away from the farm by the owner; OU = Leased out for mating; WO = Sent to the Works; ED = Euthanased because of disease;
DE = Death; LS = Live sell; ES = Escaped outside deer farm boundaries.

Appendix 3.22 : Trace element supplementation and vaccination programmes of weaners implemented on each farm in 1992 and 1993.

Farm code	Year	Copper supplementation (oxide rods) Date	Dose g	Date	Dose g	Vaccination programmes 5-in-1 Date of first injection	Yersiniavax
1	1992					1 Mar	
	1993					9 Mar	5 May
	1994						9 Mar
2	1992						
	1993	5 May	10				
3	1992	18 Dec	10				
	1993	21 Jan	5	3 Jul	5		
4	1992						
	1993	24 May	4			11 Apr	5 Jun
	1994						29 Mar
5	1992						
	1993						25 Mar
	1994						18 Mar
6	1992						
	1993						
7	1992	22 Aug	4				
	1993	5 Jun	5				2 May
	1994						24 Mar
8	1992						
	1993	17 May	10				1 Mar
9	1992	19 Jun	10				
	1993	8 Jun	10				14 May
	1994						17 Mar
10	1992					4 Mar	
	1993					3 Mar	31 Mar
11	1992						
	1993						
13	1992						
	1993	24 Jun	5	7 Oct	10	3 May	13 Apr
	1994						22 Mar
14	1992						
15	1992						
	1993						
16	1992						
	1993						

Note : On farm 14, weaners were injected only the first dose of Leptospirosis vaccine in January 1992. This farm was not monitored in 1993.
Trace element supplementation and vaccination of yearling and adult deer are presented in Table 3.13.

Appendix 3.23 : Calendar of anthelmintic treatment implemented on weaners (< 15 months) on each farm in 1992.

Farm code	Dates of drenching: Weaning and Autumn (February - May)					Winter (June - August)			Spring - Summer (Sept 1992 - Feb 1993)			Type of Drench	Individual dose ml
1	01-Mar											IOS	12
		31-Mar										IOS	15
			01-May									IOS	13
						01-Jun						IOS	13.5
							04-Jul					IOS	14
								30-Aug				IOS	15
									14-Sep			IOS	16
										14-Oct		IOS	18
2		24-Mar										VAL	6
			23-Apr									VAL	8
				23-May								IPO	7.5
							20-Jul					VAL	10
3	04-Mar	02-Apr	04-May	04-May	30-Jun	05-Aug	16-Sep			04-Nov		SYC	3
											26-Dec	IPO	7.5
4	08-Feb	29-Feb	23-Mar									OHM	10
				13-Apr	05-May	16-Jun						OHM	11
5		18-Mar				15-Jun						IPO	5
							01-Aug	28-Aug				IPO	7.5
6	27-Mar											SMD	2.5
				28-Apr								SMD	3
						02-Jun				09-Nov		VMD	6.5
7	09-Mar											SMD	3
			04-Apr									IOC	2
				02-May								IOC	3
							08-Aug					IOC	3.5
									28-Nov			SMD	4
											22-Feb	SMS	5
8	16-Mar											OCH	3
			28-Apr									OCH	7.5
						08-Jun						VES	12
9	15-Feb											OHM	10
		18-Mar										OHM	12
			10-Apr									OHM	13
						19-Jun	12-Jul					OCH	5
									12-Nov			OXC	6
10		04-Mar	13-Apr									RLS	12
				11-May		15-Jun	13-Jul	10-Aug	10-Sep			RLC	5
11		11-Mar										RLS	7.5
			10-Apr	08-May		03-Jun						RLS	10
							07-Jul					RLS	11
								11-Aug				RLS	12
									03-Sep			RLC	3
13		04-Mar										RLS	5
			21-Apr	14-May		08-Jun						RLS	10
14	15-Jan											RLS	5
			23-Mar									RLS	8
				20-Apr								RLS	10
					13-May							RLS	12
						30-Jun						RLS	15
									06-Oct			RLS	20
										04-Nov		RLS	25
15				30-Apr		26-Jun						SYS	3
							07-Aug	18-Aug				SYS	4.5
									21-Sep	21-Oct		SYC	5
16			30-Mar	28-Apr								OHM	4
						01-Jun						CID	60
									22-Sep			IOC	10
											23-Jan	IOS	27.5

IOC = Ivomec Oral Cattle; IOS = Ivomec Oral Sheep; IPO = Ivomec Pour On; OCH = Oxfen High Mineral Conc; OHM = Oxfen High Mineral
RLC = Red Label Cattle; RLS = Red Label Sheep; SMD = Synanthic Mini Dose; SMS = Synanthic Mini Dose + Se; SYC = Systamex Low Dose Cattle;
OXC = Oxfen Conc; SYS = Systamex; VAL = Valbazen; VES = Vetdectin Oral Sheep; VMD = Valbazen Mini Dose
CID = Cider Vinegar (this was given to the deer instead of an anthelmintic)

Appendix 3.24 : Calendar of anthelmintic treatment implemented on weaners (<15 months) on each farm in 1993 and early 1994.

Farm code	Dates of drenching: Weaning and Autumn (February - May)					Winter (June - August)			Spring - Summer* Sept 1993 - Jan 1994		Weaning 1994	Type of Drench	Individual dose ml
1		09-Mar	31-Mar	30-Apr		01-Jun	01-Jul	04-Aug	27-Sep		02-Mar	IOS	12
												IOS	14
												IOS	15
												IOS	18
												IOS	20
												IOS	12
2		03-Mar	15-Apr			10-Jun		12-Aug	17-Nov		08-Mar	IPO	7.5
												IPO	10
												VMD	9
												IPO	10
												IPO	NR
												VPO	5
3		16-Mar	10-Apr	07-May		01-Jun	13-Jul	13-Aug	10-Sep	22-Oct 10-Jan	11-Feb 11-Mar	IOS	10
												IOS	20
												IPO	10
												IPO	10
												CPO	10
												VPO	4
												VPO	5
4	28-Jan	25-Feb	20-Mar	11-Apr	04-May	01-Jun	01-Jul	14-Aug			24-Feb 23-Mar	OHM	8
												OHM	12
												OHM	13
												OHM	15
												OHM	14
												OHM	15
												OHM	16
												OHM	10
												OHM	12
5		10-Mar	15-Apr			10-Jun	15-Jul				18-Mar	IPO	5
												IPO	7.5
												IPO	5
6		18-Mar	01-Apr	28-Apr		02-Jun		26-Aug	15-Nov		01-Apr	VMD	3
												VMD	5
												VMD	4
												VMD	5
												ARR	16
												NR	
7		22-Mar	10-Apr	02-May	23-May			28-Aug		10-Oct	24-Mar	SMD	3
												OHM	3.5
												OCH	4
												OCH	5
												OCH	3
8	22-Feb	04-Mar	07-Apr		17-May	23-Jun	12-Jul	02-Aug 24-Aug	09-Sep		03-Mar 30-Mar	VES	12
												OCH	4
												OCH	5
												VPO	8
												VPO	9
												OHM	8
												OHM	12
9	26-Jan		09-Apr		13-May	08-Jun	01-Jul				07-Mar	OHM	10
												OHM	12
												OHM	14
												VPO	7
												VPO	7.5
10	03-Mar	23-Mar	15-Apr		12-May	14-Jun	12-Jul	10-Aug	09-Sep		28-Feb	RLS	10
												RLC	5
												RLS	10
11		18-Mar	15-Apr		15-May						03-Mar	RLS	10
												RLS	11
												RLS	10
13		15-Mar		03-May	31-May		05-Jul	05-Aug		07-Oct	22-Mar	IOS	10
												RLS	10
												IPO	10
												RLC	5
												RLS	12
15			06-Apr		14-May		12-Aug		09-Sep	28-Feb	09-Mar 30-Mar	SYC	2.5
												SYC	4
												VPO	7.5
												VPO	12
												SYS	4
												SYS	4
16		23-Mar		22-Apr		06-Jun	30-Jun		15-Oct	18-Nov	01-Apr	NR	
												IOS	18
												IOS	20
												IPO	7.5
												IOS	23
												VPO	10
												VPO	7

ARR = New Arrest;IPO = Ivomec Pour On; OCH = Oxfen High Mineral Conc; OXC = Oxfen Conc; OHM = Oxfen High Mineral
RLC = Red Label Cattle; RLS = Red Label Sheep; SYC = Systamex Low Dose Cattle;
SYS = Systamex; VES = Vetdectin Oral Sheep; VMD = Valbazen Mini Dose; VPO = Vetdectin Pour On; CPO = Cydectin Pour On
NR = not recorded.

Appendix 3.25 : Mean pasture cover measurements and paddock observations on each survey farm at each sampling visit during 1992,

Farm code	Date of visit	Number of paddocks visited	Total paddock area visited ha	Fence pacing mean score	Pasture cover kgDM/ha	Sward height cm	Clover score	Seed head density score	Ragwort score	Thistle score
					March					
1	17-Mar	23	40.2	1.22	2090.2	16.0	1.40	0.45		
2	02-Mar	12	54.4	2.25	1906.0	9.6	1.26	1.70		
3	04-Mar	10	44.5	0.70	2249.2	12.9	1.32	2.33		
4	26-Feb	17	15.0	0.47	2178.6	11.8	1.61	0.51		
5	12-Mar	12	30.3	1.58	2120.8	12.2	1.18	0.07		
6	19-Mar	15	36.5	1.47	1348.6	7.5	1.51	0.00		
7	24-Mar	9	19.8	1.44	1921.2	11.6	1.34	1.69		
8	18-Mar	15	55.8	1.40	2374.9	17.8	1.79	0.67		
9	10-Mar	9	49.6	1.11	1755.6	10.3	1.88	0.73		
11	03-Mar	13	53.6	1.23	2014.7	15.4	1.76	2.06		
13	27-Feb	12	65.8	1.33	1870.4	10.1	1.60	1.46		
14	11-Mar	43	268.2	1.40	2804.0	21.8	1.68	1.33		
15	09-Mar	27	453.3	1.15	1601.2	10.3	1.12	1.07		
					June					
1	28-May	31	53.6	1.35	1606.2	11.6	1.22		0.45	0.41
2	27-May	12	54.4	1.42	1183.9	7.3	1.00		0.00	0.54
3	03-Jun	11	44.5	1.36	1192.8	6.5	1.00		1.81	1.09
4	02-Jun	20	17.5	1.40	1626.5	11.3	1.41		0.06	0.53
5	23-Jun	12	30.3	2.25	1141.8	6.6	1.00		0.42	0.31
6	24-Jun	17	40.1	1.53	911.1	5.0	1.13		0.25	0.74
7	08-Jun	9	21.7	1.89	980.9	7.2	1.05		0.60	0.00
8	18-Jun	15	55.8	1.87	1455.5	10.3	1.33		0.00	1.70
9	15-Jun	9	49.6	1.89	1161.6	6.1	1.07		0.00	1.07
10	16-Jun	22	36.9	1.68	818.3	5.2	1.00		0.23	0.53
11	04-Jun	13	53.6	1.38	1715.2	10.7	1.04		1.41	1.08
13	30-Jun	11	62.1	1.64	933.8	5.2	1.00		0.00	0.95
14	22-Jun	44	274.2	1.75	1144.0	7.8	1.00		0.00	0.19
15	29-Jun	27	453.3	1.63	767.4	4.6	1.00		1.54	1.79
16	01-Jul	10	23.8	2.40	560.7	4.2	1.00		1.20	1.41
					September					
1	02-Sep	28	53.6	1.21	870.6	7.6	1.33			
2	30-Sep	12	54.4	2.08	671.0	4.2	1.00			
3	15-Sep	11	44.5	1.36	686.0	4.3	1.00			
4	17-Sep	19	17.5	1.16	746.1	6.4	1.93			
5	09-Sep	15	40.5	1.93	713.8	6.3	1.71			
6	05-Oct	16	40.1	2.19	604.1	4.1	1.36			
7	14-Sep	10	23.0	1.78	689.5	4.0	1.00			
8	08-Sep	17	61.1	1.67	909.8	6.7	1.26			
9	24-Sep	11	80.8	0.91	863.9	5.3	1.40			
10	10-Sep	22	36.9	1.36	679.7	5.9	1.69			
11	07-Sep	13	53.6	1.54	749.2	5.3	1.53			
13	24-Sep	13	67.9	1.31	805.0	7.1	1.96			
15	21-Sep	27	453.3	1.81	635.4	4.5	1.41			
16	09-Sep	13	45.2	2.00	640.3	5.5	1.14			
					November					
1	18-Nov	26	43.8	1.00	1480.9	10.3	1.57	0.69	1.27	0.95
2	18-Nov	12	54.4	1.58	1693.8	12.8	1.95	1.08	0.00	1.59
3	01-Dec	11	44.5	1.36	1462.1	9.9	1.00	1.22	2.69	1.41
4	01-Dec	16	14.7	0.56	1935.1	15.0	2.59	1.14	0.00	0.82
5	19-Nov	14	39.1	1.64	2227.7	15.2	1.57	1.28	0.43	1.19
6	24-Nov	16	40.1	1.56	1386.0	9.6	1.96	1.23	0.39	1.67
7	30-Nov	8	17.5	1.38	1849.9	11.5	1.73	1.36	1.16	0.76
8	25-Nov	15	55.4	1.73	1909.4	12.1	1.82	1.23	0.00	1.99
9	25-Nov	11	80.8	1.09	1616.1	9.8	1.61	1.36	0.00	2.50
10	26-Nov	22	36.9	1.68	2269.2	13.9	1.67	1.61	0.72	1.46
11	23-Nov	13	53.6	1.46	2872.7	16.9	2.14	2.00	2.64	2.56
13	02-Dec	11	62.1	1.64	3282.0	15.4	2.14	2.18	0.00	2.46
15	23-Nov	27	453.3	1.30	2216.0	12.3	2.14	1.94	1.56	2.32
16	03-Dec	13	37.2	1.62	2883.9	15.3	2.07	1.76	1.45	2.59

Note : description of measurements and scores are presented in Tables 2.21 and 2.26.

Appendix 3.26 : Mean pasture cover measurements and paddock observations on each survey farm at each sampling visit during 1993.

Farm code	Date of visit	Number of paddocks visited	Total paddock area visited ha	Fence pacing mean score	Pasture cover kgDM/ha	Sward height cm	Clover score	Seed head density score	Ragwort score	Thistle score
March										
1	24-Mar	28	53.6	0.86	1723.3	16.5	1.84	1.36	0.67	1.40
2	23-Mar	12	54.4	1.25	1562.8	11.7	1.35	1.06	0.00	2.23
3	16-Mar	11	44.5	1.36	1751.8	11.7	1.06	2.02	2.06	1.29
4	15-Mar	19	17.5	0.79	1792.4	14.4	1.80	0.49	0.07	1.18
5	03-Mar	14	38.9	0.93	1937.2	14.5	1.14	1.89	0.87	0.40
6	18-Mar	16	40.1	1.13	1702.0	11.7	1.38	1.31	0.86	1.23
7	22-Mar	9	19.4	1.00	1241.4	9.5	1.54	1.89	0.37	0.34
8	10-Mar	16	58.9	1.50	1799.7	13.8	1.47	1.59	0.07	2.43
9	08-Mar	11	80.8	0.64	1491.9	9.9	1.21	1.96	0.00	2.10
10	30-Mar	22	36.9	1.00	1514.8	13.4	1.83	0.87	0.00	0.85
11	02-Mar	13	53.6	1.31	1779.5	16.2	1.00	2.16	2.07	1.66
13	06-Apr	13	67.9	1.08	1297.6	9.5	1.09	1.14	0.00	1.75
15	29-Mar	27	453.3	0.78	1752.4	13.5	1.64	1.47	1.43	1.77
16	25-Mar	13	37.2	1.77	1501.0	10.8	1.31	2.26	1.56	2.39
June										
1	31-May	32	61.6	1.22	1192.4	10.8	1.07	0.39	0.54	0.93
2	01-Jun	12	54.4	1.83	1050.9	8.1	1.00	0.79	0.00	1.90
3	03-Jun	11	44.5	1.36	978.7	7.4	1.00	0.95	2.69	0.38
4	01-Jun	20	18.4	1.05	1561.1	13.5	1.53	0.12	0.00	0.80
5	08-Jun	14	38.9	1.79	1420.0	12.4	1.43	0.04	0.93	0.85
6	02-Jun	16	40.1	1.94	1251.9	9.5	1.09	0.59	0.87	0.87
7	07-Jun	9	19.4	1.22	939.8	8.1	1.23	0.91	0.71	0.19
8	26-May	16	58.9	1.56	1339.9	11.2	1.84	0.70	0.00	2.28
9	25-May	11	80.8	1.30	1196.7	9.3	1.32	0.81	0.00	2.48
10	09-Jun	22	36.9	1.09	822.5	7.6	1.11	0.12	0.07	0.54
11	27-May	14	61.5	1.36	1284.1	9.9	1.03	0.64	2.07	1.82
13	24-May	13	67.9	1.77	997.8	10.0	1.32	1.14	0.00	0.90
15	13-Jun	23	390.2	0.96	1483.9	11.1	1.08	0.29	1.65	1.25
16	10-Jun	13	37.2	2.15	816.7	6.8	1.00	0.26	1.39	2.36
September										
1	15-Sep	28	53.6	1.07	775.7	8.0	1.40		0.69	0.83
2	31-Aug	12	54.4	1.50	708.0	4.9	1.00		0.00	1.02
3	13-Sep	11	44.5	1.36	651.4	3.1	1.00		2.22	0.82
4	31-Aug	19	17.5	0.89	887.8	8.5	1.19		0.00	0.11
5	14-Sep	14	38.9	1.29	1118.6	7.8	1.39		0.73	0.24
6	16-Sep	17	40.1	1.71	1325.3	7.6	1.31		0.81	0.59
7	05-Sep	11	21.5	1.09	744.9	5.3	1.47		0.73	0.25
8	20-Sep	17	63.4	1.29	1399.1	8.2	1.74		0.00	1.96
9	21-Sep	11	80.8	1.36	881.7	4.9	1.47		0.00	2.46
10	02-Sep	22	36.9	1.10	786.1	5.6	1.10		0.00	0.23
11	08-Sep	15	74.0	1.47	847.0	6.4	1.16		1.40	0.93
13	07-Sep	12	65.4	1.82	720.6	5.7	1.17		0.00	0.90
15	06-Sep	22	347.3	1.14	950.7	7.0	1.25		1.51	1.46
16	01-Sep	14	41.2	1.93	693.2	4.6	1.10		1.43	1.52

Note : description of measurements and scores are presented in Tables 2.21 and 2.26.

Appendix 3.27 : Calendar of food supplementation given to weaners (3-15 months) from March 1 1992 to April 1 1994.

Farm code	Mob ID	Type of food†	Start and finish dates				Quantity: Feeding episodes	Quantity: Average intake*	Average number of deer: Weaner stags	Average number of deer: Weaner hinds	Average number of deer: Other deer
Post-weaning period (February - March - April)											
Year 1992											
3	1	MA		09-Mar	04-Apr		8	1.67	25	25	0
		PH		09-Mar	04-Apr		8	3.68	25	25	0
8	1	MA		17-Mar	21-Mar		3	3.90	98	85	0
	1A	MA			03-Apr	03-Apr	1	3.90	89	79	0
9	1	MA		10-Mar	03-Apr		25	3.57	40	34	0
10	50	MA		06-Mar	26-Mar		21	4.10	81	93	0
Year 1993											
3	1	MA		17-Mar	30-Apr		23	1.54	41	52	0
10	53	MA		03-Mar	23-Mar		21	5.89	73	55	0
	54	MA		04-Mar	23-Mar		20	5.89	13	15	0
	56	MA		24-Mar	15-Apr		23	5.89	11	8	0
	57	MA		24-Mar	15-Apr		23	5.89	33	34	0
Year 1994											
1	3S	BA		10-Mar	31-Mar		22	8.10	55	58	0
10	90	MA	28-Feb	31-Mar			32	4.64	38	39	0
	91	MA	28-Feb	31-Mar			32	4.07	44	47	0
Late autumn - winter period (May - August)											
Year 1992											
1	1	BA		10-Jun	11-Jun		2	2.86	43	45	1
		PH		09-Jun	12-Jun		2	3.22	43	45	1
3	1	MA	25-May	31-Aug			76	2.37	24	25	0
		PH		20-Jun	09-Jul		20	3.75	24	25	0
5	1	MA		25-Jun	31-Aug		68	3.75	32	39	2
6	7	PH		14-Jun	18-Jun		3	2.81	34	34	1
8	1A	MA	08-May	30-Aug			34	4.53	54	83	1
9	1	MA		03-Jun	19-Aug		78	5.58	60	34	0
10	50	PH	12-May	15-Jun			35	4.78	37	31	0
	51	PH		16-Jun	31-Aug		77	8.95	34	0	0
	52	PH		16-Jun	31-Aug		77	9.81	1	30	0
13	1	MA	01-May	13-May			13	5.95	84	89	0
	6	MA	14-May	31-Jul			79	5.95	67	2	0
		SH			01-Aug	30-Aug	30	1.96	47	11	0
	7	MA	14-May	31-Jul			79	5.95	0	34	0
		SH			01-Aug	23-Aug	23	1.72	0	26	0
16	6	BY		01-Jun	28-Aug		80	5.12	51	46	0
		MA			29-Aug	31-Aug	3	3.60	51	46	0
		SH		03-Jun	09-Jun		2	1.20	51	46	0
Year 1993											
1	20	BA	23-May	15-Aug			45	8.01	53	52	0
	27	PH		29-Jun	29-Jun		1	9.79	23	25	1
3	1	MA	02-May	30-Aug			58	2.92	27	30	0
	1B	MA	22-May	12-Aug			40	5.74	8	7	2
5	2	BY		01-Jun	31-Aug		92	4.91	23	31	9
		SH		02-Jun	27-Jul		5	2.47	27	38	9
8	10A	MA	16-May	24-Aug			22	4.69	38	8	0
	10B	MA		13-Jun	24-Aug		21	4.74	0	93	0
9	20	MA		11-Jun	25-Jul		23	8.87	33	0	0
10	57	PH		18-Jun	31-Aug		75	5.86	0	33	0
	57A	PH		18-Jun	31-Aug		73	5.72	31	0	0
13	13	MA		01-Jul	31-Aug		62	5.95	5	24	0
16	22	BY		01-Jun	31-Aug		92	3.06	60	67	0
Spring period (September - November)											
Year 1992											
3	1	MA	01-Sep	29-Sep			25	2.18	27	27	0
5	1	MA	01-Sep	03-Sep			3	4.20	11	21	2
8	1A	MA	07-Sep	15-Oct			2	5.39	54	83	2
10	51	PH	01-Sep	29-Sep			29	9.57	34	0	0
	52	PH	01-Sep	29-Sep			29	10.50	1	30	0
16	6	MA	01-Sep	09-Oct			37	3.91	51	46	0
Year 1993											
3	1	MA	02-Sep	26-Sep			10	2.13	32	34	1
5	2	BY	01-Sep	09-Sep			9	5.31	16	20	7
10	57	PH	01-Sep	09-Sep			9	7.91	0	33	0
	57A	PH	02-Sep	02-Sep			1	6.89	31	0	0
13	13	MA	01-Sep	15-Sep			15	5.95	5	23	0
16	22	BY	01-Sep	02-Oct			16	3.06	60	67	0

Mob ID = mob identification as given by the farmer

† MA = Maize; BY = Barley; PH = Peavine hay; SH = Sward hay; BA = Balage

* Estimated average energy intake (Megajoules of Metabolisabe Energy or MJME) per deer and per feeding episode based on known quantity and quality provided, and estimation of wastage

Appendix 3.28 : Calendar of food supplementation given to hinds (> 15 months) from April 1 to September 1 in 1992 and 1993.

Farm code	Mob ID	Type of food†	Start and finish dates				Quantity: Feeding episodes	Quantity: Energy intake*	Average number of deer: Yearling hinds	Average number of deer: Adult hinds	Stags
Post-mating period (Late April- May)											
Year 1992											
1	5	BA		14-May	31-May		14	15.49	0	107	0
4	2	SH	22-Apr	18-May			25	11.89	0	41	1
	2A	SH		01-May	14-May		14	3.49	10	5	1
	2B	SH		05-May	17-May		13	8.87	4	16	1
	4	SH		19-May	31-May		13	4.90	14	62	0
6	8	SH		30-May	30-May		1	4.20	46	135	1
7	2	SH		25-May	31-May		7	3.21	22	23	0
	3	SH		25-May	31-May		7	5.15	0	28	0
	7	MA		10-May	31-May		22	3.40	0	3	1
8	3A	SH		12-May	25-May		12	2.53	33	0	0
	4E	SH	07-Apr	17-Apr			6	8.59	3	20	2
	7	SH		27-May	31-May		3	4.17	0	219	0
9	5	SH		26-May	31-May		6	6.54	0	80	0
Year 1993											
1	28	BA		07-May	31-May		21	12.95	0	112	0
4	19	BA		12-May	16-May		5	9.55	12	63	1
		SH		10-May	11-May		2	3.05	12	63	1
	22	BA		25-May	31-May		7	10.79	12	63	0
8	7A	SH		19-May	25-May		7	2.77	0	190	0
10	26	SI		19-May	31-May		10	4.70	0	118	0
Winter period (June - August)											
Year 1992											
1	5	BA	01-Jun	31-Aug			57	16.69	0	105	0
		PH			09-Aug	10-Aug	2	7.13	0	102	0
	6	BA			13-Aug	23-Aug	5	8.67	14	3	0
		PH			12-Aug	24-Aug	6	11.54	14	3	0
2	6	SH	21-Jun	02-Aug			43	8.18	0	194	0
3	5	CH		31-Jul	09-Aug		10	3.26	3	144	0
4	4	SH	01-Jun	31-Aug			88	6.55	11	62	0
	8	SH			25-Aug	31-Aug	7	7.87	14	1	0
5	3	MA			01-Aug	31-Aug	31	1.21	9	75	0
6	8	MH	02-Jun	14-Aug			15	5.24	44	131	0
	9	MH		02-Jul	02-Jul		1	19.12	3	5	0
7	2	SH	01-Jun	31-Aug			91	8.61	20	23	0
	3	CH	27-Jun	19-Aug			38	5.05	0	31	0
		SH	01-Jun	31-Aug			80	7.79	0	30	0
	7	MA	01-Jun	31-Aug			92	2.67	5	1	1
8	7	KA‡	03-Jun	02-Aug			19		0	213	0
		MA			27-Aug	28-Aug	2	5.15	0	208	0
		SH	03-Jun	28-Aug			23	8.27	0	203	0
9	5	SH	01-Jun	02-Jun			2	6.54	0	80	0
10	10	SI			31-Aug	31-Aug	1	12.36	22	25	0
	6	SI	14-Jun	31-Aug			79	12.37	0	127	0
	9	SI	14-Jun	30-Aug			78	12.36	22	33	0
11	6	SH		10-Jul	26-Aug		48	3.80	0	111	0
13	3	SH			01-Aug	30-Aug	30	1.33	0	120	0
	9	SH			01-Aug	10-Aug	10	0.85	0	33	4
15	10	SH	27-Jun	31-Aug			66	2.82	0	133	0
16	7	SH	03-Jun	31-Aug			62	3.95	41	122	0
Year 1993											
1	28	BA	01-Jun	30-Jul			50	16.18	0	112	0
3	7	PH			01-Aug	31-Aug	16	2.57	17	134	0
		SH		01-Jul	30-Jul		15	2.03	17	134	0
4	22	BA	01-Jun	24-Aug			35	10.26	2	61	0
		SH	20-Jun	13-Aug			35	8.07	0	61	0
	23	SH		02-Jul	18-Jul		17	5.94	12	1	0
5	3	BY	01-Jun	13-Jul			43	2.06	7	61	0
		SH		13-Jul	25-Aug		44	3.09	7	57	0
6	23	SH	06-Jun	26-Aug			15	13.97	26	116	0
7	2	CH	01-Jun	15-Aug			67	5.32	3	51	1
		KA‡		20-Jul	15-Aug		27		3	51	1
8	7A	KA‡		05-Jul	31-Aug		20		0	190	0
		SH	22-Jun	30-Aug			23	4.43	0	190	0
10	26	SI	01-Jun	31-Aug			66	2.96	0	100	0
	27	MA			23-Aug	24-Aug	2	8.48	32	48	0
		SI	01-Jun	31-Aug			56	1.61	32	48	0
11	14	SH		05-Jul	12-Aug		39	4.39	1	104	0
13	14	SH			01-Aug	29-Aug	10	10.06	0	118	0

Mob ID = mob identification as given by the farmer

* Estimated average energy intake (Megajoules of Metabolisabe Energy or MJME) per deer and per feeding episode based on known quantity and quality provided, and estimation of wastage

† MA = Maize; BY = Barley, PH = Peavine hay; SH = Sward hay; CH = Clover hay; BA = Balage, SI = Silage; KA = Kale

‡ KA = Hinds were strip fed kale directly on crop so energy intake could not be estimated

Appendix 3.29 : Calendar of food supplementation given to hinds (> 15 months) from September 1 1992 and 1993 to April 1 the following year.

Farm code	Mob ID	Type of food†	Start and finish dates			Quantity: Feeding episodes	Quantity: Energy intake*	Average number of deer: Yearling hinds	Average number of deer: Adult hinds	Average number of deer: Stags
Spring period (September-December)										
Year 1992										
1	5	BA	01-Sep	30-Sep		7	10.98	0	99	0
		PH	02-Sep	27-Sep		10	9.60	0	100	0
	6	BA	01-Sep	05-Sep		2	7.86	14	3	1
		PH	02-Sep	04-Sep		3	11.79	14	3	1
4	4	MA		01-Oct	09-Oct	9	3.12	0	61	0
		SH	01-Sep	09-Oct		27	10.21	0	61	0
	8	MA	16-Sep	09-Oct		24	2.98	14	1	0
		SH	01-Sep	09-Oct		38	10.66	14	1	0
5	3	MA	01-Sep	03-Sep		3	1.22	9	73	0
6	8	SH		08-Oct	05-Nov	4	3.51	43	118	0
		SH	07-Sep	05-Oct		6	3.88	43	128	0
7	2	SH	01-Sep	10-Sep		10	7.32	17	22	0
	3	SH	01-Sep	10-Sep		10	8.17	0	30	0
	7	MA	01-Sep	19-Sep		19	1.98	7	1	1
8	7	MA	25-Sep	24-Oct		8	5.87	25	206	0
		SH	01-Sep	15-Sep		8	14.15	0	207	0
10	10	SI	01-Sep	08-Sep		8	12.29	22	27	0
	11	SI	01-Sep	08-Sep		8	12.36	0	121	0
15	10	SH	01-Sep	09-Nov		8	2.30	37	127	0
16	7	SH	03-Sep	03-Sep		1	2.89	40	121	0
Year 1993										
3	7	MA	02-Sep	22-Sep		11	3.31	17	134	0
10	26	SI	01-Sep	11-Sep		11	3.44	0	98	0
	27	SI	01-Sep	08-Sep		6	1.77	32	48	0
13	14	SH	01-Sep	08-Sep		2	9.14	12	118	0
Summer period (December-March)										
Year 1992										
10	15	MA		22-Feb	03-Mar	10	7.42	2	69	0
	17	MA		22-Feb	03-Mar	10	7.42	2	37	0
	18	MA		22-Feb	03-Mar	10	7.42	7	27	0
	19	MA		22-Feb	01-Mar	8	7.42	5	9	0
Year 1993										
1	20	BA			10-Mar 23-Mar	13	19.09	52	0	52
	27	PH			10-Mar 16-Mar	4	11.99	19	0	1
	34	BA			13-Mar 13-Mar	1	67.93	0	38	0
		PH			11-Mar 11-Mar	1	12.62	0	38	0
	35	PH			11-Mar 13-Mar	2	12.62	0	19	0
	36	BA			12-Mar 20-Mar	5	27.99	0	83	0
	39	BA			20-Mar 30-Mar	6	28.68	0	18	0
8	11	MA		28-Feb	06-Mar	7	5.36	28	0	0
	40	MA		28-Feb	06-Mar	7	5.36	0	21	0
	41	MA		28-Feb	06-Mar	7	5.36	0	24	0
	42	MA		28-Feb	06-Mar	7	5.36	0	22	0
	43	MA		28-Feb	06-Mar	7	5.36	0	21	0
	44	MA		28-Feb	06-Mar	7	5.36	0	39	0
	45	MA		28-Feb	06-Mar	7	5.36	0	28	0
	46	MA		28-Feb	06-Mar	7	5.36	0	33	0
10	30	MA		13-Feb	26-Feb	14	7.93	0	45	0
	32	MA		13-Feb	26-Feb	14	8.50	9	19	0
	34	MA		13-Feb	26-Feb	14	11.33	0	63	0
	35	MA		13-Feb	26-Feb	14	17.00	0	14	0
	41	MA		27-Feb	10-Mar	12	5.18	11	8	0
	42	MA			03-Mar 31-Mar	29	12.22	3	17	0
	46	SI			15-Mar 31-Mar	17	2.30	8	34	0

Mob ID = mob identification as given by the farmer

† MA = Maize; PH = Peavine hay; SH = Sward hay; BA = Balage; SI = Silage

* Estimated average energy intake (Megajoules of Metabolisabe Energy or MJME) per deer and per feeding episode based on known quantity and quality provided, and estimation of wastage

Appendix 3.30 : Calendar of food supplementation given to stags (> 15 months) from April 1 to September 1 in 1992 and 1993.

Farm code	Mob ID	Type of food†	Start and finish dates				Quantity: Feeding episodes	Quantity: Energy intake*	Average number of deer: Yearling stags	Average number of deer: Adult stags
Rut (April- May)										
Year 1992										
1	3	BA		31-May	31-May		1	13.72	55	0
	4	BA		14-May	31-May		14	23.37	0	64
3	4	PH		04-May	31-May		21	8.36	1	43
7	4	CH		25-May	31-May		7	3.41	23	0
	6	CH		31-May	31-May		1	4.11	1	18
10	60	PH		14-May	31-May		17	16.84	0	18
	61	PH		13-May	31-May		18	12.40	24	0
	71	MA		19-May	31-May		13	22.31	0	8
13	5	MA		01-May	31-May		31	11.90	13	66
15	6	SH		29-May	31-May		3	0.76	73	0
Year 1993										
1	9	BA		10-May	31-May		14	17.50	0	62
3	4	PH	17-Mar	16-May			31	8.52	0	45
10	52	SI		28-May	28-May		1	2.09	30	0
	75	SI		21-May	30-May		5	2.89	0	27
Winter period (June - August)										
Year 1992										
1	3	BA	03-Jun	31-Aug			43	17.75	55	0
		PH		08-Jul	10-Aug		5	9.23	55	0
	4	BA	02-Jun	31-Aug			52	24.67	0	64
		PH		08-Jul	09-Aug		3	10.10	0	63
3	4	CH	20-Jun	11-Aug			33	10.84	1	47
		MA			13-Aug	30-Aug	11	2.48	1	47
		PH	02-Jun	19-Jun			10	14.56	1	47
4	7	MA		25-Jul	31-Aug		38	5.95	0	2
5	5	MA	25-Jun	31-Aug			68	9.64	15	63
		SH	15-Jun	31-Aug			12	4.87	12	63
6	4	MH	16-Jun	18-Jul			5	23.00	25	0
	6	BY	15-Jun	28-Aug			67	3.42	0	61
		MH	15-Jun	31-Aug			13	22.62	0	61
		PH			28-Aug	29-Aug	2	25.41	0	61
7	4	CH	02-Jun	31-Aug			91	6.84	20	0
		KA‡	20-Jun	23-Aug			65		20	0
	6	CH	02-Jun	31-Aug			72	6.92	1	17
8	5A	SH		30-Jul	31-Aug		33	12.22	7	5
9	3	SH	23-Jun	11-Jul			19	7.54	42	0
	3A	MA	22-Jun	19-Aug			59	11.76	4	2
10	60	PH	02-Jun	20-Jun			19	22.90	0	18
		MA			03-Aug	31-Aug	29	11.90	0	19
	61	MA			10-Aug	30-Aug	21	11.90	24	0
		PH	02-Jun	13-Jun			12	16.54	24	1
		SI	14-Jun	30-Aug			78	4.61	24	0
	62	MA			31-Aug	31-Aug	1	11.90	19	0
		SI			31-Aug	31-Aug	1	4.65	19	0
	71	MA	02-Jun	31-Aug			35	15.77	0	8
11	5	MA		09-Jul	17-Aug		40	6.67	0	89
13	5	MA	02-Jun	31-Jul			60	11.90	13	69
	5	SH			01-Aug	30-Aug	30	4.20	9	67
14	9	SI		14-Jul	25-Aug		22	9.77	0	80
15	11	MA	28-Jun	09-Jul			12	11.90	0	21
		SH	03-Jun	27-Jun			25	7.16	0	21
	13	SH		10-Jul	20-Jul		11	9.05	0	108
	6	MA	05-Jun	31-Aug			87	10.47	72	6
		SH	02-Jun	31-Aug			75	9.07	72	6
	7	MA		01-Jul	31-Aug		62	11.74	0	73
		SH		01-Jul	31-Aug		62	11.58	0	73
16	10	BY	05-Jun	08-Jun			4	8.68	0	7
		SH	05-Jun	05-Jun			1	11.07	0	7
	8	BY	03-Jun	28-Aug			73	4.48	37	50
		MA			29-Aug	31-Aug	3	4.06	37	49
		SH	03-Jun	29-Aug			72	6.21	37	50
Year 1993										
1	18	BA	22-Jun	10-Aug			30	17.85	47	0
		PH	27-Jun	27-Jun			1	10.21	47	0
	9	BA	03-Jun	25-Aug			58	17.09	0	63
3	4	PH			02-Aug	30-Aug	15	9.93	9	30
		SH		01-Jul	13-Jul		4	7.68	0	30
	4A	SH		06-Jul	31-Jul		12	6.93	20	23
	4B	PH			16-Aug	30-Aug	8	6.92	27	1
5	5	BY	02-Jun	31-Aug			91	7.17	21	103
		SH	02-Jun	27-Aug			10	3.64	21	102
	5A	BY			27-Aug	31-Aug	5	5.31	0	23
	5B	BY			27-Aug	31-Aug	5	5.31	0	22

Mob ID = mob identification as given by the farmer

* Estimated average energy intake (Megajoules of Metabolisabe Energy or MJME) per deer and per feeding episode based on known quantity and quality provided, and estimation of wastage

† MA = Maize, BY = Barley; PH = Peavine hay; SH = Sward hay; CH = Clover hay; BA = Balage ; SI = Silage; KA = Kale

‡ KA = Stags were strip fed kale directly on crop so energy intake could not be estimated

Appendix 3.31 : Calendar of food supplementation given to stags (> 15 months) from September 1 1992 and June 1 1993 to April 1 the following year.

Farm code	Mob ID	Type of food†	Start and finish dates				Quantity: Feeding episodes	Quantity: Energy intake*	Average number of deer: Yearling stags	Average number of deer: Adult stags
Winter period (June - August)										
Year 1993 (Cont'd)										
6	25	SH	04-Jun	23-Jun			9	22.75	0	54
		SI	27-Jun	25-Aug			8	28.93	0	54
7	6	CH	05-Jun	06-Aug			27	12.43	0	26
		KA‡		20-Jul	06-Aug		14		0	26
8	2C	MA		23-Jul	22-Aug		23	8.97	24	0
	5A	SH	21-Jun	21-Aug			58	16.21	0	8
9	18	MA	11-Jun	25-Jul			23	10.71	0	4
	4	BA		27-Jul	30-Aug		35		0	41
10	52	MA			15-Aug	31-Aug	16	14.88	24	0
		PH	17-Jun	30-Aug			73	16.36	24	0
	75	MA			11-Aug	31-Aug	19	28.18	0	20
		SI	02-Jun	31-Aug			66	6.10	0	21
	76	MA			10-Aug	31-Aug	21	28.62	0	10
		PH	18-Jun	31-Aug			75	19.82	0	10
11	12	SH		01-Jul	22-Jul		22	5.02	0	97
13	5	MA		01-Jul	31-Aug		62	11.90	0	79
		SH		01-Jul	31-Aug		62	2.17	0	79
16	19	BY			15-Aug	31-Aug	14	5.17	0	60
		SH	02-Jun	17-Aug			66	11.84	0	70
Spring period (September-December)										
Year 1992										
1	3	BA	02-Sep	05-Sep			2	13.44	55	0
		PH	03-Sep	08-Sep			5	9.07	55	0
	4	BA	05-Sep	30-Sep			3	13.78	0	65
		MA	06-Sep	13-Oct			37	5.02	0	65
		PH	02-Sep	24-Sep			6	27.75	0	65
3	4	MA	16-Sep	29-Sep			14	3.66	0	33
4	7	MA	02-Sep	30-Oct			59	5.95	0	2
5	5	MA	02-Sep	03-Sep			2	10.71	21	62
		SH	03-Sep	03-Sep			1	4.40	21	62
6	6	SH	30-Sep	05-Oct			6	3.87	0	59
		ME	30-Sep	12-Nov			44	7.15	0	57
		MH	03-Sep	25-Sep			8	20.31	0	60
7	4	CH	02-Sep	06-Sep			5	16.52	17	0
	6	CH	02-Sep	06-Sep			3	8.26	1	20
	5A	SH	02-Sep	18-Sep			12	13.05	7	5
10	60	MA	02-Sep	05-Oct			34	11.96	0	18
	62	MA	02-Sep	14-Nov			74	11.90	19	0
		PH	10-Sep	04-Oct			25	10.96	19	0
		SI	02-Sep	08-Sep			7	4.65	19	0
	63	MA		06-Oct	14-Nov		40	16.70	0	13
	71	MA	02-Sep	04-Nov			64	11.90	0	8
		PH	10-Sep	04-Oct			25	13.01	0	8
	72	MA			05-Nov	14-Nov	10	11.90	0	11
16	19	MA		08-Oct	03-Nov		26	3.95	0	50
	8	MA	02-Sep	03-Nov			60	4.27	37	28
		SH	02-Sep	05-Sep			4	5.86	37	49
Year 1993										
3	4	MA	02-Sep	21-Sep			8	15.41	0	24
5	5	BY	02-Sep	13-Sep			12	5.05	11	39
	5A	BY	02-Sep	13-Sep			12	5.31	0	23
	5B	BY	02-Sep	13-Sep			12	5.31	0	22
	5C	BY	03-Sep	13-Sep			11	5.31	0	19
6	25	SI	07-Sep	07-Sep			1	29.41	0	53
10	52	MA	02-Sep	14-Oct			43	18.56	24	0
		PH	02-Sep	09-Sep			8	11.68	24	0
	75	MA	02-Sep	30-Oct			48	21.22	0	13
		SI	02-Sep	08-Sep			7	5.38	0	20
	75B	MA	10-Sep	18-Oct			39	22.50	0	8
	76	MA	02-Sep	20-Oct			48	24.21	0	10
		PH	02-Sep	08-Sep			7	25.94	0	10
13	5	MA	02-Sep	15-Sep			14	11.90	0	78
		SH	02-Sep	15-Sep			14	2.19	0	78
16	19	BY	02-Sep	24-Sep			16	5.40	0	60
Summer period (December-March)										
Year 1992										
3	4	PH			Mar-93	Mar-93	8	8.61	0	45
Year 1993										
1	9	BA			Mar-94	20-Mar	8	26.36	0	71
3	8	MA			Mar-94	30-Mar	8	1.51	30	49

Mob ID = mob identification as given by the farmer

* Estimated average energy intake (Megajoules of Metabolisabe Energy or MJME) per deer and per feeding episode based on known quantity and quality provided, and estimation of wastage

† MA = Maize; BY = Barley; PH = Peavine hay; SH = Sward hay; CH = Clover hay; BA = Balage; SI = Silage, KA = Kale; ME = Meal (High Energy Dairy Pellets)

‡ KA = Hinds were strip fed kale directly on crop so energy intake could not be estimated

Appendix 3.32 : Bodyweights of yearling hinds mated on each survey farm in 1992 and 1993.

	MARCH						JUNE					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	01-Mar	36	83.3	69.0	101.5	6.7	22-Jun	13	85.8	75.5	98.0	7.6
2	20-Mar	41	77.8	59.0	93.5	8.6	23-May	45	86.1	60.5	101.0	9.4
3	03-Mar	4	83.5	73.0	91.0	7.4	29-Jun	4	81.8	69.0	95.5	10.9
4	29-Feb	14	92.4	85.0	103.0	4.6	19-May	14	95.9	88.0	109.0	4.8
5	NR						NR					
6	17-Mar	47	76.2	52.0	90.0	7.1	NR					
7	07-Mar	18	80.8	68.2	92.8	5.2	01-Jun	27	79.3	71.8	90.0	4.7
8	21-Feb	31	87.8	78.0	107.0	6.5	25-Jun	32	91.5	78.5	111.5	6.8
9	11-Mar	34	89.8	70.0	105.0	8.1	03-Jun	34	96.4	76.0	114.0	8.9
10	06-Mar	22	93.4	82.0	107.0	5.3	01-Jun	22	91.5	80.5	104.5	5.0
11	23-Mar	1	103.0				27-May	1	101.0			
13	04-Mar	48	77.3	61.0	98.5	7.8	25-Jun	46	84.4	69.0	95.0	5.8
15	23-Mar	15	84.3	73.0	100.0	7.2	27-Jun	46	78.1	66.0	91.5	5.8
16	NR						01-Jul	41	72.3	53.5	83.5	6.1
All farms		311	82.8	52.0	107.0	9.4		325	84.8	53.5	114.0	10.2
Year 1993												
1	11-Mar	43	84.8	66.0	100.0	7.3	03-Jun	43	88.8	66.0	105.0	7.0
2	20-Jan	27	79.2	68.0	88.5	4.6	NR					
3	17-Mar	30	79.7	44.0	101.0	11.4	11-Jun	17	84.9	75.0	98.0	6.6
4	26-Feb	12	95.8	86.0	104.0	5.0	20-May	12	96.3	83.0	106.0	5.7
5	NR						23-Jun	7	89.4	80.5	100.0	6.0
6	17-Mar	26	78.1	61.0	93.0	7.4	19-May	26	77.2	62.0	87.0	6.4
7	20-Mar	12	74.2	57.5	83.0	7.4	07-Jun	12	78.8	59.5	85.0	7.8
8	02-Feb	56	79.3	62.0	94.0	7.0	26-May	57	83.0	61.5	96.0	7.2
9	27-Feb	47	87.7	78.0	113.0	6.1	05-Jul	47	94.8	80.0	118.0	7.3
10	03-Mar	35	89.4	77.0	99.5	5.3	08-Jun	35	90.8	78.5	102.0	5.0
11	15-Feb	1	84.0				25-May	1	90.0			
13	25-Mar	45	80.9	66.5	97.5	5.6	08-Jun	44	82.5	72.0	100.0	5.3
15	29-Mar	71	74.7	60.0	93.5	6.5	14-Jun	76	79.6	64.0	99.0	7.3
16	17-Mar	37	79.6	72.0	93.0	4.9	01-Jul	40	83.6	74.0	99.0	5.3
All farms		442	81.3	44.0	113.0	8.5		417	85.1	59.5	118.0	8.6
All hinds combined		753	81.9	44.0	113.0	8.9		742	84.9	53.5	118.0	9.3

	SEPTEMBER						NOVEMBER					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	05-Sep	36	84.4	65.0	104.0	7.8	14-Nov	23	98.3	83.0	119.0	9.2
2	NR						16-Nov	20	104.8	95.5	115.5	5.0
3	NR						07-Nov	2	97.5	93.0	102.0	4.5
4	NR						10-Nov	14	93.4	82.0	106.0	5.2
5	27-Aug	9	91.4	86.0	99.0	4.9	NR					
6	NR						09-Nov	46	79.0	52.0	95.0	9.4
7	12-Sep	23	78.5	67.5	88.5	5.8	07-Nov	16	85.4	72.0	97.0	7.3
8	NR						28-Oct	23	89.9	79.0	113.0	7.2
9	NR						26-Oct	31	96.0	77.0	113.0	7.9
10	31-Aug	22	95.5	86.5	109.5	5.0	NR					
11	NR						NR					
13	NR						16-Nov	44	98.5	78.5	110.0	7.3
15	21-Sep	47	79.3	66.0	101.0	6.9	NR					
16	14-Sep	40	69.0	58.0	81.0	5.5	15-Nov	39	83.1	65.5	99.0	8.1
All farms		177	80.5	58.0	109.5	10.4		258	91.0	52.0	119.0	11.5
Year 1993												
1	09-Sep	43	88.5	64.0	104.0	7.6	NR					
2	NR						NR					
3	10-Sep	17	82.6	71.0	98.0	6.4	02-Nov	17	86.8	75.0	100.0	6.2
4	09-Sep	12	101.5	89.0	109.0	5.2	NR					
5	NR						NR					
6	16-Sep	26	75.4	58.5	87.5	7.4	NR					
7	28-Aug	6	80.4	78.0	83.0	1.6	17-Nov	3	89.8	87.5	92.0	1.8
8	NR						NR					
9	29-Sep	47	92.9	78.0	115.0	7.6	05-Nov	47	98.8	83.0	124.0	8.6
10	01-Sep	32	89.5	82.0	100.5	4.9	NR	32	103.3	92.5	119.5	6.4
11	02-Sep	1	88.0				NR					
13	02-Sep	24	87.1	78.5	104.5	5.8	NR					
15	09-Sep	75	78.6	62.0	93.5	6.6	NR					
16	05-Oct	40	84.6	73.5	98.0	5.2	17-Nov	40	94.1	82.0	112.0	6.3
All farms		323	85.3	58.5	115.0	9.1		139	96.8	75.0	124.0	8.8
All hinds combined		500	83.6	58.0	115.0	9.8		397	93.0	52.0	124.0	11.0

Note : No yearling hinds were surveyed in farm 14
Min = minimum; Max = maximum; SD = standard deviation; NR = not recorded by the farmer

Appendix 3.33 : Bodyweights (kg) of adult hinds mated on each survey farm in 1992 and 1993.

	MARCH						JUNE					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	01-Mar	112	103.4	81.5	130.5	8.5	30-May	125	104.8	81.5	124.0	8.8
2	20-Mar											
3	03-Mar	146	97.8	78.0	124.0	9.1	29-Jun	145	96.8	80.5	130.0	8.8
4	29-Feb	76	99.7	82.0	129.0	9.0	19-May	62	101.2	87.0	122.0	8.4
5	16-Mar	78	96.1	71.5	118.0	10.4						
6	17-Mar	117	91.6	68.0	124.0	9.6						
7	07-Mar	51	89.1	67.6	110.0	7.5	01-Jun	52	89.3	70.2	115.0	7.7
8	NR						25-Jun					
9	11-Mar	86	98.5	80.0	121.0	8.5	02-Jun	86	103.9	86.0	125.0	8.6
10	06-Mar	166	106.4	84.5	133.5	9.0	01-Jun	169	98.7	82.0	126.5	8.1
11	23-Mar	129	94.5	76.0	115.0	8.3	27-May	129	95.2	78.0	116.0	7.9
13	04-Mar	175	95.6	65.0	132.0	11.3	25-Jun	140	94.4	66.5	126.5	11.7
14	09-Mar						02-Jul					
15	23-Mar	22	104.4	90.5	120.0	8.7	27-Jun	138	96.9	71.0	117.0	9.0
16							01-Jul	121	89.2	69.0	114.0	9.4
All farms		1158	98.0	65.0	133.5	10.6		1167	97.1	66.5	130.0	10.1
Year 1993												
1	11-Mar	140	102.0	77.0	124.0	8.9	03-Jun	136	105.5	85.0	128.0	8.9
2	NR											
3	17-Mar	139	97.6	77.0	121.0	7.6	11-Jun	127	96.9	82.0	119.0	7.5
4	25-Feb	64	104.1	86.0	124.0	9.1	20-May	63	102.8	88.0	122.0	8.2
5	10-Mar	59	89.0	73.0	110.5	6.5	23-Jun	62	92.1	75.0	109.0	6.5
6	18-Mar	144	97.6	69.0	127.0	9.9	19-May	117	94.9	66.0	123.0	9.6
7	20-Mar	52	90.1	75.0	115.5	6.9	07-Jun	53	89.9	76.5	115.5	7.1
8	NR						26-May	188	102.7	84.0	125.5	7.6
9	04-Mar	106	107.8	89.0	128.0	8.5	05-Jul	105	105.8	93.0	128.0	7.6
10	03-Mar	155	107.1	85.5	144.5	8.8	08-Jun	154	104.8	87.0	140.0	8.1
11	18-Mar	107	98.6	83.0	120.0	7.2	25-May	106	96.7	81.0	114.0	6.9
13	15-Mar	180	92.7	71.0	128.0	9.1	08-Jun	46	93.5	74.0	104.0	8.1
15	06-Apr	141	96.2	56.0	122.5	12.0	14-Jun	117	98.5	74.5	125.0	10.6
16	17-Mar	135	96.5	72.0	127.0	11.5	01-Jul	134	94.9	73.0	122.5	9.2
All farms		1422	98.7	56.0	144.5	10.7		1408	99.5	66.0	140.0	9.6
All hinds combined		2580	98.4	56.0	144.5	10.6		2575	98.4	66.0	140.0	9.9

	SEPTEMBER						NOVEMBER					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	05-Sep	134	99.7	83.0	116.0	7.6	11-Nov	126	111.5	91.0	132.0	8.4
2	NR						16-Nov					
3	NR						07-Nov	140	101.3	80.0	130.0	8.6
4	NR						10-Nov	62	105.6	84.0	125.0	8.6
5	27-Aug	62	92.5	72.0	110.0	8.9	NR					
6	NR						09-Nov	102	92.1	67.0	116.0	9.0
7	12-Sep	49	88.9	76.5	114.5	7.6	07-Nov	47	93.4	70.5	120.5	8.9
8	NR						28-Oct					
9	NR						26-Oct	76	105.5	89.0	124.0	8.1
10	31-Aug	153	102.1	86.0	136.5	8.1	NR					
11	NR						23-Oct	106	99.8	79.0	120.0	8.2
13	NR						17-Nov	147	110.2	84.0	139.0	14.2
14	NR						NR					
15	21-Sep	118	91.7	69.5	108.5	8.0	NR					
16	14-Sep	121	83.3	57.5	108.0	8.7	15-Nov	119	100.4	63.5	128.0	10.4
All farms		637	94.2	57.5	136.5	10.7		925	102.9	67.0	139.0	11.6
Year 1993												
1	04-Sep	130	100.5	77.5	118.5	8.5	NR					
2	NR						NR					
3	10-Sep	134	95.9	76.0	117.0	7.3	02-Nov	133	104.2	78.0	124.0	7.5
4	09-Sep	62	102.5	83.0	122.0	8.0	NR					
5	NR						NR					
6	16-Sep	117	94.2	68.5	125.0	9.4	NR					
7	28-Aug	51	88.0	76.0	111.5	6.4	17-Nov	51	100.1	87.5	126.0	7.3
8	02-Sep	186	97.0	77.0	117.0	7.2	NR					
9	29-Sep	103	107.0	91.0	124.0	8.0	05-Nov	103	115.2	95.0	136.0	9.0
10	01-Sep	145	104.5	89.0	135.5	7.6		145	117.1	93.0	156.5	9.5
11	02-Sep	102	95.4	80.0	112.0	7.0	NR					
13	02-Sep	118	98.2	81.0	130.0	9.6	NR					
15	09-Sep	123	97.1	78.0	123.0	10.0	NR					
16	05-Oct	132	97.2	77.5	120.5	8.8	17-Nov	132	107.3	85.0	133.0	9.7
All farms		1403	98.4	68.5	135.5	9.3		564	109.9	78.0	156.5	10.7
All hinds combined		2040	97.1	57.5	136.5	9.9		1489	105.7	67.0	156.5	11.5

Note : Farm 14 was not surveyed in 1993

Min = minimum; Max = maximum; SD = standard deviation; NR = not recorded by the farmer

Appendix 3.34 : Summary distributions of pre-mating, pre-calving and weaning body condition scores of adult hinds mated on each survey farm in 1992 and March 1993.

Farm code	Date	Number of hinds	Number of hinds of each score									Mean score	SD
			1	1.5	2	2.5	3	3.5	4	4.5	5		
Pre-mating condition score March 1992													
1	17-Mar	107	-	1	8	17	29	28	24	-	-	3.19	0.62
2	02-Mar	104	-	-	3	24	41	63	16	-	-	3.22	0.48
3	04-Mar	126	-	-	-	6	17	56	42	5	-	3.59	0.44
4	26-Feb	76	-	-	3	22	30	15	6	-	-	2.99	0.49
5	12-Mar	78	2	1	3	7	21	24	19	1	-	3.26	0.69
6	19-Mar	117	4	8	14	17	28	25	19	1	1	2.94	0.84
7	24-Mar	52	-	2	7	2	18	12	11	-	-	3.12	0.70
8	18-Mar	100	-	-	-	-	14	33	45	8	-	3.74	0.42
9	10-Mar	86	-	-	3	5	22	32	21	3	-	3.42	0.54
11	03-Mar	115	-	-	8	13	26	47	20	1	-	3.27	0.57
13	11-Mar	128	-	-	2	7	34	46	36	3	-	3.45	0.50
14	09-Mar	133	-	-	-	7	25	40	47	13	1	3.64	0.53
15	23-Mar	138	1	5	19	20	50	22	17	4	-	2.97	0.72
All farms		1023	7	17	67	116	275	443	215	18	1	3.23	0.66
Pre-calving condition score September 1992													
1	02-Sep	131	-	-	1	11	27	42	42	8	-	3.52	0.54
2	30-Sep	205	1	11	48	64	52	19	10	-	-	2.61	0.61
3	15-Sep	140	-	-	1	6	30	41	54	8	-	3.59	0.51
4	17-Sep	62	-	4	4	9	21	18	6	-	-	3.01	0.64
5	09-Sep	65	-	-	3	4	16	19	23	-	-	3.42	0.56
6	05-Oct	99	-	7	21	32	30	8	1	-	-	2.57	0.55
7	14-Sep	48	-	-	-	1	10	14	19	4	-	3.66	0.48
8	08-Sep	206	1	3	17	25	55	56	46	3	-	3.21	0.67
9	24-Sep	76	-	-	4	9	26	18	18	1	-	3.26	0.58
10	10-Sep	144	1	-	1	5	22	34	48	31	2	3.76	0.63
11	07-Sep	109	-	3	7	9	30	31	28	1	-	3.27	0.65
13	24-Sep	118	-	-	5	13	33	28	32	7	-	3.38	0.62
14	28-Sep	156	-	2	5	14	40	39	40	14	2	3.45	0.58
15	21-Sep	121	3	6	11	23	30	30	18	-	-	2.96	0.75
16	09-Sep	119	3	3	10	16	41	27	17	1	1	3.05	0.72
All farms		1232	7	23	68	138	316	310	402	61	3	3.30	0.70
Weaning body condition score March 1993													
1	24-Mar	115	-	3	17	20	25	20	22	8	-	3.11	0.79
2	23-Mar	133	-	-	7	12	36	24	37	17	-	3.46	0.69
3	16-Mar	136	-	6	22	32	30	23	18	5	-	2.93	0.76
4	15-Mar	61	-	1	1	7	12	19	15	5	1	3.46	0.67
5	03-Mar	65	-	4	11	23	23	3	1	-	-	2.60	0.51
6	18-Mar	108	-	5	11	17	34	16	21	3	1	3.08	0.76
7	22-Mar	47	-	1	2	6	10	12	13	3	-	3.36	0.69
8	10-Mar	184	1	2	3	8	28	44	64	29	5	3.69	0.68
9	08-Mar	77	-	-	5	8	23	15	20	6	-	3.36	0.67
10	30-Mar	144	-	1	3	8	32	25	41	24	10	3.70	0.73
11	02-Mar	107	-	1	6	16	27	29	19	9	-	3.29	0.68
13	06-Apr	145	1	3	21	34	43	24	13	6	-	2.93	0.70
15	06-Apr	99	-	3	3	7	13	17	33	19	4	3.68	0.79
16	25-Mar	94	-	2	4	10	18	16	32	11	1	3.49	0.75
All farms		1515	2	32	116	208	354	287	349	145	22	3.32	0.78

SD = standard deviation

Appendix 3.35 : Summary distributions of pre-mating, pre-calving and weaning body condition scores of adult hinds mated on each survey farm in 1993 and March 1994.

Farm code	Date	Number of hinds	Number of hinds of each score									Mean score	SD
			1	1.5	2	2.5	3	3.5	4	4.5	5		
Pre-mating condition score March 1993													
1	24-Mar	135	-	5	22	25	29	22	24	8	-	3.04	0.80
2	23-Mar	153	-	-	10	18	43	27	38	17	-	3.38	0.70
3	16-Mar	138	-	6	24	32	30	23	18	5	-	2.91	0.76
4	15-Mar	64	-	1	5	7	16	15	15	5	-	3.31	0.72
5	03-Mar	65	-	3	9	23	25	3	2	-	-	2.67	0.51
6	18-Mar	144	-	5	15	22	43	23	30	5	1	3.12	0.75
7	22-Mar	63	-	1	5	9	16	15	13	4	-	3.25	0.71
8	10-Mar	185	-	1	7	13	31	47	61	23	2	3.58	0.67
9	08-Mar	106	-	-	10	10	29	21	28	8	-	3.33	0.70
10	30-Mar	151	-	-	3	11	34	29	46	22	6	3.64	0.68
11	02-Mar	107	-	1	6	16	27	29	19	9	-	3.29	0.68
13	06-Apr	175	1	5	30	41	52	25	15	6	-	2.87	0.71
15	06-Apr	145	1	3	6	18	23	28	41	21	4	3.50	0.81
16	25-Mar	110	-	6	14	14	18	16	31	11	-	3.23	0.88
All farms		1741	2	37	166	259	416	323	381	144	13	3.25	0.78
Pre-calving condition score September 1993													
1	15-Sep	130	-	3	9	12	26	26	35	18	1	3.44	0.78
2	31-Aug	180	-	-	-	1	12	46	77	42	2	3.93	0.45
3	13-Sep	134	-	1	7	19	55	21	26	5	-	3.19	0.62
4	31-Aug	62	-	-	1	3	13	21	17	7	-	3.57	0.56
5	14-Sep	58	-	1	5	15	19	10	6	1	1	3.01	0.67
6	16-Sep	117	-	-	7	16	41	30	18	5	-	3.22	0.60
7	05-Sep	51	-	-	-	2	11	15	19	4	-	3.62	0.50
8	20-Sep	178	1	13	37	50	47	11	19	-	-	2.67	0.69
9	21-Sep	102	-	-	3	5	26	19	29	16	4	3.64	0.69
10	02-Sep	143	-	-	-	11	31	33	31	28	9	3.71	0.69
11	08-Sep	102	-	2	7	21	41	17	12	2	-	3.03	0.60
13	07-Sep	111	-	-	1	5	38	25	26	14	2	3.54	0.61
15	09-Sep	123	-	1	5	9	36	13	23	28	8	3.62	0.82
16	01-Sep	130	-	1	2	4	21	36	31	28	7	3.77	0.68
All farms		1621	1	22	84	173	417	323	369	198	34	3.43	0.75
Weaning body condition score March 1994													
1	08-Mar	119	-	2	21	21	29	14	23	8	1	3.08	0.81
2	10-Mar	177	-	-	19	29	55	15	42	14	3	3.24	0.77
3	11-Mar	134	-	-	18	37	46	11	19	3	-	2.94	0.64
4	02-Mar	61	-	2	8	6	18	16	9	2	-	3.10	0.71
5	23-Mar	53	-	3	9	18	15	3	4	1	-	2.71	0.65
6	31-Mar	114	1	10	32	28	29	5	7	2	-	2.56	0.70
7	24-Mar	48	1	1	13	16	12	2	2	1	-	2.58	0.64
8	07-Mar	32	-	-	5	3	9	3	9	1	2	3.30	0.85
9	07-Mar	100	-	-	7	12	29	17	26	8	1	3.36	0.70
10	03-Mar	143	1	7	27	26	31	13	21	14	3	3.01	0.92
11	09-Mar	96	-	-	15	21	33	11	14	2	-	2.97	0.66
13	22-Mar	121	-	5	21	40	37	10	7	1	-	2.71	0.60
15	09-Mar	121	1	-	6	14	30	10	34	19	7	3.55	0.83
16	30-Mar	125	1	3	11	27	38	12	20	8	5	3.14	0.84
All farms		1444	5	33	212	298	411	142	237	84	22	3.04	0.80

SD = standard deviation

Appendix 3.36 : Summary distributions of pre-mating, pre-calving and weaning body condition scores of yearling hinds mated on each survey farm in 1992 and March 1993.

Farm code	Date	Number of hinds	Number of hinds of each score									Mean score	SD
			1	1.5	2	2.5	3	3.5	4	4.5	5		
Pre-mating condition score March 1992													
1	17-Mar	35	-	-	2	1	13	11	8	-	-	3.31	0.52
2	02-Mar	17	-	-	-	1	3	8	5	-	-	3.50	0.42
3	04-Mar	2	-	-	-	-	1	1	-	-	-	3.25	0.25
4	26-Feb	14	-	-	1	6	7	-	-	-	-	2.71	0.31
5	12-Mar	9	-	-	-	-	4	4	1	-	-	3.33	0.33
6	19-Mar	44	-	-	-	3	13	14	13	1	-	3.45	0.49
7	24-Mar	21	-	-	1	4	7	7	2	-	-	3.12	0.51
8	18-Mar	33	-	-	-	-	7	9	17	-	-	3.65	0.40
9	10-Mar	34	-	-	-	2	2	12	17	1	-	3.69	0.44
11	03-Mar	1	-	-	-	-	1	-	-	-	-	3.00	
13	11-Mar	48	-	-	1	7	13	21	6	-	-	3.25	0.48
15	23-Mar	43	-	-	1	1	11	14	14	2	-	3.52	0.52
All farms		301	-	-	6	25	82	101	83	4	-	3.40	0.52
Pre-calving condition score September 1992													
1	02-Sep	22	-	-	-	-	5	9	8	-	-	3.57	0.38
2	30-Sep	20	-	-	-	-	6	10	3	1	-	3.48	0.40
3	15-Sep	2	-	-	-	-	1	1	-	-	-	3.25	0.25
4	17-Sep	14	1	2	2	5	4	-	-	-	-	2.32	0.62
5	09-Sep	10	-	-	1	-	7	2	-	-	-	3.00	0.39
6	05-Oct	39	-	1	7	7	18	5	1	-	-	2.78	0.54
7	14-Sep	16	-	-	1	1	5	6	3	-	-	3.28	0.53
8	08-Sep	31	-	-	-	-	3	9	15	4	-	3.82	0.41
9	24-Sep	31	-	-	-	1	10	9	7	4	-	3.55	0.54
10	10-Sep	22	-	-	-	2	7	5	8	-	-	3.43	0.51
13	24-Sep	46	-	-	2	5	16	12	10	1	-	3.28	0.57
15	21-Sep	47	-	-	2	6	18	13	8	-	-	3.20	0.52
16	09-Sep	40	-	4	9	8	16	3	-	-	-	2.56	0.57
All farms		340	1	7	24	35	116	84	63	10	-	3.19	0.66
Weaning body condition score March 1993													
1	24-Mar	19	-	2	5	4	4	2	2	-	-	2.63	0.74
2	23-Mar	20	-	-	3	6	7	3	1	-	-	2.83	0.53
3	16-Mar	2	-	-	2	-	-	-	-	-	-	2.00	-
4	15-Mar	14	-	-	4	2	5	1	2	-	-	2.82	0.67
5	03-Mar	12	-	-	2	6	4	-	-	-	-	2.58	0.34
6	18-Mar	36	-	-	4	5	8	8	9	2	-	3.26	0.71
7	22-Mar	16	-	-	3	3	6	3	-	1	-	2.91	0.64
8	10-Mar	25	-	-	5	7	7	4	2	-	-	2.82	0.60
9	08-Mar	31	-	-	6	2	7	6	8	2	-	3.23	0.78
10	30-Mar	22	-	-	1	3	4	6	6	2	-	3.43	0.66
13	06-Apr	30	-	2	9	7	10	1	1	-	-	2.53	0.58
15	06-Apr	45	1	-	3	11	9	11	8	2	-	3.13	0.73
16	25-Mar	37	-	4	12	4	3	2	7	5	-	2.88	1.04
All farms		309	1	8	59	60	74	47	46	14	0	2.96	0.77

SD = standard deviation

Note : No yearling hinds were monitored on farm 14

Appendix 3.37 : Summary distributions of pre-mating, pre-calving and weaning body condition scores of yearling hinds mated on each survey farm in 1993 and March 1994.

Farm code	Date	Number of hinds	Number of hinds of each score									Mean score	SD
			1	1.5	2	2.5	3	3.5	4	4.5	5		
Pre-mating condition score March 1993													
1	24-Mar	41	-	-	-	4	15	11	10	1	-	3.37	0.51
2	23-Mar	25	-	-	-	-	7	11	7	-	-	3.50	0.37
3	16-Mar	17	-	-	-	1	6	7	3	-	-	3.35	0.41
4	15-Mar	12	-	-	-	-	5	4	3	-	-	3.42	0.40
5	03-Mar	6	-	-	-	1	2	1	2	-	-	3.33	0.55
6	18-Mar	26	-	-	-	3	8	5	9	1	-	3.44	0.56
7	22-Mar	10	-	-	-	-	6	3	1	-	-	3.25	0.34
8	10-Mar	56	-	-	1	3	18	20	13	1	-	3.39	0.49
9	08-Mar	47	-	-	-	-	4	12	26	5	-	3.84	0.39
10	30-Mar	34	-	-	-	-	8	11	12	3	-	3.65	0.46
11	02-Mar	1	-	-	1	-	-	-	-	-	-	2.00	
13	06-Apr	39	-	-	5	11	12	8	3	-	-	2.91	0.56
15	06-Apr	72	-	-	-	7	26	16	18	5	-	3.42	0.56
16	25-Mar	40	-	-	2	4	14	11	8	1	-	3.28	0.57
All farms		426	-	-	9	34	131	120	115	17	-	3.41	0.55
Pre-calving condition score September 1993													
1	15-Sep	34	-	-	1	3	11	7	10	2	-	3.41	0.60
2	31-Aug	20	-	-	-	-	2	9	8	1	-	3.70	0.37
3	13-Sep	17	-	-	1	8	6	1	1	-	-	2.79	0.46
4	31-Aug	12	-	-	-	-	2	2	6	2	-	3.83	0.47
5	14-Sep	7	-	-	1	2	2	1	1	-	-	2.93	0.62
6	16-Sep	26	-	1	4	9	9	1	2	-	-	2.71	0.57
7	05-Sep	3	-	-	-	1	1	1	-	-	-	3.00	0.41
8	20-Sep	30	-	1	2	5	12	3	7	-	-	3.08	0.66
9	21-Sep	47	-	-	3	2	17	8	13	4	-	3.40	0.65
10	02-Sep	32	-	-	3	3	13	4	9	-	-	3.20	0.62
11	08-Sep	1	-	-	-	-	1	-	-	-	-	3.00	
13	07-Sep	19	-	-	-	1	4	4	8	2	-	3.66	0.54
15	09-Sep	75	-	2	2	17	26	14	12	2	-	3.11	0.63
16	01-Sep	34	-	1	2	4	20	6	1	-	-	2.96	0.48
All farms		357	-	5	19	55	126	61	78	13	-	3.21	0.65
Weaning body condition score March 1994													
1	08-Mar	33	-	7	9	10	3	-	2	1	1	2.42	0.86
2	10-Mar	20	-	2	7	6	2	-	2	1	-	2.53	0.80
3	11-Mar	18	-	1	3	6	5	1	2	-	-	2.72	0.65
4	02-Mar	12	-	3	4	2	-	2	1	-	-	2.38	0.82
5	23-Mar	8	-	-	3	2	1	-	2	-	-	2.75	0.79
6	31-Mar	26	-	-	4	7	8	4	2	1	-	2.92	0.65
7	24-Mar	2	-	1	1	-	-	-	-	-	-	1.75	0.25
8	07-Mar	27	-	3	9	9	4	1	-	1	-	2.41	0.64
9	07-Mar	37	-	1	5	11	11	3	4	2	-	2.91	0.72
10	03-Mar	30	2	3	9	9	3	2	2	-	-	2.37	0.74
11	09-Mar	3	-	-	-	1	2	-	-	-	-	2.83	0.24
13	22-Mar	19	-	3	11	3	2	-	-	-	-	2.11	0.42
15	09-Mar	73	-	2	22	21	9	8	9	2	-	2.73	0.76
16	30-Mar	36	1	1	5	7	12	7	3	-	-	2.85	0.69
All farms		344	3	27	92	94	62	28	29	8	1	2.63	0.76

SD = standard deviation

Note : No yearling hinds were monitored on farm 14

Appendix 3.38 : Reproductive performance of yearling hinds on each survey farm in 1992 and 1993.

Farm code	Number of hinds mated		Pregnancy testing in June					Hinds at calving			Hinds at weaning			
			Number	Percentage	Percentage of diagnosed hinds (%)			Total	Pregnancy status		Number of hinds		Weaning	Reproductive
	culled or left the farm*	breeding herd	of hinds scanned	not diagnosed	conceiving before May 1	conceiving after May 1	not pregnant**	number of hinds	Unknown	Not pregnant	weaned	diagnosed wet	rate† (%)	efficiency‡ (%)
Year 1992														
1	4	36	36	2.8	60.0	0.0	40.0	23	0	1	22	19	86.4	52.8
2	26	46	22	0.0	81.8	9.1	9.1	20	0	0	20	20	100.0	43.5
3		4	4	0.0	25.0	25.0	50.0	2	0	0	2	2	100.0	50.0
4		14	14	0.0	92.9	7.1	0.0	14	0	1	14	10	76.9	71.4
5		12	10	0.0	90.0	0.0	10.0	11	2	0	11	9	81.8	75.0
6		47	46	0.0	17.4	76.1	6.5	45	10	3	37	27	64.3	57.4
7	8	16	24	0.0	70.8	4.2	25.0	16	0	0	16	14	87.5	87.5
8		34	32	0.0	50.0	28.1	21.9	25	1	0	25	24	96.0	70.6
9		34	34	0.0	20.6	55.9	23.5	31	0	5	31	20	76.9	58.8
10		22	21	0.0	57.2	42.8	0.0	22	0	0	22	19	86.4	86.4
11		1	1	0.0	100.0	0.0	0.0	0	0	0	0	0		
13		48	46	2.2	64.4	31.1	4.4	40	2	1	38	33	84.6	68.8
15		48	47	6.4	79.5	6.8	13.6	48	12	6	46	30	71.4	62.5
16		42	41	4.9	53.8	20.5	25.6	39	2	9	39	26	86.7	61.9
All farm		404	378	1.9	56.1	27.5	16.4	336	29	26	323	253	81.6	62.6
Year 1993														
1		43	43	0.0	60.5	14.0	25.6	35	0	2	34	27	81.8	62.8
2	5	20	20	0.0	95.0	5.0	0.0	20	3	0	20	17	85.0	85.0
3	13	17	17	0.0	58.8	29.4	11.8	17	0	2	17	11	73.3	64.7
4		12	12	0.0	75.0	25.0	0.0	12	0	0	12	11	91.7	91.7
5		7	7	0.0	71.4	28.6	0.0	7	1	0	7	6	85.7	85.7
6		26	26	0.0	42.3	7.7	50.0	26	2	13	26	11	84.6	42.3
7		12	12	0.0	8.3	41.7	50.0	4	0	0	3	3	75.0	25.0
8		32	32	0.0	84.4	9.4	6.3	28	0	0	28	24	85.7	75.0
9		47	46	0.0	61.7	12.8	25.5	35	1	0	35	27	77.1	57.4
10		35	35	0.0	91.4	0.0	8.6	32	0	1	32	28	90.3	80.0
11		1	1	0.0	100.0	0.0	0.0	1	0	0	1	1	100.0	100.0
13	12	34	46	0.0	93.5	0.0	6.5	31	3	0	31	28	90.3	82.4
15		76	76	0.0	71.1	21.1	7.9	98	11	6	98	81	88.0	76.3
16		40	40	0.0	85.0	12.5	2.5	40	0	1	38	36	92.3	90.0
All farms		402	413	0.0	72.7	13.0	14.2	386	21	25	382	311	86.1	77.4
Total		806	791	0.9	64.8	19.9	15.3	722	50	51	705	564	84.1	70.0

Wet = still lactating at weaning

* For reasons not related to pregnancy results

** Hinds not pregnant at calving either from pregnancy scanning in June or from observation of physical characteristics and weight change before calving.

† Percentage of hinds not suspected not pregnant at calving that reared a calf up to weaning. The number of wet hinds was checked were possible from the number of calves actually weaned from these hinds, assuming there was no twinning.

‡ Percentage of hinds mated in the breeding herd that reared a calf up to weaning. This figure includes hinds sold or slaughtered after mating, excepted those for which the decision of culling was made prior to mating.

Notes : Year 1992
Farm 1 : 4 hinds left the farm on May 28 without being scanned
Farm 2 : 5 hinds left on May 3 and 21 hinds were culled on May 23, without being scanned
Farm 6 : 10 light-weight hinds were separated from mating mobs on 23.3.92 and 9 were joined again with back-up stag on 4.5.92. All 9 but one hind conceived in May
Farm 7 : 6 other hinds weighing 71.8-75.8 kg were culled but mated and were scanned all not pregnant; 2 hinds left the farm for calving

Year 1993
Farm 2 : 5 hinds were taken off the farm on June 2 without being scanned. Pregnancy status unknown
Farm 3 : 8 and 5 hinds were culled in May 16 and June 10, respectively, without being scanned or inspected at slaughter.
Farm 13 : 12 hinds all conceiving before May 1 were sold on June 17.
Farm 15 : Calving hinds includes 23 wapiti cross in-calf hinds bought on Oct 29; the reproductive efficiency does not include their 23 offspring in the calculation.

Appendix 3.39 : Reproductive performance of adult hinds on each survey farm in 1992 and 1993.

Farm code	Number of hinds			Pregnancy testing in June					Hinds in calving mobs			Hinds at weaning				
	Naturally mated		AI*	Number of hinds scanned	Percentage not diagnosed	Percentage of diagnosed hinds (%)			Total number of hinds	Pregnancy status		Number of hinds		Number of calves weaned	Weaning rate† (%)	Reproductive efficiency‡ (%)
	Culled**	Bred				conceiving before May 1	conceiving after May 1	not pregnant***		Unknown	Not pregnant	weaned	diagnosed wet			
Year 1992																
1		154		138	0.7	92.0	0.7	7.3	127	0	1	127	108	106	84.1	68.8
2		226		214	0.0	93.0	5.6	1.4	205	18	0	205	186	185	90.2	81.9
3		146		146	0.0	93.8	3.4	2.8	139	2	0	137	121	119	85.6	81.5
4		62		59	0.0	98.3	0.0	1.7	62	0	3	62	57	58	98.3	93.5
5		82		82	1.2	88.9	9.9	1.2	73	2	0	73	87	64	87.7	78.0
6		137		131	0.0	78.6	16.8	4.6	118	7	4	118	103	104	91.2	75.9
7	13	40		53	0.0	88.7	5.7	5.7	35	3	2	35	31	31	93.9	77.5
8		219		132	9.1	93.3	4.2	2.5	185	18	2	183	164	177	96.7	80.8
9		87		86	0.0	83.7	12.8	3.5	77	1	1	77	71	72	94.7	82.8
10	20	165		154	1.3	77.6	19.7	2.6	148	3	1	148	137	138	93.9	83.6
11		129		128	0.0	96.9	1.6	1.6	110	3	1	110	105	104	95.4	80.6
13		181		84	13.1	84.9	11.0	4.1	177	14	0	172	149	155	87.6	85.6
14		166		140	0.7	90.6	7.9	1.4	156	4	0	155	148	150	96.2	90.4
15		150		131	4.6	94.4	0.0	5.6	121	28	3	99	82	108	91.5	72.0
16		105	17	105	0.0	83.8	13.3	2.9	119	4	2	118	105	105	89.7	86.1
All farm		2049	17	1783	1.9	89.3	7.5	3.1	1852	107	20	1819	1654	1676	91.5	81.1
Year 1993																
1	9	136		136	0.0	84.6	0.0	15.4	113	0	0	113	105	105	92.9	77.2
2	18	184		184	1.1	96.2	3.3	0.5	184	25	0	184	158	156	84.8	84.8
3	4	135		134	0.0	93.3	3.7	3.0	133	1	5	132	124	126	98.4	93.3
4	1	63		63	0.0	98.4	0.0	1.6	61	0	1	61	58	58	96.7	92.1
5		66		65	0.0	89.2	6.2	4.6	60	5	1	60	53	48	81.4	72.7
6	28	119		118	0.0	94.9	4.2	0.8	118	7	1	118	105	101	86.3	84.9
7		53		53	0.0	84.9	11.3	3.8	51	1	0	51	46	46	90.2	86.8
8		194		186	0.0	97.3	2.7	0.0	188	0	0	188	178	175	93.1	90.2
9	2	80	24	79	0.0	92.4	2.5	5.1	98	1	2	98	93	93	96.9	87.7
10		155		155	0.0	96.8	1.3	1.9	146	0	3	146	141	142	99.3	91.6
11		107		106	0.0	93.4	3.8	2.8	102	4	2	102	96	96	96.0	89.7
13	27	155		178	2.8	97.7	0.0	2.3	175	7	1	175	122	153	87.9	85.2
15	34	136		115	0.9	96.5	2.6	0.9	126	14	1	126	110	111	88.8	81.6
16		111	24	111	0.0	85.6	9.0	5.4	132	0	4	132	117	117	91.4	86.7
All farm		1694	48	1683	0.5	93.7	3.1	3.2	1687	65	21	1686	1506	1527	91.7	88.9
Total		3743	65	3466	1.2	91.4	5.4	3.2	3539	172	41	3505	3160	3203	91.6	83.6

Wet = still lactating at weaning

*AI : Artificial insemination ; Farm 16 in 1992 had 9 hinds from AI, the rest conceived from back-up stag
Farms 9 and 16 in 1993 had both 12 hinds conceiving from AI and 1 hind not conceiving. Farm 9 had one foetal loss following conception from AI

** For reasons not related to pregnancy results

*** Hinds not pregnant at calving either from pregnancy scanning in June or from observation of physical characteristics and weight change before calving.

† Percentage of hinds believed to be pregnant at calving that reared a calf up to weaning. The number of wet hinds was checked were possible from the number of calves actually weaned from these hinds, assuming there was no twinning.

‡ Percentage of hinds mated in the breeding herd that reared a calf up to weaning. This figure includes hinds sold or slaughtered after mating, excepted those for which the decision of culling was made prior to mating.

Notes : Hinds at calving include bought in hinds and hinds artificially inseminated, some hinds were known (by scanning result) or suspected (by bodyweight change) not pregnant
Farms 5, 8 and 15 : Hind listings were inaccurate so best estimates of numbers of hinds mated and at calving were obtained from grazing records

Year 1992 Farm 7 : 13 hinds were taken off the farm for calving
Farm 10 : 20 hinds were culled on June 1 without being scanned
Farm 15 : Not all hinds could be mustered at weaning and some weaners stayed behind, thus the number of non-lactating hinds is underestimated

Year 1993 Farm 1 : 9 hinds went in mating mob from March 30 to April 14 before being culled
Farm 2: 18 hinds mated left the farm on June 2 before pregnancy testing
Farm 3 : 4 hinds culled on May 16
Farm 6 : 28 hinds mated and culled on May 19 without being scanned or inspected at slaughter; 5 hinds were missing at weaning
Farm 13 : 27 hinds left the farm in June 17 after pregnancy testing (all conceived before May 1), and 20 others were bought in July 10; the conception rate of hinds staying on the farm was 97.4%.
The reproductive efficiency was that of hinds staying on the farm assuming the 20 bought hinds reared a calf up to weaning, the overall reproductive efficiency was corrected accordingly.

Appendix 3.40 : Estimated percentage of blood lines (%), mean and range of bodyweights (kg) on April 1 of weaner hinds and stags, weaner removals between weaning and April 1, weaner productivity of breeding hinds on each survey farm in the survey years 1992 and 1993.

Farm code	Average percentage of deer blood lines		Weaner deer alive on survey farm on April 1										Deer weaned but not on farm on April 1				Mean weaner weight per hind	
			STAGS					HINDS					Weaning dates	Weaners leaving alive			Number of losses*	
	NZ	WAP	Number of deer	Mean	Min	Max	SD	Number of deer	Mean	Min	Max	SD		Number of stags	Number of hinds	Mean bodyweight		Mated	Calving
Year 1992 (weaning 1993)																			
1	53	4	64	51.9	37.7	67.0	6.9	61	45.9	28.7	64.0	7.3	07-Mar					32.2	41.4
2	88	0	101	44.3	25.7	55.4	6.0	103	39.3	27.3	47.5	4.0	03-Mar				1	31.3	37.9
3	96	0	69	46.4	25.4	58.4	6.6	50	43.8	29.4	54.1	5.5	17-Mar				1	36.0	38.3
4	77	0	27	51.7	37.7	61.0	6.9	41	49.2	25.8	59.7	6.6	25-Feb					44.9	47.4
5	88	12	43	48.2	34.2	59.6	6.6	30	46.6	37.3	57.3	4.3	10-Mar					36.9	41.3
6	100	0	68	43.2	22.5	58.5	7.6	63	40.1	23.5	52.5	6.2	01-Apr					29.7	35.0
7	70	0	12	45.7	31.9	61.9	9.9	19	48.3	32.4	59.1	7.9	16-Mar	9	6	42.8	1	37.6	43.0
8	83	0	78	48.9	24.6	62.6	7.6	98	45.7	26.0	57.5	5.6	10-Mar	24	0	46.9	2	37.2	45.3
9	56	0	50	53.9	30.4	64.4	7.5	46	46.8	28.1	63.2	7.5	08-Mar				1	40.1	47.6
10	90	0	70	55.5	33.4	69.1	6.9	86	50.5	36.5	61.7	5.1	03-Mar				1	44.0	48.7
11	77	23	52	53.2	36.7	66.1	5.6	49	49.9	38.4	59.4	5.1	17-Mar				3	40.1	47.8
13	100	0	88	47.2	29.9	61.1	6.1	100	44.2	29.1	58.1	5.3	15-Mar				5	37.4	39.7
15	100	0	67	46.2	31.8	59.0	5.4	71	40.3	20.4	52.9	6.5	06-Apr					30.1	37.2
16	76	0	67	48.7	28.8	64.5	8.2	61	43.6	19.9	57.4	7.1	23-Mar				3	36.1	40.3
All farm			856	48.7	22.5	69.1	7.8	878	44.7	19.9	64.0	6.9		33	6		18	35.9	41.6
Year 1993 (weaning 1994)																			
1	48	4	65	50.6	32.3	62.5	6.5	66	47.3	33.3	60.5	5.4	06-Mar					36.1	44.2
2†	83	0	79	47.1	27.0	59.0	6.2	94	42.9	23.5	51.0	5.1	08-Mar					38.0	38.0
3	79	0	29	51.8	34.8	62.8	9.3	33	47.6	26.8	59.7	7.7	11-Mar	42	32	45.6	1	42.7	45.4
4	71	0	27	58.0	40.5	69.4	7.3	42	51.3	37.3	61.3	5.2	24-Feb					49.6	51.7
5	74	0	29	52.8	44.0	61.8	4.6	25	48.2	31.6	60.2	6.9	18-Mar					37.5	41.4
6‡	94	0	34	42.0	26.5	52.0	6.1	27	39.7	25.0	50.5	5.9	01-Apr					31.6	35.3
7	64	0	11	51.1	37.8	62.6	6.8	12	48.4	42.5	58.6	4.1	24-Mar	10	16	45.9		35.9	42.5
8	79	0	103	53.7	37.3	63.3	5.6	92	48.3	25.3	60.0	6.4	07-Mar				4	45.0	47.1
9	45	0	59	59.0	36.9	73.8	8.3	29	50.6	35.9	69.8	8.8	07-Mar	0	32	60.2		45.5	52.5
10	83	0	83	53.2	39.4	67.3	5.6	86	48.9	39.9	62.8	4.6	27-Feb				1	45.7	49.9
11	75	25	47	57.3	41.4	66.2	4.9	49	50.8	34.4	63.0	4.4	03-Mar				1	48.5	51.9
13	88	12	73	53.1	33.5	70.0	6.3	80	48.6	28.0	67.5	7.4	23-Mar					37.6§	39.0
15	90	0	104	51.7	27.4	71.9	8.6	87	45.9	25.0	59.9	7.0	09-Mar				1	34.4#	38.2
16	73	0	67	49.2	33.8	58.5	5.0	86	44.4	29.6	55.0	4.8	01-Apr					40.7	42.6
All but farm 2			731	52.3	26.5	73.8	7.7	714	47.6	25.0	69.8	6.6		52	80		8	41.3	43.6
Weaning 1993 and 1994 combined*			1587	50.6	22.5	73.8	7.9	1592	46.0	19.9	69.8	7.0		85	86		26	38.5	42.7

* Losses were recorded death or deer missing at subsequent weighing (escaped)

Note : Data of 27 weaners are missing (from one calving mob including 7 yearling and 22 adult hinds)

NZ = New Zealand blood lines; WAP = Wapiti or Elk blood lines; Min = Minimum; Max = Maximum; SD = Standard deviation

† Weaning weights are reported for farm 2 in March 1994 as weaner deer were not weighed again after April 1(data were not included for calculations over all farms)

‡ One weaner deer was identified in paddocks after weaning but its sex and weight is unknown. Its weight was estimated by the average weight over all weaners (41kg)

§ 20 adult hinds bought in July 1993 and 20 weaners (based on the average weight) were excluded from this calculation

23 in-calf yearling hinds bought in October 1993 and their calves were excluded from this calculation

Appendix 3.41 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner hinds calculated monthly on each survey farm in 1992.

Date		Farm code														
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
April 1	N	43	75	25	33	27	NR	19	54	40	77	NR	82	136	NR	NR
1992	Mean	46.4	45.6	48.1	49.7	44.0		38.3	52.0	45.7	47.7		48.5	46.5		
	Min	29.2	29.1	39.5	40.8	28.6		30.1	38.2	34.1	32.7		32.9	31.5		
	Max	57.1	55.9	55.3	60.2	60.5		46.7	63.1	62.1	56.1		62.9	64.5		
	SD	6.3	5.6	4.4	4.7	7.5		5.4	7.0	7.0	4.4		6.0	7.1		
May 1	N	43	NR	25	33	32	52	31	62	40	78	NR	82	139	70	NR
	Mean	50.2		53.2	54.4	45.9	47.5	44.3	54.8	52.6	51.0		52.1	48.5	48.0	
	Min	32.2		43.5	44.3	29.0	31.9	31.5	41.1	39.9	35.2		37.0	8.7	32.5	
	Max	62.1		62.3	64.1	64.7	58.9	51.0	65.7	73.0	59.2		66.5	67.4	61.4	
	SD	6.6		4.6	4.7	7.2	5.5	4.9	6.9	7.9	4.6		6.7	8.4	6.9	
June 1	N	43	NR	32	33	27	31	8	54	59	35	59	74	136	55	NR
	Mean	53.3		50.0	59.3	47.0	48.2	46.5	58.3	55.0	56.4	51.1	51.8	51.8	45.8	
	Min	38.0		28.0	48.9	28.3	31.4	33.9	44.6	43.5	37.8	32.3	36.8	37.0	32.5	
	Max	64.0		63.5	70.6	69.0	58.4	52.7	67.9	73.0	62.8	62.4	63.3	70.0	59.3	
	SD	6.2		9.2	5.1	8.1	5.9	6.4	6.5	6.4	4.0	5.3	5.8	6.4	5.7	
July 1	N	43	NR	32	33	30	34	19	55	60	35	60	74	NR	55	50
	Mean	54.5		50.4	60.7	47.8	47.2	46.8	58.9	57.2	58.1	51.4	51.6		44.2	48.3
	Min	39.8		27.7	52.6	28.0	31.6	34.6	45.7	45.8	41.6	36.2	37.4		29.8	38.5
	Max	64.9		63.4	71.5	70.8	58.3	55.7	67.6	74.1	65.1	64.6	63.5		57.7	58.0
	SD	5.7		9.0	4.7	8.3	6.0	5.3	6.0	6.1	3.9	4.8	5.6		5.4	4.6
August 1	N	43	NR	32	33	30	34	19	55	60	35	6	74	NR	55	50
	Mean	56.8		50.7	62.1	48.8	47.8	47.4	59.5	59.0	58.8	46.4	53.0		45.3	50.0
	Min	42.2		27.4	55.7	28.0	33.7	35.3	46.8	47.2	44.6	37.7	40.0		30.6	39.6
	Max	66.6		63.2	72.5	70.5	59.5	58.8	69.2	76.1	65.7	65.0	65.5		58.7	58.8
	SD	5.7		8.8	4.5	8.6	6.0	5.8	5.8	6.0	3.6	8.8	6.3		5.3	4.5
Sept 1	N	42	NR	30	33	33	26	8	56	59	35	6	45	NR	51	49
	Mean	59.2		51.7	64.4	50.8	50.3	50.9	60.4	60.9	59.6	48.4	59.5		46.4	51.8
	Min	44.8		27.4	58.2	30.0	34.3	36.0	47.0	48.7	46.4	40.8	45.3		29.0	40.8
	Max	69.2		63.4	74.4	70.5	60.7	61.9	71.0	78.1	65.9	66.8	69.3		59.8	59.6
	SD	5.8		8.4	4.5	7.7	5.8	8.2	5.8	6.0	3.5	8.6	4.1		5.7	4.5
Oct 1	N	46	75	30	33	NR	34	8	54	59	35	6	45	NR	54	49
	Mean	61.9	60.3	53.7	67.5		49.1	53.8	63.9	62.7	63.8	52.2	61.9		49.1	54.4
	Min	40.5	46.6	28.5	60.5		34.0	39.6	49.8	50.1	52.1	44.7	49.0		30.3	43.0
	Max	73.8	78.7	65.8	77.3		61.8	63.7	74.2	80.2	70.8	70.2	73.2		62.1	62.4
	SD	6.5	5.9	8.4	4.7		6.4	8.0	5.8	5.9	3.5	8.4	4.1		5.8	4.7
Nov 1	N	57	NR	30	33	NR	26	8	54	59	35	6	45	NR	54	49
	Mean	71.3		57.3	70.8		54.2	57.8	67.8	66.9	70.0	56.4	65.0		55.1	59.7
	Min	53.0		31.7	60.5		37.9	45.2	52.9	54.5	59.9	48.7	52.4		37.4	48.3
	Max	103.4		71.4	83.5		62.8	64.9	77.7	86.7	78.2	73.8	77.2		68.7	70.5
	SD	9.3		8.5	5.3		5.7	7.2	5.9	6.0	3.8	8.2	4.2		5.7	4.9
Dec 1	N	42	NR	30	33	NR	25	8	54	59	35	6	45	NR	54	50
	Mean	72.5		62.3	76.7		59.4	61.6	71.6	72.4	74.9	59.5	68.0		60.9	65.0
	Min	56.0		34.6	68.2		42.6	50.6	55.8	60.5	65.5	51.7	55.8		44.3	53.5
	Max	86.2		77.2	88.8		69.1	68.4	82.5	93.5	83.8	76.7	81.1		75.5	77.5
	SD	6.5		9.0	5.8		6.1	6.7	6.2	6.3	4.1	8.2	4.4		5.9	5.2
Jan 1	N	42	NR	30	33	NR	25	8	54	59	35	6	45	NR	54	50
1993	Mean	76.3		67.7	82.4		65.2	65.6	75.5	78.5	79.1	62.7	71.1		66.9	70.5
	Min	59.1		37.6	72.1		47.6	53.3	58.9	66.4	69.4	54.7	59.2		51.4	58.9
	Max	90.4		83.1	94.2		77.6	72.9	88.1	100.9	88.4	79.7	85.1		82.4	83.0
	SD	6.7		9.8	6.5		6.6	6.6	6.5	6.7	4.7	8.3	4.7		6.3	5.5
Feb 1	N	42	NR	30	33	NR	26	8	54	59	35	6	47	NR	64	51
	Mean	80.1		73.0	86.4		71.5	67.4	79.4	82.4	84.3	65.9	74.5		70.3	74.6
	Min	62.2		40.4	77.0		52.8	54.3	61.9	69.4	73.3	57.7	62.1		55.1	62.2
	Max	94.7		90.3	99.6		85.4	74.8	93.8	107.5	94.0	82.7	88.5		88.3	88.0
	SD	7.0		10.5	6.4		7.0	6.6	6.9	7.0	5.0	8.3	4.9		6.2	6.0
March 1	N	42	NR	30	33	NR	26	8	56	60	35	5	47	NR	64	51
	Mean	83.5		77.7	89.7		75.7	67.1	80.2	85.6	89.1	68.9	77.7		72.0	76.1
	Min	65.0		42.9	80.0		58.0	54.1	61.9	72.0	76.8	59.1	64.4		57.6	62.7
	Max	98.6		97.8	104.0		88.3	74.6	94.5	113.0	99.2	84.8	91.7		90.9	91.2
	SD	7.3		11.1	6.5		7.1	6.6	6.9	7.2	5.3	9.0	5.3		6.4	6.1

N = number of deer; Min = minimum value; Max = maximum value; SD = standard deviation; NR = not recorded

Appendix 3.42 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner hinds calculated monthly on each survey farm in 1993.

Date		Farm code													
		1	2	3	4	5	6	7	8	9	10	11	13	15	16
April 1	N	60	91	50	41	30	63	8	96	46	86	47	84	58	61
1993	Mean	46.0	39.3	43.8	49.2	46.6	40.1	54.4	45.7	46.8	50.5	49.8	44.3	40.3	43.6
	Min	28.7	27.3	29.4	25.8	37.3	23.5	47.5	26.0	28.1	36.5	38.4	29.1	20.4	19.9
	Max	64.0	47.5	54.1	59.7	57.3	52.5	59.1	57.5	63.2	61.7	59.4	58.1	52.9	57.4
	SD	7.3	4.3	5.5	6.6	4.3	6.2	4.1	5.6	7.5	5.1	5.2	5.7	7.2	7.1
May 1	N	60	NR	32	41	23	63	32	35	46	86	47	87	57	61
	Mean	50.0		47.6	55.8	51.1	42.6	44.2	55.1	50.6	53.9	51.3	45.3	44.9	45.4
	Min	30.2		31.0	28.8	42.5	27.6	21.5	37.2	29.0	39.9	38.3	28.0	33.4	19.8
	Max	68.5		58.3	67.7	60.9	57.4	65.4	63.1	68.9	65.5	61.0	61.7	56.6	60.1
	SD	7.5		6.9	7.0	4.2	6.1	10.6	5.7	7.7	5.6	5.4	6.3	5.6	6.9
June 1	N	59	91	32	41	28	30	8	35	63	39	47	39	58	61
	Mean	54.4	44.0	48.3	59.6	53.0	46.0	63.4	55.6	54.5	58.4	52.9	44.5	49.0	47.2
	Min	31.6	31.8	34.0	29.1	44.9	30.8	55.3	39.0	42.3	40.7	39.2	32.6	39.1	19.6
	Max	73.7	51.0	58.0	71.4	62.5	60.4	70.2	64.3	71.9	67.2	62.7	65.8	60.4	62.9
	SD	7.8	4.2	6.6	7.6	4.3	7.8	5.3	5.3	5.8	6.9	5.4	6.9	5.2	6.8
July 1	N	59	NR	32	40	27	30	8	35	74	39	47	5	56	61
	Mean	55.7		48.4	61.9	57.2	48.1	64.3	56.1	58.0	59.9	54.7	64.2	51.6	49.1
	Min	34.2		36.1	44.9	48.4	33.3	56.4	39.9	45.7	41.0	42.1	59.9	40.5	19.7
	Max	75.3		57.3	73.9	66.3	62.3	70.8	65.4	73.7	68.9	64.4	70.6	62.5	65.6
	SD	7.6		6.0	5.5	4.7	7.4	5.4	5.3	5.9	7.4	5.3	4.6	4.9	6.9
August 1	N	59	NR	32	40	16	30	8	35	74	39	47	5	56	61
	Mean	57.1		50.7	64.5	64.7	50.3	65.2	56.6	61.3	61.3	56.5	68.0	53.0	51.8
	Min	37.0		38.2	47.3	59.7	35.9	57.5	40.8	48.9	41.0	45.0	63.1	41.1	27.1
	Max	76.9		59.5	76.9	71.0	64.4	71.6	66.5	76.7	70.5	66.2	75.7	64.7	68.0
	SD	7.6		5.7	5.6	3.5	7.1	5.5	5.5	5.9	8.0	5.3	5.1	5.0	6.5
Sept 1	N	59	NR	33	40	16	30	8	35	74	30	47	5	56	61
	Mean	58.5		52.5	67.1	67.7	53.0	66.7	57.0	64.5	67.0	58.4	71.8	54.5	54.6
	Min	39.7		40.4	49.8	61.9	39.1	58.5	41.8	52.2	61.2	47.9	66.3	41.8	34.5
	Max	78.6		61.2	79.8	74.6	66.8	73.8	67.7	81.4	72.1	67.9	80.7	68.1	70.5
	SD	7.6		5.5	5.8	3.9	6.8	5.6	5.9	6.0	2.9	5.4	5.6	5.4	6.4
Oct 1	N	49	NR	32	38	16	30	8	35	74	30	46	5	64	61
	Mean	61.4		56.5	71.3	70.6	57.2	72.1	60.8	67.7	71.2	62.2	75.5	59.7	57.2
	Min	44.5		44.0	53.9	64.1	44.1	62.1	45.9	55.2	66.0	50.4	69.4	46.2	41.7
	Max	72.7		65.5	85.3	78.2	70.5	79.5	71.1	86.0	76.6	71.9	85.5	73.2	72.9
	SD	6.1		5.5	6.1	4.4	6.5	5.9	5.7	6.2	3.0	5.7	6.1	5.5	6.3
Nov 1	N	49	NR	32	38	16	30	8	35	40	30	46	5	64	61
	Mean	66.5		61.8	76.0	73.6	61.6	77.7	66.0	71.8	75.5	66.2	82.0	65.8	61.9
	Min	49.7		48.1	58.2	66.3	48.6	65.9	51.4	58.6	70.0	54.0	75.2	52.2	47.5
	Max	78.7		71.6	91.1	81.8	74.4	85.4	75.6	90.9	82.3	76.9	93.3	81.2	77.0
	SD	6.4		5.9	6.3	4.8	6.2	6.3	5.3	6.6	3.4	5.8	6.6	5.5	6.7
Dec 1	N	49	NR	32	38	7	30	8	35	40	30	46	5	68	61
	Mean	71.4		67.4	80.6	75.6	65.9	83.1	71.0	76.5	81.4	70.1	88.9	71.8	66.0
	Min	54.7		51.5	62.3	69.0	52.9	69.6	56.7	63.0	76.5	57.5	81.5	58.0	50.9
	Max	84.5		76.5	96.7	84.7	78.2	91.2	80.5	95.6	89.6	81.9	101.4	89.0	80.9
	SD	6.8		6.3	6.7	5.5	6.1	6.7	5.2	6.7	3.5	6.1	7.1	6.0	7.0
Jan 1	N	49	NR	32	38	7	30	8	35	40	30	46	5	63	60
1994	Mean	76.2		73.1	84.4	77.8	69.1	86.9	76.2	81.4	85.4	73.6	96.0	73.7	67.9
	Min	59.4		55.0	66.2	71.1	56.0	72.4	62.2	67.4	80.4	60.9	88.0	59.9	52.9
	Max	90.0		83.9	100.9	87.4	80.7	95.5	85.6	100.5	96.0	86.4	109.8	90.6	83.1
	SD	7.2		6.8	6.9	5.9	6.0	7.0	5.3	6.9	3.9	6.3	7.6	6.0	7.0
Feb 1	N	49	NR	32	38	7	30	8	NR	40	30	46	5	63	60
	Mean	78.7		75.9	87.6	79.9	69.1	87.5		86.3	87.3	76.7	97.6	75.7	69.9
	Min	62.2		57.1	69.7	70.9	56.0	73.7		71.9	81.0	64.3	88.0	61.8	54.9
	Max	92.9		86.3	105.0	90.1	79.6	96.9		105.4	100.5	90.4	111.7	92.2	85.2
	SD	7.4		7.1	7.2	6.4	5.8	6.9		7.2	4.3	6.5	8.0	6.2	7.0
March 1	N	49	NR	32	38	7	30	8	NR	40	30	46	5	63	60
	Mean	81.0		77.3	90.6	81.9	69.2	88.0		90.7	87.7	79.5	98.3	77.5	71.7
	Min	64.6		58.6	72.9	70.7	56.0	74.9		76.0	81.0	67.3	89.0	63.5	56.8
	Max	95.6		87.8	109.4	92.5	79.2	98.2		109.9	101.3	94.8	112.5	95.1	87.4
	SD	7.6		7.2	7.5	7.0	5.9	6.9		7.4	4.3	6.8	8.0	6.6	7.0

N = number of deer; Min = minimum value; Max = maximum value; SD = standard deviation; NR = not recorded

Appendix 3.43 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner stags calculated monthly on each survey farm in 1992.

Date		Farm code														
		1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
April 1	N	45	53	23	39	29	NR	18	82	33	86	NR	85	119	NR	NR
1992	Mean	48.1	52.4	50.5	52.0	48.7		43.0	55.2	51.4	51.8		52.3	49.8		
	Min	30.1	29.6	43.0	33.7	29.6		36.0	36.2	34.9	35.4		30.9	36.6		
	Max	59.2	61.4	55.4	66.1	60.0		51.1	66.3	63.4	67.0		66.4	63.9		
	SD	7.8	6.2	3.5	6.6	7.7		4.4	6.7	7.3	6.7		6.9	5.5		
May 1	N	45	NR	24	39	34	NR	33	82	33	92	NR	35	120	80	NR
	Mean	51.9		54.6	58.5	50.2		48.5	60.1	59.2	54.6		57.7	53.2	54.1	
	Min	32.1		46.6	39.8	32.9		31.4	42.7	41.6	37.0		36.3	26.1	26.5	
	Max	65.1		61.3	72.8	61.7		63.4	76.1	73.5	70.4		70.5	67.4	67.9	
	SD	8.5		3.8	7.4	8.0		7.1	7.2	8.0	7.3		9.6	5.7	8.0	
June 1	N	45	NR	32	39	29	NR	31	77	33	30	68	84	119	70	NR
	Mean	55.4		51.1	64.4	53.1		51.1	63.4	61.7	63.7	55.8	56.7	57.1	51.4	
	Min	34.0		32.0	43.3	33.7		41.8	47.2	44.0	38.7	37.0	36.0	44.6	37.1	
	Max	68.0		62.0	79.3	65.6		58.9	82.0	75.3	73.9	67.1	70.5	71.0	71.8	
	SD	8.5		8.9	7.9	8.9		4.7	7.6	7.5	7.2	7.0	6.8	5.2	7.0	
July 1	N	45	NR	32	39	35	31	31	79	33	30	68	33	121	70	46
	Mean	57.5		51.5	67.5	54.0	49.8	52.6	65.1	64.3	67.1	58.7	68.6	60.7	49.3	51.0
	Min	35.8		33.1	48.0	34.0	28.9	44.8	49.1	46.9	42.1	39.6	45.6	47.5	36.3	34.6
	Max	69.8		62.3	81.2	67.7	60.7	59.2	84.0	77.9	78.1	71.9	82.2	74.5	75.6	63.6
	SD	8.3		8.9	7.8	9.1	8.0	4.1	7.5	7.4	7.4	6.8	10.5	5.4	7.4	6.7
August 1	N	45	NR	32	39	35	31	31	79	33	30	68	33	121	70	46
	Mean	61.8		51.8	70.5	54.4	51.5	54.2	66.8	67.2	69.9	60.9	69.5	60.7	50.8	53.6
	Min	37.6		34.3	52.6	34.5	31.8	46.8	50.5	49.0	45.7	42.2	45.9	47.5	38.0	37.9
	Max	74.9		62.6	83.1	69.5	63.0	59.5	85.9	81.3	81.1	74.5	82.7	74.5	73.1	68.7
	SD	8.8		9.0	7.8	8.6	7.7	3.8	7.6	7.6	7.3	6.6	9.8	5.4	7.1	7.0
Sept 1	N	45	NR	28	39	40	30	31	82	32	30	68	31	NR	58	44
	Mean	66.6		53.6	76.0	56.0	53.2	55.8	68.9	70.9	72.2	64.1	70.2		53.2	56.8
	Min	39.2		35.6	58.3	37.0	34.8	48.0	52.0	53.8	48.6	45.8	46.3		38.6	41.3
	Max	80.3		62.4	89.5	70.0	65.4	60.5	88.0	84.8	83.2	77.8	84.8		70.6	74.3
	SD	9.5		8.0	7.9	8.3	7.8	3.6	7.7	7.2	7.2	6.5	9.8		7.1	7.1
Oct 1	N	46	53	28	39	NR	31	32	44	32	30	68	31	NR	61	45
	Mean	72.0	72.6	57.1	83.3		54.9	60.0	68.4	73.9	79.9	69.4	72.1		57.3	60.7
	Min	40.0	53.8	38.1	65.0		37.6	52.6	54.8	57.2	55.0	51.5	48.6		40.8	42.8
	Max	88.7	83.9	66.4	98.6		67.7	66.1	81.0	88.2	92.0	82.0	88.3		71.7	79.9
	SD	10.5	6.3	7.9	8.3		7.6	3.7	6.4	7.4	7.5	6.4	9.7		7.2	7.9
Nov 1	N	61	NR	28	NR	NR	32	32	44	32	30	68	31	NR	61	45
	Mean	83.7		62.7			59.3	66.4	73.2	80.3	90.6	75.1	76.7		65.7	69.0
	Min	48.0		42.6			43.1	58.6	57.9	62.2	63.6	57.6	55.9		49.3	50.7
	Max	104.1		73.3			71.1	74.3	85.2	95.9	103.7	89.3	93.1		81.1	86.5
	SD	10.9		8.0			7.6	3.9	6.7	8.2	8.2	6.6	9.4		7.5	8.0
Dec 1	N	46	NR	29	NR	NR	34	32	44	32	30	NR	31	NR	61	45
	Mean	87.2		69.6			66.7	72.5	77.9	88.2	98.8		81.1		73.9	76.8
	Min	52.5		48.9			49.0	64.1	60.8	68.5	70.0		63.0		55.5	58.3
	Max	106.8		80.7			78.2	82.0	89.4	106.8	112.5		99.3		90.3	94.5
	SD	11.4		8.1			7.9	4.2	7.2	9.0	8.8		9.4		8.3	8.3
Jan 1	N	46	NR	29	NR	NR	34	32	44	33	30	NR	31	NR	61	45
1993	Mean	92.7		76.8			75.1	78.3	82.7	97.0	105.4		85.7		82.3	84.8
	Min	57.2		55.7			55.9	70.4	63.9	75.7	74.8		67.1		55.5	66.3
	Max	113.8		88.3			88.2	87.4	94.9	118.9	119.8		105.6		99.8	103.0
	SD	12.1		8.5			8.7	4.6	7.7	9.8	9.2		9.6		9.4	8.7
Feb 1	N	46	NR	29	NR	NR	NR	32	44	33	NR	NR	31	NR	68	45
	Mean	98.3		83.3				82.6	87.5	102.7			90.4		85.1	91.1
	Min	61.8		62.1				75.3	66.9	80.7			68.0		67.0	72.7
	Max	120.8		96.0				91.8	100.8	125.5			109.7		103.1	109.9
	SD	12.8		8.7				4.7	8.4	10.2			9.7		8.2	9.1
March 1	N	46	NR	29	NR	NR	NR	32	24	34	NR	NR	31	NR	68	45
	Mean	103.3		88.5				85.1	83.2	107.2			94.6		85.2	93.3
	Min	66.0		67.6				77.5	67.8	85.0			68.0		67.0	74.8
	Max	127.2		103.0				94.9	92.8	131.0			112.8		105.6	112.8
	SD	13.5		8.9				4.6	6.3	10.5			10.0		8.3	9.3

N = number of deer; Min = minimum value; Max = maximum value; SD = standard deviation; NR = not recorded

Appendix 3.44 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner stags calculated monthly on each survey farm in 1993.

Date		Farm code													
		1	2	3	4	5	6	7	8	9	10	11	13	15	16
April 1	N	61	57	68	27	42	68	12	98	50	69	52	67	54	66
1993	Mean	52.0	45.2	46.5	51.7	48.2	43.2	45.7	48.4	53.9	55.5	53.2	47.1	46.2	48.7
	Min	37.7	25.7	25.4	37.7	34.2	22.5	31.9	24.6	30.4	33.4	36.7	29.9	31.8	28.8
	Max	67.0	55.4	58.4	61.0	59.6	58.5	61.9	62.6	64.4	69.1	66.1	61.1	59.0	64.5
	SD	7.1	6.9	6.6	6.9	6.7	7.6	9.9	7.3	7.5	6.9	5.6	6.9	6.0	8.2
May 1	N	61	NR	37	27	36	68	12	102	50	69	52	65	54	66
	Mean	56.5		50.2	58.0	52.2	46.2	50.8	50.8	57.5	61.3	56.6	49.0	51.0	50.7
	Min	41.0		23.7	42.1	39.4	15.6	37.7	25.5	33.9	36.0	39.3	33.3	35.8	30.4
	Max	71.5		61.6	69.2	65.1	66.3	69.2	67.4	70.5	75.8	68.8	62.1	65.0	65.5
	SD	7.2		9.6	7.7	6.9	9.2	10.8	7.9	7.8	7.6	5.5	6.7	5.5	8.1
June 1	N	61	57	34	27	37	54	34	98	38	39	52	23	54	66
	Mean	61.5	50.9	52.6	63.0	55.9	49.1	55.7	53.9	61.2	64.3	59.1	49.3	56.1	52.7
	Min	43.5	31.0	27.0	45.2	43.0	26.6	42.6	35.2	39.5	37.1	40.1	34.1	39.8	29.7
	Max	76.6	61.2	62.0	78.2	70.1	69.0	75.2	71.2	74.0	76.3	71.1	63.8	71.2	67.8
	SD	7.5	6.9	7.5	8.1	6.9	9.0	8.9	7.6	8.0	10.0	5.9	10.2	5.8	8.2
July 1	N	61	NR	34	27	34	54	34	98	38	39	52	23	53	65
	Mean	64.0		53.1	67.7	61.3	51.8	58.4	56.3	64.8	67.1	61.5	53.7	59.1	54.7
	Min	46.5		30.6	51.4	48.0	28.8	44.8	37.5	46.5	40.3	42.7	40.8	43.8	28.6
	Max	80.0		63.4	79.0	74.2	72.2	77.7	73.5	76.4	78.7	73.7	68.4	73.8	70.2
	SD	7.6		6.8	7.5	7.3	9.0	9.0	7.3	7.3	10.9	5.4	10.1	5.8	8.3
August 1	N	61	NR	35	27	19	54	34	98	38	39	52	23	53	65
	Mean	66.7		55.3	72.6	72.6	54.7	61.2	58.8	69.6	70.4	64.0	58.3	61.6	58.8
	Min	49.6		36.3	56.4	66.1	31.1	47.1	39.9	52.9	40.5	45.3	44.7	46.8	31.9
	Max	84.5		67.1	84.2	81.1	75.4	80.3	75.9	82.5	83.4	76.3	73.5	75.0	75.4
	SD	7.8		6.7	7.3	4.5	9.1	9.3	7.4	7.0	12.2	5.2	10.1	5.8	8.6
Sept 1	N	61	NR	35	27	19	54	34	98	38	32	52	23	52	65
	Mean	69.3		58.6	77.3	78.2	58.3	64.5	61.3	74.4	79.5	66.4	62.9	64.2	63.0
	Min	52.3		40.5	61.2	70.1	34.3	49.2	41.9	59.3	50.8	47.9	48.3	49.3	35.3
	Max	89.3		69.1	89.2	87.6	79.3	83.6	78.4	88.6	88.3	78.9	79.0	76.2	80.6
	SD	8.2		6.6	7.3	5.0	9.2	9.9	7.6	6.8	6.4	5.2	10.2	6.1	8.9
Oct 1	N	47	NR	34	27	19	52	34	97	38	32	52	22	58	65
	Mean	73.6		64.3	82.7	83.7	64.5	71.6	67.1	79.1	87.0	72.4	69.3	67.7	67.0
	Min	57.8		47.5	66.9	73.8	40.6	54.7	46.4	65.5	59.2	53.9	53.6	39.0	38.5
	Max	86.9		75.5	94.9	93.9	85.9	92.3	83.4	94.4	97.4	86.3	84.0	82.0	85.6
	SD	6.6		6.6	7.5	5.7	9.3	10.7	7.7	6.9	7.0	5.3	10.1	7.4	9.3
Nov 1	N	47	NR	34	NR	19	52	34	97	38	32	52	22	58	65
	Mean	80.7		70.9		89.4	71.0	78.8	74.3	85.1	94.6	78.7	77.4	71.5	74.6
	Min	63.9		55.0		77.7	47.1	60.4	51.3	72.1	67.9	60.2	59.6	19.2	43.5
	Max	94.8		82.5		100.4	92.6	101.4	89.5	101.9	106.8	94.1	93.6	91.1	94.5
	SD	7.1		6.9		6.5	9.2	11.7	7.7	7.2	7.9	5.5	10.5	14.0	10.0
Dec 1	N	47	NR	34	NR	NR	52	34	97	38	33	52	22	56	66
	Mean	87.6		76.1			77.3	85.8	81.2	91.7	102.9	84.8	85.3	80.8	81.7
	Min	68.7		60.0			53.4	65.8	56.0	78.5	70.4	66.3	65.4	65.0	48.1
	Max	102.4		87.5			99.2	111.1	96.4	110.1	117.1	101.7	104.2	100.0	101.9
	SD	7.7		7.1			9.3	12.7	8.0	8.0	10.3	5.9	11.1	6.5	10.7
Jan 1	N	47	NR	34	NR	NR	52	32	97	15	25	50	22	30	66
1994	Mean	94.3		81.5			82.3	91.5	88.4	96.6	113.4	89.8	93.4	81.8	84.6
	Min	71.7		64.7			58.8	70.1	60.8	84.7	76.2	71.4	71.3	28.5	50.6
	Max	109.7		94.1			104.2	117.8	103.7	118.0	126.4	108.4	115.2	96.4	104.1
	SD	8.3		7.8			9.3	13.2	8.4	9.8	11.4	5.6	11.7	14.4	10.8
Feb 1	N	47	NR	4	NR	NR	52	32	NR	15	25	50	16	30	66
	Mean	99.2		92.6			83.3	93.9		102.0	119.9	94.1	101.9	87.3	87.5
	Min	80.8		91.8			61.8	71.6		88.1	80.5	75.4	75.0	57.0	53.1
	Max	114.4		93.1			104.9	118.8		125.8	133.5	114.3	122.0	99.9	106.2
	SD	8.4		0.5			9.2	13.1		10.1	12.2	5.7	12.4	8.8	10.9
March 1	N	47	NR	4	NR	NR	52	32	NR	NR	25	50	16	30	66
	Mean	103.6		94.6			84.3	96.2			120.4	98.1	102.5	92.3	90.1
	Min	83.6		94.0			64.4	73.1			81.1	79.1	78.5	76.5	55.4
	Max	119.8		95.0			105.6	121.1			133.5	119.7	120.0	103.0	108.2
	SD	8.9		0.4			9.4	13.2			12.6	6.0	11.1	6.3	11.1

N = number of deer; Min = minimum value; Max = maximum value; SD = standard deviation; NR = not recorded

Appendix 3.45 : Means, ranges, standard deviations and quartiles of bodyweights (kg) of weaner hinds and stags, both years 1992 and 1993 combined.

	DATE											
	April 1	May 1	June 1	July 1	August 1	Sept 1	Oct 1	Nov 1	Dec 1	Jan 1	Feb 1	March 1
WEANER HINDS												
Number of hinds	1432	1350	1276	1092	1027	966	1016	910	890	884	858	860
Mean	45.8	49.4	51.6	53.5	55.3	57.7	60.9	65.8	70.3	74.6	77.6	80.1
SD	7.0	7.4	7.6	7.7	8.1	8.2	8.3	8.5	8.4	8.7	8.9	9.4
Minimum	19.9	21.5	26.6	27.7	27.4	27.4	28.5	31.7	34.6	37.6	40.4	42.9
25th percentile	41.4	44.8	46.5	48.5	49.5	52.4	55.8	60.3	65.0	69.0	71.7	74.0
50th percentile	46.2	49.9	52.0	53.9	55.8	58.0	61.3	66.0	70.6	74.5	77.3	79.6
75th percentile	50.3	54.5	57.0	58.8	61.1	63.0	66.3	71.4	75.8	80.4	83.9	86.7
Maximum	64.5	73.0	73.7	75.3	76.9	81.4	86.0	103.4	101.4	109.8	107.5	113.0
WEANER STAGS												
Number of stags	1403	1315	1331	1305	1291	1148	1117	1010	915	863	649	615
Mean	50.0	53.9	56.5	58.8	61.2	64.6	69.7	75.7	81.9	87.7	91.7	94.2
SD	7.6	8.5	8.7	9.5	9.8	10.5	11.0	11.5	11.6	12.4	12.6	13.2
Minimum	22.5	23.7	26.6	28.6	31.1	34.3	37.6	42.6	48.1	50.6	53.1	55.4
25th percentile	45.1	48.6	51.2	53.0	55.0	57.3	62.2	68.0	73.8	79.8	83.4	85.2
50th percentile	50.6	54.6	56.9	59.1	61.5	64.5	69.6	75.2	81.2	86.9	91.0	93.1
75th percentile	55.4	60.0	62.2	65.4	68.0	72.0	77.2	82.9	89.1	94.4	98.6	102.0
Maximum	69.1	76.1	82.0	84.0	85.9	90.5	101.4	106.8	117.1	126.4	133.5	133.5

SD = standard deviation

Appendix 3.46 : Growth rates (g/d) of weaner hinds on each survey farm in 1992 and 1993.

Farm code*	Year 1992 Number of deer	Mean	Min	Max	SD	Year 1993 Number of deer	Mean	Min	Max	SD
Growth rates from April 1 to June 1										
1	43	114.0	80.6	225.7	27.0	59	139.0	47.4	203.6	28.0
2	NR					91	78.2	39.8	122.2	15.6
3	25	97.8	33.5	156.4	29.3	32	56.4	4.0	107.4	23.7
4	33	157.0	72.3	222.1	39.2	41	170.4	53.5	287.2	35.0
5	27	48.9	-22.5	146.1	44.1	28	106.0	32.4	146.7	22.6
6	NR					30	83.5	23.7	130.8	29.5
7	8	124.9	61.9	204.4	44.6	8	148.6	88.6	186.3	32.3
8	53	103.5	-40.9	214.9	49.9	35	94.7	38.3	144.4	22.4
9	40	153.7	84.2	196.0	23.1	44	107.2	11.3	193.9	39.7
10	35	100.3	69.3	133.7	20.9	39	98.9	49.2	134.1	20.8
11	NR					47	50.1	-9.3	113.6	28.1
13	74	48.3	-66.2	134.2	30.1	39	33.9	-114.3	156.0	51.0
14	136	86.6	-6.4	166.4	37.8					
15	NR					58	142.4	-7.7	315.4	71.3
16	NR					61	59.7	-9.5	228.6	32.3
Growth rates from June 1 to September 1										
1	42	66.2	39.3	98.1	15.4	59	43.9	0.0	133.3	23.6
2	NR					NR				
3	30	11.6	-17.6	69.0	19.3	32	43.9	5.9	115.5	23.2
4	33	54.8	-8.0	117.7	22.0	40	72.9	4.7	119.2	22.8
5	27	42.3	-50.9	180.1	40.8	14	137.1	94.7	179.0	21.1
6	25	11.7	-26.2	47.3	18.9	30	75.7	38.8	140.4	22.3
7	8	48.1	13.0	129.6	39.9	8	35.0	15.2	57.6	12.7
8	54	21.1	-92.7	129.8	37.9	35	15.8	-74.6	97.0	39.7
9	58	64.1	10.7	103.5	19.8	63	95.6	26.8	183.2	26.1
10	35	34.9	6.0	93.4	15.9	30	57.9	17.5	115.6	22.4
11	6	67.1	42.9	95.9	21.0	47	59.6	9.4	179.2	29.2
13	45	54.9	-23.2	154.2	34.5	5	122.1	102.9	161.8	20.7
14	NR									
15	51	4.7	-66.2	64.8	27.5	55	53.2	-38.7	156.7	34.9
16	NR					61	79.6	20.1	161.7	23.6
Growth rates from September 1 to December 1										
1	41	147.9	103.1	188.2	18.3	49	161.4	124.3	215.4	19.6
2	NR					NR				
3	30	116.9	75.4	183.3	26.3	32	164.8	101.8	211.7	23.6
4	33	135.1	67.8	184.5	26.5	38	150.2	108.6	186.1	20.9
5	NR					7	86.1	70.5	110.8	13.8
6	24	103.2	63.4	139.3	22.4	30	142.3	58.8	184.9	26.7
7	8	117.4	48.8	160.7	31.1	8	181.0	121.7	213.0	27.4
8	54	124.5	71.1	193.9	26.9	35	153.3	88.7	230.2	32.6
9	59	126.6	70.1	197.9	22.0	40	130.7	82.4	167.9	18.7
10	35	168.6	123.6	209.7	22.1	30	158.8	109.3	208.1	20.9
11	6	122.8	102.6	156.2	17.3	45	129.8	68.3	230.8	30.0
13	45	94.1	64.0	150.3	19.9	5	187.6	167.4	228.0	22.1
14	NR									
15	51	159.6	8.8	215.8	31.4	55	191.9	71.9	279.1	35.3
16	49	144.3	88.4	229.6	28.2	61	125.9	64.7	185.1	24.9
Growth rates from December 1 to March 1										
1	42	177.7	122.8	234.5	27.2	49	154.9	105.1	252.0	26.9
2	NR					NR				
3	30	248.0	134.5	332.5	46.0	32	160.2	113.9	253.3	30.7
4	33	209.8	148.9	281.6	32.0	38	161.0	92.6	234.6	34.4
5	NR					7	101.3	-10.9	163.7	55.2
6	24	262.5	160.9	350.3	39.9	30	53.5	-63.4	201.5	46.6
7	8	89.0	53.5	138.0	23.6	8	78.5	57.7	113.6	16.4
8	55	141.1	84.6	195.1	27.3	NR				
9	59	213.8	117.5	313.8	34.6	40	228.6	180.2	298.0	31.8
10	35	229.3	168.5	286.9	31.6	30	102.0	52.4	187.7	30.4
11	5	135.1	115.2	171.9	19.9	46	151.4	26.5	235.5	36.6
13	45	161.1	56.8	286.4	33.8	5	98.3	89.0	112.5	8.0
14	NR									
15	53	172.9	67.5	256.3	40.1	63	94.3	-44.4	340.7	56.0
16	50	183.2	113.5	266.5	32.4	60	93.2	39.4	151.9	23.8

Min = minimum; Max = maximum; SD = standard deviation; NR = not recorded

* Farm 14 was not surveyed in 1993

Appendix 3.47 : Growth rates (g/d) of weaner stags on each survey farm in 1992 and 1993.

Farm code*	Year 1992 Number of deer	Mean	Min	Max	SD	Year 1993 Number of deer	Mean	Min	Max	SD
Growth rates from April 1 to June 1										
1	45	120.0	32.2	193.4	35.2	61	155.0	57.4	245.4	36.7
2	NR					57	94.5	54.0	130.7	14.9
3	23	92.0	27.9	145.2	39.0	34	57.0	4.0	161.7	35.3
4	39	203.5	108.4	268.9	39.8	27	186.0	109.2	282.0	38.9
5	29	73.0	-11.2	168.5	47.3	37	128.8	66.3	181.7	31.6
6	NR					54	100.1	-2.9	196.2	43.6
7	18	128.3	74.4	215.1	41.6	12	155.8	-16.9	258.1	66.3
8	79	136.3	-36.1	257.4	57.4	96	88.1	-7.6	210.7	36.2
9	33	167.6	124.1	238.8	27.0	38	133.4	20.8	215.8	48.9
10	30	112.2	54.5	183.2	30.8	39	128.6	60.6	189.0	28.5
11	NR					52	95.8	-23.0	157.9	36.7
13	84	72.3	0.0	212.5	37.5	23	53.9	-9.3	115.0	33.2
14	119	119.9	25.3	212.1	39.4					
15	NR					54	163.0	-15.4	330.8	65.4
16	NR					66	66.4	-42.9	133.3	32.3
Growth rates from June 1 to September 1										
1	45	122.5	46.0	174.2	25.9	61	85.3	-55.6	178.9	36.1
2	NR					NR				
3	28	7.5	-87.8	43.9	26.9	34	69.8	26.0	146.5	25.3
4	39	126.3	74.0	174.4	23.7	27	155.8	71.8	218.3	34.5
5	28	40.1	-6.0	105.2	22.1	16	185.2	153.6	236.8	23.4
6	NR					54	99.9	54.5	184.0	25.1
7	31	51.2	-13.0	118.5	29.3	34	95.9	-38.7	275.9	46.0
8	78	58.5	-37.1	166.9	42.2	98	79.8	-34.8	234.8	43.2
9	32	95.2	8.2	146.2	29.1	38	143.2	75.1	215.2	36.1
10	30	93.2	54.3	127.5	18.2	32	125.3	82.1	171.6	19.0
11	68	89.7	0.6	179.3	29.6	52	80.0	-28.3	169.8	36.9
13	31	129.8	42.8	231.7	44.3	23	147.2	111.7	223.3	26.5
14	NR									
15	58	17.7	-85.3	70.0	29.8	52	90.0	-65.9	157.2	38.2
16	0					65	112.6	55.5	170.0	23.2
Growth rates from September 1 to December 1										
1	45	225.6	146.2	294.2	31.1	47	223.8	31.2	265.7	36.8
2	NR					NR				
3	28	174.3	91.1	294.0	34.4	34	193.6	68.4	253.5	38.2
4	NR					SOLD				
5	NR					NR				
6	31	144.8	99.7	199.4	22.1	52	210.7	151.3	277.3	29.0
7	31	186.8	136.1	237.5	23.8	34	234.1	108.7	330.4	49.2
8	44	153.5	90.5	226.2	31.7	96	217.9	65.9	309.4	35.2
9	32	190.1	132.7	265.3	32.8	38	190.1	83.6	269.2	40.3
10	30	292.0	235.3	340.7	24.4	32	268.2	121.2	340.9	50.0
11	NR					52	201.8	135.7	259.6	27.1
13	31	120.4	79.3	191.6	30.8	22	254.5	187.6	343.6	39.7
14	NR									
15	58	225.4	16.4	348.2	50.5	46	182.3	33.5	296.5	49.0
16	44	224.3	167.3	299.5	29.3	65	203.2	97.9	269.7	34.0
Growth rates from December 1 to March 1										
1	46	259.8	120.1	425.7	52.8	47	257.7	152.2	459.3	54.6
2	NR					NR				
3	29	303.7	220.8	426.5	43.4	4	187.6	176.1	194.1	7.4
4	SOLD					SOLD				
5	NR					NR				
6	NR					52	111.7	-27.7	235.3	50.2
7	32	202.9	53.4	306.0	46.6	32	164.8	84.9	401.1	68.9
8	24	167.3	98.8	233.7	31.0	NR				
9	32	305.3	223.7	389.6	49.2	15	175.3	115.2	252.6	35.7
10	NR					25	253.9	134.4	321.1	54.3
11	NR					50	216.4	15.2	344.6	51.2
13	31	217.3	39.7	288.2	51.9	16	221.6	163.4	258.7	24.8
14	NR									
15	59	177.3	118.1	273.0	29.0	28	177.8	-36.7	293.3	78.9
16	45	264.7	182.8	406.7	49.1	66	135.1	56.3	196.9	33.5

Min = minimum; Max = maximum; SD = standard deviation; NR = not recorded

* Farm 14 was not surveyed in 1993

Appendix 3.48 : Means, ranges, standard deviations and quartiles of growth rates (g/d) of weaner hinds and stags in 1992, 1993 and both year combined.

	Weaner hinds			Weaner stags		
Period	1992	1993	Both years combined	1992	1993	Both years combined
Growth rates from April 1 to June 1						
Number of deer	474.0	612.0	1086.0	499.0	650.0	1149.0
Mean	95.7	95.2	95.4	120.0	110.4	114.6
Minimum	-66.2	-114.3	-114.3	-36.1	-42.9	-42.9
Maximum	225.7	315.4	315.4	268.9	330.8	330.8
Standard deviation	48.7	52.6	50.9	55.0	53.9	54.6
25th percentile	64.0	61.9	62.0	83.3	76.2	78.3
50th percentile	96.0	89.3	92.5	116.2	103.7	109.2
75th percentile	128.7	125.5	127.2	156.6	145.3	150.2
Growth rates from June 1 to September 1						
Number of deer	414.0	479.0	893.0	468.0	586.0	1054.0
Mean	38.5	64.5	52.4	75.4	102.7	90.6
Minimum	-92.7	-74.6	-92.7	-87.8	-65.9	-87.8
Maximum	180.1	183.2	183.2	231.7	275.9	275.9
Standard deviation	35.4	37.1	38.6	51.2	44.3	49.4
25th percentile	13.6	39.7	27.8	37.1	75.4	60.5
50th percentile	37.1	64.2	54.1	74.7	100.7	92.8
75th percentile	63.3	85.0	75.5	113.9	129.9	122.2
Growth rates from September 1 to December 1						
Number of deer	435.0	435.0	870.0	374.0	518.0	892.0
Mean	132.7	150.8	141.7	196.8	213.2	206.3
Minimum	8.8	58.8	8.8	16.4	31.2	16.4
Maximum	229.6	279.1	279.1	348.2	343.6	348.2
Standard deviation	33.0	34.6	35.0	56.1	44.1	50.1
25th percentile	109.9	127.6	118.5	155.5	188.3	176.5
50th percentile	134.6	147.7	141.4	197.1	212.1	208.6
75th percentile	155.1	173.9	164.4	235.5	237.0	236.6
Growth rates from December 1 to March 1						
Number of deer	439.0	403.0	842.0	298.0	319.0	617.0
Mean	190.2	130.2	161.5	235.4	180.7	207.1
Minimum	53.5	-63.4	-63.4	39.7	-36.7	-36.7
Maximum	350.3	340.7	350.3	426.5	459.3	459.3
Standard deviation	50.7	60.1	62.9	66.2	74.4	75.7
25th percentile	156.3	88.9	119.1	186.3	132.1	157.0
50th percentile	188.7	130.1	161.6	233.1	177.1	205.2
75th percentile	223.3	168.3	204.8	277.9	227.8	259.7

Appendix 3.49 : Bodyweights (kg) of yearling stags on each survey farm in 1992 and 1993.

	MARCH						JUNE					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	NR						31-May	54	106.2	88.0	129.0	9.0
3	NR						03-Jun	1	77.5	77.5	77.5	
6	17-Mar	46	85.9	70.0	102.0	8.3	22-Jun	24	87.9	76.0	100.0	6.6
7	08-Mar	22	90.5	78.2	109.5	7.0	28-May	24	95.9	81.4	138.5	11.0
8	21-Feb	11	105.4	78.0	151.0	17.2	21-Jun	11	104.8	91.0	137.0	12.9
9	23-Feb	36	106.4	84.0	133.0	9.6	NR					
10	NR						18-Jun	24	114.8	108.0	127.5	4.9
13	NR						26-Jun	3	81.7	57.0	101.0	18.4
15	NR						15-Jun	69	104.0	86.5	118.5	7.6
16	NR						03-Jul	35	87.5	66.5	109.5	10.1
All farms		115	95.1	70.0	151.0	13.5		245	100.5	57.0	138.5	12.6
Year 1993												
1	14-Mar	46	105.7	68.0	131.0	13.9	06-Jun	46	106.9	73.0	136.0	13.2
3	13-Mar	29	90.7	70.0	106.0	9.0	NR					
6	NR						10-May	32	91.4	68.0	108.0	10.2
7	20-Mar	32	86.8	79.0	97.0	4.7	05-Jun	31	92.2	84.5	98.0	4.1
8	02-Feb	25	82.3	67.0	98.0	7.1	26-May	24	87.9	70.5	98.0	6.4
10	NR						10-Jun	28	116.6	85.5	130.5	9.5
11	NR						25-May	68	99.8	73.0	119.0	8.7
13	25-Mar	28	99.2	77.5	115.5	9.2	NR					
15	29-Mar	10	89.8	77.0	108.0	8.9	10-Jun	37	92.1	70.0	143.0	13.4
16	17-Mar	45	94.5	76.0	114.5	9.5	29-Jun	45	93.0	75.0	113.0	9.2
All farms		215	94.2	67.0	131.0	12.4		311	97.9	68.0	143.0	12.9
All stags combined		330	94.5	67.0	151.0	12.8		556	99.0	57.0	143.0	12.8

	SEPTEMBER						NOVEMBER					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	09-Sep	54	102.0	82.0	117.0	8.1	V	53	127.8	106.0	149.0	9.6
2	NR						16-Nov	11	118.2	108.5	124.5	4.6
3	NR						V	2	120.0	103.0	137.0	17.0
6	NR						09-Nov	24	94.7	78.0	110.0	7.2
7	12-Sep	16	91.1	62.5	144.5	15.9	28-Nov	18	99.0	75.0	118.5	10.9
10	31-Aug	24	116.8	109.5	127.5	5.2	V	19	142.3	121.0	158.0	9.9
13	NR						V	4	98.4	92.5	107.0	6.0
15	NR						V	55	125.6	99.0	146.0	11.2
16	13-Sep	34	83.0	65.5	104.0	9.0	05-Jan	37	113.9	85.0	140.5	12.2
All farms		128	98.4	62.5	144.5	15.0		223	119.2	75.0	158.0	17.0
Year 1993												
1	NR						V	43	130.5	94.0	166.0	16.5
3	NR						10-Jan	21	112.0	92.0	128.0	8.9
6	06-Sep	18	94.1	71.5	109.5	11.1	NR					
7	28-Aug	23	92.8	82.0	101.0	5.1	V	16	106.1	98.5	116.5	5.8
10	01-Sep	24	116.1	104.0	125.5	5.8	V	24	147.5	135.0	165.5	7.3
15	NR						V	66	109.6	81.0	127.0	9.7
16	11-Sep	45	96.0	78.0	114.0	8.9	V	23	127.4	101.5	151.0	10.8
All farms		110	99.4	71.5	125.5	12.0		193	121.0	81.0	166.0	17.6
All stags combined		238	98.8	62.5	144.5	13.7		416	120.1	75.0	166.0	17.3

Note : Farm 14 was not surveyed in 1993

Min = minimum; Max = maximum; SD = standard deviation; NR = not recorded by the farmer,
V = at velvet antler harvesting

Appendix 3.50 : Bodyweights (kg) of adult stags on each survey farm in 1992 and 1993.

	MARCH						JUNE					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	NR						25-May	58	162.8	123.0	196.0	14.5
3	NR						03-Jun	47	130.9	102.0	168.0	18.4
4	05-Feb	3	199.0	174.0	230.0	23.3	NR					
6	NR						22-Jun	54	122.7	80.0	166.0	19.9
7	08-Mar	17	142.2	83.6	187.0	28.3	01-Jun	20	125.4	82.6	158.0	19.6
10	NR						18-Jun	23	154.5	124.5	187.5	17.6
11	NR						15-Jun	90	131.9	103.0	173.0	14.9
13	NR						26-Jun	2	143.0	125.0	161.0	18.0
14	09-Mar	13	139.8	122.0	163.0	11.7	08-Aug	74	136.8	117.0	154.0	8.9
15	NR						15-Jun	69	139.5	103.0	168.5	12.1
16	NR						03-Jul	49	123.7	92.5	167.5	18.9
All farms		33	146.4	83.6	230.0	28.2		486	136.3	80.0	196.0	19.8
Year 1993												
1	10-Mar	4	215.5	202.0	223.0	8.2	20-Jun	63	156.1	120.0	186.0	15.0
3	17-Mar	4	202.8	155.0	231.0	28.6	19-Jun	47	144.1	106.0	179.0	17.2
7	NR						05-Jun	23	130.6	72.5	167.0	20.1
10	NR						16-Jun	36	160.9	138.0	204.0	16.0
11	NR						25-May	139	136.4	95.0	242.0	22.2
15	NR						10-Jun	44	128.1	81.0	158.0	19.3
16	NR						29-Jun	86	123.1	80.5	171.0	17.9
All farms		8	209.1	155.0	231.0	22.0		438	138.3	72.5	242.0	22.7
All stags combined		41	158.6	83.6	231.0	36.7		924	137.3	72.5	242.0	21.2

	SEPTEMBER						NOVEMBER					
Farm code	Date	Number of deer	Mean	Min	Max	SD	Date	Number of deer	Mean	Min	Max	SD
Year 1992												
1	09-Sep	58	146.2	116.0	174.0	13.6	V	62	163.5	128.0	215.0	16.3
3	NR						V	48	147.4	112.0	197.0	19.2
7	12-Sep	20	120.8	77.0	154.0	19.7	V	22	130.3	89.5	167.0	19.8
10	02-Sep	24	156.6	126.5	198.0	20.5	V	25	176.5	147.0	221.0	19.0
11	NR						V	105	149.2	108.0	222.0	23.3
13	NR						V	17	157.5	144.0	192.0	11.8
15	NR						V	43	142.3	107.0	171.5	13.9
16	13-Sep	49	114.6	88.5	155.5	16.6	V	49	142.4	112.0	192.5	18.7
All farms		151	134.2	77.0	198.0	23.7		371	150.7	89.5	222.0	22.1
Year 1993												
1	05-Sep	63	145.2	110.5	169.0	13.1	V	53	165.1	133.0	203.0	14.9
3	NR						V	30	167.8	127.0	203.0	17.8
7	NR						V	12	135.3	114.0	178.5	15.3
10	01-Sep	29	155.1	132.0	199.5	16.7	V	28	179.2	153.0	219.0	16.6
15	NR						V	81	145.4	36.0	183.0	21.3
16	11-Sep	63	120.7	91.5	163.0	15.3	V	63	148.0	116.0	199.0	17.4
All farms		155	137.1	91.5	199.5	20.4		267	155.5	36.0	219.0	22.0
All stags combined		306	135.7	77.0	199.5	22.1		638	152.7	36.0	222.0	22.2

Note : Farm 14 was not surveyed in 1993

Min = minimum; Max = maximum; SD = standard deviation; NR = not recorded by the farmer;

V = at velvet antler harvesting

Appendix 3.51 : Bodyweight changes (kg) of adult and yearling stags on each survey farm in 1992 and 1993.

Farm code	Yearling stags					Adult stags				
	Number of deer	Mean	Min	Max	SD	Number of deer	Mean	Min	Max	SD
Bodyweight change between June and September (g/d)										
Year 1992										
1	54	-41.4	-128.7	19.8	20.8	57	-153.8	-233.6	-46.7	40.8
7	16	-45.4	-189.3	58.3	62.2	19	-37.9	-106.8	271.8	81.4
10	24	25.9	-27.0	108.1	30.8	23	37.2	-118.4	230.3	93.0
16	34	-61.9	-222.2	13.9	53.3	49	-126.1	-402.8	305.6	104.7
All farms	128	-34.7	-222.2	108.1	50.1	148	-100.1	-402.8	305.6	105.9
Year 1993										
1						63	-141.5	-376.6	0.0	67.4
6	18	19.8	-21.0	67.2	22.9					
7	22	27.9	-59.5	89.3	32.0					
10	22	-44.4	-96.4	60.2	39.8	29	-103.9	-214.3	32.5	66.0
16	45	41.4	-40.5	236.5	49.6	63	-86.8	-432.4	148.6	72.6
All farms	107	17.4	-96.4	236.5	52.0	155	-112.2	-432.4	148.6	73.7
All stags combined	235	-11.0	-222.2	236.5	57.2	303	-106.3	-432.4	305.6	91.1
Bodyweight change between June and the time of velvet antler removal (g/d)										
Year 1992										
1	52	105.5	34.7	143.6	20.2	58	-1.2	-100.0	114.9	45.4
3	1	114.9	114.9	114.9		47	82.9	-18.6	187.2	42.2
5	24	48.4	-28.6	100.0	33.0					
6	10	38.2	-91.1	67.2	44.8					
7						19	34.1	-67.6	206.0	63.3
9	19	151.7	62.9	212.3	38.2					
10						22	159.3	-34.0	338.8	89.0
11						87	74.9	-65.5	379.6	66.1
13	55	115.8	40.5	206.0	38.1					
14	35	131.1	-161.1	194.6	75.5					
15						42	25.4	-160.2	137.6	58.3
16	49	114.6	88.5	155.5	16.6	49	124.0	-26.9	205.5	44.5
All farms	196	107.1	-161.1	212.3	53.8	324	66.8	-160.2	379.6	74.6
Year 1993										
1						53	47.7	-300.0	164.3	66.3
3						29	110.6	-21.6	331.4	65.9
7	15	88.8	56.4	125.0	21.6	12	84.4	27.2	267.0	60.1
10	22	149.2	111.4	230.4	26.3	28	108.6	-15.0	208.9	59.8
15	33	106.2	44.0	189.5	39.1	31	21.4	-88.6	182.4	61.5
16	16	174.9	130.7	232.1	25.2	63	141.7	-14.8	300.0	60.4
All farms	129	127.0	44.0	232.1	42.5	216	89.7	-300.0	331.4	77.0
All stags combined	325	115.0	-161.1	232.1	50.6	540	76.0	-300.0	379.6	76.4
Percentage of bodyweight change between June and the time of velvet antler removal (%)										
Year 1992										
1	52	19.6	6.5	28.4	4.2	58	0.1	-8.8	11.1	4.6
3	1	32.9				47	12.2	-2.0	35.5	6.8
6	24	7.8	-4.9	16.7	5.5					
7	10	7.3	-17.9	13.4	8.8	19	6.5	-7.0	32.5	9.5
10	19	22.5	8.8	32.8	6.0	22	16.3	-2.9	41.4	9.6
11						87	8.7	-7.4	32.8	6.9
15	55	19.3	7.0	34.6	6.4	42	2.9	-19.5	14.0	6.2
16	35	30.0	19.4	45.1	5.6	49	15.6	-3.4	31.9	6.1
All farms	196	19.7	-17.9	45.1	8.9	324	8.4	-19.5	41.4	8.7
Year 1993										
1	43	22.5	13.0	38.9	6.1	53	4.4	-22.7	12.8	5.5
3						29	12.2	-1.8	51.8	9.2
7	15	19.2	12.1	24.7	4.4	12	15.1	4.0	24.7	3.7
10	22	23.3	17.1	39.7	4.9	28	10.2	-1.3	22.8	6.2
15	33	22.1	7.5	51.4	10.0	31	2.7	-9.9	21.8	7.5
16	16	29.9	23.0	35.9	4.1	63	17.1	-1.4	35.8	8.6
All farms	129	23.1	7.5	51.4	7.4	216	10.2	-22.7	51.8	9.2
All stags combined	325	21.0	-17.9	51.4	8.5	540	9.1	-22.7	51.8	9.0

Min = minimum; Max = maximum; SD = standard deviation; V = at velvet antler harvesting

Appendix 3.52 : Velvet antler production from yearling stags on each survey farm in 1992 and 1993 Percentage of each velvet grade (%) and average velvet weight per stag (kg) within each grade and all grade combined.

Farm code	Number of stags	VELVET ANTLER GRADE						Average velvet weight/stag
		B	C	D	E	Others	Not graded	
Year 1992								
1	53	24.5	28.3	41.5			5.7	
	Velvet weight	1.9	1.6	1.4			0.8	1.54
2	12						100.0	
	Velvet weight						1.1	1.14
3	2				50.0		50.0	
	Velvet weight				0.8		2.3	1.50
5	37		5.4	45.9	32.4	10.8	5.4	
	Velvet weight		0.9	1.1	0.8	0.9	1.0	0.97
6	12			100.0				
	Velvet weight			1.3				1.30
7	15	6.7	13.3	80.0				
	Velvet weight	2.5	1.3	1.1				1.26
8	1			100.0				
	Velvet weight			1.5				1.50
9	44	4.5	25.0	59.1	11.4			
	Velvet weight	1.5	1.6	1.1	1.0			1.24
10	19	5.3	15.8	42.1		36.8		
	Velvet weight	1.5	1.6	1.4		0.7		1.17
11	57			84.2	15.8			
	Velvet weight			0.9	0.8			0.89
13	7		28.6	42.9			28.6	
	Velvet weight		1.4	1.2			1.3	1.29
15	63	9.5	22.2	61.9	3.2		3.2	
	Velvet weight	1.5	1.3	1.1	0.9		0.5	1.14
16	37		5.4	75.7	18.9			
	Velvet weight		1.3	1.1	0.9			1.05
All farms	359	6.4	14.2	60.2	10.0	3.1	6.1	100.00
	Velvet weight	1.8	1.5	1.1	0.8	0.8	1.1	1.16
Year 1993								
1	47	23.4	53.2	23.4				
	Velvet weight	1.9	1.5	1.2				1.52
3	21	4.8		61.9	33.3			
	Velvet weight	1.5		1.1	1.0			1.10
5	9	11.1	55.6	11.1	22.2			
	Velvet weight	1.4	1.2	1.0	0.9			1.12
6	8	12.5	25.0	25.0	25.0		12.5	
	Velvet weight	1.9	1.7	1.2	0.9		0.5	1.25
7	16	12.5	37.5	43.8	6.3			
	Velvet weight	1.0	1.3	1.1	0.9			1.16
9	21	14.3	38.1	47.6				
	Velvet weight	1.9	1.1	1.1				1.23
10	24	8.3	41.7	50.0				
	Velvet weight	1.6	1.4	1.2				1.31
11	24	4.2	4.2	41.7	50.0			
	Velvet weight		1.2	1.1	0.9			1.01
15	67		7.5	76.1	16.4			
	Velvet weight		1.2	1.1	0.8			1.04
16	16	6.3	25.0	62.5			6.3	
	Velvet weight	1.4	1.2	1.0			1.1	1.11
All farms	253	9.1	26.1	50.2	13.8		0.8	
	Velvet weight	1.7	1.4	1.1	0.9		0.8	1.19

Note : Velvet antler grades are defined in the GIB velvet antler removal guidelines (see Appendix 1.1)

Appendix 3.53 : Velvet antler production from adult stags on each survey farm in 1992 and 1993 Percentage of each velvet grade (%) and average velvet weight per stag (kg) within each grade and all grade combined, and average corrected velvet weight per stag (kg).

Farm code	Number of stags	VELVET ANTLER GRADE							Average velvet weight per stag*	
		A - SA	B	C	D	E	Others	Not graded	MVW	MCVW
Year 1992										
1	64	32.8	48.4	15.6	1.6			1.6		
	Velvet weight	3.1	2.7	2.0	1.8			3.6	2.72	1.28
2	9		100.0							
	Velvet weight		2.1						2.09	0.56
3	46	2.2	13.0	28.3	52.2	4.3				
	Velvet weight	2.6	1.8	1.5	1.2	0.9			1.38	0.39
4	2	50.0	50.0							
	Velvet weight	2.5	2.3						2.40	1.27
5	74	4.1	24.3	37.8	25.7	2.7	5.4			
	Velvet weight	2.6	2.5	1.7	1.5	1.1	1.8		1.88	0.64
6	56	7.1	41.1	17.9	33.9					
	Velvet weight	2.7	2.0	1.8	1.4				1.80	0.43
7	22	4.5	40.9	36.4	13.6			4.5		
	Velvet weight	2.5	2.2	1.5	0.9			0.6	1.72	0.55
8	5		20.0					80.0		
	Velvet weight		2.7					2.0	2.12	0.43
9	31	3.2	32.3	38.7	25.8					
	Velvet weight	2.4	2.1	1.8	1.6				1.87	0.75
10	25	15.6	52.0	24.0	8.0					
	Velvet weight	4.0	2.5	1.8	1.6				2.43	1.21
11	107		17.8	29.0	51.4	1.9				
	Velvet weight		2.4	1.9	1.5	1.3			1.78	0.72
13	65	15.2	46.2	30.8	6.2		1.5			
	Velvet weight	2.6	2.3	2.0	1.6		2.4		2.24	0.85
14	70	2.9	78.6	18.6						
	Velvet weight	2.2	2.0	1.6					1.96	1.12
15	67	3.0	26.9	38.8	14.9			16.4		
	Velvet weight	2.7	2.1	1.7	1.6			1.5	1.77	0.83
16	49	6.1	30.6	32.7	30.6					
	Velvet weight	2.9	2.1	1.6	1.3				1.74	0.62
All farms	414	7.7	37.3	27.9	23.1	0.9	0.7	2.5		
	Velvet weight	2.9	2.2	1.8	1.4	1.1	1.9	1.7	1.94	0.78
Year 1993										
1	59	42.1	50.8	5.1	1.7					
	Velvet weight	3.2	2.5	2.1	0.9				2.76	1.37
3	30	3.3	63.3	23.3	10.0					
	Velvet weight	3.5	2.3	1.8	1.5				2.13	0.82
4	4	50.0	50.0							
	Velvet weight	2.8	2.2						2.52	1.26
5	91	14.3	48.4	25.3	11.0		1.1			
	Velvet weight	2.6	2.3	1.7	1.5		2.0		2.10	0.71
6	52	15.4	46.2	34.6	3.8					
	Velvet weight	2.6	2.1	1.8	1.5				2.06	0.56
7	12	25.0	50.0	25.0						
	Velvet weight	2.3	2.0	1.7					1.95	0.81
9	43	30.2	53.5	11.6	4.7					
	Velvet weight	2.6	2.1	1.6	1.3				2.15	1.07
10	27	29.6	55.6	14.8						
	Velvet weight	2.9	2.4	1.6					2.42	1.25
11	97	2.1	34.0	38.1	25.8					
	Velvet weight	2.7	2.3	1.9	1.6				1.97	0.65
13	62	38.7	46.8	11.3	3.2					
	Velvet weight	2.6	2.3	1.8	1.5				2.37	0.73
15	93	3.2	39.8	33.3	20.4		1.1	2.2		
	Velvet weight	3.5	2.3	1.8	1.5		0.8	1.4	1.99	1.01
16	63	3.2	47.6	38.1	11.1					
	Velvet weight	2.7	2.1	1.7	1.5				1.93	0.69
All farms	633	16.4	46.1	25.6	11.2		0.3	0.3		
	Velvet weight	2.8	2.3	1.8	1.5		1.4	1.4	2.15	0.85

Note : Velvet antler grades are defined in the GIB velvet antler removal guidelines (see Appendix 1.1)

* Mean velvet antler weight was corrected for the age of the stag at the time of velvet antler removal as described in Table 2.36.

MVW = mean velvet weight; MCVW = mean corrected velvet weight

Appendix 3.54 : Mortalities and estimated mortality rates of weaner hinds and stags (3-15 months) from April 1 1992 to April 1 1994 on each survey farm and all farms combined.

Health problems		Farm codes 1	2	3	4	5	6	7	8	9	10	11	13	15	16	Total number	%	Mortality rates (/100 weaner-years)
Unconfirmed	Yersiniosis ?								1	4		1	13	58		77	41.0	2.40
	Lungworm								1							1	0.5	0.03
	Lameness								3							3	1.6	0.09
	Swollen joint								1							1	0.5	0.03
	Fading				1											1	0.5	0.03
	Septicaemia								1							1	0.5	0.03
	Hepatitis												1			1	0.5	0.03
	Enteritis													1		1	0.5	0.03
	Other		1			1	3	1	6				2	9	3	26	13.8	0.81
														Total unconfirmed :		112	59.6	3.50
Yersiniosis		3						1					29		2	35	18.6	1.09
Misadventure	Other	1							1			2		1		5	2.7	0.16
	Broken neck			1		1	1		2		4	1		3	2	15	8.0	0.47
	Broken leg	1		1	1				2					2		7	3.7	0.22
	Injury	1														1	0.5	0.03
	Stress at weaning											1				1	0.5	0.03
														Total misadventure :		29	15.4	0.91
Osteochondrosis				9												9	4.8	0.28
Malignant catarrhal fever*				1												1	0.5	0.03
Miscellaneous	Malformation									1						1	0.5	0.03
	Blind														1	1	0.5	0.03
														Total miscellaneous :		2	1.1	0.06
Total losses :		6	1	12	2	2	4	2	18	5	4	5	45	74	8	188	100.0	
Mortality rates	(/100 weaner-years)	2.52	0.35	8.98	1.67	2.15	2.70	2.39	6.49	2.49	2.38	2.69	30.30	8.01	4.00			5.87
Number of weaner-years at risk		238	282	134	119	93	148	84	277	200	168	186	149	923	200			3202

* This weaner died on August 28 1993 (8-9.5 months)

Appendix 3.55 : Mortalities and estimated mortality rates of yearling and adult stags from April 1 1992 to April 1 1994 on each survey farm and all farms combined.

Health problems		Farm codes														Total number	%	Mortality rates (/100 stag-years)
		1	2	3	4	5	6	7	8	9	10	11	13	15	16			
Unconfirmed	Other		1				10					2	4	1	2	20	31.7	0.81
	Fading					1	2			1						4	6.3	0.16
	Interstitial nephritis													1		1	1.6	0.04
	Black-leg						1									1	1.6	0.04
	Johnes disease ?									1						1	1.6	0.04
														Total unconfirmed :		27	42.2	1.10
MCF*	Acute	1						1		2		1		5		10	15.9	0.41
	Chronic	1									1	1				3	4.8	0.12
														Total MCF :		13	20.6	0.53
Misadventure	Other	1		1		1		1						4		8	12.7	0.33
	Handling stress						1				1					2	3.2	0.08
	Broken neck													3		3	4.8	0.12
	Broken leg							2								2	3.2	0.08
	Stag fight						1					1				2	3.2	0.08
	Injury	1		1										1		3	4.8	0.12
														Total misadventure :		20	31.7	0.81
Miscellaneous	Facial abcesses													2		2	3.2	0.08
	Gun shot					1										1	1.6	0.04
														Total miscellaneous :		3	4.8	0.12
Total mortalities		4	1	2	0	3	15	4	0	4	2	5	4	17	2	63	99.3	
Mortality rates	(/100 stag-years)	1.82	2.14	1.76	0.00	1.32	9.62	4.44	0.00	2.80	1.84	1.47	2.14	2.93	0.99			2.56
Number of stag-years at risk		220	47	113	6	226	156	90	39	143	109	340	187	581	202			2459

*MCF = malignant catarrhal fever

Appendix 3.56 : Mortalities and estimated mortality rates of yearling and adult hinds from April 1 1992 to April 1 1994 on each survey farm and all farms combined.

Health problems		Farm codes 1	2	3	4	5	6	7	8	9	10	11	13	15	16	Total number	%	Mortality rates (/100 hind-years)
Unconfirmed	Fading		2				1	1	4			2	1	1	1	13	15.7	0.28
	Ataxia		1													1	1.2	0.02
	Pneumonia														1	1	1.2	0.02
	Enteritis	1				1										2	2.4	0.04
	Rumenitis					1										1	1.2	0.02
	Dystocia ?			1				1								2	2.4	0.04
	Other	1	4	2			6		1		1		2	7	1	25	30.1	0.53
														Total unconfirmed :		45	54.2	0.96
Dystocia		1		1					2						4	8	9.6	0.17
Malignant catarrhal fever		2	1					1	1	1					1	7	8.4	0.15
	Chronic MCF*														1	1	1.2	0.02
														Total MCF :		8	9.6	0.17
Misadventure	Other					1										1	1.2	0.02
	Drowned						7									7	8.4	0.15
	Injury	1														1	1.2	0.02
	Broken neck		2					2						1		5	6.0	0.11
	Broken leg		1						1					1		3	3.6	0.06
														Total misadventure :		17	20.5	0.36
Miscellaneous	Enzootic ataxia			3												3	3.6	0.06
	Liver cancer	1														1	1.2	0.02
	Volvulus	1														1	1.2	0.02
														Total miscellaneous :		5	6.0	0.11
Total mortalities :		8	11	7	0	3	14	5	9	1	1	2	3	10	9	83	100.0	
Mortality rates	(/100 hind-years)	2.34	2.40	2.30	0.00	1.90	4.33	3.96	1.87	0.36	0.27	0.83	0.70	1.51	2.56			1.77
Number of hind-years at risk		342	459	305	155	158	323	126	482	279	369	241	428	663	351			4683

* MCF = malignant catarrhal fever

Appendix 3.57 : Diagnoses of calf mortality from birth to March 1 (2-3 months) on each survey farm in 1992 and 1993 and estimated overall calf mortality rates

	Farm codes															Total	
Mortality diagnoses	1	2	3	4	5	6	7	8	9	10	11	13	15	16		number	%
Hind-calf relationship																	
Dystocia	3		1	1	2		2	2		4				6		21	22.1
Stillbirth	1			1	1		2			3				1		9	9.5
Small weak fawn			1											1		2	2.1
Overmothered	1															1	1.1
Mismothering	2									3	1					6	6.3
Fawn victimised	1			2										3		6	6.3
Ruptured stomach	3															3	3.2
															Total :	48	50.5
Calf diseases																	
Malformation (scoliosis)				1												1	1.1
Cryptosporidiosis	1															1	1.1
Liver abscess (navel infection)										1						1	1.1
															Total :	3	3.2
Direct management related																	
Weather stress		2														2	2.1
Handling stress			1													1	1.1
Fawn lost				1												1	1.1
Lost through fence						1		3		1		2		1		8	8.4
Left behind	1													1		2	2.1
Misadventure										1				1		2	2.1
Broken neck	1															1	1.1
Broken leg			1													1	1.1
Broken back	1															1	1.1
															Total :	19	20.0
Unconfirmed	10		2	4		1	1	3			1	3				25	26.3
Total diagnoses :	25	2	6	10	3	2	5	8	0	13	2	5	0	14		95	100.0

Appendix 3.58 : Calculation of progeny loss rates (%) of yearling (<26 months) and adult hinds on each survey farm in 1992, 1993 and both years combined.

		FARM CODES														All
		1	2	3	4	5	6	7	8	9	10	11	13	15	16	farms
YEARLING HINDS																
1992	Number of hinds at risk*	22	20	2	14	11	44	16	25	26	22		39	42	30	313
	Suspected foetal losses				1											1
	Observed calf losses†	3			3						3				2	11
	Hind lactating at weaning	19	20	2	10	9	27	14	24	20	19		33	30	26	253
	Unobserved foetal or calf losses					2	17	2	1	6			6	12	2	48
	Progeny loss rates	13.6	0.0	0.0	28.6	18.2	38.6	12.5	4.0	23.1	13.6		15.4	28.6	13.3	19.2
1993	Number of hinds at risk*	33	20	15	12	7	13	4	28	35	32	1	31	70	39	340
	Suspected foetal losses										1					1
	Observed calf losses†				1			1			1				2	5
	Hind lactating at weaning	27	17	11	11	6	11	3	24	27	28	1	28	59	36	289
	Unobserved foetal or calf losses	6	3	4		1	2		4	8	2		3	11	1	45
	Progeny loss rates	18.2	15.0	26.7	8.3	14.3	15.4	25.0	14.3	22.9	12.5	0.0	9.7	15.7	7.7	15.0
Both years	Number of hinds at risk*	55	40	17	26	18	57	20	53	61	54	1	70	112	69	653
	Suspected foetal losses				1						1					2
	Observed calf losses†	3			4			1			4				4	16
	Hind lactating at weaning	46	37	13	21	15	38	17	48	47	47	1	61	89	62	542
	Unobserved foetal or calf losses	6	3	4	0	3	19	2	5	14	2	0	9	23	3	93
	Progeny loss rates	16.4	7.5	23.5	19.2	16.7	33.3	15.0	9.4	23.0	13.0	0.0	12.9	20.5	10.1	17.0
ADULT HINDS																
1992	Number of hinds at risk*	126	205	139	61	73	115	35	185	76	148	110	175	121	119	1688
	Suspected foetal losses	1			1		1	2	2		1	1				9
	Observed calf losses†	18		5	3	1		2	6		7	1	1		7	51
	Number of calves weaned‡	106	185	119	58	64	104	31	177	72	138	104	155	108	105	1526
	Unobserved foetal or calf losses	1	20	15		8	10				2	4	19	13	7	99
	Progeny loss rates	15.9	9.8	14.4	4.9	12.3	9.6	11.4	4.3	5.3	6.8	5.5	11.4	10.7	11.8	9.6
1993	Number of hinds at risk*	113	186	129	61	59	117	51	188	97	144	102	175	126	128	1676
	Suspected foetal losses			1	1					1	1	2			1	7
	Observed calf losses**	4	2	1	3		2	2	2		2	1			3	22
	Number of calves weaned‡	105	156	126	58	48	101	46	175	93	142	96	153	111	117	1527
	Unobserved foetal or calf losses	4	28	1		11	14	3	11	3		3	22	15	7	122
	Progeny loss rates	7.1	16.1	2.3	0.0	18.6	13.7	9.8	6.9	4.1	0.0	5.9	12.6	11.9	8.6	8.9
Both years	Number of hinds at risk*	239	391	268	122	132	232	86	373	173	292	212	350	247	247	3364
	Suspected foetal losses	1	0	1	2	0	1	2	2	1	2	3	0	0	1	16
	Observed calf losses†	22	2	6	6	1	2	4	8	0	9	2	1	0	10	73
	Number of calves weaned‡	211	341	245	116	112	205	77	352	165	280	200	308	219	222	3053
	Unobserved foetal or calf losses	5	48	16		19	24	3	11	7	1	7	41	28	14	224
	Progeny loss rates	11.7	12.8	8.6	4.9	15.2	11.6	10.5	5.6	4.6	4.1	5.7	12.0	11.3	10.1	9.2

Note : Farms 5 and 13 in 1992, and farm 13 in 1993 observed 2, 1 and 3 calf losses, respectively, that could not be attributable to yearling or adult hinds, so they were not included with "observed calf losses".
Farm 15 in 1992 : 23 in-calf yearling wapiti-cross hinds bought prior to calving were not included in this calculation

* Number of hinds at risk = Estimated number of hinds pregnant in June (number of hinds mated X conception rate /100) that were on farms for calving including hinds artificially inseminated

† Includes calves found dead and death of pregnant hinds during calving, 8 adult and 1 yearling hinds that were diagnosed pregnant in June died during calving for reasons not identified as related to calving difficulties, so were not reported as "observed calf loss"

‡ All dry (not lactating) hinds at weaning were not identified according to the number of calves weaned. For convenience, the number of calves from yearling hinds have been counted as the actual number of hinds recorded wet (lactating) at weaning, but misclassification could have occurred.

Appendix 3.59 : Health problems of weaners (3-15 months), hinds and stags which did not lead to death on each survey farm from April 1 1992 to April 1 1994.

	FARM CODE															
Health problems	1	2	3	4	5	6	7	8	9	10	11	13	14	15	16	All farms
WEANERS																
Abscess	3	-	-	-	-	-	-	1	-	-	1	-	-	-	-	5
Broken leg	2	-	-	-	-	-	-	1	-	-	-	3	-	-	-	6
Fading	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Injury	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2
Lameness	-	-	1	-	-	-	-	3	-	-	-	-	-	-	-	4
Osteochondrosis	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	10
Pink eye	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Ryegrass staggers	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Scouring	1	-	-	-	-	-	-	-	-	-	3	-	-	1	-	5
Yersiniosis	18	-	-	-	-	-	-	-	-	-	-	14	-	-	13	45
Total	25	1	11	1	-	-	-	6	-	-	5	17	-	1	13	80
HINDS																
Abscess	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2
Enzootic ataxia	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	3
Foot abscess	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Fading	-	-	-	-	-	-	-	2	-	-	1	-	-	1	-	4
Injury	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Lameness	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2
Osteomyelitis	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Scouring	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2
Total	4	-	2	-	2	-	-	6	-	-	1	1	-	2	-	18
STAGS																
Abscess	3	-	1	-	-	-	-	-	-	-	-	-	-	-	0	4
Balanoposthitis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Blind	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Enteritis	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Enzootic ataxia	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Foot abscess	1	-	-	-	-	-	1	-	-	-	-	-	-	2	-	4
Fading	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3
Injury	1	-	-	-	1	-	-	1	-	-	-	-	-	-	-	3
Lameness	2	-	1	-	-	-	-	-	-	-	1	-	-	-	-	4
Scouring	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Total	11	-	3	-	1	-	1	2	2	-	1	-	-	3	-	24

Appendix 3.60 : Mortalities due to misadventure from March 1 1992 to April 1 1994.

Year	Farm code	Date of observ.	Date of death*	Number and class of deer	Diagosis Vet	Diagosis PM	Diagosis Lab	Other information
Broken leg								
1992	1	11-Mar		WS				
	15	30-Apr		WH				
	8	18-Jun	19-Jun	YH				Broken leg in the new crush
	14	29-Jun		WS				
	15	01-Sep		WH				
	2	30-Sep	01-Oct	AH	Y			
	15	23-Nov		WS				
1993	1	03-Jan		WH				
	3	16-Mar		WH	Y			
	8	28-Jul	30-Jul	WH	Y	Y		
	8	12-Nov		WS				
	4	05-Nov		WH				
	7	24-Jan		2 WS				
Broken neck								
1992	7	07-Mar		YH				
	14	16-Mar		WS				
	14	23-Mar		WS				
	7	24-Mar		WH				
	7	24-Mar		WS				
	14	20-Apr		WS				
	14	22-Apr		WS				
	6	28-Apr		WH				
	10	29-Apr		WS				
	15	11-Jul		2 WS				
	2	24-Jul		AH				
	7	27-Sep		AH				Hit the fence†
	15	02-Dec		YS				
	15	02-Dec		YS				
1993	15	16-Feb		AS				
	15	16-Feb		WS				
	10	03-Mar		WS				
	16	17-Mar		WH				Hit the fence in the race
	7	23-Mar		WH				
	16	26-Mar		WS				
	15	29-Mar		AH				
	10	15-Apr		WS				
	5	15-Jul		WS				
	8	15-Oct		WS				
Broken neck (Cont'd)								
1992	11	14-Dec		WH				Broken skull too ,accident in yard
1994	10	28-Feb		WS				Hit the fence
	8	10-Mar		WH				
	3	21-Mar		WS				Hit the fence
	7	24-Mar		AH				Hit the fence
	2	30-Mar		AH				A top-dressing plane flew over the farm
Drowned								
1992	6	22-Jul		7 AH				Following a bad storm and heavy rain
Handling stress								
1993	10	07-Nov		AS	Y	Y	Y	Stress-induced DIC during velvetting in crush
1994	6	11-Feb		AS				Died in the yards
	11	04-Mar		WH				Died 24 hours after being stressed at weaning
Injury								
1992	1	29-May		YS	Y	Y		Perforated abdomen - Peritonitis
	15	14-Dec		YS		Y	Y	Haemothorax trauma-related after velvetting
1993	11	18-Mar		WS				Back leg caught in the fence
	1	13-Jul	28-Jul	WH	Y	Y	Y	Infected fracture - Abscess in Liver
	3	22-Aug		AS	Y	Y	Y	Haemorrhages in the neck
	1	24-Mar	26-Mar	YH	Y			Rupture Achilles tendon
Other misadventure								
1992	3	04-Mar	16-Mar	WS				Deer hit the fence - Uncoordination
	1	31-Mar	07-Apr	YS	Y			Hit by a car - treatment Streptopen
	14	21-Jun		WS				Stuck in a gate
	15	11-Jul		AS	Y			Fight with other stags
	1	02-Oct		WH		Y		Strangled by wires
1993	2	04-Mar		WS				Caught badly in fences - leg bruises
	8	16-Mar		WH	Y	Y	Y	Uncoordination after hitting the fence
	11	24-Mar		WS				
	15	08-May		WS				Found hang in a tree
	3	01-Jun		AS	Y	Y	Y	Sudden death while mustering
	5	15-Jul		AH				Stuck in mud during handling
	5	15-Jul		AS				Was tramped on during handling
	7	25-Oct		AS				Drowned in dam after being tangled in fence
	15	15-Mar		2 AS				Stags fell from a cliff 30 m high
Stag fight								
1992	15	11-Jul		AS	Y			
	11	16-Aug		AS	Y	Y		Broken ribs
1993	6	16-Aug		AS	Y	Y		In the yards while Tuberculosis testing

W = Weaner; WS = Weaner stag; WH = Weaner hind; YH = Yearling hind; AH = Adult hind; YS = Yearling stag; AS = Adult stag

Vet = Veterinary diagnosis; PM = Post mortem examination; Lab = Laboratory confirmation; DIC = disseminated intravascular coagulation; Y = Yes

* date of death if different from date of observation

Appendix 3.61 : Disease history of confirmed or suspected yersiniosis in weaner deer mobs on each survey farm in 1992 and 1993

Year	Farm code	Mob ID	Dates of observation		Date shifted*	Sward characteristics		Number of weaners			Mortality risk	Diagnosis				Treatment	
			First	Last		Clover content	Residual height	Total	Observed diseased	Death		Vet	PM	Histo	Yers	Antibiotics†	Vaccination Yersiniavax
1992	7	1	20-May	20-May	20-May	G	8	60		1	0.02	Y	Y	Y	C		
	13	6	01-Jun	13-Jun	01-Jun	G	7	84		7	0.08	Y	Y	Y	S		
		7	31-May	18-Jul	31-May	G	6	37		6	0.16	Y	Y	Y	S		
	15	1A	22-Jun	08-Aug	22-Jun	G	4	375		38‡	0.10	Y	Y	Y	S		
		1B	01-Jun	13-Jul	01-Jun	G	4	461		3	0.01	N	N	N	S		
		2	15-Jun	31-Jul	22-Jun	G	7	148		17§	0.11	Y	Y	Y	S		
	16	6	31-May	31-May	31-May			99	13	2	0.02	Y	Y	Y	C	Oxytetrin LA	
1993	1	20	15-Apr	16-May	20-Apr	M	16	108	18	3	0.03	Y	Y	Y	C	Tribrissen - Scourfix	Y
	9	10	28-Apr	13-May	28-Apr	M	8	86		4	0.05	Y	N	N	S		Y
	11	2	14-May	15-May	17-May	G	13	101	3	1	0.01	N	N	N	S	Terramycin	
	13	13	13-Apr	06-Jun	13-Apr		4	184	14	29	0.16	Y	Y	Y	C	Terramycin	Y

* Dates when weaner were shifted from the paddock after the first death was noticed.

Mob ID = Mob identification code given by farmers; Vet = Veterinary diagnosis; PM = Post-mortem examination of at least one deer;

Histo = Histological investigation from at least one deer; Yer = Yersiniosis diagnosis; G = Grass dominant sward; M = Sward mixed ryegrass/white clover.

Y = Yes; N = No; C = Confirmed; S = Suspected

† Oxytetrin LA & Tribissen (Pitman-Moore New Zealand Ltd); Scourfix (Techvet Laboratories Ltd); Terramycin (Pfizer Laboratories Ltd).

‡ 15 died by Jul 13 and 23 others were found dead on Aug 8.

§ Two were euthanased by the farmer.

Appendix 3.62 : Individual characteristics of deer that died from malignant catarrhal fever and time of occurrence

Year	Farm code	Date first observation	Date of death	Form of MCF*	Class of deer	Age**	%NZ blood	Hind lactation status†	Conception status June‡	Body condition score		Body weight (kg)			Comments
										March	Sept	March	June	Sept	
Weaner deer															
1993	3	29-Aug	29-Aug		S		100						59.0	63.0§	
Hinds > 15 months															
1992	1	27-Jun	27-Jun		A	5	0	Wet	A				108.0		Newly purchased hind
	7	01-Jul	30-Jun		Y	1	100	Wet	MT	3.5		77.0	74.4		
	8	15-Jul	15-Jul		A	3	100	Dry	L				117.5		
	16	20-Jun	15-Jul	Chronic	A	4	100	Wet	MT				67.5		Scouring/Fading
		20-Jun	01-Aug		Y	1	75		MT				53.5		Scouring/Fading
	2	05-Oct	05-Oct		A	7	100		A		2				
1993	9	16-Jun	15-Jun		A	3	100	Wet		2		96.0	100.0		
	1	27-Aug	29-Aug		A	2	50	Wet	A	2.5		80.0	85.0		
Stags > 15 months															
1992	15	25-May	25-May		A										
	7	20-Jun	20-Jun		A	2	100								
	11	11-Jul	11-Jul		A										
	9	03-Aug	03-Aug		A	3	100								
	10	24-Aug	13-Sep	Chronic	A	2	100						139.0	104.0	Haemorrhagic scour
	15	12-Sep	12-Sep		A	2	100						147.0		
	9	02-Nov	02-Nov		Y	1						80.0			
	15	04-Dec	04-Dec		A	3	100						134.5		
1993	15	18-Aug	18-Aug		A	3	100								48H after TB testing
		04-Oct	04-Oct		A	2	100						123.0		
	1	15-Jul	17-Nov	Chronic	A	6	100						172.0	157.5	
		26-Dec	26-Dec		Y	1	75					118.0	116.0		
	11	23-Nov	19-Jan	Chronic	A		100						174.0		Scouring/Fading

A = Adult(>27 months); Y = Yearling(>15 months, <27 months); S = Stag; %NZ blood = Percentage of New Zealand blood lines

* Chronic malignant catarrhal fever (MCF) based on histological investigation (one hind was fading prior to death from acute MCF)

** Age at the beginning of the year

† Udder status at weaning at the beginning of the year (lactating = wet; not lactating = dry).

‡ Conception status in June as diagnosed by ultrasound (A = advanced conception (before May 1); L = late conception; MT = empty (not pregnant)

§ This weaner stag was almost the heaviest weaner in the mob (weight percentile in June : 87.6). The last weight (63 kg) was recorded on Aug 13.

Appendix 3.63 : Dystocia occurences on each survey farm in 1992 and 1993

				Calf characteristics				Intervention‡			Outcome	
Year	Farm code	Date	BCS* September	Sex†	Weight (kg)	Status	Calf presentation	Person	Method of restraint	Treatment of the hind	Hind	Calf
Yearling hinds												
1992	1	Dec	4			Dead	Unknown	-	-	-	Dead	Dead
	16	14-Nov	1.5			Dead	Front legs first	Farmer	Crush	-	Dead	Dead
1993	2	02-Dec				Dead	Unknown	Veterinarian	Drug	-	Survived and healthy	Dead
	4	25-Dec	4.5	S	7.5	Dead	Back legs first	-	-	-	Survived and healthy	Dead
	10	21-Dec	4	S		Dead	Head back	Veterinarian	Crush	-	Survived and healthy	Dead
	16	28-Dec	3			Dead	Head back	-	-	-	Killed by the farmer	Dead
		17-Dec				Dead	Head back	-	-	-	Killed by the farmer	Dead
Adult hinds												
1992	3	19-Dec	3			Dead	Front legs first	-	-	-	Dead	Dead
	5	05-Dec	4			Alive	Back legs first	Farmer	Crush	-	Survived and healthy	Dead
	8	15-Dec	3			Dead	Front legs first	-	-	-	Dead	Dead
		24-Dec	3.5			Dead	Unknown	-	-	-	Dead	Dead
	10	20-Nov	4.5	H		Dead	Back legs and head first	Farmer	Crush	Penicillin	Survived and healthy	Dead
		24-Nov	4	S	10.3	Dead	Head back	Veterinarian	Drug	Tetracycline	Survived and healthy	Dead
	16	03-Dec	2			Dead	Back legs first	Farmer	Crush	-	Dead	Dead
	16	03-Dec	2.5			Dead	Front legs first and head back	Farmer	Crush	-	Survived and healthy	Dead
1993	7	06-Dec	4			Alive	Front legs first	Farmer	-	-	Survived and healthy	Dead
	7	03-Dec	4	H		Dead	Back legs first	Farmer	-	-	Survived and healthy	Dead
	10	03-Dec	4.5	S		Alive	Back legs first	Farmer	Crush	-	Survived and healthy	Dead
	10	14-Nov	4.5	S		Alive	Back legs first	Farmer	Crush	-	Survived and healthy	Survived and mothered
	10	18-Nov	4	H		Alive	Back legs first	Farmer	Crush	Penicillin	Survived and healthy	Survived and mothered
	10	20-Nov	3.5	S	11.5	Dead	Front legs first	Farmer	Crush	-	Survived and healthy	Dead
	16	13-Dec	4	S		Dead	Head back	Farmer	-	-	Survived and healthy	Dead

* BCS = Body condition score

† Sex where recorded : H = Hind; S = Stag

‡ Intervention : - = None

Appendix 3.64 : Means, ranges and standard deviations of shoulder height (cm), thoracic girth (cm), coat length (mm) and coat density (g) of sentinel yearling and adult stags and hinds, and weaner stags and hinds (3-15 months).

YEARLING AND ADULT HINDS AND STAGS

		Yearling					Adult				
Year	Visit	n	Mean	Min	Max	SD	n	Mean	Min	Max	SD
SHOULDER HEIGHT											
Stags											
	March	51	99.2	92.7	108.0	3.4	25	107.0	96.5	111.8	3.9
	June	87	101.5	91.4	111.8	4.1	39	106.5	96.5	114.3	3.7
	September	62	100.9	91.4	110.5	3.9	35	107.6	96.5	114.3	4.1
	November	30	102.9	80.0	110.5	5.9	20	108.0	97.8	116.8	4.4
Hinds											
	March	120	96.3	88.9	104.1	3.2	131	97.4	91.4	104.1	3.0
	June	117	97.3	77.5	106.7	3.9	133	97.8	91.4	104.1	3.2
	September	123	96.9	88.9	105.4	3.3	136	97.5	91.4	105.4	3.1
THORACIC GIRTH											
Stags											
1992	March	36	113.7	102	121	5.2	10	126.0	118.0	133.0	4.5
	June	35	116.8	107	128	5.2	22	127.0	120.0	136.0	4.1
	September	34	114.7	102	126	5.4	21	123.0	115.0	130.0	4.4
	November	30	115.6	106	122	4.8	18	126.5	115.0	137.0	5.6
1993	March	46	107.5	96	118	4.8	15	120.9	110.0	133.0	5.8
	June	55	113.3	100	121	4.2	18	123.7	112.0	135.0	5.8
	September	37	113.0	101	123	5.5	18	123.2	116.0	131.0	5.0
Hinds											
1992	March	63	107.7	97	123	4.9	70	114.4	104.0	122.0	4.5
	June	60	112.9	101	125	5.6	69	115.7	106.0	125.0	4.6
	September	62	109.2	99	120	4.5	75	113.3	103.0	131.0	4.8
1993	March	70	102.7	87	114	5.0	68	108.5	99.0	123.0	4.4
	June	68	109.0	101	118	3.9	70	112.8	106.0	128.0	4.2
	September	68	107.3	96	116	4.3	69	111.5	102.0	125.0	3.9
COAT LENGTH											
Stags											
1992	March	24	47.7	40	60	5.0	22	47.7	40	55	3.6
	June	55	56.6	45	75	5.9	57	54.7	45	67	5.2
	September	55	59.8	47	70	5.4	56	56.6	37	70	6.8
1993	March	59	47.9	24	62	5.6	22	46.3	30	55	5.5
	June	60	52.2	44	66	4.6	48	51.4	30	64	6.1
	September	54	56.9	43	70	5.1	40	53.2	43	70	5.4
Hinds											
1992	March	58	44.5	35	60	4.9	70	38.9	30	50	4.2
	June	60	50.4	40	60	5.2	68	47.7	30	63	6.1
	September	62	55.1	46	65	4.3	75	52.7	43	70	4.8
1993	March	69	48.5	37	58	4.5	70	43.6	35	55	4.6
	June	68	50.0	40	62	3.9	70	45.8	37	57	3.7
	September	68	53.6	45	68	4.7	70	50.5	44	65	4.2
COAT DENSITY											
Stags											
1992	March	10	1.32	0.86	1.94	0.32					
	June	15	1.76	0.59	3.03	0.79	4	1.85	1.61	2.15	0.24
Hinds											
1992	March	49	1.09	0.10	2.12	0.31	65	1.01	0.40	1.60	0.27
	June	39	1.95	1.02	3.08	0.46	35	1.65	0.98	2.40	0.37

WEANERS

		Weaner stags					Weaner hinds				
Year	Visit	n	Mean	Min	Max	SD	n	Mean	Min	Max	SD
SHOULDER HEIGHT											
1992	November	57	96.6	91.4	106.7	4.0	38	94.5	91.4	100.3	2.7
THORACIC GIRTH											
1992	March	70	85.1	71.0	96.0	5.0	70	84.0	75.0	92.0	3.8
	June	75	96.1	78.0	108.0	6.2	70	94.7	83.0	107.0	4.8
	September	75	98.2	79.0	112.0	6.3	69	95.2	80.0	106.0	4.6
	November	71	101.8	85.0	113.0	5.8	69	97.2	70.0	107.0	5.6
1993	March	70	83.6	72.0	93.0	4.8	70	82.1	73.0	92.0	4.5
	June	70	93.5	81.0	106.0	5.3	69	92.5	80.0	101.0	4.8
	September	70	98.7	87.0	110.0	5.5	70	96.0	84.0	108.0	4.8
COAT LENGTH											
1992	March	51	48.5	20.0	70.0	10.3	51	50.4	25.0	70.0	10.0
	June	69	52.3	31.0	66.0	7.6	64	54.2	35.0	70.0	6.0
	September	76	57.6	42.0	70.0	5.5	69	58.2	43.0	70.0	5.2
1993	June	70	51.2	37.0	64.0	5.9	69	51.5	36.0	67.0	6.2
	September	70	55.3	45.0	70.0	4.7	70	55.7	47.0	70.0	5.1
COAT DENSITY											
		Weaner stags and hinds									
1992	March	84	0.58	0.19	1.00	0.16					
	June	81	1.70	0.59	3.28	0.57					

n= number of deer; Min = minimum; Max = maximum; SD = standard deviation

Appendix 3.65 : Means and standard deviations of body height at shoulder (cm) and body condition score of sentinel weaners (3-15 months), hinds and stags on each survey farm. Data from 1992 and 1993 combined.

Year or visit	Class of deer		FARM CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BODY HEIGHT AT SHOULDER																		
WEANERS																		
June		n	NR	NR	2	5	NR	NR	NR	NR	NR	2	NR	NR	NR	NR	NR	NR
		Mean			90.8	93.2						90.8						
		SD			0.6	3.6						0.6						
September		n	NR	NR	NR	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
		Mean				94.0												
		SD																
November		n	5	4	5	5	5	NR	6	10	7	10	7	10	5	NR	7	9
		Mean	95.0	92.7	94.7	97.8	97.0		91.7	96.5	97.6	96.6	93.8	97.8	97.5		95.1	94.4
		SD	3.4	1.6	3.1	1.6	2.6		0.5	5.0	4.7	3.1	2.3	3.8	1.2		2.3	3.1
HINDS																		
March	Yearling	n	7	10	5	10	9	5	10	10	10	5	6	5	8	5	10	5
		Mean	96.3	96.5	97.5	99.2	96.0	94.5	93.1	98.7	98.2	96.3	93.1	95.8	96.7	95.8	96.0	94.7
		SD	3.6	3.5	3.7	2.8	1.1	3.3	1.6	2.4	2.8	2.8	3.2	2.2	2.5	1.9	2.6	1.3
	Adult	n	10	10	9	10	10	5	10	10	10	3	10	5	10	5	10	4
		Mean	97.9	96.0	98.5	97.7	96.8	96.3	94.9	98.7	98.2	97.8	97.2	97.8	96.8	100.6	99.2	94.9
		SD	3.4	2.4	2.9	2.5	3.7	3.4	2.1	1.5	2.3	3.7	3.1	2.1	2.7	1.0	1.8	2.7
June	Yearling	n	10	4	5	9	10	10	10	10	10	9	2	NR	10	NR	10	8
		Mean	98.0	98.1	98.6	100.3	97.9	95.9	94.1	99.3	98.9	98.1	85.7		98.7		95.6	94.6
		SD	3.6	2.4	2.4	1.3	2.3	3.8	1.9	3.3	2.2	3.4	8.3		2.9		3.3	2.6
	Adult	n	9	3	10	10	10	9	10	10	10	9	10	NR	9	5	10	9
		Mean	99.2	97.8	97.8	98.7	98.2	97.4	95.1	98.2	100.2	98.4	96.5		97.8	100.6	98.3	94.4
		SD	2.8	1.0	3.5	1.8	4.4	2.9	1.7	2.1	2.6	4.1	2.8		2.7	2.2	2.1	2.8
September	Yearling	n	10	10	7	10	10	10	9	10	5	9	4	NR	10	NR	10	9
		Mean	96.8	95.5	98.2	97.7	97.5	96.4	95.1	97.5	97.8	98.8	95.3		98.7		95.8	94.8
		SD	2.7	4.5	2.7	2.3	2.7	4.0	2.4	2.9	1.4	3.2	3.5		2.7		3.1	3.1
	Adult	n	10	10	9	10	10	10	10	9	5	10	10	NR	9	5	10	9
		Mean	98.8	97.7	96.7	99.2	97.4	97.3	94.7	95.7	99.3	99.8	96.0		96.5	100.3	99.3	95.1
		SD	3.5	2.2	2.8	2.5	2.2	3.2	2.5	2.3	1.7	3.2	3.5		1.9	1.1	2.1	1.5
STAGS																		
March	Yearling	n	1	5	2	NR	9	4	5	5	2	NR	10	NR	3	NR	5	NR
		Mean	104.1	101.9	97.2		100.0	95.6	95.5	99.8	99.7		98.0		102.0		100.8	
		SD		3.3	3.2		3.3	3.2	1.5	1.0	0.6		3.3		1.2		1.7	
	Adult	n	NR	NR	NR	NR	5	NR	NR	NR	NR	NR	10	NR	NR	5	5	NR
		Mean					102.1						107.1			109.2	109.7	
		SD					4.9						2.5			1.6	1.3	
June	Yearling	n	NR	4	6	NR	9	10	10	5	10	5	10	NR	4	NR	10	4
		Mean		102.2	98.8		100.5	99.8	98.7	99.1	105.5	106.2	101.2		106.7		102.5	98.7
		SD		4.2	1.7		3.4	3.0	2.8	1.4	4.2	1.7	3.0		1.8		2.3	5.1
	Adult	n	NR	NR	6	NR	8	6	NR	NR	NR	NR	10	NR	NR	4	5	NR
		Mean			106.3		102.1	106.5					107.1			111.1	109.5	
		SD			2.9		2.4	4.0					1.7			1.1	2.0	
September	Yearling	n	5	5	4	NR	8	10	5	NR	NR	NR	10	NR	5	NR	10	NR
		Mean	102.1	101.1	97.8		102.1	97.0	100.3				100.3		100.6		105.3	
		SD	2.6	2.1	2.4		2.2	4.2	2.0				2.7		3.9		2.8	
	Adult	n	NR	NR	1	NR	9	5	NR	NR	NR	NR	10	NR	NR	5	5	NR
		Mean			109.2		105.4	105.9					108.2			110.2	108.7	
		SD					3.2	6.8					2.7			1.5	3.7	
November	Yearling	n	5	5	NR	NR	5	5	5	NR	NR	NR	NR	NR	NR	NR	5	NR
		Mean	99.3	105.7			100.3	99.8	105.4								106.7	
		SD	10.0	2.8			2.8	4.1	2.5								3.3	
	Adult	n	5	NR	NR	NR	5	NR	NR	NR	NR	NR	5	NR	NR	5	NR	NR
		Mean	109.7				103.4						108.7			110.2		
		SD	5.5				4.1						1.3			1.0		
BODY CONDITION SCORE (BCS)																		
HINDS																		
March		n	20	20	15	18	20	20	20	20	20	10	20	10	19	10	18	10
		Mean	3.3	3.3	3.2	3.1	3.2	3.5	3.4	3.6	3.6	3.5	2.7	3.2	2.9	3.3	3.3	3.2
		SD	0.6	0.5	0.7	0.6	0.5	0.8	0.6	0.3	0.7	0.4	0.7	0.2	0.6	0.5	0.6	0.7
June		n	19	20	15	20	20	20	20	20	20	20	13	NR	20	5	20	20
		Mean	4.2	4.2	3.8	4.3	3.7	3.6	3.6	3.6	4.2	4.0	3.2		3.8	3.7	3.3	3.5
		SD	0.5	0.4	0.4	0.5	0.6	0.6	0.4	0.5	0.6	0.5	0.5		0.7	0.2	0.9	0.7
September		n	20	20	10	20	20	20	16	20	20	20	14	NR	19	5	20	20
		Mean	3.3	3.4	2.8	2.9	3.2	2.8	3.4	3.2	3.4	3.5	2.9		3.4	3.2	3.1	3.0
		SD	0.5	0.6	0.2	0.8	0.7	0.5	0.6	0.8	0.6	0.8	0.5		0.5	0.2	0.6	1.0
STAGS																		
All visits combined		n	59	15	53	NR	62	41	59	10	52	49	65	NR	44	19	65	47
		Mean	3.1	3.3	3.3		3.1	2.7	3.4	3.1	3.6	3.4	3.2		3.2	3.6	3.4	3.1
		SD	0.5	0.4	0.7		0.6	0.7	0.6	0.6	0.6	0.5	0.7		0.8	0.6	0.6	0.6

n = number of sentinel deer; SD = standard deviation

NR = Not recorded because either deer were not handled or could not be measured. Farm 12 was not visited after March 1992, farm 14 was not visited after November 1992.

Appendix 3.66 : Means and standard deviations of the thoracic girth (cm) of sentinel weaners (3-15 months) and hinds on each survey farm in 1992 and 1993.

Year or visit	Class of age or sex		FARM CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
WEANERS																		
1992																		
March	Hind	n	5	5	5	5	5	5	5	5	5	NR	5	5	5	5	5	NR
		Mean	83.4	80.8	87.0	86.2	82.0	81.8	84.0	86.4	85.4		82.0	88.6	87.0	88.2	88.6	
		SD	4.8	4.2	3.1	3.5	4.7	4.0	4.0	6.5	2.9		5.9	5.6	2.4	1.7	3.5	
	Stag	n	5	5	5	5	5	5	5	5	5	NR	5	5	5	5	5	NR
		Mean	83.2	81.8	85.0	82.6	79.2	83.2	85.0	84.2	82.0		85.0	87.2	85.0	88.6	83.8	
		SD	2.9	5.5	2.5	1.4	2.1	2.9	3.0	2.6	4.3		1.3	2.0	1.4	2.1	4.7	
June	Hind	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	5	5	5
		Mean	94.4	94.6	95.0	102.2	92.0	87.8	92.4	99.4	100.8	100.2	95.8		101.2	98.4	91.4	95.6
		SD	7.1	5.0	2.4	4.1	7.8	2.5	2.2	5.8	3.5	2.1	7.6		4.5	2.0	3.5	3.0
	Stag	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	96.6	93.2	93.0	101.0	92.2	89.0	92.8	97.2	96.4	98.6	96.4		95.6		88.2	95.6
		SD	4.5	3.5	2.9	4.0	4.3	3.6	3.1	3.1	3.3	2.2	3.1		1.9		3.7	3.4
September	Hind	n	5	5	5	5	5	5	5	5	4	5	6	NR	5	5	5	5
		Mean	98.8	96.2	94.4	106.2	95.2	91.0	95.4	102.8	100.8	104.6	95.3		102.6	97.8	94.6	97.8
		SD	5.3	3.8	1.4	4.0	8.3	1.8	3.1	5.7	5.0	2.9	6.5		2.9	4.7	5.2	5.0
	Stag	n	5	5	5	5	5	5	5	5	5	5	4	NR	5	NR	5	5
		Mean	97.4	94.4	96.2	99.6	96.2	91.6	91.8	99.4	95.0	97.8	90.8		95.8		91.4	94.6
		SD	3.3	3.3	2.9	1.6	8.7	2.1	2.0	1.4	2.6	2.6	5.5		0.4		3.3	3.7
November	Hind	n	5.0	5.0	5.0	NR	5.0	5.0	5.0	5.0	5.0	5.0	6.0	NR	5.0	5.0	5.0	5.0
		Mean	102.0	99.6	98.2		99.4	93.6	98.0	106.2	105.6	107.6	99.0		107.0	105.0	96.8	107.6
		SD	2.8	3.0	2.5		7.6	2.9	3.0	3.4	4.8	1.7	5.4		2.0	2.3	3.7	3.8
	Stag	n	5	5	5	5	5	5	5	5	5	5	4	NR	5	0	5	5
		Mean	100.0	94.4	96.8	103.0	93.4	93.2	93.8	103.6	97.0	99.8	92.5		97.6	NR	93.2	101.6
		SD	2.4	3.1	4.4	0.6	11.8	1.6	3.2	1.9	1.9	2.1	4.6		1.7		3.7	2.7
1993																		
March	Hind	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	92.6	90.8	91.6	96.6	90.2	90.6	91.0	93.4	95.6	100.0	95.0		93.8		95.0	92.2
		SD	3.8	4.5	2.2	1.9	5.6	7.2	8.8	2.3	4.2	2.4	3.3		3.4		2.3	5.6
	Stag	n	5	5	5	4	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	91.0	86.0	89.8	100.0	91.2	91.0	98.4	91.0	90.8	97.0	92.2		94.6		93.4	89.8
		SD	5.4	2.8	2.3	1.2	0.7	1.9	2.0	6.4	4.7	1.7	3.2		3.8		2.3	1.6
June	Hind	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	97.8	93.2	95.2	102.4	105.8	95.2	94.8	98.2	100.6	104.0	99.0		99.4		102.0	94.6
		SD	4.4	2.6	1.5	3.4	2.3	5.7	9.2	2.3	3.1	1.8	3.1		2.6		2.4	5.1
	Stag	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	94.6	88.8	93.0	102.4	97.0	94.0	99.6	93.2	96.0	98.2	97.8		101.0		97.2	91.4
		SD	3.9	2.6	3.3	5.4	2.7	2.4	2.9	4.4	2.8	2.0	2.7		3.6		2.3	1.4
September	Hind	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	83.0	77.8	83.0	83.4	81.2	83.2	80.0	85.6	85.0	88.6	84.2		88.4		86.6	80.0
		SD	3.2	4.7	2.098	2.2	3.7	5.2	7.5	1.4	3.8	2.1	3.2		2.6		2.7	3.3
	Stag	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	79.0	76.2	82.4	82.8	81.2	78.6	86.6	81.4	80.2	84.6	81.4		87.6		86.4	86.8
		SD	4.7	2.3	3.8	5.2	2.5	1.6	3.2	0.8	4.1	1.7	3.9		3.4		2.7	2.2
HINDS																		
1992																		
March	Yearling	n	4	5	NR	5	5	5	5	5	5	NR	5	5	4	5	5	NR
		Mean	109.3	111.2		113.0	106.6	107.6	107.2	110.6	111.2		98.4	107.0	106.0	107.0	104.8	
		SD	5.8	2.6		5.3	3.1	2.3	4.0	3.1	3.9		1.0	2.2	1.4	3.5	1.8	
	Adult	n	5	5	5	5	5	5	5	5	5	NR	5	5	5	5	5	NR
		Mean	113.0	116.2	116.8	113.8	112.6	114.0	107.8	119.2	114.4		111.4	119.2	113.8	117.4	111.8	
		SD	2.8	2.3	4.6	4.5	2.4	3.7	2.3	1.3	3.9		2.4	2.2	2.8	1.0	5.7	
June	Yearling	n	5	5	NR	5	5	5	5	5	5	5	NR	NR	5		5	5
		Mean	112.6	118.2		117.8	114.0	110.6	110.0	115.2	117.2	116.4			110.6		105.4	106.6
		SD	7.6	1.2		1.9	3.6	3.0	3.7	2.1	5.7	2.7			4.7		1.6	2.9
	Adult	n	4	5	5	5	5	4	5	5	5	2	5	NR	4	5	5	5
		Mean	120.3	117.2	117.6	116.8	118.2	116.5	109.2	119.2	118.2	113.5	110.4		116.0	117.2	112.6	113
		SD	2.5	1.7	3.1	4.6	3.5	5.9	2.3	3.1	4.1	0.5	1.4		1.2	1.7	3.4	4.9
September	Yearling	n	5	5	2	5	5	5	5	5	5	5	NR	NR	5	NR	5	5
		Mean	111.2	112.0	109.0	109.8	111.8	106.8	103.2	114.4	111.0	112.8			110.0		104.0	104.0
		SD	3.3	3.2	0	2.3	2.8	2.3	2.4	2.9	4.4	2.6			1.4		2.8	2.4
	Adult	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	5	5	5
		Mean	113.8	109.6	110.6	114.4	118.0	113.0	106.2	115.4	114.6	118.6	110.8		114.8	116.8	111.8	110.8
		SD	1.7	1.7	4.2	3.2	2.2	4.3	3.7	3.0	3.8	7.4	1.9		1.7	1.7	2.9	5.0
1993																		
March	Yearling	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	106.8	103.4	105.6	106.6	103.2	101.6	98.6	107.0	104.6	103.6	95.4		101.6		99.6	100.6
		SD	4.2	3.7	2.6	0.5	8.5	2.6	2.9	2.0	3.1	1.497	4.0		2.4		3.6	4.1
	Adult	n	5	5	5	5	5	5	5	5	5	3	5	NR	5	NR	5	5
		Mean	107.8	108.2	107.2	110.8	108.8	108.4	105.8	113.8	111.2	112.7	108.6		107.0		105.4	105.4
		SD	1.9	1.9	2.3	4.8	2.4	5.5	4.1	2.5	2.7	7.6	2.0		3.0		2.4	4.6
June	Yearling	n	5	5	5	5	5	5	5	5	5	5	3	NR	5	NR	5	5
		Mean	112.8	109.8	110.4	112.8	111.4	106.8	107.2	109.0	110.4	109.4	101.7		107.8		107.0	106.6
		SD	4.1	2.8	3.6	1.3	1.6	3.1	2.3	2.8	1.6	2.3	0.9		2.6		3.8	4.4
	Adult	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	112.8	114.6	114.0	116.0	111.8	112.6	108.8	114.8	114.6	116.8	109.2		109.2		111.4	112.2
		SD	2.5	3.5	2.0	3.9	2.3	3.7	2.5	1.5	2.8	6.4	1.9		1.7		4.7	4.4
September	Yearling	n	5	5	5	5	5	5	4	5	5	5	4	NR	5	NR	5	5
		Mean	110.4	107.0	109.4	113.0	109.8	103.8	105.5	109.2	109.0	107.4	100.3		105.2		105.8	105.0
		SD	2.9	3.0	4.2	2.3	2.3	3.0	3.8	2.7	2.1	2.3	2.9		1.7		2.5	4.6
	Adult	n	5	5	5	5	5	5	5	5	5	5	5	NR	4	NR	5	5
		Mean	111.0	113.2	113.8	113.6	112.8	110.6	106.8	110.6	112.0	115.2	108.6		111.5		110.4	110.4
		SD	3.5	1.5	1.7	3.4	3.4	3.9	2.7	4.4	2.2	5.6	1.5		1.7		3.6	3.8

n = number of sentinel deer; SD = standard deviation

NR = Not recorded because either deer were not handled or could not be measured. Farm 12 was not visited after March 1992, farm 14 was not visited after November 1992.

Appendix 3.67 : Means and standard deviations of the thoracic girth (cm) and coat length (mm). of sentinel stags (> 15 months) on each survey farm in 1992 and 1993.

Year or visit	Class of deer		FARM CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
THORACIC GIRTH																		
STAGS																		
1992																		
March	Yearling	n	4	5	NR	NR	5	5	5	NR	2	NR	NR	5	NR	NR	NR	5
		Mean	115.8	119.6			111.0	108.6	115.0		117.0			109.6				115.2
		SD	3.0	1.4			5.0	3.7	3.4		1.0			5.0				3.7
	Adult	n	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	5	NR	NR	5	NR
		Mean												122.6			129.4	
		SD												3.6			2.2	
June	Yearling	n	NR	5	1	NR	4	5	5	NR	5	NR	5	NR	NR	NR	5	NR
		Mean		122.4	113.0		117.0	111.2	117.8		119.4		112.6				117.8	
		SD		3.6			6.0	2.9	3.1		4.2		3.0				3.7	
	Adult	n	NR	NR	NR	NR	4	4	NR	NR	NR	NR	5	NR	NR	4	NR	NR
		Mean					125.0	127.8					123.6			128.3		
		SD					3.5	3.7					2.6			2.5		
September	Yearling	n	NR	5	NR	NR	4	5	5	NR	NR	NR	5	NR	5	NR	5	NR
		Mean		119.4			118.3	108.8	114.6				110.4		114.2		117.8	
		SD		2.3			6.0	4.5	2.1				3.4		2.7		4.7	
	Adult	n	NR	NR	NR	NR	5	5	NR	NR	NR	NR	5	NR	NR	5	NR	2
		Mean					121.8	121.8					121.0			127.2		63.3
		SD					5.2	4.1					1.9			2.5		59.8
November	Yearling	n	5	5	NR	NR	5	5	5	NR	NR	NR	NR	NR	NR	NR	5	NR
		Mean	116.4	118.2			112.4	109.6	116.4								120.8	
		SD	3.9	2.4			4.5	2.7	2.5								1.9	
	Adult	n	NR	NR	3	NR	5	NR	NR	NR	NR	NR	5	NR	NR	5	NR	NR
		Mean			132.7		121.6						124.2			130.0		
		SD			3.3		5.5						2.4			2.6		
1993																		
March	Yearling	n	NR	3	NR	5	5	5	5	NR	4	5	NR	4	NR	5	5	NR
		Mean		106.7		107.8	104.0	105.0	106.2		114.8	107.0		108.8		105.6	110.4	
		SD		1.7		6.0	4.0	3.6	1.7		1.9	3.7		2.2		3.4	5.5	
	Adult	n	NR	NR	NR	5	NR	NR	NR	NR	NR	5	NR	NR	NR	5	NR	NR
		Mean				116.2						121.8				124.8		
		SD				3.8						6.7				2.3		
June	Yearling	n	4	NR	5	NR	5	5	5	5	3	5	5	NR	4	NR	5	4
		Mean	116.8		108.8		112.6	115.8	114.0	111.2	117.3	116.6	110.0		115.3		112.2	112.0
		SD	3.0		2.2		1.0	2.7	3.3	1.9	2.9	2.4	5.6		2.9		5.3	2.5
	Adult	n	NR	NR	3	NR	4	1	NR	NR	NR	NR	5	NR	NR	NR	5	NR
		Mean			132.0		120.0	117.0					121.8				125.0	
		SD			2.4		6.0						3.5				3.3	
September	Yearling	n	5	NR	4	NR	4	5	5	NR	4	NR	5	NR	NR	NR	5	NR
		Mean	115.4		107.8		116.5	109.0	111.8		118.5		110.4				115.2	
		SD	5.3		2.3		2.1	4.9	2.3		2.6		5.8				5.7	
	Adult	n	0		2		5		0			0	5				5	1
		Mean			129.5		121.4						120.0				126.8	117.0
		SD			1.5		4.5						3.9				1.9	
COAT LENGTH																		
STAGS																		
1992																		
March	Yearling	n	4	5	NR	NR	5	NR	NR	NR	5	NR	5	NR	NR	NR	NR	NR
		Mean	48.8	46.0			52.0				49.0		43.0					
		SD	7.4	2.0			2.4				2.0		4.0					
	Adult	n	NR	NR	4	NR	3	NR	NR	NR	5	NR	5	NR	NR	5	NR	NR
		Mean			51.3		50.0				46.0		46.0			47.0		
		SD			2.2		0.0				3.7		3.7			2.4		
June	Yearling	n	5	5	1	NR	4	5	5	NR	5	5	5	NR	5	NR	5	5
		Mean	54.0	54.0	55.0		61.8	53.6	53.6		61.6	62.2	54.0		62.0		53.6	51.4
		SD	3.7	3.7			1.1	3.8	2.4		4.1	7.305	3.4		7.5		2.9	3.6
	Adult	n	5	NR	6	NR	4	5	4	NR	5	5	4	NR	5	4	5	5
		Mean	52.0		57.5		56.0	50.2	53.3		55.0	53.4	48.8		61.8	55.5	58.0	53.6
		SD	4.0		4.8		3.1	2.9	4.7		1.4	6.0	2.2		4.8	2.9	3.7	3.4
September	Yearling	n	5	NR	5	NR	5	5	5	5	5	4	5	NR	5	NR	5	5
		Mean	50.0		46.0		50.0	47.0	48.8	43.8	47.6	47.5	51.4		51.0		46.4	45.6
		SD	1.3		5.8		6.3	4.6	3.2	2.6	1.6	1.7	2.2		5.2		12.1	2.9
	Adult	n	NR	NR	NR	NR	5	NR	5	NR	2	NR	5	NR	NR	NR	5	NR
		Mean					42.6		46.4		42.0		48.6				49.4	
		SD					7.1		2.7		4.0		4.1				3.8	
1993																		
March	Yearling	n	5	NR	5	NR	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	52.4		49.8		52.4	55.6	55.2	52.2	53.6	49.6	48.0		51.2		55.6	51.0
		SD	5.0		3.0		3.2	3.6	3.8	3.6	3.9	4.6	1.8		4.0		5.9	3.4
	Adult	n	5	NR	5	NR	4	1	5	NR	5	5	5	NR	3	NR	5	5
		Mean	49.2		55.6		48.0	47.0	44.6		56.6	55.6	47.0		54.3		54.0	50.8
		SD	6.6		6.0		2.1		7.6		2.2	3.0	2.7		3.3		4.2	3.7
June	Yearling	n	5	5	1	NR	4	5	5	NR	5	5	5	NR	5	NR	5	5
		Mean	60.2	63.0	55.0		65.5	55.2	57.6		64.4	59.6	56.6		63.2		58.4	56.0
		SD	4.7	5.4			1.8	3.2	2.1		5.0	4.7	5.5		5.2		4.5	2.1
	Adult	n	5	NR	6	NR	5	5	5	NR	5	5	5	NR	NR	5	5	5
		Mean	55.6		57.5		61.6	53.4	55.6		55.2	59.2	48.6			61.2	64.6	49.6
		SD	3.0		6.5		1.0	5.6	3.2		3.5	4.7	7.7			5.1	2.9	6.7
September	Yearling	n	5	NR	5	NR	4	5	5	NR	5	5	5	NR	5	NR	5	5
		Mean	58.2		55.2		55.8	58.6	55.8		55.6	53.8	57.0		62.4		57.0	55.8
		SD	6.7		3.9		4.5	1.2	4.2		6.9	2.1	1.9		2.2		4.5	7.0
	Adult	n	5	NR	5	NR	5	NR	5	NR	NR	5	5	NR	NR	NR	5	5
		Mean	51.4		53.4		55.6		52.0			56.2	50.0				55.8	50.8
		SD	3.7		3.8		3.4		5.2			8.6	3.0				4.1	4.8

n = number of sentinel deer; SD = standard deviation

NR = Not recorded because either deer were not handled or could not be measured. Farm 12 was not visited after March 1992, farm 14 was not visited after November 1992.

Appendix 3.68 : Means and standard deviations of the coat length (mm) of sentinel weaners (3-15 months) and hinds, and the coat density (g) of sentinel weaners, hinds and stags on each survey farm in 1992 and 1993, or both years combined as appropriate.

Year or visit	Class of age or sex		FARM CODE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
COAT LENGTH																		
WEANERS																		
1992																		
March	Hind	n	5	5	5	5	5	NR	NR	2	5	NR	5	5	5	4	NR	NR
		Mean	45.0	47.0	55.0	37.0	57.0			55.0	52.0		55.0	30.0	49.0	57.5		
		SD	5.5	4.0	4.5	2.4	5.1			0.0	7.5		9.5	5.5	8.0	2.5		
	Stag	n	5	5	5	5	5	NR	NR	1	5	NR	5	5	5	5	NR	NR
		Mean	52.0	47.0	57.0	38.0	58.0			50.0	56.0		51.0	39.2	52.0	54.0		
		SD	6.8	4.0	6.0	5.1	7.5				3.7		4.9	14.3	5.1	11.1		
June	Hind	n	5	5	5	5	5	5	5	NR	5	5	5	NR	4	5	5	5
		Mean	39.0	42.0	54.0	47.0	58.4	50.6	57.2		59.8	52.6	49.0		62.3	55.0	57.2	50.8
		SD	3.7	6.0	2	5.1	4.2	2.3	2.6		4.0	3.2	9.0		1.5	1.4	4.3	2.1
	Stag	n	5	5	4	5	5	5	5	NR	5	5	5	NR	5	NR	5	5
		Mean	45.0	49.0	55.0	50.0	56.4	56.6	54.8		58.0	54.0	54.2		62.8		54.2	54.4
		SD	5.5	2.0	3.5	4.5	6.1	5.7	4.5		2.2	3.5	4.8		5.0		2.8	2.7
September	Hind	n	5	5	5	5	5	5	5	5	5	5	6	NR	5	5	5	5
		Mean	49.6	56.8	59.0	59.2	59.6	54.6	58.4	55.8	62.2	52.6	56.8		63.4	62.8	59.0	54.4
		SD	6.0	4.1	7.403	2.7	4.0	3.7	2.4	5.5	4.2	3.499	3.0		2.4	3.7	3.0	2.2
	Stag	n	5	5	5	5	5	5	5	5	5	5	4	NR	5	5	5	NR
		Mean	57.6	55.6	64.0	57.0	57.0	61.0	56.2	60.2	61.0	52.2	54.8		62.6	57.2	57.6	
		SD	4.3	3.4	3.7	3.7	6.0	4.2	7.3	4.9	2.4	5.0	2.2		2.0	1.9	2.9	
1993																		
June	Hind	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	45.4	48.6	53.0	51.0	47.2	52.0	49.8	56.2	51.4	54.4	48.0		50.4		57.4	51.4
		SD	4.5	6.2	4.604	1.8	3.2	9.1	3.7	2.6	3.7	2.7	6.7		7.0		2.5	5.5
	Stag	n	5	5	4	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	43.8	46.8	56.0	50.8	50.2	58.4	50.8	52.8	45.8	56.4	53.8		47.2		56.6	52.2
		SD	4.3	7.0	2.5	3.4	3.1	3.9	2.0	3.3	5.3	3.1	3.7		7.0		5.6	4.3
September	Hind	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	53.8	54.8	55.8	52.4	53.4	62.8	54.6	57.8	53.2	54.2	52.0		59.6		56.6	52.8
		SD	4.4	2.6	3.2	1.9	3.8	6.0	2.2	2.2	2.9	4.4	2.6		3.4		2.1	5.6
	Stag	n	5	5	5	5	5	5	5	5	5	5	5	NR	5	NR	5	5
		Mean	53.4	50.8	54.4	55.8	53.4	57.8	52.0	58.6	52.4	54.8	57.4		64.2		60.6	54.6
		SD	1.4	3.5	3.4	3.5	3.8	2.0	4.6	5.2	3.4	5.3	3.3		3.3		3.8	3.7
HINDS																		
March	yearling	n	10	10	5	10	10	10	10	9	10	5	10	5	9	5	4	5
		Mean	45.9	46.3	52.0	48.1	45.6	44.9	45.8	45.8	46.6	47.2	45.4	43.0	52.8	45.0	47.3	45.4
		SD	3.8	5.0	3.4	4.3	3.3	7.1	5.0	3.3	4.3	3.7	5.0	2.4	3.3	3.2	5.4	6.2
	adult	n	10	10	10	10	10	10	10	10	10	5	10	5	10	5	10	5
		Mean	41.2	42.1	42.6	40.3	38.2	40.1	40.3	40.1	44.0	43.6	41.7	39.0	41.3	38.0	43.0	44.4
		SD	4.9	4.4	4.1	6.1	2.6	2.5	5.2	3.8	3.5	3.4	4.5	3.7	6.7	5.1	6.2	5.3
June	yearling	n	NR	10	5	10	10	10	10	10	10	10	3	10	NR	10	10	NR
		Mean		49.7	52.6	49.9	50.5	51.9	49.8	51.1	52.2	47.9	48.7	53.8		48.9	48.6	
		SD		3.6	5.9	3.0	4.6	2.9	4.5	4.8	3.3	3.6	1.9	4.5		4.0	4.5	
	adult	n	9	10	9	10	10	10	10	10	10	10	10	10	5	5	10	NR
		Mean	44.1	47.0	46.9	44.6	45.5	48.7	46.9	43.5	48.1	51.7	43.6	47.4	50.6	47.4	47.2	
		SD	3.7	7.5	2.8	3.9	2.9	3.6	4.0	1.6	5.6	7.2	4.9	5.7	4.0	2.1	4.1	
September	yearling	n	10	10	7	10	10	10	9	10	10	10	4	10	NR	10	10	NR
		Mean	53.1	54.9	57.7	52.1	55.7	58.1	53.1	56.7	53.4	50.9	51.8	58.5		53.1	50.7	
		SD	2.3	3.9	4.6	2.3	3.8	4.4	4.6	4.8	3.3	3.6	5.4	3.4		4.5	3.0	
	adult	n	10	10	10	10	10	10	10	10	10	10	10	10	5	10	10	NR
		Mean	49.5	51.1	54.3	52.3	50.1	51.4	49.7	48.4	52.5	52.8	51.5	56.2	53.8	51.7	50.0	
		SD	2.9	4.0	4.7	3.6	2.7	2.8	4.6	2.8	5.3	5.9	4.3	6.1	2.5	4.1	3.8	
COAT DENSITY																		
WEANERS																		
March		n	10	10	10	10	10	NR	NR	4	NR	NR	10	NR	10	10	NR	NR
		Mean	0.48	0.51	0.50	0.61	0.74			0.53			0.64		0.64	0.57		
		SD	0.1	0.1	0.2	0.1	0.2			0.0			0.1		0.1	0.2		
June		n	10	10	10	10	NR	8	10	NR	9	10	NR	NR	NR	NR	4	NR
		Mean	1.10	0.87	1.74	1.63		1.74	1.92		2.47	1.95					2.44	
		SD	0.2	0.2	0.2	0.3		0.4	0.2		0.5	0.3					0.2	
HINDS																		
March	Yearling	n	5	5	NR	5	5	5	5	4	NR	NR	5	5	NR	5	NR	NR
		Mean	1.1	1.2		1.0	1.3	1.0	1.0	1.0			1.2	0.9		1.2		
		SD	0.1	0.2		0.1	0.4	0.2	0.2	0.1			0.5	0.6		0.1		
	Adult	n	5	5	5	5	5	5	5	5	NR	NR	5	5	5	5	5	NR
		Mean	1.2	0.7	1.0	0.7	1.1	0.9	0.8	0.9			1.2	1.0	1.2	1.2	1.1	
		SD	0.3	0.1	0.2	0.1	0.3	0.1	0.0	0.1			0.2	0.4	0.2	0.1	0.2	
June	Yearling	n	5	5	NR	5	NR	5	5	NR	4	5	NR	NR	NR	5	NR	NR
		Mean	1.4	1.9		1.5		2.5	1.9		2.4	2.1				2.1		
		SD	0.2	0.2		0.4		0.4	0.2		0.2	0.202				0.4		
	Adult	n	5	5	4	5	NR	4	5	NR	5	2	NR	NR	NR	NR	NR	NR
		Mean	1.3	1.5	1.5	1.6		2.0	1.5		2.1	1.8						
		SD	0.1	0.4	0.2	0.2		0.3	0.2		0.3	0.2						
STAGS																		
March		n	NR	5	NR	NR	NR	NR	NR	NR	NR	5	NR	NR	NR	NR	NR	NR
		Mean		1.1								1.5						
		SD		0.3								0.3						
June		n	NR	5	NR	NR	NR	NR	NR	5	NR	NR	9	NR	NR	NR	NR	NR
		Mean		0.8						2.6			1.9					
		SD		0.2						0.4			0.3					

n = number of sentinel deer; SD = standard deviation

NR = Not recorded because either deer were not handled or could not be measured. Farm 12 was not visited after March 1992, farm 14 was not visited after November 1992.

Appendix 3.69 : Number of sentinel weaners (3-15 months), hinds and stags observed with sign of hair loss (VICTIM) sampled without firm physical restraint (EASES), lying, stressed and showing signs of aggression during sampling, respectively, on each survey farm in 1992 and 1993, or both years combined as appropriate.

			FARM CODE															
Visit or year	Class of age		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	All farm
DEER WITH SIGN OF HAIR LOSS (VICTIMISATION)																			
WEANERS																			
March		n	20	20	20	20	20	20	20	20	20	10	20	10	20	10	20	10	280
		hair loss	-	-	1	-	-	-	-	-	-	-	1	-	-	1	-	-	3
June		n	20	20	20	20	20	20	20	20	20	20	20	-	20	5	20	20	285
		hairloss	-	-	-	-	2	-	1	-	1	-	-	-	-	-	1	2	7
September		n	20	20	20	20	20	20	20	20	20	20	20	-	20	5	20	20	285
		hair loss	9	14	2	6	15	11	5	4	12	15	11	-	9	2	8	12	135
November		n	10	10	9	5	10	10	10	10	10	10	10	-	10	5	10	10	139
		hair loss	-	2	-	-	1	2	-	-	-	-	-	-	-	-	-	-	5
HINDS																			
March	Yearling	n	10	10	5	10	10	10	10	10	10	5	10	5	9	5	10	5	134
		hair loss	1	2	-	1	7	2	-	-	6	-	3	-	1	1	-	-	24
	Adult	n	10	10	10	10	10	10	10	10	10	5	10	5	10	5	10	5	140
		hairloss	1	2	1	2	4	-	4	1	2	-	3	-	1	3	-	-	24
June	Yearling	n	10	10	4	10	10	10	10	10	10	10	-	-	10	-	10	10	124
		hair loss	-	1	1	2	4	1	-	-	1	1	-	-	-	-	2	3	16
	Adult	n	10	10	10	10	10	10	10	10	10	10	10	-	10	5	10	10	145
		hair loss	-	1	-	1	-	-	-	2	1	1	1	-	1	-	-	-	8
September	Yearling	n	10	10	7	10	9	10	9	10	10	10	4	-	10	-	10	10	129
		hairloss	10	6	6	10	9	9	5	10	9	10	3	-	6	-	8	9	110
	Adult	n	10	10	10	10	6	10	10	10	10	10	10	-	10	5	10	10	141
		hair loss	6	9	5	9	5	4	7	9	6	9	7	-	5	4	7	6	98
STAGS																			
March		n	10	5	14	-	20	10	15	5	17	5	20	-	5	5	20	5	156
		hair loss	-	1	-	-	7	-	2	1	-	-	9	-	-	5	-	-	25
June		n	19	5	16	-	17	16	10	5	15	20	20	-	19	4	20	20	206
		hair loss	20	5	17	-	18	15	19	-	15	20	20	-	10	5	20	20	204
September		n	5	4	4	-	6	5	5	-	4	3	7	-	-	3	14	10	70
		hair loss	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2
November		n	10	5	5	-	10	5	10	-	-	6	5	-	4	5	10	2	77
		hair loss	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
DEER QUIET AT BLOOD SAMPLING (EASES)																			
WEANERS																			
1992		n	40	40	40	35	40	40	40	40	40	30	40	10	38	25	40	30	568
		quiet	35	37	38	31	36	33	38	39	33	27	33	9	20	25	38	29	501
1993		n	30	30	30	30	29	30	30	30	30	30	30	-	25	-	30	30	414
		quiet	27	30	30	30	27	26	30	29	29	30	30	-	24	-	30	30	402
STAGS																			
March	Yearling	n	10	5	5	-	10	10	10	5	10	5	10	-	5	-	10	5	100
		quiet	4	5	4	-	10	10	10	5	2	5	10	-	3	-	10	5	83
	Adult	n	-	-	9	-	10	-	5	-	7	-	10	-	-	5	10	-	56
		quiet	-	-	-	-	10	-	-	-	-	-	9	-	-	5	5	-	29
June	Yearling	n	10	5	6	-	9	10	5	5	5	10	10	-	10	-	10	10	105
		quiet	-	5	1	-	7	10	-	3	1	1	8	-	4	-	10	4	54
	Adult	n	10	-	11	-	8	6	9	-	10	10	10	-	9	4	10	10	107
		quiet	-	-	-	-	7	4	-	-	-	-	10	-	-	2	5	-	28
September	Yearling	n	10	5	6	-	8	10	10	-	10	10	10	-	10	-	10	10	109
		quiet	-	4	-	-	7	10	7	-	-	-	10	-	5	-	10	-	53
	Adult	n	10	-	11	-	10	5	10	-	5	10	10	-	-	5	10	10	96
		quiet	-	-	-	-	8	5	-	-	-	-	10	-	-	5	5	2	35
November	Yearling	n	2	5	-	-	5	5	5	-	-	3	-	-	4	-	5	-	34
		quiet	2	4	-	-	5	5	5	-	-	-	-	-	-	-	5	-	26
	Adult	n	5	-	5	-	5	-	5	-	-	3	5	-	5	5	5	2	45
		quiet	-	-	-	-	5	-	-	-	-	-	5	-	-	5	-	-	15
HINDS																			
1992		n	30	27	17	30	30	30	30	30	30	18	20	10	29	20	30	20	401
		quiet	16	22	16	30	27	25	24	29	24	6	18	8	20	18	28	15	326
1993		n	30	30	29	30	30	29	29	30	30	30	27	-	30	-	30	30	414
		quiet	24	29	27	25	29	25	27	29	28	27	25	-	21	-	28	29	373
DEER LYING DOWN																			
WEANERS		n	70	70	70	65	69	70	70	70	70	60	70	10	63	25	70	60	982
		lying	-	6	-	-	1	4	4	3	-	4	-	-	1	1	-	3	27
STAGS		n	57	20	53	-	65	46	59	10	47	51	65	-	43	19	70	47	652
		lying	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	3
HINDS		n	60	57	46	60	60	59	59	60	60	48	47	10	59	20	60	50	815
		lying	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2
STRESSED DEER																			
WEANERS		n	70	70	70	65	69	70	70	70	70	60	70	10	63	25	70	60	982
		stressed	2	-	-	-	-	-	-	1	1	1	-	-	-	-	2	-	7
STAGS		n	57	20	53	-	65	46	59	10	47	51	65	-	43	19	70	47	652
		stressed	-	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-	3
HINDS		n	60	57	46	60	60	59	59	60	60	48	47	10	59	20	60	50	815
		stressed	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-	3
AGGRESSIVE DEER																			
WEANERS		n	70	70	70	65	69	70	70	70	70	60	70	10	63	25	70	60	982
		aggressive	1	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	4
STAGS		n	57	20	53	-	65	46	59	10	47	51	65	-	43	19	70	47	652
		aggressive	-	1	-	-	-	-	1	-	-	1	-	-	-	-	-	1	4
HINDS		n	60	57	46	60	60	59	59	60	60	48	47	10	59	20	60	50	815
		aggressive	-	1	-	-	-	3	1	2	1	-	-	-	1	-	-	1	10

n = number of deer examined

Appendix 3.70 : Summary of results of statistical analyses of farm, visit and sex effects on blood characteristics of weaner deer (<15 months).

	Standard ANOVA								Repeated Measures ANOVA					Standard ANOVA per visit							
	1992				1993				Between Subjects effects		Within Subjects effects			MARCH		JUNE		SEPTEMBER		NOVEMBER	
Blood characteristics	F	V(F)	S	SxV(F)	F	V(F)	S	SxV(F)	F(Y)	S	V	VxF(Y)	VxS	F(Y)	S	F(Y)	S	F(Y)	S	F(Y)	S
Haematological characteristics																					
White Cell Count	**	**	NS	NS	**	**	NS	*	**	NS	**	**	**	**	NS	**	*	**	NS	**	NS
Neutrophils	**	**	NS	*	**	**	NS	*	**	NS	**	**	NS	**	NS	**	NS	**	NS	**	NS
Eosinophils	**	**	*	NS	**	**	NS	NS	**	NS	**	**	NS								
Basophils	**	**	*	NS	**	**	NS	NS	**	NS	**	**	NS								
Lymphocytes	**	**	NS	*	**	**	NS	*	**	NS	NS	**	NS	**	NS	**	NS	**	NS	**	NS
Haemoglobin	**	**	**	**	**	**	NS	NS	**	**	NS	**	NS								
Packed Cell Volume	**	**	**	*	**	**	NS	NS	**	**	**	**	NS								
MCHC	**	**	NS	**	**	**	NS	NS	**	NS	**	**	NS	**	NS	**	NS	**	NS	**	*
Biochemical characteristics																					
Total Protein	**	**	NS	NS	**	**	NS	*	**	NS	**	**	NS	**	NS	**	NS	**	NS	*	*
Albumin	**	**	*	NS	**	**	NS	*	**	NS	**	**	NS	**	NS	**	NS	**	NS	**	NS
Globulin	**	**	**	NS	**	**	NS	**	**	NS	**	**	NS	**	NS	**	NS	**	*	**	*
Phosphorus	**	**	NS	NS	**	**	NS	NS	**	NS	**	**	NS								
GGT	**	**	NS	NS	**	**	NS	NS	**	NS	**	**	NS								
Blood Urea Nitrogen	**	**	NS	NS	**	**	NS	NS	**	NS	**	**	NS								
Copper	**	**	NS	NS	**	**	NS	NS	**	NS	**	**	**	**	NS	**	NS	**	*	**	NS
Vitamin B12	**	**	NS	NS	**	**	NS	NS	**	NS	**	**	*	**	NS	**	NS	**	NS	**	NS
GSHPx	**	**	NS	NS	**	**	*	NS	**	NS	**	**	NS								
Pepsinogen	**	**	**	NS	**	**	**	NS	**	**	**	**	NS								

MCHC = mean cell haemoglobin concentration; GGT = ganuna glutamyl transferase; GSHPx = glutathione peroxidase

Effects in models : F = Farm; F(Y) = Farm within years; V(F) = Visit within farm ; S = Sex ;
SxV(F) = Sex x Visit within farms interaction; VxF(Y) = Visit x Farm within years interaction; VxS = Visit x Sex interaction

Notes on statistical tests : Standard analyses of variance (ANOVA) were run separately on 1992 and 1993 data as if animals were randomly selected each time, then data from both years were pooled for analyses of repeated measures.
Repeated measures ANOVA were run on a data subset including weaners that were sampled three times, November visit excluded
When the SxV(Y) interaction term was significant standard ANOVA were carried out per visit to identify sex differences

Results of statistical tests : ** $p<0.01$; * $p<0.05$; NS = Not significant

Appendix 3.71 : Summary of results of statistical analyses of farm, visit and age effects on blood characteristics of hinds and stags (> 15 months), respectively.

HINDS	Standard ANOVA								Paired t-test		
	1992				1993				March - September		
Blood characteristics	F	V(F)	A	AxV(F)	F	V(F)	A	AxV(F)	AH	YH	All hinds†
Haematological characteristics											
White Cell Count	**	**	NS	NS	**	**	*	**	**	**	**
Neutrophils	**	**	**	NS	**	**	**	**	NS	NS	NS
Eosinophils	**	**	**	NS	**	**	**	**	NS	**	*
Basophils	**	**	**	NS	**	**	**	**	**	**	**
Lymphocytes	**	**	**	NS	**	NS	**	*	NS	*	NS
Haemoglobin	**	**	**	*	**	**	NS	**	NS	**	**
Packed Cell Volume	**	**	**	*	**	**	**	*	**	**	**
MCHC	**	**	**	*	**	**	**	*	NS	NS	NS
Biochemical characteristics											
Total Protein	**	**	**	NS	**	**	NS	NS	NS	NS	NS
Albumin	**	**	**	NS	**	**	*	*	*	**	**
Globulin	**	NS	**	**	**	**	*	NS	NS	**	NS
Phosphorus	**	**	*	**	**	**	**	**	**	**	**
GGT	**	**	*	**	**	**	*	**	**	**	**
Blood Urea Nitrogen	**	**	*	**	**	**	NS	**	**	*	NS
Copper	**	**	NS	**	**	**	NS	NS	**	NS	**
Vitamin B12	**	**	NS	**	**	**	NS	**	**	**	**
GSHPx	**	**	NS	NS	**	NS	NS	NS	not carried out		**
Pepsinogen	**	NS	NS	**	**	**	*	**	NS	**	*

	Standard ANOVA per visit			
	MARCH		SEPTEMBER	
Blood characteristics	F(Y)	A	F(Y)	A
Haematological characteristics				
White Cell Count	**	NS	**	*
Haemoglobin	**	NS	**	*
Biochemical characteristics				
Total Protein	**	NS	**	NS
Blood Urea Nitrogen	**	**	**	*
Copper	**	NS	**	*
Vitamin B12	**	NS	**	NS
Pepsinogen	**	NS	**	**

STAGS	Standard ANOVA						Paired T-Test		
	June 1992 & 1993		June & November 1992				June - November 1992		
Blood characteristics	F(Y)	A	F	V(F)	A	AxV(F)	AS	YS	AS and YS
Haematological characteristics									
White Cell Count	**	**	**	*	NS	NS	NS	**	**
Neutrophils	**	**	**	**	**	**	**	NS	**
Eosinophils	**	NS	**	**	NS	NS	NS	NS	NS
Basophils	**	NS	**	**	NS	*	NS	**	**
Lymphocytes	**	**	**	**	**	**	**	NS	**
Haemoglobin	**	NS	**	*	*	**	NS	*	**
Packed Cell Volume	**	NS	**	**	NS	**	NS	NS	NS
MCHC	**	*	NS	*	**	*	**	**	**
Biochemical characteristics									
Total Protein	**	**	**	**	**	NS	NS	**	NS
Albumin	**	NS	**	**	NS	**	NS	NS	**
Globulin	**	**	**	**	**	NS	NS	**	**
Phosphorus	**	**	**	**	NS	NS	NS	NS	*
GGT	**	NS	**	**	NS	*	**	**	**
Blood Urea Nitrogen	**	**	**	**	*	**	**	NS	**
Copper	**	**	**	NS	NS	NS	NS	NS	NS
Vitamin B12	**	NS	**	NS	NS	**	NS	NS	NS
GSHPx	**	NS	**	**	*	NS	NS	NS	NS
Pepsinogen	**	NS	**	**	NS	*	NS	NS	NS

MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferase; GSHPx = glutathione peroxidase

Effects in models : F = Farm; F(Y) = Farm within years; V(F) = Visit within farm ; A = Age;
AxV(F) = Age x Visit within farms interaction ; VxF(Y) = Visit x Farm within years interaction;

Notes on statistical tests : Standard ANOVA were run separately on 1992 and 1993 data as if animals were randomly selected each time, then data from both years were pooled for analyses of repeated measures.
Paired t-tests were run on data subsets including hinds and stags sampled twice during each year, animals sampled both years were considered statistically independent
† All hinds = t-tests were carried out with yearling and adult hinds combined
YH = Yearling hinds; AH = Adult hinds; YS = Yearling stags; AS = Adult stags

Results of statistical tests : ** $p<0.01$; * $p<0.05$, NS = Not significant

Appendix 3.72 : Estimates of variance components of blood characteristics of weaners (3-15 months) due to year and farm, by visit and by sex (where appropriate). Data from 1992 and 1993 combined.

Blood characteristics		Model components	MARCH Variance components	%	JUNE Variance components	%	SEPTEMBER Variance components	%	NOVEMBER Variance components	%
HAEMATOLOGICAL CHARACTERISTICS										
White Cell Count		Year	0.0045	4.8	0.0095	5.6	0.0006	0.5		
		Farm(Year)	0.0320	35.9	0.0416	26.0	0.0246	19.9	0.0646	62.8
		Error	0.0571		0.1182		0.0993		0.0382	
Neutrophils		Year	0.0000	0.0	0.0000	0.0	7.9569	5.3		
		Farm(Year)	96.6476	58.8	19.6438	19.0	50.3216	35.4	59.7905	53.5
		Error	67.8006		83.9857		91.6791		52.0409	
Eosinophils		Year	0.0000	0.0	0.0319	5.9	0.1232	17.1		
		Farm(Year)	0.1576	27.7	0.1503	29.3	0.2395	40.2	0.2289	41.8
		Error	0.4105		0.3632		0.3568		0.3185	
Lymphocytes		Year	0.2877	0.2	5.8139	4.8	3.7539	2.3		
		Farm(Year)	76.8455	51.2	22.5535	19.6	71.7228	45.9	55.4340	50.0
		Error	73.2040		92.3685		84.3921		55.4670	
Haemoglobin	Stags	Year	0.0000	0.0	0.0000	0.0	0.6400	9.0		
		Farm(Year)	1.5650	28.0	1.4997	29.0	2.5590	39.6	1.6003	35.4
		Error	4.0243		3.6639		3.9053		2.9145	
	Hinds	Year	0.0000	0.0	0.2693	3.5	0.2771	3.8		
		Farm(Year)	3.0565	37.9	0.6360	8.7	4.1343	58.2	0.7923	38.6
		Error	5.0121		6.6833		2.9695		1.2608	
Packed Cell Volume	Stags	Year	0.0000	0.0	0.0000	0.0	0.0000	0.6		
		Farm(Year)	0.0017	46.5	0.0008	31.6	0.0004	18.0	0.0006	28.1
		Error	0.0020		0.0018		0.0018		0.0015	
	Hinds	Year	0.0000	0.0	0.0000	0.0	0.0001	3.5		
		Farm(Year)	0.0013	43.5	0.0009	31.7	0.0007	33.6	0.0003	30.8
		Error	0.0017		0.0019		0.0014		0.0008	
MCHC		Year	0.0009	6.6	0.0000	0.0	0.0003	2.2		
		Farm(Year)	0.0020	15.4	0.0022	16.8	0.0056	38.4	0.0005	10.8
		Error	0.0110		0.0109		0.0090		0.0039	
BIOCHEMICAL CHARACTERISTICS										
Total Protein		Year	0.0000	0.0	0.0000	0.0	0.6610	3.7		
		Farm(Year)	4.1154	25.1	8.8387	30.9	3.5329	20.4	1.9582	11.1
		Error	12.2841		19.7941		13.7973		15.6537	
Albumin		Year	0.0000	0.0	0.0000	0.0	1.7210	22.6		
		Farm(Year)	6.7239	55.0	11.2921	53.5	1.8578	31.5	3.7635	40.7
		Error	5.5093		9.8058		4.0469		5.4767	
Globulin		Year	0.0000	0.0	2.0609	6.7	0.0000	0.0		
		Farm(Year)	6.6534	40.6	8.7223	30.5	6.2660	30.2	3.5199	18.1
		Error	9.7337		19.8503		14.4513		15.9111	
Phosphorus		Year	0.0000	0.0	0.0286	10.9	0.0000	0.0		
		Farm(Year)	0.0682	24.7	0.0727	31.3	0.0361	23.7	0.0496	27.1
		Error	0.2084		0.1599		0.1163		0.1334	
GGT		Year	0.0000	0.0	0.0000	0.0	0.0000	0.0		
		Farm(Year)	0.0154	6.3	0.0420	16.1	0.0235	23.8	0.0148	14.5
		Error	0.2285		0.2183		0.0753		0.0874	
Blood Urea Nitrogen		Year	0.0000	0.0	0.0000	0.0	0.0000	0.0		
		Farm(Year)	2.4080	63.4	1.4876	53.5	1.6975	67.2	1.4368	60.5
		Error	1.3902		1.2930		0.8295		0.9364	
Copper		Year	0.0000	0.0	0.0000	0.0	0.0000	0.0		
		Farm(Year)	11.3748	46.4	8.8354	46.2	5.5181	27.1	3.7407	22.7
		Error	13.1613		10.2725		14.8449		12.7495	
Vitamin B12		Year	0.0000	0.0	0.0000	0.0	0.0080	2.7		
		Farm(Year)	0.2135	49.0	0.1573	48.7	0.1763	62.1	0.2505	70.2
		Error	0.2220		0.1659		0.1074		0.1062	
GSHPx		Year	0.0000	0.0	0.0000	0.0	0.0000	0.0		
		Farm(Year)	30.6285	77.6	24.9036	79.6	28.4362	72.9	37.0781	90.0
		Error	8.8370		6.4008		10.5553		4.1175	
Pepsinogen	Stags	Year	0.0000	0.0	0.0333	8.5	0.0043	1.6		
		Farm(Year)	0.0532	16.6	0.1022	28.6	0.0811	31.0	0.0922	44.1
		Error	0.2671		0.2552		0.1804		0.1170	
	Hinds	Year	0.0000	0.0	0.0158	5.1	0.0109	4.1		
		Farm(Year)	0.0230	8.3	0.1202	40.9	0.0661	26.0	0.0262	16.2
		Error	0.2532		0.1735		0.1880		0.1354	

MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferase activity ; GSHPx = glutathione peroxidase activity

Appendix 3.73 : Estimates of variance components of blood characteristics of stags (> 15 months) due to year and farm, by visit and by age (where appropriate). Data from 1992 and 1993 combined.

		JUNE				NOVEMBER			
		Yearling stags		Adult stags		Yearling stags		Adult stags	
Blood characteristics	Model components	Variance components	%	Variance components	%	Variance components	%	Variance components	%
HAEMATOLOGICAL CHARACTERISTICS									
White Cell Count	Year	0.0240	14.3	0.0229	15.9				
	Farm(Year)	0.0175	12.2	0.0329	27.2	0.0511	56.7	0.0519	57.6
	Error	0.1262		0.0881		0.0390		0.0383	
Neutrophils	Year	0.0000	0.0	0.0000	0.0				
	Farm(Year)	44.8571	36.8	18.0236	18.2	68.5670	42.7	121.3834	69.3
	Error	77.0521		80.7543		92.0046		53.8471	
Basophils	Year	0.1685	32.5	0.1652	33.1				
	Farm(Year)	0.0295	8.4	0.0581	17.4	0.0000	0.0	0.0110	9.3
	Error	0.3198		0.2764		0.1314		0.1077	
Lymphocytes	Year	0.0000	0.0	28.3066	24.1				
	Farm(Year)	16.7847	14.6	12.1472	13.6	54.6373	41.1	103.2364	62.8
	Error	98.3970		77.1537		78.2347		61.2271	
Haemoglobin	Year	0.0000	0.0	0.0000	0.0				
	Farm(Year)	1.7727	30.1	2.8184	26.0	1.2710	42.3	4.5324	49.8
	Error	4.1202		8.0211		1.7322		4.5607	
MCHC	Year	0.0004	3.6	0.0000	0.0				
	Farm(Year)	0.0020	20.0	0.0008	4.1	0.0000	0.0	0.0071	41.5
	Error	0.0079		0.0187		0.0018		0.0101	
	All stags combined								
Packed Cell Volume	Year	0.0000	0.0						
	Farm(Year)	0.0008	42.6			0.0005	20.9		
	Error	0.0011				0.0017			
	Both visit and all stags combined								
Eosinophils	Year	0.0676	13.3						
	Farm(Year)	0.0265	6.0						
	Error	0.4152							
BIOCHEMICAL CHARACTERISTICS									
Total Protein	Year	0.0000	0.0	0.0000	0.0				
	Farm(Year)	5.0434	18.8	8.8923	27.2	2.4455	14.9	7.1794	25.4
	Error	21.7764		23.7706		13.9256		21.0637	
Globulin	Year	0.4804	2.4	0.0000	0.0				
	Farm(Year)	2.5216	12.7	1.8111	9.1	5.2668	27.2	11.1099	44.9
	Error	17.3449		18.0572		14.0630		13.6566	
Phosphorus	Year	0.0386	12.5	0.0000	0.0				
	Farm(Year)	0.0909	33.7	0.0149	5.1	0.0000	0.0	0.0549	18.8
	Error	0.1789		0.2756		0.2046		0.2371	
Blood Urea Nitrogen	Year	0.1076	3.6	0.0000	0.0				
	Farm(Year)	1.8462	64.4	3.1332	69.3	1.1072	52.0	1.4761	40.9
	Error	1.0198		1.3870		1.0227		2.1361	
	All stags combined								
Albumin	Year	0.9108	8.1						
	Farm(Year)	2.6332	25.5			4.6541	50.5		
	Error	7.6990				4.5604			
GGT	Year	0.0000	0.0						
	Farm(Year)	0.0201	15.7			0.0314	38.0		
	Error	0.1080				0.0513			
Copper	Year	3.5259	10.0						
	Farm(Year)	17.3788	54.9			14.7139	36.5		
	Error	14.2757				25.5766			
	Both visit and all stags combined								
Vitamin B12	Year	0.0000	0.0						
	Farm(Year)	0.1045	36.1						
	Error	0.1852							
GSHPx	Year	0.0000	0.0						
	Farm(Year)	39.3652	73.8						
	Error	13.9420							
Pepsinogen	Year	0.0331	8.3						
	Farm(Year)	0.0416	11.3						
	Error	0.3259							

MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferase activity ; GSHPx = glutathione peroxidase activity

Appendix 3.74 : Estimates of variance components of blood characteristics in hinds (> 15 months) due to year and farm, by visit and by age (where appropriate). Data from 1992 and 1993 combined.

		MARCH				SEPTEMBER			
		Yearling hinds		Adult hinds		Yearling hinds		Adult hinds	
Blood characteristics	Model components	Variance components	%	Variance components	%	Variance components	%	Variance components	%
HAEMATOLOGICAL CHARACTERISTICS									
White Cell Count	Year	0.0000	0.0	0.0000	0.0	0.0067	6.0	0.0058	4.5
	Farm(Year)	0.0465	47.9	0.0325	34.9	0.0340	32.2	0.0092	7.5
	Error	0.0505		0.0605		0.0715		0.1135	
Eosinophils	Year	0.0000	0.0	0.0000	0.0	0.0238	4.6	0.0008	0.2
	Farm(Year)	0.1378	28.8	0.0467	13.3	0.1598	32.5	0.0591	13.9
	Error	0.3409		0.3042		0.3312		0.3651	
Basophils	Year	0.0525	12.5	0.2696	47.9	0.4423	56.3	0.3153	47.3
	Farm(Year)	0.0989	26.8	0.0555	18.9	0.0389	11.3	0.0212	6.1
	Error	0.2702		0.2375		0.3049		0.3295	
Lymphocytes	Year	0.0000	0.0	22.7070	10.1	1.7073	1.4	3.7884	2.4
	Farm(Year)	73.6842	42.6	83.2238	41.3	20.2706	16.7	42.7687	28.2
	Error	99.2885		118.4297		101.0867		108.6448	
Haemoglobin	Year	0.0000	0.0	0.0000	0.0	0.0206	0.4	0.0000	0.0
	Farm(Year)	0.6491	13.2	8.2220	61.6	2.0564	38.9	3.9718	34.2
	Error	4.2598		5.1153		3.2275		7.6307	
Packed Cell Volume	Year	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	Farm(Year)	0.0003	17.7	0.0007	31.7	0.0004	25.2	0.0006	32.9
	Error	0.0012		0.0014		0.0013		0.0013	
	BOTH VISITS								
Neutrophils	Year	0.0000	0.0	2.9446	1.6				
	Farm(Year)	50.5483	35.5	57.7922	31.0				
	Error	91.6521		128.5417					
MCHC	Year	0.0000	0.0	0.0000	0.0				
	Farm(Year)	0.0018	13.3	0.0046	16.2				
	Error	0.0121		0.0240					
BIOCHEMICAL CHARACTERISTICS									
Albumin	Year	0.0000	0.0	0.0022	0.0	3.7784	34.9	2.3632	22.5
	Farm(Year)	2.6604	32.7	1.9662	25.0	2.5593	36.3	1.0998	13.5
	Error	5.4821		5.8896		4.4934		7.0252	
Globulin	Year	0.0000	0.0	0.3488	1.5	2.5435	16.1	0.0000	0.0
	Farm(Year)	6.8375	36.2	5.4725	23.1	2.6290	19.8	3.5076	18.5
	Error	12.0620		18.1875		10.6552		15.4150	
Phosphorus	Year	0.0000	0.0	0.0000	0.0	0.0000	0.0	0.0000	0.0
	Farm(Year)	0.0137	8.4	0.0936	37.6	0.0685	40.5	0.0626	33.5
	Error	0.1501		0.1556		0.1005		0.1245	
GGT	Year	0.0000	0.0	0.0000	0.0	0.0026	2.7	0.0000	0.0
	Farm(Year)	0.0206	20.9	0.0187	12.2	0.0155	16.1	0.0165	12.2
	Error	0.0779		0.1346		0.0806		0.1187	
Blood Urea Nitrogen	Year	0.0000	0.0	0.0000	0.0	0.3066	11.6	0.0000	0.0
	Farm(Year)	1.1651	58.6	1.2270	40.4	1.6241	69.4	2.6314	67.2
	Error	0.8233		1.8088		0.7161		1.2851	
Copper	Year	0.0000	0.0	0.0000	0.0	0.4083	1.7	0.0000	0.0
	Farm(Year)	10.3996	50.7	4.7938	27.1	12.2756	50.5	9.5449	42.5
	Error	10.1130		12.8983		12.0532		12.8942	
Vitamin B12	Year	0.0033	1.4	0.0076	4.2	0.0090	5.6	0.0000	0.0
	Farm(Year)	0.1220	53.9	0.0550	31.8	0.0387	25.5	0.1340	46.6
	Error	0.1046		0.1181		0.1128		0.1537	
GSHPx	Year			0.0000	0.0			0.0000	0.0
	Farm(Year)			33.0471	66.8			37.6457	80.3
	Error			16.3950				9.2097	
Pepsinogen	Year	0.1196	22.1	0.0712	9.7	0.0000	0.0	0.0000	0.0
	Farm(Year)	0.1240	29.4	0.2078	31.3	0.2215	46.9	0.2497	37.9
	Error	0.2978		0.4553		0.2511		0.4087	
	BOTH VISITS								
Total Protein	Year	0.0000	0.0	0.3149	1.3				
	Farm(Year)	3.4234	20.3	4.1374	16.7				
	Error	13.4264		20.6932					

MCHC = mean cell haemoglobin concentration; GGT = gamma glutamyl transferase activity ; GSHPx = glutathione peroxidase activity

Appendix 3.75 : Faecal egg and lungworm larval counts (/g) from weaners (3-15 months) on each survey farm in February - March 1992, 1993 and 1994, and in June 1992.

Farm code	Date of sampling	Time after last drench (days)	Number of deer sampled	Number of deer with FEC *				Faecal larval counts >0			
				0	50	100 150	>=200	Number of deer positive	Geometric mean	Min	Max
FEBRUARY - MARCH											
Year 1992											
1	17-Mar	16	10	10	-	-	-	0	-	-	-
2	02-Mar		10	3	2	1	4	10	32.7	5.5	93.0
3	04-Mar		10	7	3	-	-	8	1.5	0.3	3.8
4	26-Feb	18	10	6	3	1	-	0	-	-	-
5	12-Mar		10	5	1	3	1	9	7.8	1.5	72.0
6	19-Mar		10	6	1	2	1	10	24.0	0.3	162.0
7	24-Mar	15	10	6	4	-	-	1	0.3	0.3	0.3
8	18-Mar	2	10	6	2	2	-	10	25.2	3.0	148.0
9	10-Mar	24	10	5	3	1	1	9	18.9	2.0	72.8
11	03-Mar		10	2	1	5	2	10	19.1	4.0	141.3
13	11-Mar	7	10	10	-	-	-	1	0.3	0.3	0.3
14	09-Mar	54	10	5	2	1	2	8	4.5	0.3	19.5
15	23-Mar		9	4	3	1	1	9	25.5	6.3	83.5
Year 1993											
1	05-Mar		10	2	4	3	1	10	33.4	11.8	274.5
2	03-Mar		10	2	3	4	1	10	106.3	47.5	1807.5
3	16-Mar		10	2	2	5	1	10	165.4	63.0	855.8
4	28-Jan		9	8	1	-	-	6	4.4	0.8	26.0
5	03-Mar		10	-	2	5	3	10	14.4	0.3	155.5
6	18-Mar		10	1	2	1	6	10	72.0	10.8	797.3
7	22-Mar		10	6	3	1	-	10	114.9	47.5	416.5
8	04-Mar		10	2	4	3	1	10	23.6	1.5	131.5
9	02-Mar		10	6	3	1	-	9	25.3	0.8	300.0
10	30-Mar	27	10	6	4	-	-	9	1.5	0.3	7.8
11	02-Mar		10	6	2	1	1	10	31.8	4.8	262.3
13	06-Apr	22	10	-	-	-	-	0	-	-	-
15	29-Mar		10	2	4	3	1	10	35.2	4.5	157.5
16	25-Mar		10	4	3	3	-	9	29.4	1.3	196.3
Year 1994											
1	02-Mar		10	-	2	2	6	10	58.6	13.8	299.3
2	09-Mar		9	1	2	1	5	10	10.3	2.8	101.5
3	11-Mar		10	4	-	5	1	8	5.4	1.0	32.0
4	25-Feb		10	4	-	-	6	9	16.5	1.3	48.5
5	18-Mar		10	-	2	3	5	10	7.6	2.5	25.8
6	31-Mar		10	2	2	5	1	10	9.9	0.5	81.8
7	24-Mar		8	1	2	2	3	9	2.9	0.3	17.3
8	08-Mar		9	1	-	3	5	8	24.0	5.0	74.3
9	08-Mar		10	6	2	2	-	2	1.8	1.0	3.3
10	01-Mar		10	2	3	3	2	10	37.2	3.8	283.8
11	09-Mar		10	3	3	1	3	10	13.0	2.0	101.5
13	23-Mar		10	1	5	3	1	9	5.8	0.3	51.0
15	09-Mar		9	2	2	4	1	9	7.2	0.3	36.5
16	30-Mar		10	3	2	2	3	10	13.3	2.3	85.8
JUNE											
Year 1992											
1	28-May	27	9	6	2	1	-	0	-	-	-
2	27-May	4	10	10	-	-	-	0	-	-	-
3	03-Jun	1	11	5	2	1	1	8	1.3	0.3	4.8
4	02-Jun	28	10	9	1	-	-	6	1.1	0.3	2.3
5	23-Jun	8	10	7	3	-	-	1	0.3	-	-
6	24-Jun	22	10	10	-	-	-	6	3.1	1.8	10.3
7	08-Jun	37	9	6	3	-	-	6	1.6	0.3	6.3
8	18-Jun	10	10	8	2	-	-	0	-	-	-
9	15-Jun	66	10	5	2	1	2	4	0.7	0.3	2.0
10	16-Jun	1	10	7	3	-	-	4	0.5	0.3	2.3
11	04-Jun	1	10	10	-	-	-	9	3.9	0.5	22.0
13	30-Jun	22	10	7	3	-	-	8	1.2	0.3	6.0
14	22-Jun	40	10	2	-	6	2	1	1.0	-	-
15	29-Jun	3	10	9	1	-	-	10	19.7	3.0	113.5
16	01-Jul	30	10	8	1	1	-	10	10.2	1.0	576.5

Min = minimum; Max = maximum

* FEC : faecal egg count

Appendix 3.76 : Faecal egg and lungworm larval counts (/g) from weaners (3-15 months) on each survey farm in June 1993, September 1992 and 1993, and in November-December 1992**

Farm code	Date of sampling	Time after last drench if <60 days	Number of deer sampled	Number of deer with FEC *				Faecal larval counts >0			
				0	50	100 150	>=200	Number of deer positive	Geometric mean	Min	Max
JUNE											
Year 1993											
1	31-May	26	10	3	3	3	1	6	0.9	0.3	3.3
2	01-Jun	47	10	8	1	1	-	0	-	-	-
3	03-Jun	2	10	3	-	6	1	1	0.5	0.5	0.5
4	01-Jun	27	9	5	4	-	-	8	2.0	0.3	6.5
5	08-Jun	54	10	3	3	4	-	7	8.0	0.3	41.0
6	02-Jun	33	10	7	1	1	1	10	7.2	0.5	173.3
7	07-Jun	15	10	6	3	1	-	0	-	-	-
8	26-May	9	10	10	-	-	-	0	-	-	-
9	25-May	12	10	10	-	-	-	0	-	-	-
10	09-Jun	28	10	8	1	1	-	9	1.4	0.3	20.5
11	27-May	12	10	8	2	-	-	0	-	-	-
13	24-May	21	10	8	1	1	-	10	3.4	0.8	29.3
15	13-Jun	30	10	7	3	-	-	10	7.9	2.0	44.5
16	10-Jun	4	10	-	6	4	-	7	0.9	0.3	3.0
SEPTEMBER											
Year 1992											
1	02-Sep	3	10	1	-	-	-	1	0.3	-	-
2	30-Sep		10	6	4	-	-	8	1.2	0.3	4.3
3	15-Sep	41	10	7	2	-	1	10	6.6	0.5	53.0
4	17-Sep		10	7	2	1	-	9	2.6	0.3	9.5
5	09-Sep	12	10	6	3	1	-	0	-	-	-
6	05-Oct		10	8	2	-	-	10	11.0	1.0	31.8
7	14-Sep	37	10	9	1	-	-	4	1.7	0.3	11.0
8	08-Sep		10	9	-	1	-	7	4.1	0.5	108.5
9	24-Sep		10	10	-	-	-	10	2.8	0.5	13.5
10	10-Sep	31	10	7	3	-	-	7	4.7	1.3	38.5
11	07-Sep	4	10	7	1	2	-	10	2.1	0.5	5.3
13	24-Sep		10	4	5	1	-	9	7.4	1.0	63.0
14	28-Sep		10	8	-	2	-	5	5.5	4.0	9.0
15	21-Sep	34	10	7	2	1	-	10	6.3	0.3	86.3
16	09-Sep		10	5	3	1	1	6	4.5	0.3	21.5
Year 1993											
1	15-Sep	42	9	8	1	-	-	4	0.7	0.3	3.3
2	31-Aug	19	10	9	1	-	-	0	-	-	-
3	13-Sep	3	10	8	2	-	-	0	-	-	-
4	31-Aug	17	9	5	2	2	-	5	0.7	0.3	1.8
5	14-Sep		10	7	1	2	-	0	-	-	-
6	16-Sep	21	10	8	1	1	-	4	1.4	0.5	6.3
7	05-Sep	8	10	7	3	-	-	0	-	-	-
8	20-Sep	11	10	10	-	-	-	0	-	-	-
9	21-Sep		10	10	-	-	-	0	-	-	-
10	02-Sep	23	10	5	-	4	1	5	1.1	0.3	2.5
11	08-Sep		10	5	2	2	1	9	4.0	0.3	28.0
13	07-Sep	33	10	8	2	-	-	1	0.3	-	-
15	06-Sep	25	10	9	1	-	-	8	2.2	0.3	30.5
16	01-Sep		10	9	1	-	-				
NOVEMBER 1992											
1	18-Nov	35	10	10	-	-	-	0	-	-	-
2	18-Nov		10	9	1	-	-	1	0.3	0.3	0.3
3	01-Dec	27	10	9	1	-	-	1	0.5	0.5	0.5
4	01-Dec		10	8	2	-	-	3	0.8	0.3	3.0
5	19-Nov		10	8	1	1	-	4	1.1	0.5	5.0
6	24-Nov	15	10	7	3	-	-	0	-	-	-
7	30-Nov	2	10	9	1	-	-	0	-	-	-
8	25-Nov		10	8	1	1	-	9	1.4	0.3	5.8
9	25-Nov	13	10	8	2	-	-	0	-	-	-
10	26-Nov		10	8	2	-	-	9	2.4	0.5	11.8
11	23-Nov		10	9	1	-	-	8	1.8	0.3	7.5
13	02-Dec		10	8	2	-	-	9	2.1	0.3	60.3
14	02-Dec	28	10	10	-	-	-	1	0.3	0.3	0.3
15	23-Nov	33	10	10	-	-	-	4	0.5	0.3	1.8
16	03-Dec		10	10	-	-	-	0	-	-	-

Min = minimum; Max = maximum

* FEC = faecal egg count

** Weaners were not sampled in November-December 1993

Appendix 3.77 : Faecal egg and lungworm larval counts (/g) from yearling and adult hinds* on each survey farm in March 1992 and 1993

Farm code	Date of sampling	Days after last drench**	Number of deer sampled	Number of deer with FEC ***				Faecal larval counts >0			
				0	50	100	>=150	Number of deer positive	Geometric mean	Min	Max
MARCH											
Year 1992											
1	17-Mar		10	8	1	1	-	6	1.0	0.3	3.8
2	02-Mar		10	7	1	1	1	0	-	-	-
3	04-Mar		5	3	1	1	-	1	0.3	-	-
4	26-Feb		10	6	2	-	2	1	3.3	-	-
5	12-Mar		10	9	1	-	-	7	0.6	0.3	1.8
6	19-Mar		10	10	-	-	-	5	1.2	0.3	14.8
7	24-Mar		10	7	2	1	-	7	1.4	0.3	4.3
8	18-Mar		10	8	2	-	-	7	1.0	0.3	2.5
9	10-Mar		10	10	-	-	-	7	0.9	0.5	2.8
11	03-Mar		10	10	-	-	-	3	0.5	0.3	1.3
12	27-Feb		10	7	2	-	1	0	-	-	-
13	11-Mar	1	10	10	-	-	-	2	0.4	0.3	0.5
14	09-Mar		10	8	1	1	1	2	0.4	0.3	0.5
15	23-Mar		10	8	2	-	-	2	2.2	1.8	2.8
Year 1993											
1	24-Mar		10	9	1	-	-	5	0.7	0.3	3.3
2	23-Mar		10	8	2	-	-	3	0.6	0.3	1.3
3	16-Mar		10	10	-	-	-	3	0.8	0.5	1.5
4	15-Mar		10	10	-	-	-	7	0.7	0.3	2.0
5	03-Mar		10	5	4	-	1	6	1.0	0.3	4.5
6	18-Mar		10	6	3	-	1	8	1.3	0.3	5.8
7	22-Mar		10	9	1	-	-	7	1.9	0.3	5.3
8	10-Mar		10	10	-	-	-	7	2.6	0.3	5.5
9	08-Mar		10	7	2	1	-	10	3.1	0.5	21.8
10	30-Mar		10	7	2	1	-	6	1.1	0.3	7.8
11	02-Mar		10	9	1	-	-	7	1.5	0.3	5.5
13	06-Apr		10	10	-	-	-	10	1.1	0.3	9.3
15	29-Mar		10	10	-	-	-	7	1.2	0.3	2.8
16	25-Mar		10	7	2	1	-	3	0.4	0.3	1.3
SEPTEMBER											
Year 1992											
1	02-Sep		10	9	1	-	-	6	0.9	0.3	3.5
2	30-Sep		10	7	1	1	1	2	2.3	2.0	2.8
3	15-Sep		7	5	2	-	-	4	1.2	0.8	2.0
4	17-Sep		10	5	1	1	3	7	1.9	0.5	6.8
5	09-Sep		10	5	3	-	2	5	3.7	1.8	15.5
6	05-Oct		10	6	3	-	1	8	3.2	0.3	30.8
7	14-Sep	29	10	8	1	-	1	9	2.1	0.3	5.0
8	08-Sep		10	4	6	-	-	8	1.1	0.3	7.5
9	24-Sep		10	8	2	-	-	8	2.6	0.5	18.0
10	10-Sep		10	8	2	-	-	6	1.7	0.3	6.5
11	07-Sep		10	10	-	-	-	3	9.0	4.5	15.0
13	24-Sep		10	8	2	-	-	7	1.9	0.8	5.3
14	28-Sep		10	8	2	-	-	3	0.5	0.3	0.8
15	21-Sep	87	10	7	3	-	-	3	0.3	0.3	0.5
16	09-Sep	9	10	10	-	-	-	0	-	-	-
Year 1993											
1	15-Sep		10	9	-	1	-	2	1.8	1.3	2.5
2	31-Aug		10	6	4	-	-	4	0.7	0.3	1.8
3	13-Sep		10	4	2	3	1	7	1.9	0.3	13.5
4	31-Aug		10	2	-	5	3	5	0.7	0.3	1.5
5	14-Sep		10	4	6	-	-	5	1.3	0.5	3.0
6	16-Sep		10	4	3	2	1	5	0.9	0.3	2.8
7	05-Sep		9	5	4	-	-	2	1.4	0.5	3.8
8	20-Sep		10	8	2	-	-	6	2.5	0.3	8.3
9	21-Sep		10	4	3	3	-	6	3.4	1.3	31.5
10	02-Sep		10	6	4	-	-	4	1.1	0.5	3.5
11	08-Sep		9	8	1	-	-	4	2.5	1.0	6.0
13	07-Sep		10	6	3	-	1	5	1.1	0.3	2.5
15	06-Sep		10	6	2	1	1	5	0.8	0.3	3.3
16	01-Sep	31	10	9	1	-	-	0	-	-	-

* FEC and FLC were not statistically significantly different (using Chi-square test and T-test, respectively, P>0.05) between yearling and adult hinds, so data were pooled for presentation.

** Farm 13 drenched yearling hinds only in March 1992, Farm 7 drenched adult hinds only in August 1993. Farms 15 and 16 drenched adult hinds in June 1992, and in August 1993, respectively
Drenching programs implemented on each farm are presented in Table 3.13.

*** FEC = faecal egg count

Appendix 3.78 : Faecal egg and lungworm larval counts (/g) from yearling (15-28 months) and adult (>28 months) stags on each survey farm in June 1992 and 1993, and November 1992**

Farm code	Date of sampling	Days after last drench	Number of deer sampled		Number of deer with FEC *				Adult stags with FLC >0**				Yearling stags with FLC >0**			
			Adult	Yearling	0	50	100	>=150	Number of deer positive	Geometric mean	Minimum	Maximum	Number of deer positive	Geometric mean	Minimum	Maximum
JUNE																
Year 1992																
1	28-May		5	5	7	2	1	-	5	1.3	0.3	6.3	4	6.9	3.0	24.5
2	27-May	4	0	5	4	1	-	-	Deer not sampled				0	-	-	-
3	03-Jun	79	6	1	5	-	-	1	3	2.7	0.3	28.0	0	-	-	-
5	23-Jun		4	4	1	5	1	1	4	1.3	0.3	5.5	4	6.4	0.8	37.5
6	24-Jun		5	5	4	2	1	3	3	6.0	1.0	95.3	4	8.7	3.5	44.8
7	08-Jun	71	4	5	7	2	-	-	2	0.6	0.3	1.3	1	0.3	0.3	0.3
9	15-Jun		5	5	4	3	-	3	4	1.8	0.8	7.0	5	3.8	1.5	12.5
10	16-Jun		5	5	10	-	-	-	4	1.1	0.3	3.3	4	0.9	0.3	5.5
11	04-Jun		5	5	8	2	-	-	3	0.7	0.3	2.5	4	0.9	0.3	2.8
13	30-Jun	111	4	4	7	1	-	-	3	1.6	0.8	4.5	2	2.9	1.5	5.8
14	22-Jun		5	0	2	2	1	-	2	0.7	0.3	1.8	Deer not sampled			
15	29-Jun	25-14	5	5	10	-	-	-	0	-	-	-	0	-	-	-
16	01-Jul		5	5	4	2	4	-	4	1.8	0.5	8.3	4	4.3	1.0	33.8
Year 1993																
1	31-May		5	5	8	2	-	-	1	4.5	4.5	4.5	4	2.7	1.3	13.5
3	03-Jun		5	5	7	3	-	-	1	0.8	0.8	0.8	4	2.7	0.8	6.3
5	08-Jun		4	5	7	2	-	-	3	1.3	0.5	2.8	3	1.5	0.5	4.3
6	02-Jun		1	5	2	3	-	1	0	-	-	-	3	0.5	0.3	0.8
7	07-Jun	65	5	5	9	1	-	-	1	0.3	0.3	0.3	3	0.9	0.5	1.8
8	26-May		0	5	5	-	-	-	Deer not sampled				4	9.6	6.0	15.3
9	25-May		5	5	7	2	1	-	1	0.5	0.5	0.5	5	2.8	0.5	13.3
10	09-Jun		5	5	5	3	2	-	3	0.9	0.5	1.3	5	4.5	2.3	16.3
11	27-May		5	5	8	2	-	-	4	4.0	0.5	29.8	3	4.6	1.8	8.3
13	24-May		4	5	9	-	-	-	1	1.0	1.0	1.0	5	2.0	0.8	4.5
15	13-Jun		5	5	10	-	-	-	5	1.5	0.3	3.3	4	1.4	0.3	9.0
16	10-Jun		5	5	7	1	1	1	3	0.5	0.3	1.0	4	1.9	0.8	5.8
NOVEMBER 1992***																
1	18-Nov	81	5	5	10	-	-	-	2	0.4	0.3	0.5	1	1.3	1.3	1.3
2	18-Nov		0	5	5	-	-	-	Deer not sampled				0	-	-	-
3	01-Dec		5	0	5	-	-	-	2	0.4	0.3	0.5	Deer not sampled			
5	19-Nov		5	5	9	1	-	-	1	2.0	2.0	2.0	0	-	-	-
6	24-Nov		0	5	5	-	-	-	Deer not sampled				0	-	-	-
7	30-Nov	120	5	5	8	1	-	1	1	2.0	2.0	2.0	4	2.0	0.8	4.0
10	26-Nov	93	3	3	6	-	-	-	2	0.6	0.3	1.5	2	1.1	1.0	1.3
11	23-Nov	101	5	0	3	2	-	-	1	0.8	0.8	0.8	Deer not sampled			
13	02-Dec		5	5	9	1	-	-	1	0.3	0.3	0.3	2	1.0	0.3	3.8
14	02-Dec		5	0	5	-	-	-	3	0.8	0.5	1.5	Deer not sampled			
15	23-Nov		5	5	6	4	-	-	1	3.0	3.0	3.0	2	0.6	0.3	1.5
16	03-Dec	81	2	0	1	1	-	-	0	-	-	-	Deer not sampled			

* Faecal egg counts (FEC) were not statistically significantly different (using Chi-square test, P>0.05) between yearling and adult stags, so data were pooled for presentation.

**Positive faecal larval counts (FLC) were statistically significantly different (using t-test, P<0.01) between yearling and adult stags.

***Stags were not sampled in November-December 1993

Note . Actual dates of anthelmintic treatment are presented in Table 3.13.

Appendix 3.79 : Serological immune response to *Yersinia pseudotuberculosis* from March to June and from March to September in weaners (3-15 months) on each survey farm in 1992 and 1993.

	Year 1992					Year 1993				
		Number of deer seroconverting** against serotype :					Number of deer seroconverting** against serotype :			
Farm code	Number of deer*	I	II	III	Prevalence*** %	Number of deer*	I	II	III	Prevalence*** %
JUNE										
1	10	9	2	2	90.0	10	-	2	5	50.0
2	4	4	3	3	100.0	8	-	-	-	0.0
3	9	6	3	3	66.7	10	7	5	6	70.0
4	10	7	7	5	70.0	10	-	-	-	0.0
5	9	8	4	3	88.9	9	1	-	-	11.1
6	9	8	5	4	88.9	5	1	1	1	20.0
7	10	8	9	3	90.0	9	4	8	9	100.0
8	7	4	1	4	57.1	4	4	3	3	100.0
9	10	1	1	4	40.0	8	1	1	5	62.5
10	NS					10	3	5	7	70.0
11	10	1	3	6	60.0	10	5	3	4	50.0
13	6	-	-	3	50.0	10	7	6	8	80.0
14	4	-	1	1	25.0	NS				
15	8	2	3	5	62.5	10	1	1	1	10.0
16	NS					10	3	4	-	40.0
All farm	106	58	42	46	54.7	123	37	39	49	39.8
SEPTEMBER										
1	10	-	-	1	10.0	10	-	-	-	0.0
2	4	-	-	-	0.0	8	-	-	-	0.0
3	8	3	-	2	37.5	10	8	2	-	80.0
4	8	-	1	-	12.5	10	-	-	1	10.0
5	3	-	-	1	33.3	5	1	-	-	20.0
6	8	1	-	-	12.5	5	3	-	-	60.0
7	10	1	-	-	10.0	9	3	3	2	33.3
8	6	-	-	-	0.0	4	1	3	-	75.0
9	10	-	-	-	0.0	8	2	1	3	37.5
10	NS					10	3	1	2	30.0
11	0					10	6	4	1	60.0
13	5	-	-	-	0.0	9	1	-	-	11.1
14	4	-	-	-	0.0	Farm not monitored				
15	8	1	1	1	12.5	10	3	2	3	30.0
16	NS					10	6	6	4	60.0
All farm	84	6	2	5	7.1	118	37	22	16	31.4

NS = weaners not sampled

* Number of deer sampled in March and in June (JUNE) or in March and September (SEPTEMBER)

** There was a positive seroconversion when the Optical Density (OD)(test result) increased by over 20 units for individual weaners from March to June, or from March to September, respectively. Interpretation was based on the assumption weaners did not experienced subclinical infection with *Yersinia pseudotuberculosis* before the first sampling in March.

*** Maximum prevalence recorded for any of the three serotypes considered

Note : In 1993, farms 1, 9 and 13 vaccinated their weaners with Yersiniavax in response to clinical yersiniosis, while farms 5, 7, 8 and 10 vaccinated their weaners preventively.
Farm 14 was not monitored in 1993.

APPENDICES

CHAPTER 4

Appendix 4.1 : Significance level of Chi-square test of association of dichotomous risk factors with ability of yearling and adult hinds of conceiving early (before May 1) (ADVC) and of conceiving *per se* (CONC), respectively, and unadjusted odds ratios (OR).

Risk factor code	Yearling hinds: Number of deer	Chi-square P value	Unadjusted odds ratio*: OR	95%CI		Adult hinds: Number of deer	Chi-square P value	Unadjusted odds ratio*: OR	95%CI	
Hind conception before May 1 (ADVC)										
BLOCK 1 : Animal management										
AGE3						2601	0.000	2.04	1.48	2.81
NZ100						2594	0.000	2.80	1.94	4.05
WET						2552	0.000	3.09	2.11	4.51
YSPM	700	0.000	2.22	1.61	3.05					
CLAH	700	0.102	0.77	0.56	1.05					
SSIRE	700	0.006	0.63	0.45	0.88	2601	0.005	0.53	0.33	0.83
YS	700	0.093	0.70	0.47	1.06	2601	0.778			
EXP	700	0.008	0.65	0.47	0.89	2561	0.003	1.64	1.18	2.29
WAPS	700	0.474				2601	0.049	1.55	1.00	2.41
NZS	700	0.269				2601	0.412			
BACK	700	0.000	2.79	1.71	4.56	2601	0.267			
Back-up mating mob characteristics **										
SSIRE2	138	0.290				1203	0.626			
EXP2	138	0.021	0.18	0.10	0.40	1203	0.330			
CLAH2	138	0.253								
USED	138	0.245				1203	0.388			
Body condition score										
BCSM25	668	0.027	1.95	1.07	3.53	2421	0.021	0.68	0.49	0.94
BCSM4	668	0.012	0.65	0.46	0.91	2421	0.829			
BLOCK 2 : Environment and grazing management										
RSWH5	700	0.869				2427	0.029	0.58	0.36	0.95
RSWH10	700	0.227				2427	0.022	0.70	0.51	0.95
MACRO	700	0.813				2573	0.517			
OTHERST	700	0.008	0.65	0.47	0.89	2601	0.181	0.77	0.53	1.13
Hind conception (CONC)										
BLOCK 1 : Animal management										
AGE3						2603	0.005	1.91	1.20	3.03
NZ100						2596	0.000	4.77	3.01	7.58
WET						2554	0.000	3.28	1.98	5.46
CLAH	700	0.761								
SSIRE	700	0.073	0.66	0.42	1.04	2603	0.059	0.53	0.27	1.04
YS	700	0.691				2603	0.203			
EXP	700	0.001	0.48	0.31	0.76	2563	0.000	2.30	1.48	3.58
WAPS	700	0.678				2603	0.031	2.20	1.06	4.58
NZS	700	0.949				2603	0.687			
CHS	700	0.039	1.67	1.02	2.75	2603	0.001	2.13	1.35	3.37
Back-up mating mob characteristics **										
SSIRE2	217	0.035	0.23	0.05	1.01	1227	0.793			
EXP2	197	0.024	0.32	0.11	0.90	1209	0.851			
USED	217	0.543				1227	0.350			
BACK	217	0.912				1227	0.468			
BACKM	217	0.993				1227	0.164	1.52	0.84	2.76
CHS2	217	0.000	0.19	0.07	0.51	1227	0.480			
Body condition score										
BCSM25	662	0.034	2.92	1.04	8.23	2423	0.000	0.37	0.24	0.57
BCSM4	662	0.143	0.72	0.46	1.12	2423	0.433			
BLOCK 2 : Environment and grazing management										
RSWH5	700	0.010	5.33	1.28	22.18	2603	0.274			
RSWH10	700	0.334				2603	0.000	0.34	0.22	0.51
MACRO	700	0.201				2603	0.603			
OTHERS	700	0.697				2603	0.974			
FSUP	706	0.533				2603	0.036	0.63	0.41	0.97

Number of yearling hinds ADVC = 1 : 467 and ADVC = 0 : 233
Number of adult hinds ADVC = 1 : 2405 and ADVC = 0 : 191
Number of yearling hinds CONC = 1 : 597 and CONC = 0 : 103
Number of adult hinds CONC = 1 : 2513 and ADVC = 0 : 90
* Unadjusted odds ratios and their 95% confidence limits (95%CI) are presented if P < 0.20
** Back-up mob characteristics were analysed separately with hinds from mating mob that had a back-up stag before May 1 including hinds for which grazing records were missing.
Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.1 (Cont'd)

Risk factor code	Yearling hinds: Number of deer	Fisher exact P value	Unadjusted odds ratio* OR	95%CI		Adult hinds: Number of deer	Fisher exact P value	Unadjusted odds ratio* OR	95%CI	
Hind conception before May 1 (ADVC)										
Sentinel hind characteristics										
AGE3						128	0.088	3.00	0.90	10.03
NZ100						128	0.035	4.77	1.24	18.44
WET						128	0.021	5.89	1.48	23.40
VICTIM	108	1.000				128	0.462			
TEETH						128	0.396			
EASES	108	0.619				128	0.112	2.88	0.78	10.64
Biological markers										
CU8	108	0.168	5.16	0.63	42.03	128	0.620			
B12185	108	0.064	0.36	0.12	1.04	128	0.292			
MGSHPx3	108	0.001	11.11	2.21	55.56	128	1.000			
FEC>0	108	0.599				128	1.000			
FLC>0	108	0.834				128	1.000			
Hind conception (CONC)										
Sentinel hind characteristics										
AGE3						128	0.020	11.87	1.28	110.27
NZ100						128	0.011	13.88	2.11	91.45
WET						128	0.081	6.73	1.01	44.68
VICTIM	108	0.451				128	1.000			
TEETH						128	0.210			
EASES	108	0.145	2.67	0.78	9.14	128	1.000			
Biological markers										
CU8	108	np				128	0.445			
B12185	108	0.178	0.20	0.03	1.61	128	1.000			
MGSHPx3	108	0.100	3.77	0.84	16.95	128	np			
FEC>0	108	0.255				128	1.000			
FLC>0	108	0.007	0.10	0.01	0.77	128	1.000			

Number of yearling hinds ADVC = 1 : 74 and ADVC = 0 : 34 Number of yearling hinds CONC = 1 : 95 and CONC = 0 : 13
Number of adult hinds ADVC = 1 : 116 and ADVC = 0 : 12 Number of adult hinds CONC = 1 : 123 and ADVC = 0 : 5
* Unadjusted odds ratios and their 95% confidence limits (95%CI) are presented if $P < 0.20$
Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.2 : Range of all values, number of cases, mean and standard deviation of continuous risk factors screened for association with the ability of yearling hinds of conceiving early (before May 1)(ADVC) and of conceiving *per se* (CONC), respectively, in a preliminary univariate analysis, and t-test p values.

Risk factor code	Unit	t-test P value	Range of all values Min	Max	ADVC or CONC = 1* Number of deer	Mean	SD	ADVC or CONC = 0* Number of deer	Mean	SD
Hind conception before May 1 (ADVC)										
BLOCK 1 : Animal management										
Risk factor selected for multivariable analysis										
JOIN	day	0.000	31.00	91.00	467	62.69	19.62	233	68.85	17.26
YH		0.000	1.00	52.00	467	34.56	13.57	233	30.44	13.06
W4	kg	0.004	58.56	114.29	370	83.66	7.73	206	82.17	9.63
NZ	%	0.007	12.50	100.00	467	88.97	20.21	233	84.07	26.93
BCSM	Dis. 1-5;0.5	0.009	2.00	4.50	440	3.38	0.56	228	3.49	0.50
Risk factors rejected after univariable screening										
AH		0.509	0.00	66.00	467	6.37	11.02	233	5.82	10.00
GR46	g/day	0.713	-174.92	285.71	341	3670	48.09	171	34.92	53.54
RATIO	hinds/stag	0.969	1.59	71.00	467	28.99	14.46	233	29.04	14.21
BLOCK 2 : Environment and grazing management										
Risk factor selected for multivariable analysis										
SUR	%	0.000	0.00	100.00	467	13.71	28.42	233	39.04	44.78
DEER		0.000	10.38	74.38	467	45.99	14.41	233	39.62	14.17
AVWIND		0.000	0.36	3.63	467	1.22	0.68	233	1.03	0.53
DEER/Ha	Deer/ha	0.000	2.44	37.30	467	14.16	9.07	233	11.56	9.12
ISWH	cm	0.001	4.00	24.00	467	13.77	4.84	233	12.36	5.10
AVMAT	°C	0.002	14.40	21.23	467	18.03	2.03	233	17.53	2.08
AVMMT	°C	0.003	6.77	15.28	467	11.43	2.43	233	10.85	2.38
SHELT		0.004	3.11	32.00	467	16.97	7.02	233	18.59	7.10
PASTT	Score 1-3	0.010	1.00	3.00	467	2.14	0.60	233	2.01	0.65
TREES	Score 0-3	0.014	0.00	3.00	467	0.99	1.24	233	1.24	1.27
STOCK		0.111	1.00	3.00	467	1.21	0.44	233	1.27	0.46
CLOVER	Score 1-3	0.190	1.00	2.43	467	1.66	0.42	233	1.71	0.45
Risk factors rejected after univariable screening										
SUN	Score 0-1	0.219	0.29	0.70	467	0.43	0.11	233	0.44	0.11
FAREA	ha	0.354	0.82	18.20	467	5.29	4.70	233	5.63	4.19
AVMIT	°C	0.499	3.30	9.00	467	6.60	1.39	233	6.67	1.42
RAIND	mm/day	0.652	1.50	6.81	467	3.07	1.40	233	3.02	1.15
TOPO	1-3	0.659	1.00	3.00	467	1.78	0.59	233	1.76	0.62
SHIFT		0.718	1.00	6.00	467	2.22	1.35	233	2.18	1.56
M%AH	%	0.867	0.00	97.90	467	15.93	24.99	233	15.62	22.91
Hind conception (CONC)										
BLOCK 1 : Animal management										
Risk factor selected for multivariable analysis										
NZ	%	0.007	12.50	100.00	597	88.70	21.00	103	79.75	29.88
GR46	g/day	0.021	-174.92	285.71	427	38.69	47.59	79	24.61	60.47
JOIN	day	0.032	31.00	91.00	597	64.08	19.34	103	68.19	17.48
YH		0.058	1.00	52.00	597	33.62	13.65	103	30.98	12.86
REMD		0.067	29.00	78.00	597	44.56	13.89	103	42.16	11.92
BCSM	Dis. 1-5;0.5	0.329	2.00	4.50	562	3.42	0.55	100	3.47	0.50
W4	kg	0.419	58.56	114.29	486	83.38	8.15	84	82.49	9.48
Risk factors rejected after univariable screening										
RATIO	hinds/sire	0.413	1.59	71.00	597	28.84	14.18	103	30.20	15.84
AH		0.857	0.00	66.00	597	6.21	10.90	103	6.40	9.56
BLOCK 2 : Environment and grazing management										
Risk factor selected for multivariable analysis										
AVMMT	°C	0.000	6.88	15.15	597	10.61	2.43	103	9.64	2.07
TREES	Score 0-3	0.000	0.00	3.00	597	1.21	1.16	103	1.78	1.25
AVMAT	°C	0.001	13.19	20.45	597	16.67	2.20	103	15.98	1.91
SHELT		0.011	4.73	32.00	597	18.17	6.30	103	20.08	7.02
ISWH	cm	0.013	4.00	20.00	592	12.42	4.06	102	13.45	3.80
AVWIND		0.018	0.34	2.82	597	1.09	0.58	103	0.95	0.57
AVMIT	°C	0.048	3.21	8.26	597	6.05	1.37	103	6.33	1.33
DEER		0.058	13.00	109.18	597	53.22	20.83	103	48.86	21.46
SHIFT		0.080	1.00	11.00	592	3.74	2.56	102	4.24	3.02
Risk factors rejected after univariable screening										
FAREA	ha	0.233	0.78	18.20	597	5.98	4.65	103	5.45	4.05
SUN	Score 0-1	0.273	0.26	0.65	597	0.41	0.12	103	0.40	0.11
SUR	%	0.395	0.00	100.00	597	20.28	34.29	103	23.45	34.95
TOPO	Score 1-3	0.412	1.00	3.00	597	1.80	0.57	103	1.75	0.56
PASTT	Score 1-3	0.596	1.00	3.00	597	2.15	0.55	103	2.18	0.60
CLOVER	Score 1-3	0.665	0.20	2.51	597	1.58	0.39	103	1.60	0.48
STOCK		0.672	1.00	4.00	597	2.21	0.73	103	2.24	0.69
RAIND	mm	0.886	1.56	5.09	597	3.00	0.91	103	3.02	0.95
M%AH	%	0.968	0.00	100.00	597	18.12	25.14	103	18.22	23.08
DEER/Ha	Deer/ha	0.988	3.06	65.17	597	14.45	10.88	103	14.47	11.63

Min = minimum; Max = maximum; SD = standard deviation

* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conceiving after May 1 or not pregnant
CONC = 1 : Hind conceiving; CONC=0 : Hind not pregnant

Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.3 : Range of all values, number of cases, means and standard deviations of continuous risk factors screened for association with the ability of adult hinds of conceiving early (before May 1)(ADVC) and of conceiving *per se* (CONC), respectively, in a preliminary univariate analysis, and t-test p values.

Risk factor code	Unit	t-test P value	Range of all values Min	Max	ADVC or CONC = 1* Number of deer	Mean	SD	ADVC or CONC = 0* Number of deer	Mean	SD
Hind conception before May 1 (ADVC)										
BLOCK 1 : Animal management										
Risk factor selected for multivariable analysis										
JOIN	day	0.000	42.00	91.00	2405	72.97	12.01	196	77.24	9.20
W4	kg	0.009	68.00	144.50	1876	97.98	10.03	164	95.80	11.29
BCSM	Dis. 1-5;0.5	0.012	1.00	5.00	2242	3.25	0.71	179	3.10	0.84
RATIO	hinds/stag	0.071	8.00	82.00	2405	38.78	14.76	196	40.78	14.91
AH		0.072	4.00	150.00	2405	50.64	31.73	196	46.43	28.05
WEAN	day	0.269	10.00	75.00	2405	28.21	14.44	196	29.39	12.72
Risk factors rejected after univariable screening										
GR46	g/day	0.685	-190.13	216.87	1584	0.83	51.82	130	-1.02	49.66
BLOCK 2 : Environment and grazing management block										
Risk factor selected for multivariable analysis										
TREES	Score 0-3	0.003	0.00	3.00	2405	1.14	1.11	196	0.89	0.99
AVMIT	°C	0.008	3.30	9.00	2382	6.85	1.20	191	7.09	1.20
SUR	%	0.013	0.00	100.00	2405	32.57	42.85	196	40.96	45.14
FAREA	ha	0.015	0.82	25.86	2405	6.41	6.23	196	5.30	5.02
SHIFT		0.022	1.00	9.00	2382	2.59	1.94	191	2.94	2.56
SHELT		0.039	2.89	40.00	2405	18.69	9.19	196	17.33	8.84
ISWH	cm	0.039	3.50	20.00	2249	13.15	3.56	178	12.57	4.24
TOPO	Score 1-3	0.046	1.00	3.00	2405	1.78	0.69	196	1.68	0.68
STOCK		0.070	1.00	6.00	2382	1.60	0.82	191	1.71	0.97
AVMAT	°C	0.110	14.40	21.23	2382	17.64	1.85	191	17.87	1.96
DEER/Ha	Deer/ha	0.150	2.24	43.10	2405	14.99	8.71	196	15.94	8.80
SUN	Score 0-1	0.164	0.29	0.70	2382	0.45	0.12	191	0.44	0.11
CLOVER	Score 1-3	0.187	1.00	2.00	2275	1.48	0.42	186	1.53	0.42
DEER		0.189	10.38	301.92	2405	64.11	59.77	196	58.33	51.32
Risk factors rejected after univariable screening										
RAIND	mm	0.264	1.36	6.45	2382	2.95	1.19	191	3.04	1.07
PASTT	Score 1-3	0.553	1.00	3.00	2405	2.18	0.61	196	2.16	0.62
AVWIND		0.689	0.33	4.29	2405	1.07	0.72	196	1.05	0.59
AVMMT	°C	0.951	6.77	15.28	2382	10.79	2.01	191	10.78	1.89
Hind conception (CONC)										
BLOCK 1 : Animal management										
Risk factor selected for multivariable analysis										
BCSM	Dis. 1-5;0.5	0.001	1.00	5.00	2339	3.25	0.72	84	2.96	0.89
JOIN	day	0.008	42.00	91.00	2513	73.19	11.90	90	76.30	10.72
REMD	day	0.010	29.00	78.00	2513	46.41	13.57	90	42.63	15.96
YH		0.054	0.00	49.00	2513	1.59	5.51	90	2.74	7.55
Risk factors rejected after univariable screening										
AH		0.226	4.00	150.00	2513	50.44	31.37	90	45.94	34.50
RATIO	hinds/sire	0.243	8.00	82.00	2513	39.01	14.85	90	37.16	12.21
GR46	g/day	0.725	-190.13	216.87	1651	0.73	51.64	64	-1.62	52.34
W4	kg	0.820	68.00	144.50	1963	97.80	10.11	78	98.11	11.67
WEAN	day	0.894	10.00	75.00	2513	28.28	14.26	90	28.51	15.87
BLOCK 2 : Environment and grazing management										
Risk factor selected for multivariable analysis										
DEER/Ha	Deer/ha	0.000	3.77	66.03	2513	19.57	14.46	90	27.94	21.39
SHIFT		0.000	1.00	14.00	2451	4.25	2.94	87	6.47	4.78
SUN	Score 0-1	0.000	0.26	0.65	2513	0.43	0.12	90	0.38	0.11
RAIND	mm	0.001	1.04	4.74	2513	2.96	0.96	90	3.32	0.96
SUR	%	0.005	0.00	100.00	2513	30.00	37.12	90	42.87	41.34
AVMIT	°C	0.011	3.21	8.26	2513	6.25	1.29	90	6.61	1.29
SHELT		0.036	2.73	40.00	2513	18.84	8.52	90	16.82	8.87
TOPO	Score 1-3	0.042	1.00	3.00	2513	1.80	0.64	90	1.67	0.57
PASTT	Score 1-3	0.068	1.00	3.00	2513	2.22	0.55	90	2.31	0.48
STOCK		0.120	1.00	7.00	2513	2.94	1.04	90	3.11	1.20
AVMMT	°C	0.135	6.88	15.15	2513	10.17	1.99	90	9.86	1.86
FAREA	ha	0.160	0.77	26.84	2513	6.85	6.20	90	5.96	5.82
TREES	Score 0-3	0.173	0.00	3.00	2513	1.11	0.99	90	0.96	0.97
Risk factors rejected after univariable screening										
ISWH	cm	0.302	4.00	20.00	2423	12.40	3.15	87	12.77	3.26
CLOVER	Score 1-3	0.417	0.20	2.00	2485	1.34	0.38	90	1.38	0.38
AVWIND		0.695	0.37	3.35	2513	1.02	0.57	90	1.04	0.50
AVMAT	°C	0.771	13.39	20.45	2513	16.42	1.87	90	16.47	1.75
DEER		0.923	24.10	233.31	2513	77.65	41.86	90	78.09	48.97

Min = minimum; Max = maximum; SD = standard deviation

* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conception after May 1 or not pregnant

CONC = 1 : Hind conceiving; CONC=0 : Hind not pregnant

Note on units : "Score 0-1" means "Score ranging from 0 to 1"

"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.4 : Range of all values, numbers of cases, means and standard deviations of continuous back-up mating mob management risk factors screened for association with the ability of yearling and adult hinds of conceiving early (before May 1)(ADVC) and of conceiving *per se* (CONC), respectively, in a preliminary univariate analysis, and t-test p values.

Risk factor		t-test	Range of all values		ADVC or CONC = 1*			ADVC or CONC = 0*		
code	Unit	P value	Min	Max	Number of deer	Mean	SD	Number of deer	Mean	SD
Hind conception before May 1 (ADVC)										
Yearling hinds										
AH2		0.069	0.00	66.00	107	14.02	17.58	31	21.03	18.67
YH2		0.062	1.00	41.00	107	28.31	10.82	31	24.09	10.83
RATIO2	hinds/Sire	0.149	8.00	71.00	107	36.28	17.62	31	41.25	16.40
BACKD	day	0.582	19.00	29.00	107	23.22	3.29	31	23.61	3.48
Hind conception (CONC)										
Yearling hinds										
CHD	day	0.476	19.00	55.00	194	30.42	9.60	23	28.91	9.46
AH2		0.032	0.00	136.00	194	40.86	51.41	23	20.96	38.64
YH2		0.564	0.00	41.00	194	28.36	11.30	23	27.17	8.91
RATIO2	hinds/sire	0.158	8.00	174.00	194	59.99	56.18	23	46.04	42.07
REMD		0.609	34.00	78.00	194	52.51	15.60	23	50.86	14.21
Adult hinds										
CHD	day	0.308	15.00	55.00	1200	32.85	10.93	27	35.59	13.62
AH2		0.751	8.00	182.00	1200	92.38	48.44	27	89.59	44.61
YH2		0.008	0.00	38.00	1200	5.42	11.30	27	11.30	14.98
RATIO2	hinds/sire	0.553	22.50	174.00	1200	71.29	41.85	27	76.17	57.69
REMD	day	0.050	34.00	78.00	1200	53.09	13.82	27	59.48	16.02

Min = minimum; Max = maximum; SD = standard deviation

* Conception before May 1 (ADVC : Yes = 1; No = 0) or conception *per se* (CONC : Yes = 1; No = 0)

Note : Back-up management risk factors for early conception of adult hinds were not investigated as the use of a back-up sire before May 1 was not significant in the analysis of animal management risk factors.

Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.5 : Range of all values, means and standard deviations of sentinel adult hind individual characteristics and biological markers screened for association with the ability of adult hinds of conceiving early (before May 1)(ADVC) and of conceiving *per se* (CONC), respectively, in a preliminary univariate analysis, and Rank sum test p values.

				Hind conception before May 1*						Hind conception*						
				Rank sum	ADVC = 1			ADVC = 0			Rank sum	CONC =1			CONC = 0		
Variable		Range of all values		test	Number	Mean	SD	Number	Mean	SD	test	Number	Mean	SD	Number	Mean	SD
code	Unit	Min	Max	P value	of deer			of deer			P value	of deer			of deer		
Sentinel hind characteristics																	
BCSM	Dis. 1-5;0.5	1.50	4.50	0.180	114	3.12	0.72	11	3.41	0.74	0.804	120	3.15	0.72	5	3.00	0.94
W4	kg	76.22	121.50	0.374	98	96.68	9.83	10	98.96	8.39	0.853	104	96.91	9.84	4	96.39	5.16
SIZE	cm	91.44	104.14	0.011	107	97.58	3.12	12	95.78	2.26	0.246	114	97.44	3.14	5	96.27	0.57
GIRTH	cm	99.00	123.00	0.651	114	111.27	5.19	12	112.17	5.04	0.518	121	111.43	5.17	5	109.60	5.13
COATL	mm	30.00	55.00	0.690	116	40.94	4.95	12	41.42	3.70	0.381	123	40.96	4.88	5	41.60	3.91
Biological markers																	
Haematological markers																	
WCC	10E9 /l	2.50	13.60	0.486	116	5.45	1.73	12	5.46	1.09	0.430	123	5.44	1.70	5	5.54	0.90
HB	g/dl	8.80	28.10	0.157	116	16.02	3.32	12	18.63	4.97	0.573	123	16.21	3.53	5	17.58	4.77
PCV	%	0.23	0.48	0.121	116	0.39	0.05	12	0.41	0.05	0.265	123	0.39	0.05	5	0.42	0.05
MCHC	g/dl	29.17	77.42	0.997	116	41.64	7.52	12	46.00	13.20	0.630	123	42.07	8.28	5	41.61	8.05
NP	%	16.00	75.00	0.017	115	48.45	14.98	12	40.42	10.44	0.050	122	48.17	14.75	5	36.00	10.51
EOP	%	0.00	25.00	0.249	115	6.87	4.55	12	7.83	3.64	0.726	122	7.00	4.53	5	6.00	2.92
LP	%	18.00	81.00	0.010	115	42.07	14.77	12	48.92	9.57	0.027	122	42.25	14.46	5	54.20	10.18
Biochemical markers																	
TP	g/l	55.70	86.20	0.313	116	70.74	5.53	12	69.48	4.28	0.037	123	70.77	5.48	5	66.88	0.68
ALB	g/l	28.50	41.50	0.764	116	35.07	2.87	12	34.75	2.53	0.820	123	35.05	2.86	5	34.70	2.50
GLOB	g/l	24.80	50.70	0.451	116	35.67	5.05	12	34.73	4.26	0.036	123	35.72	5.01	5	32.18	2.32
P	mmol/l	1.14	3.84	0.008	116	2.35	0.48	12	2.83	0.49	0.002	123	2.36	0.49	5	3.05	0.19
GGT	IU	17.00	211.00	0.711	116	41.51	25.13	12	35.50	9.25	0.623	123	41.20	24.47	5	34.80	12.99
BUN	mmol/l	6.71	15.98	0.821	116	11.06	1.71	12	11.19	1.75	0.114	123	11.09	1.74	5	10.63	0.61
CU	µmol/l	2.70	23.00	0.652	116	13.23	4.16	12	13.28	3.73	0.657	123	13.22	4.13	5	13.68	3.94
B12	pmol/l	65.00	530.00	0.403	116	160.66	76.67	12	134.17	37.25	0.413	123	159.48	74.93	5	126.00	46.20
GSHPx		0.90	29.70		62	6.86	6.70	3	13.97	8.62		64	7.10	6.89	1	13.30	
MGSHPx**	kIU/l	1.37	24.13	0.374	116	7.27	5.96	12	7.49	5.84	0.058	123	7.24	6.03	5	8.35	1.82
PEPS	mU Tyrosine/l	18.00	2719.00	0.948	116	585.36	447.42	12	528.33	332.75	0.988	123	581.41	439.60	5	545.80	416.00
Parasitological markers																	
FEC	egg/g	0.00	150.00	0.549	116	9.91	26.56	12	12.50	43.30	Inv	123	10.57	28.81	5	0.00	0.00
FLC	larvae/g	0.00	14.75	0.862	116	0.81	1.39	12	1.90	4.31	0.983	123	0.83	1.41	5	3.05	6.54

SD = Standard deviation; Inv = Test invalid

* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conception after May 1 or not pregnant ;CONC = 1 : Hind conceiving; CONC=0 : Hind not pregnant

** The mean of the 3 individual measures of GSHPx from each farm each year has been taken has individual values for multivariable analysis of individual data

Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.6 : Range of all values, means and standard deviations of sentinel yearling hind individual characteristics and biological markers screened for association with the ability of adult hinds of conceiving early (before May 1)(ADVC) and of conceiving *per se* (CONC), respectively, in a preliminary univariate analysis, and Rank sum test p values.

				Hind conception before May 1							Hind conception						
				Rank sum	ADVC = 1			ADVC = 0			Rank sum	CONC =1			CONC = 0		
Variable		Range of all values		test	Number	Mean	SD	Number	Mean	SD	test	Number	Mean	SD	Number	Mean	SD
code	Unit	Min	Max	P value	of deer			of deer			P value	of deer			of deer		
Sentinel hind characteristics																	
BCSM	Dis. 1-5;0,5	2.00	4.50	0.416	66	3.48	0.51	34	3.57	0.46	0.600	87	3.52	0.51	13	3.46	0.43
W4	kg	59.36	106.25	0.149	61	86.16	7.48	27	83.62	9.84	0.515	77	85.53	7.93	11	84.36	10.97
SIZE	cm	88.90	104.14	0.345	72	96.77	3.09	27	96.19	3.70	0.893	92	96.58	3.18	7	97.06	4.39
GIRTH	cm	87.00	123.00	0.761	74	105.96	4.80	33	105.52	5.51	0.559	95	105.92	4.74	12	105.08	7.03
COATL	mm	35.00	60.00	0.321	72	46.57	4.98	30	47.90	5.55	0.337	89	46.71	5.13	13	48.69	5.20
NZ	%	25.00	100.00	0.969	74	89.03	18.73	34	86.41	24.69	0.223	95	89.74	18.50	13	76.92	31.39
Biological markers																	
Haematological markers																	
WCC	10E9 /l	2.80	22.00	0.572	74	5.50	1.52	34	6.29	3.42	0.560	95	5.58	1.67	13	6.93	4.91
HB	g/dl	12.10	26.60	0.534	74	16.54	1.56	34	17.49	3.37	0.522	95	16.68	2.00	13	17.98	3.85
PCV	%	0.33	0.52	0.928	74	0.42	0.04	34	0.42	0.04	0.507	95	0.42	0.04	13	0.41	0.04
MCHC	g/dl	32.16	73.89	0.585	74	39.54	3.30	34	41.97	8.27	0.097	95	39.87	5.01	13	43.48	7.51
NP	%	11.00	67.00	0.244	74	36.19	12.91	34	39.35	12.74	0.638	95	36.84	12.60	13	39.69	15.16
EOP	%	0.00	17.00	0.546	74	4.86	3.93	34	5.12	3.71	0.673	95	4.89	3.81	13	5.31	4.21
LP	%	23.00	82.00	0.075	74	56.73	12.51	34	51.88	12.59	0.227	95	55.85	12.41	13	50.46	14.11
Biochemical markers																	
TP	g/l	56.20	83.20	0.050	74	69.01	4.46	34	67.15	4.32	0.084	95	68.72	4.33	13	66.30	5.13
ALB	g/l	30.00	42.90	0.219	74	36.47	2.78	34	35.64	3.07	0.005	95	36.49	2.86	13	34.21	2.28
GLOB	g/l	22.40	44.70	0.149	74	32.54	4.38	34	31.51	4.09	0.821	95	32.23	4.35	13	32.09	4.05
P	mmol/l	1.53	3.49	0.454	74	2.55	0.41	34	2.61	0.37	0.894	95	2.57	0.40	13	2.55	0.39
GGT	IU	16.00	139.00	0.969	74	30.95	11.38	34	33.44	20.65	0.098	95	31.63	15.69	13	32.46	6.63
BUN	mmol/l	6.51	13.50	0.291	74	9.98	1.14	34	10.14	1.79	0.428	95	9.99	1.31	13	10.28	1.78
CU	umol/l	1.00	24.00	0.178	74	13.13	4.71	34	14.27	3.07	0.003	95	13.14	4.36	13	16.08	2.47
B12	pmol/l	65.00	1500.00	0.031	74	170.27	81.25	34	136.18	53.14	0.019	95	165.60	76.15	13	115.23	48.36
GSHPx	kIU/l	2.00	29.20		10	8.44	8.21	3	9.63	7.87		11	9.37	8.38	2	5.10	0.85
MGSHPx**	kIU/l	1.37	24.13	0.011	74	9.13	6.79	34	5.70	3.55	0.212	95	8.40	6.42	13	5.53	2.71
PEPS	mU Tyrosine/l	18.00	1522.00	0.910	72	450.65	257.28	33	457.76	251.14	0.812	93	452.68	255.52	12	454.50	254.54
Parasitological markers																	
FEC	egg/g	0.00	150.00	0.555	74	14.19	31.54	34	13.24	35.48	0.290	95	11.58	28.67	13	30.77	52.20
FLC	larvae/g	0.00	21.75	0.353	74	1.61	3.43	34	0.68	0.90	0.040	95	1.35	3.08	13	1.10	1.03

SD = Standard deviation

* ADVC = 1 : Hind conceiving before May 1; ADVC=0 : Hind conception after May 1 or not pregnant ;CONC = 1 : Hind conceiving; CONC=0 : Hind not pregnant

** The mean of the 3 individual measures of GSHPx from each farm each year has been taken has individual values for multivariable analysis of individual data

Note : Risk factor codes are described in the glossary and in Table 4.3.

Appendix 4.7: Range of all values, means and standard deviations of continuous risk factors screened for association with the ability of adult hinds to rear a calf up to weaning in a preliminary univariate analysis, and t-test p value.

Risk factor code**	Unit	t-test p value	Range of all values Min	Max	WET HINDS* Number of deer	Mean	SD	DRY HINDS* Number of deer	Mean	SD
BLOCK 1 : Individual hind variables										
Risk factors selected for multivariable analysis										
BCSS	Dis. 1-5;0.5	0.001	1.00	5.00	2611	3.31	0.72	165	3.12	0.83
W6	kg	0.005	66.00	140.00	2178	99.43	9.58	132	96.85	10.19
BCSD	Dis. 1-5;0.5	0.014	-3.00	2.50	2139	0.00	0.80	131	-0.19	0.85
GR69	g/d	0.100	-165.71	216.65	1149	-17.20	43.53	64	-26.48	51.39
Risk factors rejected after univariable screening										
NZ	%	0.171	25.00	100.00	2682	95.39	14.82	168	93.60	16.41
CHW9C	kg	0.533	-7.50	34.00	733	11.46	4.69	47	11.02	4.65
BLOCK 2 : Calving paddock characteristics and calving management										
Risk factors selected for multivariable analysis										
PRAG	Score 0-3	0.008	0.00	3.00	2658	0.82	1.05	168	1.04	1.15
PWIRE%	%	0.024	0.00	100.00	2682	56.34	46.83	168	64.67	45.88
SET	day	0.044	0.00	85.00	2682	66.71	11.48	168	68.43	10.60
PFP	Score 0-3	0.060	0.00	3.00	2682	1.23	0.71	168	1.13	0.70
PAREA	ha	0.104	0.67	24.30	2682	7.05	5.89	168	7.82	7.05
PBULLR	Score 0-3	0.161	0.00	3.00	2682	0.85	1.01	168	0.74	0.95
Risk factors rejected after univariable screening										
HIND/Ha	Deer/ha	0.260	2.69	32.80	2682	10.34	5.91	168	9.81	5.47
%AHCM	%	0.262	3.70	100.00	2682	94.83	12.41	168	93.71	14.38
PTREES	Dis 0-3; 1	0.335	0.00	3.00	2682	1.05	1.28	168	1.15	1.34
ENTERP	Dis. 1-4; 1	0.457	0.00	4.00	2682	2.23	1.50	168	2.13	1.62
PTOPO	Dis 1-3; 1	0.490	1.00	3.00	2682	1.81	0.69	168	1.85	0.70
HINDCM		0.545	6.00	169.00	2682	56.47	40.21	168	58.42	45.24
PTHISTLE	Score 0-3	0.792	0.00	3.00	2682	1.32	0.90	168	1.34	0.82
PGULLY	Dis 0-3; 1	0.870	0.00	3.00	2682	1.86	1.29	168	1.84	1.31
VISIT/W		0.977	0.00	14.00	2682	2.50	3.24	168	2.49	3.28
BLOCK 3 : Environment and grazing management between November 1 and January 1										
Risk factors selected for multivariable analysis										
SUN	Score 0-1	0.000	0.16	0.73	2560	0.44	0.13	168	0.40	0.12
AVMAT	°C	0.001	17.11	22.49	2560	20.18	1.26	168	20.50	1.15
STOCK		0.002	1.00	11.00	2682	2.52	1.73	168	2.96	2.46
RAG	Score 0-3	0.010	0.00	3.00	2682	0.79	0.99	168	1.01	1.06
DEER		0.038	11.59	172.00	2682	66.75	36.19	168	73.27	39.39
SHIFT		0.044	1.00	12.00	2682	3.19	2.03	168	3.52	2.64
FAREA	ha	0.083	0.88	24.30	2682	7.06	5.40	168	7.82	6.69
SHELT		0.088	0.52	36.00	2682	17.73	8.95	168	18.85	8.17
AVMIT	°C	0.115	7.26	10.60	2560	9.04	0.99	168	9.17	1.03
M%AH	%	0.148	3.83	100.00	2682	94.26	11.27	168	92.95	12.69
PASTT	Score 1-3	0.176	1.00	3.00	2682	2.03	0.56	168	2.09	0.52
AVMMT	°C	0.186	8.43	13.85	2560	11.05	1.46	168	11.22	1.55
Risk factors rejected after univariable screening										
DEER/Ha	Deer/ha	0.259	4.12	28.84	2682	12.76	6.18	168	13.34	6.54
BULLR	Score 0-3	0.275	0.00	3.00	2682	0.86	0.96	168	0.78	0.88
SUR	%	0.325	0.00	100.00	2682	30.49	42.36	168	27.29	40.63
TOPO	Score 1-3	0.363	1.00	2.99	2682	1.79	0.63	168	1.84	0.62
AVWIND		0.377	0.13	3.50	2560	0.86	0.61	168	0.81	0.51
THISTLE	Score 0-3	0.381	0.00	3.00	2682	1.38	0.84	168	1.44	0.85
TREES	Score 0-3	0.414	0.00	3.00	2682	1.05	1.13	168	1.12	1.21
CLOVER	Score 1-3	0.545	1.00	3.00	2682	1.94	0.43	168	1.92	0.49
DAM	%	0.664	0.00	100.00	2682	38.09	43.29	168	36.57	43.80
GULLY	Score 0-3	0.681	0.00	3.00	2682	1.86	1.20	168	1.90	1.16
ISWH	cm	0.831	3.00	21.00	2682	10.16	3.54	168	10.22	3.49
RAIND	mm/d	0.952	2.13	6.41	2560	3.95	1.06	168	3.95	1.01

MIn - minimum; Max = maximum; SD = standard deviation

* Wet hind = hind rearing a calf up to weaning; Dry hind = hind not rearing a calf up to weaning

** Risk factor codes are described in the glossary and Table 4.10.

Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Appendix 4.8 : Range of all values, means and standard deviations of continuous risk factors screened for association with the ability of yearling hinds to rear a calf up to weaning in a preliminary univariate analysis, and t-test p value.

Risk factor code**	Unit	t-test p value	Range of all values Min	Max	WET HINDS* Number of deer	Mean	SD	DRY HINDS* Number of deer	Mean	SD
BLOCK 1 : Individual hind variables										
Risk factors selected for multivariable analysis										
BCSD	Dis. 1-5;0.5	0.064	-2.00	2.00	418	-0.15	0.71	64	-0.31	0.63
NZ	%	0.187	12.50	100.00	509	87.62	21.30	76	90.63	17.93
Risk factors rejected after univariable screening										
CHW9C	kg	0.209	-4.50	21.50	160	10.14	4.73	17	8.88	3.70
BCSS	Dis. 1-5;0.5	0.301	1.50	4.50	483	3.24	0.65	73	3.16	0.61
BCSM	Dis. 1-5;0.5	0.584	2.00	4.50	439	3.41	0.55	67	3.45	0.54
GR69	g/d	0.610	-158.67	168.48	208	9.16	35.64	20	4.10	42.28
W6	kg	0.963	64.00	118.00	461	86.57	8.71	61	86.62	7.92
BLOCK 2 : Calving paddock characteristics and calving management										
Risk factors selected for multivariable analysis										
ENTERP	Cat. 1-4;1	0.025	0.00	4.00	509	2.15	1.60	76	1.68	1.66
PFP	Score 1-3	0.091	0.00	2.67	509	1.44	0.47	76	1.34	0.50
PTOPO	Score 1-3	0.092	1.00	3.00	509	1.76	0.60	76	1.88	0.59
PWIRE%	%	0.097	0.00	100.00	509	68.03	43.07	76	76.32	39.85
HINDCM		0.110	6.00	169.00	509	46.58	38.90	76	55.39	45.14
SET		0.122	0.00	86.00	509	67.16	15.27	76	64.16	15.68
PTHISTLE	Score 0-3	0.190	0.00	2.67	509	1.47	0.89	76	1.59	0.76
PTREES	Dis. 0-3;1	0.200	0.00	3.00	509	1.70	1.39	76	1.91	1.29
Risk factors rejected after univariable screening										
PAREA	ha	0.250	0.67	24.30	509	7.26	7.95	76	8.52	8.97
PBULLR	Score 0-3	0.393	0.00	3.00	509	0.68	1.00	76	0.80	1.17
HIND/Ha	Deer/ha	0.515	4.03	32.80	509	8.96	5.30	76	9.41	5.59
%AHCM	%	0.726	0.00	97.67	509	24.66	31.78	76	26.06	32.47
PRAG	Score 0-3	0.829	0.00	3.00	509	0.86	0.99	76	0.83	0.91
PGULLY	Dis. 0-3;1	0.869	0.00	3.00	509	1.55	1.28	76	1.53	1.37
VISIT/W		0.928	0.00	14.00	509	2.73	3.38	76	2.78	3.76
BLOCK 3 : Environment and grazing management between November 1 and January 1										
Risk factors selected for multivariable analysis										
SUN	Score 0-1	0.068	0.16	0.73	509	0.43	0.13	76	0.40	0.11
SHIFT		0.085	1.00	8.00	509	2.55	1.68	76	2.20	1.37
TOPO	Score 1-3	0.094	1.00	2.99	509	1.80	0.62	76	1.92	0.61
SHELT		0.110	4.16	28.93	509	16.14	6.81	76	17.50	6.88
FAREA	ha	0.187	0.95	24.30	509	6.78	6.47	76	7.97	7.36
Risk factors rejected after univariable screening										
DEER		0.222	11.59	172.00	509	55.66	36.68	76	61.31	43.13
DEER/Ha	Deer/ha	0.240	4.34	26.99	509	11.13	5.61	76	10.35	5.28
TREES	Score 0-3	0.266	0.00	3.00	509	1.65	1.31	76	1.82	1.22
AVWIND		0.274	0.24	2.82	509	0.82	0.55	76	0.75	0.49
BULLR	Score 0-3	0.301	0.00	2.87	509	0.65	0.94	76	0.77	1.10
THISTLE	Score 0-3	0.311	0.00	2.60	509	1.35	0.87	76	1.45	0.77
ISWH	cm	0.326	3.00	21.00	509	9.61	3.82	76	9.15	3.78
DAM	%	0.348	0.00	100.00	509	30.93	42.66	76	26.36	38.86
PASTT	Score 1-3	0.354	1.00	3.00	509	2.05	0.63	76	1.97	0.65
STOCK		0.386	1.00	11.00	509	2.52	2.07	76	2.30	1.67
AVMMT	°C	0.396	8.43	13.85	509	11.28	1.63	76	11.11	1.62
RAIND	mm/d	0.519	2.13	6.41	509	3.92	1.03	76	3.84	0.99
AVMAT	°C	0.559	17.11	22.49	509	20.29	1.40	76	20.18	1.61
CLOVER	Score 1-3	0.600	1.00	3.00	509	1.93	0.52	76	1.89	0.61
AVMIT	°C	0.750	7.26	10.60	509	8.91	1.03	76	8.96	1.09
SUR	%	0.821	0.00	100.00	509	17.18	33.25	76	18.14	34.69
M%AH	%	0.844	0.00	97.00	509	30.35	30.27	76	29.62	30.27
GULLY	Score 0-3	0.915	0.00	3.00	509	1.59	1.19	76	1.60	1.24
RAG	Score 0-3	0.928	0.00	3.00	509	0.94	1.06	76	0.93	1.02

Mln - minimum; Max = maximum; SD = standard deviation

* Wet hind = hind rearing a calf up to weaning; Dry hind = hind not rearing a calf up to weaning

** Risk factor codes are described in the glossary and Table 4.10.

Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Appendix 4.9 : Significance level of Chi-square test of association of dichotomous risk factors with the ability of yearling and adult hinds to rear a calf up to weaning and corresponding unadjusted odds ratios.

	Yearling hinds					Adult hinds				
Risk factor code**	Number of deer	Chi-square P value	Unadjusted odd ratio* OR	95%CI		Number of deer	Chi-square P value	Unadjusted odd ratio* OR	95%CI	
BLOCK 1 : Individual hind variables										
AGE3						2850	0.000	3.14	2.27	4.36
NZ100						2850	0.031	1.62	1.04	2.53
ADVC	585	0.166	1.46	0.85	2.50	2850	0.000	2.78	1.72	4.49
WET-1 (Data 1992 only)						1495	0.000	0.28	0.17	0.45
WET-1 (Data 1993 only)						1355	0.755	0.86	0.34	2.20
Body condition score risk factors										
BCSS2	556	0.543	1.39	0.48	4.03	2775	0.000	0.39	0.26	0.59
BCSS4	556	0.146	1.59	0.85	3.00	2775	0.060	1.42	0.98	2.06
BLOCK 2 : Calving paddock characteristics and calving management										
VISITCP	585	0.015	1.82	1.12	2.95	2850	0.002	1.63	1.19	2.22
TAGB	585	0.275	1.48	0.73	2.98	2850	0.022	0.64	0.44	0.94
PSUR	585	0.625	1.19	0.60	2.34	2850	0.137	1.31	0.92	1.88
PSTUMP	585	0.173	0.71	0.44	1.16	2850	0.225	0.82	0.596	1.13
PDAM	585	0.433	1.22	0.74	2.03	2850	0.626	1.08	0.78	1.50
PRIVER	585	0.319	1.45	0.70	3.02	2850	0.710	0.94	0.69	1.29
BLOCK 3 : Environment and grazing management between November 1 and January 1										
RSWH5	585	0.698	1.50	0.19	11.91	2850	0.022	0.58	0.36	0.93
RSWH10	585	0.273	1.31	0.81	2.13	2850	0.142	0.79	0.58	1.08
STAG	585	0.522	0.70	0.23	2.11	2850	0.000	0.32	0.21	0.50
OSTOCK	585	0.837	0.95	0.58	1.55	2850	0.179	1.34	0.88	2.04
AH	585	0.869	1.05	0.58	1.90					
BLOCK 4 : Sentinel hind characteristics and biological markers										
NZ100	101	0.739								
ADVC	101	0.685								
VICTIM	100	0.058	5.18	1.09	25.00					
EASES	101	1.000								
Biological markers										
B12185	101	0.492								
CU8	101	0.175	0.38	0.11	1.34					
FEC>0	101	0.318								
FLC>0	101	0.091	0.16	0.02	1.28					

* Unadjusted odd ratios (OR) and their 95% confidence limits (95%CI) are presented if P < 0.20

** Risk factor codes are described in the glossary and Table 4.10.

Block 1-3 : Number of lactating yearling hinds : 509; non-lactating : 76
Number of lactating yearling hinds : 2682; non-lactating : 168

Block 4 : Number of lactating yearling hinds : 90; non-lactating : 11

Appendix 4.10 : Range of all values, mean and standard deviation of sentinel hind characteristics, and biological markers, and mean yearling and adult hind blood characteristics screened for association with the ability of yearling and adult hinds to rear a calf up to weaning (individual data, Rank sum test) or weaning rates of yearling and adult hinds (farm data, Spearman correlation), respectively, in a preliminary univariate analysis.

Risk factor code*	Unit	Rank-sum test P value	Range of all values Min	Max	WET HINDS** Number of deer	Mean	SD	DRY HINDS** Number of deer	Mean	SD
INDIVIDUAL SENTINEL YEARLING HINDS										
Sentinel hind characteristics										
NZ	%	0.989	25.00	100.00	90	88.06	19.91	11	90.95	13.78
BCSS	Dis. 1-5;0.5	0.268	1.50	4.50	75	3.19	0.64	10	3.45	0.60
BCSD	Dis. 1-5;0.5	0.073	-1.50	1.00	63	-0.35	0.65	10	0.00	0.41
SIZE	cm	0.884	91.44	105.41	85	97.40	3.19	11	97.21	3.23
GIRTH	cm	0.674	99.00	120.00	90	108.81	4.35	11	108.27	3.00
COATL	mm	0.750	45.00	65.00	90	53.79	4.31	11	54.91	4.95
Biological markers										
Haematological markers										
WCC	10E9/l	0.849	2.40	14.60	90	5.04	1.86	11	5.12	1.69
HB	g/dl	0.472	13.00	22.20	90	17.41	2.03	11	16.85	2.21
PCV	l/l	0.437	0.37	0.55	90	0.47	0.04	11	0.46	0.05
NP	%	0.900	12.00	75.00	90	34.03	11.01	11	34.00	8.54
EOP	%	0.384	0.00	26.00	90	6.37	4.52	11	7.00	4.27
LP	%	0.354	12.00	80.00	90	56.82	11.55	11	53.73	8.88
Biochemical markers										
TP	g/l	0.520	61.00	77.20	90	68.99	3.64	11	68.26	3.67
ALB	g/l	0.922	26.50	39.00	90	33.16	2.97	11	33.19	2.31
P	mmol/l	0.802	1.09	3.08	90	2.09	0.39	11	2.11	0.21
GGT	IU	0.823	15.00	67.00	90	25.17	7.81	11	23.82	4.81
BUN	mmol/l	0.246	5.70	14.51	90	11.20	1.55	11	10.77	1.27
CU	µmol/l	0.148	0.20	23.00	90	10.48	5.01	11	8.05	6.63
B12	pmol/l	0.772	92.00	940.00	90	248.76	111.74	11	230.00	87.75
GSHPx	kIU/l	0.432	5.90	29.90	8	11.19	8.23	2	10.40	0.71
MGSHPx***	kIU/l	0.362	3.13	24.07	90	10.32	5.77	11	9.04	4.91
PEPS	mU Tyrosine/l	0.168	0.00	2310.00	89	506.44	355.31	11	739.09	568.02
Parasitological markers										
FEC	egg/g	0.175	0.00	150.00	90	20.56	35.07	11	45.45	61.05
FLC	larvae/g	0.020	0.00	31.50	90	1.90	4.32	11	2.32	1.98

MEAN SENTINEL HIND BLOOD MARKERS								
Yearling hinds		p-level	Min	Max	Number of farm-years	Mean	SD	Spearman rank corr. coef.
Haematological characteristics								
MWCC	10E9/l	0.996	3.35	7.51	26	5.03	1.18	0.00
MNP	%	0.265	23.00	55.50	26	35.24	7.06	-0.22
MLP	%	0.761	30.00	65.80	26	55.51	7.25	0.06
MEOP	%	0.881	2.05	13.51	26	6.41	2.83	0.03
MHB	g/dl	0.036	14.18	20.38	26	17.42	1.63	0.40
MPCV	l/l	0.686	0.42	0.51	26	0.47	0.03	0.08
Biochemical characteristics								
MTP	g/l	0.081	65.28	72.45	26	68.67	1.99	0.34
MALB	g/l	0.940	29.28	37.46	26	32.93	2.31	0.02
MBUN	mmol/l	0.146	7.27	13.14	26	11.17	1.39	-0.29
MGGT	IU	0.072	19.48	37.87	26	25.04	5.05	0.35
MP	mmol/l	0.138	1.61	2.75	26	2.09	0.29	-0.29
MCU	µmol/l	0.388	1.45	17.20	26	10.20	4.12	-0.17
MGSHPx	kIU/l	0.254	3.13	24.07	26	10.38	5.91	0.23
MB12	pmol/l	0.946	157.64	480.29	26	241.83	70.87	-0.01
MPEPS	mU Tyrosine/l	0.477	126.82	1296.57	26	504.68	258.97	-0.14
Adult hinds								
Haematological characteristics								
MWCC	10E9/l	0.271	4.54	3.03	29	6.40	0.85	-0.21
MNP	%	0.470	44.02	32.80	29	67.40	9.23	-0.14
MLP	%	0.335	45.60	26.40	29	58.20	8.15	0.19
MEOP	%	0.087	7.18	3.20	29	12.52	2.44	-0.32
MHB	g/dl	0.427	18.03	14.44	29	24.20	2.31	-0.15
MPCV	l/l	0.369	0.44	0.40	29	0.52	0.03	-0.17
Biochemical characteristics								
MTP	g/l	0.104	64.82	74.90	29	69.07	2.70	-0.31
MALB	g/l	0.863	29.44	35.78	29	32.74	1.93	-0.03
MBUN	mmol/l	0.348	6.80	13.68	29	10.74	1.70	-0.18
MGGT	IU	0.738	14.67	39.29	29	24.60	5.03	-0.07
MP	mmol/l	0.458	1.26	2.49	29	1.98	0.29	0.14
MCU	µmol/l	0.774	1.74	15.80	29	9.08	3.43	0.06
MGSHPx	kIU/l	0.658	2.17	24.07	29	9.83	6.06	-0.09
MB12	pmol/l	0.790	110.17	615.26	29	264.15	110.28	-0.05
MPEPS	mU Tyrosine/l	0.067	52.91	1124.72	29	367.38	252.64	-0.34

Min = minimum; Max = maximum; SD = Standard deviation; Corr. Coef. = correlation coefficient

* Risk factor codes are described in the glossary and Table 4.10.

** Wet hind = hind rearing a calf up to weaning; Dry hind = hind not rearing a calf up to weaning

*** The mean of the 3 individual measures of GSHPx from each farm each year has been taken has individual values for multivariable analysis of individual data

Appendix 4.11 : Means and standard deviations of weaner stag and hind bodyweight standardised to April 1 (W4) at each level of dichotomous risk factors screened for univariate association with W4 and t-test (or rank sum test as appropriate) p values

	WEANER HINDS							WEANER STAGS						
	No = 0			Yes = 1				No = 0			Yes = 1			
Risk factor code*	Number of deer	Mean	SD	Number of deer	Mean	SD	p value	Number of deer	Mean	SD	Number of deer	Mean	SD	p value
BLOCK 1 : Animal individual characteristics														
ADULT	90	43.08	5.12	428	48.51	5.89	0.000	85	47.06	6.00	373	53.50	6.55	0.000
ADVC	54	43.23	7.57	453	47.94	5.55	0.000	36	45.30	7.42	415	52.74	6.44	0.000
BLOCK 2 : Lactation and weaning management risk factors (December 1 - weaning)														
RSWH10	640	46.80	6.72	746	46.22	7.01	0.115	657	52.20	7.72	683	50.54	7.49	0.000
STAG	1182	46.86	6.76	264	44.25	7.14	0.000	1187	51.45	7.62	261	49.53	7.90	0.000
OTHERST	1069	46.45	6.92	377	46.20	6.87	0.545	1041	51.29	7.77	407	50.62	7.54	0.133
FSUP	1290	46.27	6.96	156	47.30	6.34	0.059	1269	51.02	7.80	179	51.71	7.06	0.243
YARDBW	381	45.09	7.29	1067	46.86	6.68	0.000	414	49.68	8.13	1034	51.63	7.48	0.000
VCLOST	1045	45.56	6.89	403	48.55	6.39	0.000	1066	50.44	7.94	382	52.86	6.76	0.000
VYERS1	1072	45.63	6.84	376	48.57	6.56	0.000	1036	50.13	7.70	412	53.44	7.26	0.000
BLOCK 3 : Post-weaning grazing management risk factors (weaning- April 1)														
RSWH10	844	46.60	7.07	331	48.02	6.28	0.001	878	51.53	8.08	319	52.66	6.77	0.025
ODEER	840	46.47	6.96	347	48.32	6.46	0.000	779	50.73	7.65	429	53.80	7.57	0.000
OSTOCK	1061	46.90	6.77	126	47.96	7.53	0.100	982	51.42	8.01	226	53.55	6.32	0.000
FSUP	955	46.56	7.16	232	48.89	5.09	0.000	986	51.54	7.99	222	53.08	6.54	0.007
BLOCK 4 : Blood biological markers														
Individual weaner blood characteristics														
CU8	28	48.54	4.51	87	47.43	6.43	0.366	25	48.85	6.40	85	51.94	7.50	0.035
B12185	59	47.08	6.63	56	48.35	5.28	0.255	57	50.84	7.96	53	51.66	6.68	0.619
GHSPx3	8	47.96	4.74	17	46.29	4.70	0.524	12	55.90	6.66	29	49.95	7.44	0.034
Mean weaner blood characteristics														
CU8	3	45.31	2.43	19	45.90	3.96	0.590	3	48.63	1.84	20	50.06	3.71	0.336
B12185	11	45.95	4.43	11	45.68	3.13	0.925	11	50.28	3.89	12	49.49	3.28	0.514
GHSPx3	6	45.29	4.82	16	46.02	3.43	0.810	6	49.75	4.60	17	49.91	3.24	1.000

SD = Standard deviation

Note : the rank sum test was performed on block 4.

* Risk factor codes are described in the glossary and Table 4.12

Appendix 4.12 : Means, ranges, standard deviations of continuous animal, weaning and grazing management risk factors screened for association with weaner stag and hind bodyweight standardised to April 1, Spearman correlation coefficients and p values.

	WEANER STAG							WEANER HIND						
Risk factor code*	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef	P value	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef	P value
BLOCK 1 : Animal individual characteristics														
W4	461	52.34	28.79	71.91	6.90			523	47.61	19.93	67.91	6.11		
NZC	449	70.86	6.25	100.00	24.12	0.07	0.142	511	71.85	6.40	100.00	22.78	0.07	0.099
NZD	461	85.06	12.50	100.00	23.11	0.13	0.005	521	86.35	12.50	100.00	22.17	0.20	0.000
BCSS	455	3.49	1.00	5.00	0.71	0.22	0.000	514	3.55	1.00	5.00	0.67	0.28	0.000
BCSL	426	-0.47	-2.50	2.50	0.90	0.08	0.084	488	-0.38	-3.00	2.50	0.85	0.09	0.041
WD6	398	99.98	72.86	127.90	10.07	0.46	0.000	454	100.42	75.58	140.32	10.25	0.41	0.000
CHW9C	266	12.47	1.50	34.00	4.58	0.22	0.000	291	12.16	-2.50	30.00	4.66	0.24	0.000
BIRTH	155	31.34	3.00	82.00	10.03	-0.48	0.000	173	31.52	16.00	60.00	9.33	-0.51	0.000
BLOCK 2 : Lactation and weaning management (from December 1 to weaning)														
W4	1446	51.07	25.67	73.80	7.72			1448	46.39	19.93	69.78	6.89		
NZC	1446	79.27	6.25	100.00	18.81	-0.23	0.000	1448	79.93	6.40	100.00	18.37	-0.18	0.000
WAPC	1446	2.94	0.00	25.00	7.25	0.16	0.000	1448	2.90	0.00	25.00	7.24	0.23	0.000
Risk factors selected for multivariable analysis														
ANTH	1446	1.12	0.00	3.00	0.62	0.27	0.000	1448	1.14	0.00	3.00	0.66	0.29	0.000
SIPC	1446	67.33	27.00	95.00	14.38	-0.23	0.000	1448	67.12	27.00	95.00	15.16	-0.22	0.000
SHIFT	1446	4.47	1.00	18.00	4.31	0.23	0.000	1448	4.54	1.00	23.00	4.35	0.30	0.000
WEAN	1446	70.27	54.00	95.00	10.37	-0.22	0.000	1448	70.30	54.00	95.00	10.85	-0.20	0.000
RAIND	1446	3.15	1.63	6.01	1.20	-0.22	0.000	1448	3.22	1.63	6.01	1.22	-0.19	0.000
SUN	1446	0.55	0.26	0.87	0.14	0.21	0.000	1448	0.55	0.26	0.87	0.15	0.21	0.000
M%AH	1446	84.86	0.00	100.00	28.93	0.21	0.000	1448	84.39	0.00	100.00	28.77	0.19	0.000
SUR	1446	26.16	0.00	100.00	35.79	0.12	0.000	1448	24.87	0.00	100.00	34.65	0.22	0.000
PASTT	1446	1.92	1.00	3.00	0.56	-0.11	0.000	1448	1.93	1.00	3.00	0.56	-0.11	0.000
MJME/Ha	1446	549.23	16.08	1550.07	346.43	0.06	0.026	1448	570.17	16.08	1870.60	342.00	0.15	0.000
FAREA	1446	7.33	0.93	24.30	6.07	-0.05	0.040	1448	6.95	0.93	24.30	6.07	-0.12	0.000
AVMMT	1446	12.02	7.92	15.37	1.85	-0.05	0.074	1448	12.04	7.87	15.37	1.90	-0.04	0.152
Risk factors rejected after univariate screening														
AVWIND	1446	0.80	0.16	2.66	0.57	-0.11	0.000	1448	0.86	0.16	2.66	0.61	-0.03	0.285
CLOVER	1382	1.88	1.00	2.52	0.33	-0.03	0.195	1398	1.89	1.00	2.52	0.31	0.07	0.010
RAG	1446	0.85	0.00	3.00	1.04	-0.03	0.285	1448	0.82	0.00	3.00	1.02	0.00	0.925
TOPO	1446	1.83	1.00	3.00	0.58	-0.03	0.312	1448	1.81	1.00	3.00	0.58	-0.16	0.000
ISWH	1446	12.37	5.50	23.50	3.67	-0.02	0.430	1448	12.40	5.50	23.50	3.79	0.08	0.001
AVMAT	1446	22.59	18.14	26.62	1.95	-0.02	0.433	1448	22.58	18.14	26.62	2.01	0.01	0.776
STOCK	1446	2.25	1.00	5.00	0.98	-0.02	0.496	1448	2.29	1.00	8.00	0.98	-0.03	0.231
SHELT	1446	20.76	3.00	36.00	8.96	0.02	0.508	1448	20.14	3.00	36.00	9.34	-0.05	0.072
DEER	1446	64.57	11.21	174.27	42.11	-0.02	0.519	1448	63.13	11.21	174.27	43.08	-0.06	0.014
THISTLE	1432	1.41	0.00	3.00	0.78	0.02	0.563	1431	1.38	0.00	3.00	0.75	-0.07	0.012
TREES	1446	1.39	0.00	3.00	1.16	0.01	0.646	1448	1.34	0.00	3.00	1.14	0.09	0.001
AVMIT	1446	10.49	8.90	12.76	0.87	0.00	0.933	1448	10.47	8.90	12.76	0.88	-0.04	0.098
BLOCK3 : Post-weaning grazing management (from weaning to April 1)														
W4	1208	51.82	25.67	73.80	7.76			1187	47.01	19.93	69.78	6.86		
NZC	1208	77.86	6.25	100.00	19.46	-0.19	0.000	1187	78.89	6.40	100.00	19.10	-0.14	0.000
WAPC	1208	3.37	0.00	25.00	7.64	0.13	0.000	1187	3.31	0.00	25.00	7.59	0.21	0.000
Risk factors selected for multivariable analysis														
DEER	1208	125.49	25.00	225.00	48.74	-0.28	0.000	1187	123.47	24.43	225.00	49.00	-0.34	0.000
ISWH	1197	16.24	7.00	21.75	4.37	-0.24	0.000	1175	16.08	7.00	21.75	4.38	-0.26	0.000
RAIND	1208	2.73	0.50	5.07	1.30	-0.22	0.000	1187	2.73	0.50	5.07	1.29	-0.24	0.000
SUN	1208	0.53	0.07	0.75	0.15	0.18	0.000	1187	0.54	0.07	0.75	0.15	0.21	0.000
CLOVER	1197	1.72	1.00	2.44	0.48	0.15	0.000	1175	1.71	1.00	2.00	0.42	0.09	0.002
AVMIT	1208	8.24	5.95	11.29	1.28	-0.14	0.000	1187	8.17	5.95	11.29	1.30	-0.15	0.000
AVWIND	1135	1.32	0.27	3.21	0.92	-0.14	0.000	1107	1.42	0.27	3.21	0.91	-0.05	0.078
SUR	1208	39.31	0.00	100.00	39.81	0.14	0.000	1187	36.24	0.00	100.00	38.75	0.13	0.000
MJME/Ha	1208	592.02	86.64	1168.99	287.73	-0.14	0.000	1187	608.02	86.64	1168.99	298.91	-0.06	0.058
TOPO	1208	1.40	1.00	2.50	0.54	-0.08	0.004	1187	1.41	1.00	2.50	0.57	-0.15	0.000
FAREA	1208	4.72	1.03	17.44	3.84	-0.07	0.017	1187	4.60	1.03	17.44	4.02	-0.15	0.000
TREES	1208	0.84	0.00	3.00	0.88	0.07	0.022	1187	0.82	0.00	3.00	0.88	0.09	0.002
RAG	1208	0.57	0.00	2.50	0.83	0.07	0.023	1187	0.55	0.00	2.50	0.83	0.09	0.002
AVMAT	1208	19.56	17.36	23.64	1.69	-0.05	0.109	1187	19.54	17.36	23.64	1.58	0.04	0.132
Risk factors rejected after univariate screening														
STOCK	1208	1.65	1.00	4.00	0.73	0.03	0.235	1187	1.64	1.00	3.00	0.72	-0.05	0.090
SHELT	1208	14.52	1.00	36.00	7.96	0.02	0.430	1187	14.22	1.00	36.00	8.03	-0.05	0.080
THISTLE	1208	1.16	0.00	2.50	0.72	-0.02	0.487	1187	1.20	0.00	2.50	0.81	0.00	0.961
AVMMT	1208	11.32	7.86	16.43	2.04	-0.01	0.699	1187	11.37	7.86	16.43	2.00	0.08	0.004
PASTT	1120	1.86	1.00	3.00	0.57	0.01	0.857	1087	1.85	1.00	3.00	0.63	0.04	0.153

Min = minimum; Max = maximum; SD = standard deviation; Corr. Coef. = correlation coefficient

* Risk factor codes are described in the glossary and Table 4.12

Appendix 4.13 : Means, ranges, standard deviations of continuous individual and farm mean biological markers screened for association with weaner stag and hind bodyweight standardised to April 1 (W4) and farm mean weaner stag and hind bodyweight standardised to April 1 (MW4), respectively, Spearman correlation coefficients and p values.

	WEANER STAGS							WEANER HINDS						
Risk factor code*	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
BLOCK 4 : Individual weaner biological characteristics														
W4	110	51.24	34.08	66.54	7.35			115	47.70	32.76	59.67	6.02		
Risk factors selected for multivariable analysis														
TP	110	63.24	50.50	72.60	3.82	0.31	0.001	115	63.17	52.50	82.90	4.35	0.34	0.000
ALB	110	35.56	22.50	43.20	3.76	0.25	0.009	115	35.76	26.30	43.40	3.43	0.29	0.001
Risk factors rejected after univariate screening														
CU	110	12.35	2.30	26.00	4.88	0.15	0.109	115	11.90	1.40	29.00	4.96	-0.04	0.640
NP	110	35.52	16.00	66.00	12.20	-0.15	0.111	115	34.51	13.00	76.00	12.54	-0.06	0.505
PEPS	110	190.47	0.00	628.00	98.59	-0.14	0.158	115	200.97	0.00	581.00	101.47	-0.06	0.536
LP	110	58.16	30.00	83.00	11.59	0.12	0.198	115	59.59	23.00	80.00	12.01	0.11	0.263
P	110	2.99	1.58	4.82	0.53	0.12	0.198	115	2.99	1.34	4.21	0.54	-0.03	0.742
EOP	110	3.98	0.00	14.00	3.65	0.11	0.266	115	3.24	0.00	19.00	3.56	-0.02	0.827
GSHPx	110	6.55	1.30	28.90	5.60	0.10	0.286	115	7.35	1.30	32.20	6.29	0.04	0.685
BUN	110	9.43	6.33	16.00	1.90	0.09	0.356	115	9.38	6.01	18.18	1.99	0.20	0.035
PCV	108	0.41	0.21	0.55	0.06	0.03	0.781	115	0.43	0.25	0.53	0.05	-0.15	0.117
HB	109	16.85	7.80	25.80	2.29	0.03	0.796	115	17.31	11.90	27.30	2.79	-0.06	0.555
WCC	109	5.61	2.30	29.50	2.69	-0.03	0.796	115	5.29	2.70	9.70	1.39	0.04	0.655
B12	110	215.28	53.00	1800.00	214.86	0.02	0.809	115	231.43	65.00	3000.00	314.81	0.10	0.279
GGT	110	32.96	13.00	300.00	34.25	0.00	0.979	115	39.08	13.00	809.00	78.26	-0.03	0.721
FEC	105	59.52	0.00	400.00	90.43	-0.12	0.215	110	46.36	0.00	350.00	67.97	-0.14	0.145
FLC	110	35.35	0.00	416.50	67.78	-0.07	0.493	115	46.42	0.00	855.75	126.13	-0.15	0.116
Farm mean weaner blood markers (weaner crops 1992 and 1993)														
MW4	23†	49.87	43.02	55.53	3.53			22†	45.82	38.35	51.81	3.75		
Variables selected for multivariable analysis														
MALB	23†	35.62	29.96	39.11	2.81	0.43	0.042	22†	35.85	29.96	39.11	2.66	0.51	0.015
Variables rejected after univariate screening														
MLP	23†	59.17	40.60	72.89	8.93	0.32	0.139	22†	59.33	40.60	72.89	9.11	0.17	0.437
MNP	23†	34.86	21.78	57.00	10.12	-0.27	0.215	22†	34.75	21.78	57.00	10.34	-0.16	0.471
MP	23†	2.99	2.41	3.50	0.32	0.25	0.258	22†	3.00	2.41	3.50	0.32	0.26	0.242
MHB	23†	16.86	14.10	18.68	1.39	-0.22	0.311	22†	17.34	14.42	22.28	1.99	-0.14	0.526
MTP	23†	63.03	57.01	67.95	2.41	0.16	0.468	22†	62.92	57.01	67.95	2.41	0.27	0.221
MEOP	23†	2.62	0.47	6.07	1.57	-0.13	0.551	22†	2.59	0.47	6.07	1.60	-0.04	0.853
MB12	23†	190.43	75.14	399.84	78.50	-0.12	0.578	22†	187.93	75.14	399.84	79.41	-0.07	0.759
MGGT	23†	28.98	19.43	45.05	5.78	-0.11	0.631	22†	29.22	19.43	45.05	5.80	0.13	0.577
MCU	23†	11.94	4.41	18.70	3.62	0.10	0.644	22†	11.96	4.41	18.70	3.70	0.10	0.669
MGSHPx	23†	7.05	1.70	23.27	5.92	0.08	0.710	22†	7.20	1.70	23.27	6.01	-0.01	0.954
MPCV	23†	0.42	0.31	0.48	0.05	0.06	0.802	22†	0.43	0.33	0.50	0.04	-0.04	0.857
MPEPS	23†	162.83	50.66	283.13	64.25	-0.05	0.823	22†	171.62	75.00	249.43	52.07	-0.12	0.584
MBUN	23†	9.39	6.94	14.43	1.64	0.05	0.837	22†	9.16	6.94	12.67	1.24	0.32	0.140
MWCC	23†	5.30	3.76	7.93	1.05	-0.02	0.914	22†	5.32	3.76	7.93	1.07	0.03	0.899
Farm weaner faecal parasite markers (calf crops 1992, 1993 and 1994)														
MW4	27†	50.94	41.94	59.03	4.16			27†	46.34	39.27	51.32	3.50		
Variables selected														
FLCI	27†	285.55	3.60	1654.00	363.77	-0.29	0.146	27†	285.55	3.60	1654.00	363.77	-0.46	0.016
Variables rejected after univariate screening														
NFEC>0	27†	7.02	1.20	10.00	2.26	-0.31	0.120	27†	7.02	1.20	10.00	2.26	-0.25	0.208

Min = minimum; Max = maximum; SD = standard deviation; Corr. Coef. = correlation coefficient

* Risk factor codes are described in the glossary and Table 4.12

† Number of farm-years

Appendix 4.14 : Means and standard deviations of weaner stag and hind growth rates between April 1 and June 1 (GR46) at each level of dichotomous risk factors screened for univariate association with GR46 and t-test p values.

WEANER AUTUMN GROWTH

	WEANER HINDS							WEANER STAGS						
	No = 0			Yes = 1				No = 0			Yes = 1			
Risk factor code*	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**
BLOCK 1 : Weaner individual characteristics, grazing management, weaning and disease control and health problems														
Disease control														
Risk factors selected for multivariable analysis														
VCLOST	525	94.98	54.91	139	138.70	35.78	0.000	721	115.75	57.23	201	125.52	54.00	0.026
IVE	402	109.85	61.59	262	95.37	39.75	0.001	525	134.23	57.22	397	96.27	48.07	0.000
Risk factors rejected after univariate screening														
MINSUP	309	104.66	51.24	355	103.67	57.18	0.817	334	114.83	55.89	588	119.61	57.06	0.216
VYERS	551	99.31	55.36	113	127.62	42.85	0.000	713	117.79	59.23	209	118.18	46.94	0.930
DRUG	622	104.56	55.85	42	97.88	26.25	0.442	764	125.13	56.50	158	82.84	42.76	0.000
DOSEOK	194	82.34	49.68	446	116.15	53.39	0.000	432	120.18	52.86	462	119.32	59.12	0.820
Environment and grazing management														
Risk factors selected for multivariable analysis														
RSWH5	591	111.02	52.79	73	48.36	30.50	0.000	890	120.07	56.09	32	56.99	34.43	0.000
STRIP	544	93.08	51.75	120	154.24	34.84	0.000	813	109.37	52.95	109	181.35	41.03	0.000
OTHERST	609	100.75	54.58	55	141.62	36.29	0.000	862	116.10	56.91	60	143.43	46.13	0.000
Risk factors rejected after univariate screening														
FSUP	425	112.07	56.99	239	90.03	46.52	0.000	706	116.77	57.02	216	121.51	55.43	0.275
RSWH10	282	108.20	58.07	382	101.14	51.50	0.099	288	118.30	68.92	634	117.69	50.16	0.894
ODEER	566	108.79	55.30	98	77.26	40.05	0.000	796	118.77	58.85	126	112.29	39.84	0.233
Health problems														
Risk factors selected for multivariable analysis														
LAME	521	107.84	57.20	143	90.65	40.46	0.001	690	123.79	56.70	232	100.33	52.88	0.000
DEATH1	466	106.12	59.07	198	99.48	41.44	0.151	591	124.29	59.80	331	106.44	48.59	0.000
YERS1	610	101.57	55.54	54	133.13	27.07	0.000	817	119.03	56.22	105	108.99	59.53	0.104
BLOCK 2 : Sentinel deer blood markers														
March data														
EASES	8	85.70	60.01	90	108.76	50.35	0.212	10	104.83	36.44	86	124.64	59.45	0.144
GSHPx3	NP							NP						
B12185‡	53	127.54	48.46	52	85.90	43.27	0.000	55	129.94	56.60	48	109.28	60.17	0.106
CU8	24	90.04	47.27	81	111.92	50.36	0.057	24	105.15	57.29	79	124.92	58.99	0.230
June data														
EASES	7	107.69	54.75	105	108.74	47.60	0.857	5	138.86	43.23	113	114.54	57.55	0.332
GSHPx3	NP							NP						
B12185	80	114.12	49.52	28	103.07	40.50	0.359	77	122.82	57.70	35	103.09	54.97	0.114
CU8†	16	78.57	38.62	97	113.90	47.30	0.004	22	87.21	55.85	96	122.08	55.63	0.007
BLOCK 3 : Farm mean weaner blood markers														
March data														
MGSHPx3	6†	97.18	44.71	14†	104.46	35.86	0.669	6†	122.82	38.63	15†	115.44	44.66	0.549
MB12185‡	9†	112.99	40.66	11†	93.52	34.40	0.196	9†	132.80	45.49	12†	106.11	37.42	0.191
MCU8‡	3†	67.72	26.35	17†	108.38	36.52	0.060	3†	74.01	17.54	18†	124.81	40.85	0.007
Junedata														
MGSHPx3	NP							NP						
MB12185	16†	105.37	39.42	4†	89.93	30.91	0.430	16†	123.61	44.46	5†	98.14	29.56	0.098
MCU8†	2†	52.67	5.33	18†	107.79	35.51	0.002	2†	65.00	11.35	19†	123.08	40.40	0.001

* Risk factor codes are described in the glossary and Table 4.14

** t-tests were carried out on the ranks (procedure Rank in SAS) in 2nd and 3rd blocks, which is equivalent to the Wilcoxon rank sum test.

SD = standard deviation; NP = Statistical test not possible because of the limited number of observations in one category.

† Number of farm-years

‡ Blood markers selected for multivariable analyses.

Appendix 4.15 : Means, ranges, standard deviations of continuous risk factors (weaner characteristics, grazing management, weaning and disease control, and health problems) screened for association with weaner stag and hind growth rates between April 1 and June 1 (GR46), Spearman correlation coefficients and p values.

WEANER AUTUMN GROWTH

Risk factor code*	Unit	WEANER STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	WEANER HINDS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
GR46	g/d	922	117.88	-42.86	330.77	56.66			664	104.14	-66.19	315.38	54.47		
Weaner individual characteristics															
Risk factors selected for multivariable analysis															
NZ	%	772	83.61	12.50	100.00	21.03	-0.33	0.000	571	79.05	12.50	100.00	21.68	-0.23	0.000
WAP	%	772	2.49	0.00	25.00	6.76	-0.21	0.000	571	2.78	0.00	25.00	7.15	-0.03	0.345
Risk factors rejected after univariate screening															
W4	kg	922	50.75	25.45	69.11	7.46	-0.14	0.000	664	47.07	19.93	64.00	7.12	0.00	0.903
PERC4	%	862	58.21	1.00	99.49	28.27	-0.13	0.002	567	43.35	0.78	97.30	26.25	0.01	0.852
MAXW4	kg	922	11.93	0.00	35.71	6.86	0.04	0.353	664	15.26	0.00	44.57	7.05	0.03	0.439
Weaning and disease control															
Risk factors selected for multivariable analysis															
WEAN	day	922	72.39	55.00	95.00	9.30	-0.21	0.000	664	70.87	55.00	95.00	10.04	-0.39	0.000
NANTH		922	2.95	2.00	6.00	0.81	0.22	0.000	664	2.97	2.00	6.00	0.92	0.14	0.000
IVE	%	922	32.28	0.00	100.00	42.51	-0.27	0.000	664	35.59	0.00	100.00	46.42	-0.12	0.002
Risk factors rejected after univariate screening															
DRENCH1	day	922	36.83	20.60	55.67	9.69	-0.05	0.200	664	33.44	17.17	46.00	6.54	-0.02	0.476
Environment and grazing management															
Risk factors selected for multivariable analysis															
STOCK		922	2.11	1.00	4.00	0.72	-0.13	0.001	664	2.01	1.00	5.00	0.66	-0.20	0.000
SHIFT		922	4.01	1.00	8.00	2.06	0.24	0.000	664	4.12	1.00	8.00	2.10	0.16	0.000
ISWH	cm	922	17.71	9.44	28.00	5.62	0.14	0.000	664	16.48	9.44	28.00	5.62	0.11	0.001
CLOVER	1-3	922	1.78	1.00	3.00	0.61	0.25	0.000	664	1.67	1.00	2.74	0.54	0.06	0.088
DEER		922	116.11	17.25	220.54	49.40	-0.31	0.000	664	100.60	17.25	146.74	31.27	-0.15	0.000
PASTT	Score 1-3	922	1.72	1.00	2.77	0.48	-0.27	0.000	664	1.60	1.00	2.40	0.44	-0.20	0.000
THISTLE	Score 0-3	922	1.13	0.00	2.23	0.71	-0.26	0.000	664	1.28	0.15	2.62	0.63	-0.23	0.000
RAG	Score 0-3	922	0.56	0.00	2.33	0.80	-0.34	0.000	664	0.72	0.00	2.33	0.89	-0.11	0.001
AVMAT	°C	922	15.23	12.54	19.62	2.16	-0.25	0.000	664	15.33	12.54	19.62	2.33	-0.20	0.000
AVMMT	°C	922	9.73	6.74	14.28	2.08	-0.38	0.000	664	9.60	6.74	14.28	2.22	-0.12	0.000
RAIND	mm/day	922	2.73	1.26	4.64	0.67	0.12	0.001	664	2.87	1.26	4.64	0.76	0.06	0.065
SUN	Score 0-1	922	0.41	0.23	0.65	0.12	-0.50	0.000	664	0.37	0.23	0.58	0.10	-0.32	0.000
TOPO	Score 1-3	922	1.57	1.00	2.54	0.56	-0.10	0.010	664	1.56	1.00	2.30	0.46	-0.20	0.000
TREES	Score 0-3	922	1.05	0.00	3.00	0.95	0.08	0.044	664	1.19	0.00	3.00	0.91	0.19	0.000
SHELT		922	15.93	3.72	37.00	8.46	-0.09	0.020	664	17.50	4.56	37.00	8.60	-0.12	0.000
AVWIND		922	1.11	0.28	2.61	0.56	0.20	0.000	664	1.04	0.28	2.70	0.48	0.08	0.031
Risk factors rejected after univariate screening															
AVMIT	°C	922	5.50	3.28	7.82	1.46	0.11	0.005	664	5.72	3.28	7.82	1.48	-0.07	0.029
MJME/Ha		922	716.53	99.65	3916.28	753.36	0.07	0.056	664	770.47	99.65	3916.28	841.46	0.01	0.767
FAREA	ha	922	4.84	0.72	20.20	4.20	-0.17	0.000	664	4.85	0.72	20.20	5.03	-0.02	0.452
SUR	%	922	33.58	0.00	100.00	32.15	0.04	0.284	664	36.99	0.00	100.00	33.22	-0.02	0.591

* Risk factor codes are described in the glossary and in Table 4.14

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = Correlation coefficient.

Note on units : D = Dichotomous variable : Yes=1 ; No=0

"Score 0-1" means "Score ranging from 0 to 1"

Appendix 4.16 : Means, ranges, standard deviations of sentinel deer risk factors and blood markers screened for association with weaner stag and hind growth rates between April 1 and June 1 (GR46), Spearman correlation coefficients and p values.

WEANER AUTUMN GROWTH

Risk factor code*	Unit	WEANER STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef	P value	WEANER HINDS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	P value
MARCH VISIT DATA															
GR46	g/d	103	120.32	-16.85	258.11	58.93			105	106.92	-16.85	208.32	50.30		
Individual weaner characteristics															
GIRTH	cm	103	84.48	72.00	96.00	4.62	0.07	0.496	105	82.90	73.00	92.00	4.40	0.11	0.264
Blood markers															
Risk factors rejected after univariate screening															
WCC	10E9/l	102	5.62	2.30	29.50	2.77	0.14	0.159	105	5.32	2.70	9.70	1.42	0.04	0.660
HB	g/dl	102	16.77	7.80	25.80	2.29	0.13	0.193	105	17.24	11.90	27.30	2.86	-0.01	0.952
PCV	l/l	101	0.41	0.21	0.50	0.06	0.15	0.122	105	0.42	0.25	0.53	0.05	-0.02	0.810
NP	%	103	35.50	16.00	66.00	11.80	-0.16	0.117	105	34.53	13.00	76.00	12.55	0.04	0.708
EOP	%	103	4.00	0.00	14.00	3.68	0.07	0.508	105	3.35	0.00	19.00	3.66	0.08	0.430
LP	%	103	58.12	30.00	83.00	11.40	0.13	0.207	105	59.42	23.00	80.00	11.98	-0.05	0.582
TP	g/l	103	63.36	50.50	72.60	3.87	-0.02	0.804	105	63.30	52.50	82.90	4.31	0.05	0.640
ALB	g/l	103	35.50	22.50	43.20	3.79	0.12	0.228	105	35.91	26.30	43.40	3.33	-0.05	0.578
P	mmol/l	103	3.00	1.58	4.82	0.53	0.04	0.653	105	2.99	1.34	4.21	0.55	0.17	0.091
GGT	IU	103	30.72	14.00	203.00	23.31	0.00	0.971	105	40.37	13.00	809.00	81.81	-0.07	0.506
BUN	mmol/l	103	9.51	6.33	16.00	1.92	-0.20	0.044	105	9.49	6.01	18.18	2.01	-0.04	0.684
CU	µmol/l	103	12.34	2.30	26.00	4.98	0.12	0.234	105	12.10	1.40	29.00	4.99	0.18	0.073
B12	pmol/l	103	204.96	53.00	1800.00	193.32	-0.08	0.421	105	228.95	65.00	3000.00	319.84	-0.40	0.000
GSHPx	kIU/l	39	5.99	1.30	28.90	5.26	-0.15	0.352	24	7.43	1.30	32.20	7.09	-0.06	0.768
PEPS	mU Tyrosine/l	103	183.68	0.00	397.00	79.78	-0.03	0.783	105	200.47	0.00	581.00	103.63	-0.04	0.703
JUNE VISIT DATA															
GR46		118	115.58	-16.85	258.11	57.09			113	108.90	-16.85	208.32	47.65		
Individual weaner characteristics															
COATL		113	52.17	35.00	66.00	6.75	0.00	0.971	105	52.54	35.00	70.00	6.69	-0.10	0.316
Blood markers															
Risk factors selected for multivariable analysis															
ALB	g/l	118	33.87	19.50	45.20	4.18	0.27	0.004	113	34.23	14.00	44.40	4.39	0.29	0.002
GGT	IU	118	50.64	18.00	228.00	31.02	-0.20	0.029	113	51.17	20.00	309.00	37.55	-0.14	0.144
BUN	mmol/l	118	11.10	5.99	15.42	1.64	-033	0.000	113	11.02	6.98	14.98	1.67	-0.17	0.064
CU	µmol/l	118	11.80	2.20	21.00	4.17	0.26	0.004	113	12.24	3.30	22.00	4.06	0.28	0.003
B12	pmol/l	112	173.83	65.00	850.00	106.85	-0.18	0.052	108	177.81	65.00	1900.00	195.33	-0.17	0.080
Risk factors rejected after univariate screening															
WCC	10E9/l	118	6.24	2.30	55.00	5.06	0.01	0.943	112	7.27	2.40	45.30	5.64	0.05	0.574
HB	g/dl	118	16.14	6.00	24.40	2.35	0.14	0.137	112	16.70	11.40	28.10	2.87	-0.01	0.891
PCV	l/l	118	0.42	0.16	0.54	0.05	0.03	0.769	112	0.42	0.28	0.52	0.05	-0.04	0.640
NP	%	118	32.27	5.00	63.00	10.84	0.01	0.906	113	32.46	11.00	58.00	9.64	-0.12	0.188
EOP	%	118	4.58	0.00	30.00	4.48	0.09	0.343	113	4.79	0.00	20.00	4.00	0.08	0.388
LP	%	118	59.34	29.00	91.00	11.59	-0.01	0.932	113	59.07	29.00	81.00	10.26	0.12	0.189
TP	g/l	118	71.18	55.70	87.70	5.03	0.08	0.388	113	70.10	60.50	85.30	4.82	0.19	0.043
P	mmol/l	118	2.92	1.97	3.94	0.44	-0.04	0.700	113	2.90	1.57	3.98	0.49	0.04	0.641
GSHPx	kIU/l	46	9.36	0.10	17.60	4.72	0.16	0.282	25	10.13	0.70	23.60	6.06	-0.01	0.977
PEPS	mU Tyrosine/l	118	403.53	0.00	1490.00	231.12	0.01	0.955	113	428.66	0.00	1306.00	217.10	-0.02	0.837

* Risk factor codes are described in the glossary and in Table 4.14

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = Correlation coefficient.

Appendix 4.17 : Means, ranges, standard deviations of farm mean weaner blood markers screened for association with farm mean weaner stag and hind growth rates between April 1 and June 1 (MGR46), Spearman correlation coefficients and p values.

WEANER AUTUMN GROWTH

		WEANER STAGS							WEANER HINDS						
Risk factor code*	Unit	Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	P value	Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	P value
MARCH VISIT DATA															
MGR46		21	117.55	52.91	203.50	42.20			20	102.28	48.36	173.32	37.66		
Risk factors selected for multivariable analysis															
MP	mmol/l	21	2.97	2.41	3.50	0.33	0.37	0.103	20	2.98	2.41	3.50	0.33	0.40	0.078
MCU	µmol/l	21	11.92	4.41	18.70	3.79	0.36	0.109	20	11.95	4.41	18.70	3.89	0.31	0.186
MB12	pmol/l	21	195.60	75.14	399.84	79.46	-0.45	0.041	20	193.12	75.14	399.84	80.68	-0.47	0.036
Risk factors rejected after univariate screening															
MWCC	10E9/l	21	5.35	3.76	7.93	1.08	0.33	0.148	20	5.37	3.76	7.93	1.11	0.25	0.292
MHB	g/dl	21	16.72	14.10	18.56	1.38	0.11	0.638	20	17.28	14.42	22.28	2.08	0.13	0.582
MPCV	l/l	21	0.42	0.31	0.48	0.05	0.18	0.433	20	0.43	0.33	0.50	0.04	0.09	0.705
MNP	%	21	35.40	23.10	57.00	10.18	-0.11	0.638	20	35.30	23.10	57.00	10.43	-0.10	0.668
MEOP	%	21	2.58	0.47	6.07	1.61	-0.12	0.608	20	2.55	0.47	6.07	1.64	-0.05	0.828
MLP	%	21	58.83	40.60	70.90	8.72	0.08	0.716	20	58.99	40.60	70.90	8.91	0.07	0.767
MTP	g/l	21	63.01	57.01	67.95	2.52	-0.14	0.552	20	62.89	57.01	67.95	2.53	-0.05	0.850
MALB	g/l	21	35.65	29.96	39.11	2.94	0.07	0.758	20	35.90	29.96	39.11	2.79	-0.12	0.622
MP	mmol/l	21	2.97	2.41	3.50	0.33	0.37	0.103	20	2.98	2.41	3.50	0.33	0.40	0.078
MGGT	IU	21	28.87	19.43	45.05	5.93	0.15	0.518	20	29.13	19.43	45.05	5.96	0.07	0.767
MBUN	mmol/l	21	9.45	6.94	14.43	1.69	-0.07	0.758	20	9.20	6.94	12.67	1.28	0.04	0.855
MGSHPx	kIU/l	21	6.31	1.70	23.27	5.43	-0.10	0.674	20	6.43	1.70	23.27	5.54	0.02	0.920
MPEPS	mU Tyrosine/l	21	157.93	50.66	283.13	63.80	-0.01	0.969	20	167.94	75.00	249.43	52.30	-0.16	0.506
JUNE VISIT DATA															
MGR46		21	117.55	52.91	203.50	42.20			20	102.28	48.36	173.32	37.66		
Risk factors selected for multivariable analysis															
MCU	µmol/l	21	11.75	4.70	15.70	2.95	0.54	0.012	20	11.90	4.70	15.70	2.94	0.49	0.029
MB12	pmol/l	21	154.45	0.00	393.76	77.30	-0.34	0.136	20	142.48	0.00	237.84	55.90	-0.30	0.195
Risk factors rejected after univariate screening															
MWCC	10E9/l	21	5.87	4.22	10.10	1.25	-0.22	0.339	20	5.82	4.22	10.10	1.27	-0.15	0.519
MHB	g/dl	21	16.22	12.96	21.36	1.61	0.16	0.489	20	15.67	0.00	19.70	3.92	-0.07	0.772
MPCV	l/l	21	0.42	0.35	0.49	0.03	0.09	0.711	20	0.40	0.00	0.48	0.10	-0.20	0.403
MNP	%	21	32.66	24.80	44.50	5.55	-0.20	0.374	20	33.05	25.60	44.50	5.39	-0.33	0.160
MEOP	%	21	3.69	0.53	6.42	1.76	0.24	0.294	20	3.55	0.53	6.42	1.69	0.32	0.175
MLP	%	21	59.31	43.60	66.50	6.04	0.04	0.862	20	59.06	43.60	66.50	6.08	0.08	0.748
MTP	g/l	21	70.20	67.75	75.60	1.88	-0.05	0.827	20	70.09	67.75	75.60	1.86	0.25	0.289
MALB	g/l	21	34.04	28.47	39.13	3.20	0.39	0.077	20	34.21	28.47	39.13	3.18	0.28	0.232
MP	mmol/l	21	2.89	2.44	3.25	0.29	-0.18	0.447	20	2.87	2.44	3.24	0.28	0.10	0.673
MGGT	IU	21	46.64	33.85	80.38	12.71	-0.47	0.032	20	45.27	33.85	80.38	11.35	-0.27	0.248
MBUN	mmol/l	21	10.90	8.57	13.76	1.26	-0.38	0.089	20	10.85	8.57	13.76	1.28	-0.11	0.636
MGSHPx	kIU/l	21	9.34	1.20	17.50	4.93	0.09	0.687	20	9.50	1.20	17.50	5.00	-0.03	0.895
MPEPS	mU Tyrosine/l	21	362.42	35.20	546.76	132.78	-0.10	0.658	20	357.18	0.00	614.37	164.36	0.10	0.673
SEROYERJ	%	21	54.35	0.00	100.00	28.93	-0.37	0.102	20	53.07	0.00	100.00	29.06	-0.18	0.460

* Risk factor codes are described in the glossary and in Table 4.14. The "M" in front of the code means that they are mean blood markers.
Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = Correlation coefficient.

Appendix 4.18 : Means and standard deviations of weaner stag and hind growth rates between June 1 and September 1 (GR69) at each level of dichotomous risk factors screened for univariate association with GR69 and t-test p values.

WEANER WINTER GROWTH

	WEANER HINDS							WEANER STAGS						
	No = 0			Yes = 1				No = 0			Yes = 1			
Risk factor code*	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**
BLOCK 1 : Weaner characteristics, grazing management, disease control and health problems														
Disease control														
Risk factors selected for multivariable analysis														
JULYD	502	48.07	39.12	357	57.27	35.59	0.000	667	81.42	49.64	373	107.91	42.63	0.000
VYERS	616	47.27	35.43	243	63.61	41.49	0.000	713	82.01	45.76	327	110.35	49.97	0.000
COPPER	629	48.09	37.57	230	62.30	37.08	0.000	757	86.22	48.12	283	103.49	48.87	0.000
Risk factors rejected after univariate screening														
JUNED	165	50.99	42.16	694	52.11	36.90	0.735	245	97.90	45.82	795	88.77	49.65	0.008
Environment and grazing management														
Risk factors selected for multivariable analysis														
RSWH5	746	56.26	38.11	113	23.03	20.06	0.000	944	93.85	47.26	96	62.15	55.35	0.000
RSWH10	701	54.26	34.36	158	41.38	49.66	0.000	797	93.44	48.36	243	82.67	49.88	0.003
ODEER	507	56.56	34.86	352	45.17	41.11	0.000	527	96.69	43.49	513	84.99	53.31	0.000
OTHERST	583	53.95	35.40	276	47.54	42.57	0.021	753	98.52	45.45	287	70.98	52.03	0.000
Risk factors rejected after univariate screening														
STRIP	709	52.70	39.33	150	48.09	30.35	0.177	923	88.29	48.91	117	111.65	43.84	0.000
FSUP	376	58.57	36.95	483	46.70	37.93	0.000	519	92.73	48.09	521	89.12	49.69	0.235
Health problems														
Risk factors selected for multivariable analysis														
YERS1	689	48.57	38.03	170	65.35	34.56	0.000	835	89.56	49.06	205	96.47	47.99	0.067
DEATH2	558	62.63	32.12	301	31.99	39.87	0.000	669	99.71	45.36	371	75.08	51.10	0.000
LAME	708	58.10	35.66	151	22.80	34.73	0.000	803	99.18	46.90	237	62.95	45.15	0.000
BLOCK 2 : Sentinel deer individual characteristics and blood markers														
June data														
VICTIM	NP							110	90.62	49.65	2	46.16	56.50	0.383
EASES	9	43.62	38.43	101	56.24	35.72	0.289	5	104.33	20.43	107	89.15	50.75	0.310
LYING	104	56.61	36.36	6	30.87	12.16	0.003	110	90.14	50.19	2	72.50	24.03	0.395
GSHPx3	4	39.94	53.37	21	58.63	34.70	0.472	6	45.54	54.02	37	99.90	48.81	0.033
B12185	79	55.92	34.66	27	55.35	41.91	0.806	74	100.28	47.32	32	73.08	52.21	0.006
CU8	15	44.23	45.92	96	56.33	34.40	0.152	21	82.03	61.02	91	91.62	47.11	0.436
September data														
VICTIM	61	49.06	36.76	60	59.89	36.04	0.077	75	93.68	50.60	44	91.94	53.46	0.931
EASES	7	57.16	26.84	113	53.50	36.53	0.642	12	120.20	52.84	107	89.99	50.65	0.070
LYING‡	118	54.24	36.02	2	22.39	7.69	0.077	NP						
GSHPx3	NP							4	37.63	60.92	44	99.27	52.91	0.219
B12185	74	59.17	38.61	47	46.97	32.36	0.113	75	92.59	53.21	44	93.80	48.93	0.974
CU8‡	20	41.98	36.96	101	56.89	36.28	0.158	22	74.36	53.08	97	97.27	50.41	0.095
BLOCK 3 : Farm mean weaner blood markers														
June data														
MGSHPx3‡	3†	19.56	19.97	21†	60.96	30.95	0.006	2†	28.89	15.84	21†	102.41	40.05	0.000
MB12185	18†	55.29	32.05	6†	57.25	37.34	0.952	17†	102.16	42.41	6†	78.59	46.80	0.335
MCU8‡	2†	43.06	1.13	22†	56.94	33.88	0.003	2†	54.95	21.01	21†	99.93	43.62	0.022
September data														
MGSHPx3	NP							NP						
MB12185	15†	60.71	37.06	9†	47.56	23.06	0.452	15†	107.16	42.77	8†	75.11	40.06	0.105
MCU8‡	2†	26.91	21.72	22†	58.41	32.49	0.117	2†	23.77	23.08	21†	102.89	38.88	0.000

* Risk factor codes are described in the glossary and in Table 4.14.

** t-tests were carried out on the ranks (procedure Rank in SAS) in 2nd and 3rd blocks, which is equivalent to the Wilcoxon rank sum test.

NP = Statistical test not possible because of the limited number of observations in one category.

† Number of farm-years

‡ Blood markers selected for multivariable analyses.

Appendix 4.19 : Means, ranges, standard deviations of continuous risk factors (weaner characteristics, grazing management, disease control and health problems) screened for association with weaner stag and hind growth rates between June 1 and September 1 (GR69), Spearman correlation coefficients and p values.

WEANER WINTER GROWTH

Risk factor code*	Unit	WEANER STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	WEANER HINDS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
GR69		1039	90.74	-87.79	236.84	48.59			859	51.89	-92.74	179.25	37.94		
Weaner individual characteristics															
Risk factors selected for multivariable analysis															
NZ	%	938	85.89	12.50	100.00	20.56	-0.30	0.000	824	81.53	0.00	100.00	23.32	-0.29	0.000
WAP	%	938	1.76	0.00	25.00	6.05	0.06	0.066	824	1.70	0.00	25.00	5.92	0.13	0.000
PERCW6	%	1038	56.94	1.09	99.24	28.62	-0.11	0.001	840	43.76	0.76	99.01	26.44	-0.19	0.000
MAXW6	kg	1038	13.88	0.00	42.49	8.23	0.03	0.356	859	16.09	0.00	48.15	8.58	0.14	0.000
Risk factors rejected after univariate screening															
W6	kg	1038	57.06	26.55	82.03	9.10	0.04	0.190	859	53.28	19.64	73.74	7.78	-0.13	0.000
GR46	g/d	872	117.31	-42.86	330.77	57.75	0.08	0.015	733	105.49	-66.19	315.38	52.12	0.01	0.787
Disease control															
Risk factors selected for multivariable analysis															
STARTD	day	1039	21.14	0.00	91.00	27.52	-0.12	0.000	859	19.27	0.00	91.00	26.49	-0.08	0.018
Risk factors rejected after univariate screening															
NANTH		1039	1.95	0.00	4.00	0.95	-0.03	0.418	859	1.89	0.00	4.00	0.97	-0.06	0.061
Environment and grazing management															
Risk factors selected for multivariable analysis															
SHIFT		1039	10.64	2.00	25.00	6.20	-0.05	0.106	859	9.95	2.00	25.00	5.68	-0.18	0.000
STOCK		1039	3.13	1.00	9.00	2.12	-0.04	0.184	859	3.23	1.00	9.00	2.19	-0.24	0.000
ISWH	cm	1039	13.09	5.50	21.57	4.60	0.04	0.170	859	12.13	6.33	21.57	4.26	0.09	0.006
DEER		1039	84.79	13.21	150.25	37.18	-0.34	0.000	859	84.19	13.21	150.25	37.27	-0.11	0.001
TOPO	Score 1-3	1039	1.63	1.00	2.50	0.56	-0.15	0.000	859	1.59	1.00	2.50	0.52	-0.12	0.000
PASTT	Score 1-3	1039	1.68	1.00	2.71	0.50	-0.22	0.000	859	1.67	1.00	2.71	0.52	-0.25	0.000
SUR	%	1039	32.88	0.00	95.65	28.34	-0.08	0.014	859	35.36	0.00	97.83	33.49	-0.06	0.061
TREES	Score 0-3	1039	0.95	0.00	2.97	0.76	-0.29	0.000	859	1.06	0.00	2.97	0.81	-0.27	0.000
SHELT		1039	16.87	5.13	34.99	7.63	-0.25	0.000	859	16.85	4.84	34.99	7.73	-0.24	0.000
AVMMT	°C	1039	8.64	5.79	13.12	1.86	0.12	0.000	859	8.71	5.79	13.12	1.96	0.10	0.004
RAIND	mm/day	1039	3.59	1.59	8.38	1.65	-0.12	0.000	859	3.91	1.59	8.38	1.68	-0.28	0.000
Risk factors rejected after univariate screening															
CLOVER	Score 1-3	1039	1.42	1.00	2.66	0.53	0.01	0.733	859	1.35	1.00	2.66	0.47	0.16	0.000
MJME/Ha	Score 0-3	1039	895.99	68.01	7511.70	1682.67	0.01	0.638	859	1329.36	68.01	7628.50	2322.87	-0.11	0.001
FAREA	Ha	1039	5.15	0.71	20.79	4.86	-0.21	0.000	859	5.47	0.72	20.79	5.33	0.01	0.844
AVWIND		1039	1.14	0.37	3.34	0.57	0.20	0.000	859	1.06	0.37	3.49	0.63	0.03	0.332
AVMIT	°C	1039	3.59	1.48	5.51	1.13	-0.07	0.023	859	3.65	1.48	5.51	1.09	0.04	0.264
AVMAT	°C	1039	12.25	8.96	15.88	1.98	0.03	0.293	859	12.38	8.96	15.88	1.96	0.04	0.298
SUN	Score 0-1	1039	0.36	0.13	0.70	0.14	0.04	0.247	859	0.34	0.13	0.70	0.15	0.05	0.122

* Risk factor codes are described in the glossary and in Table 4.14.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Note on units : D = Dichotomous variable : Yes=1 ; No=0

"Score 0-1" means "Score ranging from 0 to 1"

Appendix 4.20 : Means, ranges, standard deviations of sentinel deer risk factors and blood markers screened for association with weaner stag and hind growth rates between June 1 and September 1 (GR69), Spearman correlation coefficients and p values.

WEANER WINTER GROWTH

Risk factor code*	Unit	WEANER STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	P value	WEANER HINDS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	P value
JUNE VISIT DATA															
GR69	g/d	112	89.82	-36.28	211.96	49.84			111	54.70	-9.27	161.76	36.16		
Weaner physical characteristics															
Risk factors selected for multivariable analysis															
COATL	mm	107	52.69	35.00	66.00	6.75	-0.18	0.063	103	53.17	35.00	70.00	6.59	-0.28	0.004
Risk factors rejected after univariate screening															
GIRTH	cm	112	95.30	78.00	108.00	5.82	0.34	0.000	109	94.04	80.00	107.00	4.93	0.08	0.380
COATD	g	32	1.79	0.77	3.20	0.55	-0.18	0.313	31	1.83	0.94	3.28	0.49	-0.42	0.018
Blood markers															
Risk factors selected for multivariable analysis															
NP	%	112	32.13	5.00	62.00	10.61	-0.13	0.168	111	32.72	11.00	54.00	9.59	-0.20	0.039
P	mmol/l	112	2.88	0.68	3.94	0.51	0.18	0.057	111	2.85	1.57	3.98	0.49	0.20	0.036
B12	pmol/l	106	175.70	60.00	850.00	117.16	-0.34	0.000	106	160.77	65.00	870.00	102.27	-0.13	0.193
Risk factors rejected after univariate screening															
WCC	10E9/l	112	6.23	2.30	55.00	5.18	-0.09	0.361	110	7.42	2.40	45.30	5.73	-0.06	0.564
HB	g/dl	112	16.18	6.00	24.40	2.42	0.09	0.354	110	16.90	11.40	28.10	2.91	-0.08	0.394
PCV	l/l	112	0.42	0.16	0.54	0.05	-0.01	0.926	110	0.42	0.28	0.52	0.05	0.02	0.797
EOP	%	112	3.84	0.00	14.00	3.16	0.10	0.316	111	4.46	0.00	16.00	3.64	0.30	0.001
LP	%	112	60.37	31.00	91.00	10.66	0.10	0.298	111	59.25	29.00	81.00	10.13	0.12	0.195
TP	g/l	112	70.19	51.60	87.70	5.53	0.05	0.586	111	69.57	58.50	82.80	4.82	0.02	0.806
ALB	g/l	112	33.45	19.50	45.20	4.89	0.29	0.002	111	33.89	14.00	44.40	4.60	0.11	0.250
GGT	IU	112	52.87	18.00	296.00	40.18	-0.17	0.068	111	51.28	20.00	309.00	38.05	-0.06	0.510
BUN	mmol/l	112	11.13	5.99	15.42	1.64	-0.09	0.351	111	10.96	6.50	14.98	1.72	-0.08	0.409
CU	µmol/l	112	11.98	2.50	21.00	4.22	0.08	0.377	111	12.36	3.30	22.00	4.07	-0.11	0.235
GSHPx	kIU/l	43	8.97	0.10	17.60	5.01	0.50	0.001	25	9.16	0.70	23.60	6.47	0.26	0.212
PEPS	mU Tyrosine/l	112	394.07	0.00	1490.00	229.82	0.14	0.139	111	443.93	0.00	1351.00	238.34	0.06	0.504
SEPTEMBER VISIT DATA															
GR69		119	93.04	-36.28	211.96	51.46			121	54.43	-9.27	161.76	36.66		
Blood markers															
Risk factors selected for multivariable analysis															
TP	g/l	119	66.63	55.00	90.70	4.56	-0.24	0.010	121	66.06	58.20	77.70	3.85	-0.15	0.098
Risk factors rejected after univariate screening															
WCC	10E9/l	119	6.13	2.90	38.40	3.58	0.22	0.017	120	6.38	3.00	34.70	3.61	0.04	0.696
HB	g/dl	119	16.07	8.70	24.60	2.40	-0.05	0.579	120	16.77	10.80	25.50	2.79	0.01	0.872
PCV	l/l	119	0.44	0.24	0.64	0.05	-0.08	0.379	120	0.45	0.32	0.58	0.05	-0.05	0.606
NP	%	119	35.43	14.00	79.00	12.14	-0.05	0.575	121	34.99	16.00	84.00	12.39	-0.12	0.178
EOP	%	119	4.05	0.00	32.00	4.59	-0.07	0.473	121	3.59	0.00	17.00	3.46	-0.08	0.372
LP	%	119	57.30	10.00	80.00	12.65	-0.01	0.902	121	58.44	12.00	82.00	12.87	0.11	0.227
ALB	g/l	119	32.49	26.40	38.50	2.32	-0.05	0.554	121	32.98	25.90	39.60	2.82	-0.11	0.244
P	mmol/l	119	2.46	1.60	3.62	0.36	0.10	0.293	121	2.41	1.31	3.24	0.38	-0.04	0.696
GGT	IU	119	28.89	13.00	82.00	9.20	-0.03	0.786	121	32.64	14.00	278.00	24.54	-0.04	0.643
BUN	mmol/l	119	9.47	5.17	12.64	1.49	-0.02	0.790	121	9.59	5.45	12.87	1.47	-0.02	0.804
CU	µmol/l	119	11.22	2.20	27.00	4.19	0.14	0.138	121	12.31	2.10	44.00	4.98	-0.02	0.853
B12	pmol/l	119	200.76	65.00	1500.00	180.30	-0.04	0.680	121	195.55	65.00	1400.00	185.28	-0.11	0.212
GSHPx	kIU/l	48	10.81	1.50	29.20	6.41	0.18	0.226	24	10.74	2.80	23.00	5.76	0.10	0.627
PEPS	mU Tyrosine/l	117	478.28	47.00	1153.00	223.30	-0.12	0.180	121	581.45	140.00	2609.00	332.69	-0.06	0.549

* Risk factor codes are described in the glossary and in Table 4.14.

Min = minimum; Max = maximum; SD = standard deviation; Corr Coef. = correlation coefficient.

Appendix 4.21 : Means, ranges, standard deviations of farm mean weaner blood markers screened for association with farm mean weaner stag and hind growth rates between June 1 and September 1 (MGR69), Spearman correlation coefficients and p values.

WEANER WINTER GROWTH

Risk factor code*		WEANER STAGS Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	P value	WEANER HINDS Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	P value
JUNE VISIT DATA															
MGR69		23	96.01	7.45	185.20	43.80			24	55.78	4.73	137.15	32.61		
Blood markers															
Risk factors selected for multivariable analysis															
MEOP	%	23	3.47	0.53	6.42	1.79	0.42	0.044	24	3.40	0.53	6.42	1.78	0.37	0.075
MP	mmol/l	23	2.87	2.07	3.25	0.32	0.43	0.039	24	2.85	2.07	3.25	0.33	0.54	0.007
MGSHPx	kIU/l	23	9.10	1.20	17.50	4.98	0.45	0.032	24	8.83	1.20	17.50	5.05	0.32	0.125
SEROYERJ		23	58.21	0.00	100.00	28.38	-0.30	0.159	24	59.49	0.00	100.00	28.45	-0.46	0.024
Risk factors rejected after univariate screening															
MWCC	10E9/l	23	6.25	4.22	13.59	2.01	-0.10	0.657	24	6.20	4.22	13.59	1.98	-0.15	0.485
MHB	g/dl	23	16.19	12.96	21.36	1.54	-0.10	0.655	24	16.73	14.06	19.70	1.43	-0.35	0.090
MPCV	l/l	23	0.42	0.35	0.49	0.03	-0.05	0.835	24	0.42	0.36	0.48	0.03	0.07	0.737
MNP	%	23	33.12	24.80	41.50	5.46	-0.27	0.217	24	33.30	24.80	44.50	5.42	-0.14	0.511
MLP	%	23	59.09	43.60	66.50	5.63	0.20	0.359	24	58.96	43.60	66.50	5.54	0.06	0.798
MTP	g/l	23	69.78	58.85	75.60	3.01	0.11	0.633	24	69.85	58.85	75.60	2.96	0.02	0.913
MALB	g/l	23	33.79	24.20	39.13	3.81	0.37	0.079	24	33.79	24.20	39.13	3.72	0.22	0.308
MGGT	IU	23	47.11	31.66	80.38	12.71	-0.16	0.457	24	47.39	31.66	80.38	12.51	0.03	0.904
MBUN	mmol/l	23	11.03	8.57	13.76	1.21	-0.03	0.886	24	10.96	8.57	13.76	1.22	0.05	0.818
MCU	µmol/l	23	12.18	4.70	17.00	3.13	-0.10	0.638	24	12.26	4.70	17.00	3.09	-0.16	0.459
MB12	pmol/l	23	161.80	0.00	393.76	82.17	-0.28	0.188	24	162.72	0.00	393.76	80.49	-0.11	0.613
MPEPS	mUTyrosine/l	23	367.35	35.20	604.91	137.17	0.31	0.152	24	395.73	163.05	790.05	160.51	0.21	0.332
SEPTEMBER VISIT DATA															
MGR69		23	96.01	7.45	185.20	43.80			24	55.78	4.73	137.15	32.61		
Blood markers															
Risk factors selected for multivariable analysis															
MTP	g/l	23	66.25	61.63	71.78	2.40	-0.37	0.079	24	66.37	61.63	71.78	2.43	-0.50	0.013
Risk factors rejected after univariate screening															
MWCC	10E9/l	23	5.96	4.61	8.85	1.03	0.07	0.768	24	5.89	4.28	8.85	1.07	0.06	0.784
MHB	g/dl	23	16.03	13.46	19.40	1.56	-0.16	0.466	24	16.71	13.76	22.98	2.32	0.04	0.846
MPCV	l/l	23	0.43	0.37	0.48	0.03	-0.16	0.468	24	0.45	0.39	0.53	0.03	-0.03	0.889
MNP	%	23	35.33	25.20	64.50	8.21	-0.16	0.472	24	35.10	25.20	64.50	8.11	-0.04	0.861
MEOP	%	23	3.04	0.07	8.09	2.29	-0.12	0.580	24	3.11	0.07	8.09	2.27	-0.29	0.164
MLP	%	23	57.79	20.80	69.30	9.47	0.12	0.596	24	57.97	20.80	69.30	9.31	0.03	0.875
MALB	g/l	23	32.63	29.80	36.00	1.79	-0.14	0.532	24	32.67	29.80	36.00	1.76	-0.26	0.216
MP	mmol/l	23	2.42	1.98	2.73	0.18	-0.08	0.727	24	2.43	1.98	2.73	0.18	-0.01	0.974
MGGT	IU	23	29.36	22.59	46.06	5.81	-0.10	0.641	24	29.36	22.59	46.06	5.68	-0.06	0.768
MBUN	mmol/l	23	9.52	5.66	11.15	1.21	-0.16	0.457	24	9.48	5.66	11.15	1.20	-0.04	0.837
MCU	µmol/l	23	11.55	4.18	16.10	2.56	0.08	0.723	24	11.61	4.18	16.10	2.52	-0.06	0.767
MB12	pmol/l	23	182.93	72.56	615.89	109.75	-0.18	0.409	24	186.17	72.56	615.89	108.51	-0.05	0.821
MGSHPx	kIU/l	23	10.20	3.17	20.07	4.78	0.26	0.239	24	9.86	2.23	20.07	4.95	0.09	0.660
MPEPS	mUTyrosine/l	23	454.83	132.27	699.96	131.87	-0.04	0.868	24	537.30	291.42	1023.16	180.32	-0.07	0.738
SEROYERS		22	27.74	0.00	80.00	24.96	-0.13	0.555	23	27.08	0.00	80.00	24.59	0.01	0.962

* Risk factor codes are described in the glossary and in Table 4.14. The "M" in front of the code means that they are mean blood markers.
Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Appendix 4.22 : Means and standard deviations of weaner stag and hind growth rates between September 1 and December 1 (GR912) at each level of dichotomous risk factors screened for univariate association with GR912 and t-test p values.

WEANER SPRING GROWTH

	WEANER HINDS							WEANER STAGS						
	No = 0			Yes = 1				No = 0			Yes = 1			
Risk factor code*	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**
BLOCK 1 : Weaner characteristics, grazing management, disease control and health problems														
Disease control														
Risk factor selected for multivariable analysis														
LAUGD	738	139.61	35.59	129	154.36	25.51	0.000	612	199.51	52.88	276	222.42	35.72	0.000
Environment and grazing management														
Risk factors selected for multivariable analysis														
RSWH5	843	142.91	34.32	24	103.23	22.88	0.000	857	208.87	48.59	31	144.79	22.52	0.000
ODEER	498	149.45	33.69	369	131.49	33.30	0.000	518	218.97	47.55	370	189.36	46.58	0.000
Risk factors rejected after univariate screening														
RSWH10	673	141.10	34.98	194	144.26	33.50	0.254	540	204.39	50.87	348	210.11	46.71	0.086
OTHERST	489	136.72	32.39	378	148.39	36.40	0.000	454	210.69	54.27	434	202.39	43.24	0.012
FSUP	626	141.21	35.31	241	143.37	32.95	0.397	656	202.67	44.52	232	217.83	59.64	0.000
BLOCK 2 : Sentinel deer individual characteristics and blood markers														
September data														
VICTIM	61	150.51	44.33	57	136.57	38.12	0.103	60	204.40	52.17	42	207.68	67.11	0.436
EASES	7	129.86	43.76	110	145.03	41.79	0.483	8	204.92	52.60	94	205.82	59.21	0.791
LYING	115	144.84	41.55	2	102.81	55.72	0.458	NP						
GSHPx3	NP							4	180.69	56.32	38	213.01	47.11	0.400
B12185‡	72	150.48	37.36	46	133.27	46.57	0.019	63	220.90	50.31	39	181.27	62.97	0.003
CU8	13	140.14	39.48	105	144.22	42.30	0.592	17	180.40	42.20	85	210.82	60.15	0.010
November data														
VICTIM	NP							NP						
EASES	8	127.87	34.40	50	127.70	34.13	0.847	6	194.42	49.62	40	205.23	60.57	0.710
LYING	NP							NP						
GSHPx3	4	131.38	43.69	10	128.17	32.28	0.740	6	193.36	57.53	14	209.68	64.13	0.566
B12185	31	130.90	34.90	27	124.08	32.90	0.426	32	213.07	56.89	16	171.69	63.36	0.073
CU8	4	127.60	22.75	54	127.73	34.69	1.000	2	186.53	28.74	46	199.83	62.83	0.731
BLOCK 3 : Farm mean weaner blood markers														
September data														
MGSHPx3	NP							NP						
MB12185‡	15†	147.32	24.99	8†	125.27	29.41	0.033	12†	215.62	30.97	7†	173.38	30.49	0.003
MCU8	NP							NP						
November data														
MGSHPx3	3†	129.11	28.47	7†	122.99	16.74	0.798	3†	174.56	44.22	5†	179.45	38.11	0.697
MB12185‡	6†	133.92	17.16	4†	111.17	14.90	0.081	5†	200.44	23.62	3†	139.58	17.15	0.005
MCU8	NP							NP						

* Risk factor codes are described in the glossary and in Table 4.14

** t-tests were carried out on the ranks (procedure Rank in SAS) in 2nd and 3rd blocks, which is equivalent to the Wilcoxon rank sum test.

NP = Statistical test not possible because of the limited number of observations in one category.

† Number of farm-years

‡ Blood markers selected for multivariable analyses.

Appendix 4.23 : Means, ranges, standard deviations of continuous risk factors (weaner characteristics, grazing management, and disease control) screened for association with weaner stag and hind growth rates between September 1 and December 1 (GR912), Spearman correlation coefficients and p values.

WEANER SPRING GROWTH

Risk factor code*	Unit	WEANER STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	WEANER HINDS Number of deer	Mean	Min	Max	SD	Spearman Corr.Coef.	p value
GR912	g/d	888	206.63	31.15	348.21	49.34			867	141.81	48.76	279.07	34.66		
Weaner individual characteristics															
Risk factors selected for multivariable analysis															
NZ	%	789	84.32	12.50	100.00	21.52	-0.21	0.000	832	81.13	6.40	100.00	23.73	-0.03	0.439
WA	%	789	1.52	0.00	25.00	5.81	-0.02	0.489	832	1.31	0.00	25.00	5.27	-0.14	0.000
PERCW9	%	887	58.93	1.09	99.21	28.15	0.06	0.071	866	39.03	0.72	98.31	24.74	0.07	0.046
MAXW9	kg	887	14.80	0.00	45.33	8.43	-0.09	0.008	866	19.49	0.00	41.57	8.66	-0.16	0.000
Risk factors rejected after univariate screening															
W9	kg	887	63.23	34.26	88.55	10.03	0.16	0.000	866	57.48	27.38	81.45	7.92	-0.04	0.197
GR69	g/d	811	87.32	-87.79	275.90	47.66	0.14	0.000	806	49.77	-92.74	179.25	36.41	-0.03	0.436
Disease control															
Risk factors selected for multivariable analysis															
STARTD	day	888	50.03	2.00	91.00	34.02	-0.31	0.000	867	47.79	2.00	91.00	35.12	-0.46	0.000
NANTH		888	1.14	0.00	3.00	0.88	0.26	0.000	867	1.14	0.00	3.00	0.89	0.23	0.000
Environment and grazing management															
Risk factors selected for multivariable analysis															
STOCK		888	2.54	1.00	6.00	1.46	-0.18	0.000	867	2.42	1.00	6.00	1.49	-0.09	0.006
ISWH	cm	888	14.03	6.20	22.92	5.39	0.11	0.002	867	12.87	5.75	22.56	4.62	0.09	0.006
CLOVER	Score 1-3	888	1.81	1.00	2.82	0.54	0.14	0.000	867	1.78	1.00	2.76	0.51	0.37	0.000
OTHERST		888	10.71	0.00	65.73	18.68	-0.13	0.000	867	10.07	0.00	51.64	17.86	0.18	0.000
M%WS	%	888	61.87	20.62	100.00	19.19	0.22	0.000	867	39.58	0.00	96.77	20.65	-0.18	0.000
PASTT	Score 1-3	888	1.96	1.13	2.74	0.38	0.33	0.000	867	1.84	1.13	2.74	0.39	0.11	0.002
AVMIT	°C	888	6.43	4.09	8.04	1.01	-0.09	0.005	867	6.29	4.09	8.04	0.97	-0.18	0.000
AVMAT	°C	888	17.03	15.02	19.63	1.32	0.05	0.159	867	16.88	15.02	19.64	1.38	0.04	0.187
SUN	Score 0-1	888	0.46	0.20	0.63	0.10	0.08	0.014	867	0.43	0.20	0.63	0.11	0.06	0.072
Risk factors rejected after univariate screening															
SHIFT		888	10.17	2.00	28.00	7.22	0.03	0.393	867	10.15	2.00	28.00	7.09	-0.07	0.031
DEER		888	88.54	27.43	138.73	31.70	-0.07	0.035	867	86.32	27.43	138.73	32.74	0.02	0.655
MJME/Ha	MJME/ha	888	456.04	27.24	1327.36	305.45	0.03	0.309	867	461.55	42.43	1327.36	293.73	-0.11	0.002
FAREA		888	4.87	1.27	16.46	3.48	-0.21	0.000	867	5.21	1.08	21.16	4.76	0.01	0.745
TOPO	Score 1-3	888	1.71	1.02	2.63	0.49	-0.28	0.000	867	1.72	1.00	2.60	0.46	-0.02	0.621
THISTLE	Score 0-3	888	1.26	0.19	2.45	0.74	0.02	0.498	867	1.28	0.19	2.45	0.73	0.16	0.000
RAG	Score 0-3	888	0.68	0.00	2.66	0.79	0.02	0.510	867	0.68	0.00	2.66	0.83	0.19	0.000
SUR	%	888	25.87	0.00	92.31	23.02	-0.04	0.209	867	28.05	0.00	93.41	25.60	0.09	0.009
TREES	Score 0-3	888	1.05	0.00	2.77	0.65	-0.08	0.011	867	1.17	0.00	2.77	0.71	0.27	0.000
SHELT		888	17.97	4.22	30.71	6.66	-0.23	0.000	867	18.59	6.03	32.48	7.24	0.20	0.000
AVWIND		888	0.96	0.42	2.09	0.42	0.01	0.771	867	1.02	0.36	2.22	0.50	0.06	0.103
AVMMT	°C	888	10.53	8.55	12.84	1.56	0.02	0.564	867	10.51	8.55	13.12	1.59	0.07	0.034
RAIND	mm/day	888	3.48	1.93	6.07	1.16	0.02	0.554	867	3.85	1.93	6.56	1.27	-0.01	0.688

* Risk factor codes are described in the glossary and in Table 4.14.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Note on units : D = Dichotomous variable : Yes=1 ; No=0

"Score 0-1" means "Score ranging from 0 to 1"

Appendix 4.24 : Means, ranges, standard deviations of sentinel deer risk factors and blood markers screened for association with weaner stag and hind growth rates between September 1 and December 1 (GR912), Spearman correlation coefficients and p values.

WEANER SPRING GROWTH

Risk factor code*	Unit	WEANER STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	WEANER HINDS Number of deer	Mean	Min	Max	SD	Spearman Corr.Coef.	p value
SEPTEMBER VISIT DATA															
GR912	g/d	102	205.75	33.45	340.91	58.49			118	143.77	48.76	279.07	41.86		
Individual weaner characteristics															
Risk factor selected for multivariable analysis															
GIRTH	cm	101	98.01	87.00	110.00	5.41	0.28	0.004	118	95.91	86.00	108.00	4.47	0.29	0.001
Risk factor rejected after univariate screening															
COATL	mm	102	56.11	42.00	70.00	5.45	-0.13	0.209	118	57.47	43.00	70.00	5.21	-0.17	0.063
Blood markers															
Risk factors selected for multivariable analysis															
WCC	10E9/l	102	6.26	2.90	38.40	3.94	0.21	0.032	117	6.53	3.00	34.70	3.66	0.18	0.046
B12	pmol/l	102	181.78	65.00	680.00	92.62	-0.25	0.012	118	192.64	65.00	1400.00	186.08	-0.29	0.001
Risk factors rejected after univariate screening															
HB	g/dl	102	16.37	8.70	24.60	2.53	-0.05	0.585	117	16.93	11.40	25.50	2.71	-0.20	0.027
PCV	l/l	102	0.44	0.24	0.56	0.04	-0.11	0.258	117	0.45	0.34	0.58	0.05	-0.21	0.023
NP	%	102	35.62	15.00	79.00	12.38	0.01	0.955	118	35.83	14.00	84.00	12.51	0.03	0.779
EOP	%	102	3.99	0.00	32.00	4.36	0.15	0.132	118	3.65	0.00	17.00	3.47	0.09	0.355
LP	%	102	56.93	10.00	80.00	12.98	-0.10	0.315	118	57.42	12.00	82.00	12.71	-0.06	0.543
TP	g/l	102	67.24	58.10	90.70	4.68	0.03	0.761	118	66.24	5.820	77.70	3.91	-0.22	0.017
ALB	g/l	102	32.10	26.40	38.50	2.24	-0.04	0.657	118	32.89	25.90	39.60	2.83	-0.31	0.001
P	mmol/l	102	2.43	1.60	3.62	0.37	0.25	0.011	118	2.38	1.31	3.24	0.38	-0.03	0.735
GGT	IU	102	28.07	13.00	82.00	9.06	-0.14	0.158	118	32.46	18.00	278.00	24.65	-0.08	0.380
BUN	mmol/l	102	9.48	4.10	12.64	1.66	-0.03	0.731	118	9.49	5.45	12.87	1.57	0.07	0.431
CU	µmol/l	102	11.51	2.20	27.00	4.24	0.25	0.011	118	12.85	2.10	44.00	4.89	0.11	0.253
GSHPx	kIU/l	42	10.52	1.40	29.20	6.39	0.42	0.005	23	11.40	2.80	23.00	6.02	0.00	0.984
PEPS	mU Tyrosine/l	102	471.86	47.00	1137.00	214.11	-0.25	0.012	118	600.50	140.00	2609.00	342.73	0.01	0.890
DECEMBER VISIT DATA															
GR912		48	199.28	83.62	337.00	61.68			58	127.72	48.76	189.39	33.86		
Blood markers															
Risk factor selected for multivariable analysis															
B12	pmol/l	48	165.56	71.00	310.00	57.92	-0.38	0.008	58	212.72	65.00	1400.00	207.05	-0.18	0.177
Risk factors rejected after univariate screening															
WCC	10E9/l	48	5.94	2.80	10.40	1.83	0.05	0.733	58	5.66	2.80	9.60	1.69	-0.06	0.651
HB	g/dl	48	16.19	8.20	22.70	2.08	0.31	0.032	58	17.17	13.20	19.90	1.34	-0.24	0.071
PCV	l/l	48	0.40	0.22	0.51	0.04	0.08	0.566	58	0.43	0.33	0.52	0.03	-0.16	0.242
NP	%	48	36.25	13.00	62.00	12.16	-0.16	0.271	58	36.45	19.00	60.00	9.41	-0.39	0.003
EOP	%	48	4.56	0.00	14.00	3.45	0.00	0.990	58	4.84	0.00	19.00	3.73	0.25	0.057
LP	%	48	57.96	35.00	85.00	11.78	0.15	0.325	58	57.26	38.00	74.00	8.91	0.32	0.013
TP	g/l	48	69.33	61.60	80.40	4.20	0.06	0.668	58	67.32	58.70	75.70	3.89	0.08	0.555
ALB	g/l	48	34.73	29.10	41.70	2.83	0.07	0.616	58	34.84	29.20	40.80	2.57	-0.12	0.373
P	mmol/l	48	2.74	1.70	3.89	0.46	0.23	0.115	58	2.63	1.51	3.44	0.43	0.04	0.779
GGT	IU	48	30.27	18.00	66.00	9.57	0.09	0.539	58	32.60	18.00	96.00	14.72	0.08	0.533
BUN	mmol/l	48	9.10	6.39	12.64	1.44	0.11	0.441	58	9.22	5.92	12.14	1.46	0.19	0.148
CU	µmol/l	48	14.89	3.90	24.00	4.00	0.34	0.018	58	14.70	5.50	25.00	3.82	0.05	0.697
GSHPx	kIU/l	20	7.75	1.00	20.60	5.56	0.23	0.319	14	10.79	1.10	22.60	7.35	0.00	0.994
PEPS	mU Tyrosine/l	47	529.92	152.80	1069.60	222.69	-0.10	0.499	58	590.12	152.80	1375.20	231.55	0.28	0.030

* Risk factor codes are described in the glossary and in Table 4.14.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef = correlation coefficient.

Appendix 4.25 : Means, ranges, standard deviations of farm mean weaner blood markers screened for association with farm mean weaner stag and hind growth rates between September 1 and December 1 (MGR912), Spearman correlation coefficients and p values.

WEANER SPRING GROWTH

Risk factor code*		WEANER STAGS Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	WEANER HINDS Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
SEPTEMBER VISIT DATA															
MGR912		19	200.06	120.43	268.16	36.53			23	139.65	86.06	191.93	28.07		
Blood markers															
Risk factors selected for multivariable analysis															
MWCC	10E9/l	19	5.88	4.28	8.85	1.13	0.32	0.180	23	5.93	4.28	8.85	1.08	0.37	0.082
MALB	g/l	19	32.32	29.80	35.82	1.68	-0.52	0.021	23	32.62	29.80	36.00	1.79	-0.57	0.004
MB12	pmol/l	19	169.29	72.56	283.89	59.53	-0.51	0.026	23	183.07	72.56	615.89	109.86	-0.37	0.078
Risk factors rejected after univariate screening															
MHB	g/dl	19	16.31	13.46	20.18	1.85	-0.24	0.333	23	16.78	13.76	22.98	2.35	-0.47	0.022
MPCV	l/l	19	0.44	0.39	0.48	0.03	-0.24	0.321	23	0.45	0.39	0.53	0.03	-0.51	0.012
MNP	%	19	35.95	25.20	64.50	8.70	0.01	0.977	23	35.24	25.20	64.50	8.26	0.29	0.178
MEOP	%	19	3.02	0.07	8.09	2.31	0.04	0.867	23	3.17	0.07	8.09	2.29	-0.03	0.897
MLP	%	19	57.16	20.80	69.30	9.96	-0.10	0.697	23	57.69	20.80	69.30	9.41	-0.32	0.132
MTP	g/l	19	66.61	61.63	71.78	2.63	-0.34	0.160	23	66.37	61.63	71.78	2.48	-0.18	0.423
MP	mmol/l	19	2.40	1.98	2.73	0.19	0.08	0.732	23	2.42	1.98	2.73	0.18	-0.30	0.168
MGGT	IU	19	28.00	22.59	46.06	5.31	-0.15	0.538	23	29.13	22.59	46.06	5.68	-0.06	0.795
MBUN	mmol/l	19	9.62	5.66	11.15	1.29	-0.18	0.468	23	9.52	5.66	11.15	1.21	0.13	0.559
MCU	µmol/l	19	11.84	4.18	16.10	2.55	0.20	0.409	23	11.83	4.18	16.10	2.32	0.09	0.685
MGSHPx	kIU/l	19	9.65	2.23	18.53	4.50	0.50	0.028	23	10.14	2.23	20.07	4.86	0.22	0.312
MPEPS	mU Tyrosine/l	19	457.80	132.27	699.96	125.12	-0.12	0.632	23	542.87	291.42	1023.16	182.25	0.03	0.907
SEROYERS		19	28.79	0.00	80.00	26.52	0.24	0.322	22	26.79	0.00	80.00	25.13	0.24	0.272
DECEMBER VISIT DATA															
MGR912		8	177.62	120.43	225.65	37.35			10	124.82	94.15	159.61	19.38	SPEARMAN P_LEVEL	
Blood markers															
Risk factors selected for multivariable analysis															
MNP	%	8	36.38	26.60	51.30	9.36	-0.60	0.120	10	35.06	24.40	51.30	9.07	-0.59	0.074
MLP	%	8	57.25	43.40	67.60	8.95	0.55	0.160	10	57.79	43.40	67.60	8.18	0.58	0.082
Risk factors rejected after univariate screening															
MWCC	10E9/l	8	5.63	3.90	8.13	1.60	-0.05	0.911	10	5.52	3.90	8.13	1.48	0.08	0.829
MHB	g/dl	8	16.00	13.90	17.68	1.26	0.17	0.691	10	17.11	15.24	18.40	1.05	-0.27	0.446
MPCV	l/l	8	0.39	0.36	0.44	0.02	-0.24	0.570	10	0.43	0.40	0.47	0.03	-0.30	0.405
MEOP	%	8	4.21	0.97	6.74	1.73	0.10	0.823	10	5.08	0.97	8.88	2.38	0.30	0.405
MTP	g/l	8	67.70	64.75	69.89	1.92	-0.26	0.531	10	67.86	64.75	69.89	1.82	-0.61	0.060
MALB	g/l	8	34.35	32.14	37.42	1.77	-0.33	0.420	10	34.84	32.14	37.77	1.93	-0.10	0.777
MP	mmol/l	8	2.64	2.14	3.12	0.29	0.33	0.420	10	2.65	2.14	3.12	0.25	0.07	0.855
MGGT	IU	8	29.45	25.46	38.09	4.21	0.36	0.385	10	30.62	25.46	38.09	4.52	0.44	0.200
MBUN	mmol/l	8	8.94	6.99	10.58	1.13	-0.14	0.736	10	8.75	6.99	10.58	1.11	-0.03	0.934
MCU	µmol/l	8	14.46	10.07	16.50	2.15	0.40	0.320	10	14.76	10.07	17.28	2.09	0.33	0.347
MB12	pmol/l	8	170.84	100.40	263.00	55.96	-0.71	0.047	10	203.10	99.30	564.98	138.23	-0.41	0.244
MGSHPx	kIU/l	8	6.50	1.27	15.33	4.84	-0.07	0.867	10	8.87	1.27	20.85	6.68	-0.04	0.907
MPEPS	mU Tyrosine/l	8	539.72	306.60	811.56	166.04	0.24	0.570	10	551.63	332.43	792.52	142.37	0.25	0.487

* Risk factor codes are described in the glossary and in Table 4.14. The "M" in front of the code means that they are mean blood markers.
Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Appendix 4.26 : Means and standard deviations of weaner stag and hind growth rates between December 1 and March 1 (GR123) at each level of dichotomous risk factors screened for univariate association with GR123 and t-test p values.

WEANER SUMMER GROWTH

	WEANER HINDS							WEANER STAGS						
	No = 0			Yes = 1				No = 0			Yes = 1			
Risk factor code*	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**
BLOCK 1 : Weaner characteristics, grazing management, and disease control														
Disease control														
NOVD†	621	164.21	56.60	222	154.00	77.16	0.038	329	226.97	67.22	226	187.07	84.13	0.000
SUMD†	633	149.31	62.26	210	198.33	48.44	0.000	417	191.77	72.02	138	267.99	62.05	0.000
Environment and grazing management														
RSWH5	NP													
RSWH10†	266	200.34	45.89	403	143.88	61.64	0.000	80	272.58	56.47	398	195.88	74.15	0.000
ODEER†	263	152.69	79.60	580	165.53	53.04	0.006	333	197.06	82.36	222	231.21	63.11	0.000
OTHERST	481	166.00	68.50	362	155.57	53.79	0.017	385	208.12	79.74	170	216.62	70.39	0.209
BLOCK 2 : Sentinel deer individual characteristics and blood markers														
November data														
VICTIM	NP							NP						
EASES	8	187.45	61.05	49	181.03	63.02	0.847	5	251.97	60.02	30	245.80	45.45	0.673
LYING	NP							NP						
STRESS	NP							33	248.18	47.64	2	222.01	23.72	0.419
GSHPx3	4	153.97	80.79	9	185.59	49.15	0.408	3	205.36	28.30	12	258.68	35.59	0.023
B12185	31	194.73	61.78	26	166.67	60.46	0.023	24	244.34	52.27	13	248.19	32.53	0.752
CU8	4	212.41	82.39	53	179.63	60.87	0.558	2	262.79	41.11	35	244.72	46.45	0.693

* Risk factor codes are described in the glossary and in Table 4.14.

** t-tests were carried out on the ranks (procedure Rank in SAS) in block 2, which is equivalent to the Wilcoxon rank sum test.

NP = Statistical test not possible because of the limited number of observations in one category.

† Blood markers selected for multivariable analyses.

Appendix 4.27 : Means, ranges, standard deviations of continuous risk factors (weaner characteristics and grazing management) screened for association with weaner stag and hind growth rates between December 1 and March 1 (GR123), Spearman correlation coefficients and p values.

WEANER SUMMER GROWTH

		WEANER STAGS							WEANER HINDS						
Risk factor code*	Unit	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
GR123		555	210.72	-36.66	426.49	77.04			843	161.52	-63.43	350.27	62.78		
Weaner individual characteristics															
Risk factors selected for multivariable analysis															
NZ	%	552	81.68	12.50	100.00	22.30	-0.35	0.000	843	81.32	6.40	100.00	23.69	-0.19	0.000
WAP	%	552	2.11	0.00	25.00	6.76	0.03	0.551	843	1.32	0.00	25.00	5.30	-0.07	0.037
W12	kg	554	82.36	48.06	117.06	11.55	0.18	0.000	842	70.30	34.59	96.74	8.50	0.06	0.107
PERCW12	%	554	62.83	0.78	99.22	26.20	0.15	0.001	842	38.24	0.88	98.53	24.65	0.05	0.113
Risk factors rejected after univariate screening															
MAXW12	kg	554	17.53	0.00	54.26	9.77	-0.22	0.000	842	23.70	0.00	51.05	11.48	-0.04	0.251
GR912	g/d	546	204.92	79.34	343.63	47.33	0.11	0.014	825	141.35	48.76	279.07	34.46	-0.05	0.194
Environment and grazing management															
Risk factors selected for multivariable analysis															
SHIFT		555	3.19	1.00	9.00	2.30	0.34	0.000	843	2.97	1.00	9.00	2.16	0.15	0.000
STOCK		555	1.15	1.00	2.00	0.36	0.21	0.000	843	1.26	1.00	2.00	0.44	0.37	0.000
ISWH	cm	555	18.68	7.67	32.50	7.38	-0.61	0.000	843	15.53	5.00	32.50	7.39	-0.40	0.000
DEER		555	76.53	28.00	127.00	30.88	-0.25	0.000	843	77.19	28.00	131.03	32.25	-0.22	0.000
M%WS	%	555	65.39	18.45	100.00	23.00	-0.24	0.000	843	27.27	0.00	96.77	23.65	-0.23	0.000
MJME/Ha	MJME/ha	555	418.75	45.35	876.13	268.16	0.19	0.000	843	374.12	46.33	882.56	266.24	0.09	0.010
TOPO	Score 1-3	555	1.48	1.00	2.56	0.48	0.31	0.000	843	1.76	1.00	2.68	0.57	0.10	0.003
PASTT	Score 1-3	555	2.10	1.09	3.00	0.51	-0.18	0.000	843	2.05	1.00	3.00	0.51	-0.16	0.000
THISTLE	Score 0-3	555	1.06	0.00	2.27	0.71	-0.14	0.001	843	1.30	0.00	3.00	0.83	-0.18	0.000
RAG	Score 0-3	555	0.81	0.00	2.34	0.68	-0.13	0.003	843	0.78	0.00	2.55	0.85	-0.20	0.000
SUR	%	555	30.26	0.00	100.00	27.75	0.11	0.009	843	21.49	0.00	100.00	24.95	0.26	0.000
AVMIT	°C	555	10.99	9.58	12.90	1.06	-0.42	0.000	843	10.62	8.81	12.90	0.97	-0.43	0.000
AVMAT	°C	555	23.41	19.23	27.23	2.23	-0.62	0.000	843	22.59	18.24	27.23	2.26	-0.59	0.000
AVMMT	°C	555	12.30	9.46	15.49	1.91	-0.34	0.000	843	11.90	7.90	15.49	1.99	-0.43	0.000
RAIND	mm/day	555	2.65	1.48	4.92	1.00	0.37	0.000	843	3.11	1.48	5.39	1.15	0.41	0.000
SUN	0-1	555	0.56	0.36	0.88	0.13	-0.51	0.000	843	0.53	0.28	0.88	0.12	-0.58	0.000
Risk factors rejected after univariate screening															
CLOVER	Score 1-3	480	1.83	1.00	2.72	0.44	0.19	0.000	765	1.96	1.00	2.72	0.45	-0.10	0.008
FAREA	Ha	555	3.21	1.08	6.74	1.54	0.01	0.777	843	6.22	0.85	24.07	6.64	-0.11	0.002
TREES	Score 0-3	555	0.49	0.00	2.47	0.57	0.10	0.017	843	1.17	0.00	3.00	1.07	-0.01	0.795
SHELT		555	15.93	4.53	25.73	6.06	0.22	0.000	843	20.56	3.93	38.89	8.90	-0.01	0.726
AVWIND		555	0.99	0.46	1.53	0.34	0.04	0.335	843	1.00	0.20	3.88	0.82	0.12	0.000

* Risk factor codes are described in the glossary and in Table 4.14.
Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.
Note on units : D = Dichotomous variable : Yes=1 ; No=0

Appendix 4.28 : Means, ranges, standard deviations of sentinel deer risk factors and blood markers screened for association with weaner stag and hind growth rates between December 1 and March 1 (GR123), Spearman correlation coefficients and p values.

WEANER SUMMER GROWTH

		WEANER STAGS							WEANER HINDS						
Risk factor code*	Unit	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
NOVEMBER VISIT DATA															
GR123	g/d	37	245.69	163.07	335.08	45.85			57	181.93	67.48	332.51	62.25		
Weaner physical characteristics															
GIRTH	cm	37	102.30	91.00	113.00	5.35	0.47	0.004	57	98.00	89.00	107.00	4.51	0.27	0.040
Blood markers															
Risk factors selected for multivariable analysis															
P	mmol/l	37	2.78	1.70	3.89	0.46	0.36	0.030	57	2.63	1.51	3.44	0.43	0.31	0.021
GSHPx	kIU/l	15	8.27	1.00	20.60	5.53	0.53	0.043	13	10.42	1.10	22.60	7.51	0.43	0.146
PEPS	mU Tyrosine/l	36	577.24	152.80	1069.60	228.43	-0.51	0.001	57	587.07	152.80	1375.20	232.43	-0.22	0.093
Risk factors rejected after univariate screening															
WCC	10E9/l	37	6.13	2.80	10.40	1.93	-0.21	0.207	57	5.70	2.80	9.60	1.67	-0.43	0.001
HB	g/dl	37	16.09	8.20	22.70	2.19	-0.27	0.105	57	17.14	13.20	19.90	1.34	-0.07	0.609
PCV	l/l	37	0.39	0.22	0.51	0.05	-0.28	0.094	57	0.43	0.33	0.52	0.03	-0.07	0.608
NP	%	37	36.76	13.00	62.00	12.50	-0.09	0.593	57	36.28	19.00	60.00	9.40	-0.52	0.000
EOP	%	37	4.54	0.00	14.00	3.83	-0.07	0.692	57	4.82	0.00	19.00	3.76	0.11	0.432
LP	%	37	57.65	35.00	85.00	12.14	0.16	0.355	57	57.42	38.00	74.00	8.90	0.45	0.000
TP	g/l	37	69.02	61.60	80.40	4.41	-0.02	0.915	57	67.31	58.70	75.70	3.92	0.19	0.154
ALB	g/l	37	34.14	29.10	41.00	2.78	0.22	0.191	57	34.80	29.20	40.80	2.57	0.04	0.742
GGT	IU	37	29.57	18.00	66.00	10.06	-0.14	0.401	57	32.56	18.00	96.00	14.85	-0.08	0.546
BUN	mmol/l	37	9.19	6.90	12.64	1.43	0.18	0.290	57	9.24	5.92	12.14	1.47	-0.28	0.032
CU	µmol/l	37	14.94	3.90	24.00	4.15	-0.14	0.401	57	14.66	5.50	25.00	3.84	-0.12	0.390
B12	pmol/l	37	170.00	71.00	310.00	56.11	0.02	0.886	57	191.89	65.00	840.00	134.24	-0.36	0.005

* Risk factor codes are described in the glossary and in Table 4.14.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Appendix 4.29 : Interrelationships between mean daily sunshine scores (SUN) and other risk factors potentially associated with weaner hind and stag autumn growth rate (GR46)

	Weaner stags			Weaner hinds		
Risk factor codes	Number of deer	Spearman R	p value	Number of deer	Spearman R	p value
Individual weaner characteristic						
NZ	772	0.53	0.000	571	0.48	0.000
Grazing and environmental factors						
STOCK	922	0.15	0.000	664	-0.07	0.054
SHIFT	922	-0.02	0.628	664	-0.19	0.000
ISWH	922	0.21	0.000	664	0.13	0.001
AVMAT	922	0.23	0.000	664	0.18	0.000
AVMMT	922	0.54	0.000	664	0.60	0.000
RAIND	922	-0.49	0.000	664	-0.52	0.000
CLOVER	922	-0.37	0.000	664	-0.40	0.000
DEER	922	0.45	0.000	664	0.38	0.000
TOPO	922	0.18	0.000	664	0.49	0.000
PASTT	922	0.46	0.000	664	0.29	0.000
THISTLE	922	-0.27	0.000	664	0.06	0.149
RAG	922	0.15	0.000	664	0.46	0.000
TREES	922	-0.18	0.000	664	0.37	0.000
SHELT	922	0.06	0.067	664	0.54	0.000
NANTH	922	0.07	0.046	664	-0.19	0.000
WEAN	922	0.51	0.000	664	0.50	0.000

	Yes			No			rank-sum test
	Number of deer	Mean	SD	Number of deer	Mean	SD	p value
Weaner stags							
STRIP	109	0.26	0.022	813	0.427	0.107	0.000
RSWH5	32	0.53	0.000	890	0.403	0.115	0.000
OSTOCK	60	0.32	0.045	862	0.413	0.117	0.000
IVE	397	0.38	0.110	525	0.428	0.115	0.000
VCLOST	201	0.41	0.166	721	0.406	0.097	0.307
LAME	232	0.39	0.021	690	0.414	0.132	0.538
DEATH1	331	0.40	0.145	591	0.409	0.095	0.857
Weaner hinds							
STRIP	120	0.25	0.021	544	0.401	0.095	0.000
RSWH5	73	0.53	0.000	591	0.355	0.093	0.000
OSTOCK	55	0.32	0.039	609	0.379	0.106	0.000
IVE	262	0.34	0.065	402	0.399	0.115	0.000
VCLOST	139	0.29	0.071	525	0.397	0.099	0.000
LAME	143	0.39	0.026	521	0.370	0.115	0.000
DEATH1	198	0.36	0.137	466	0.380	0.084	0.003

SD = standard deviation; R = correlation coefficient

Appendix 4.30 : Means and standard deviations of the velvet antler monetary value of 2-year-old and adult stag (VELVS) at each level of dichotomous risk factors screened for univariate association with VELVS and t-test p values.

	ADULT STAGS							YEARLING STAGS						
	No = 0			Yes = 1				No = 0			Yes = 1			
Risk factor code*	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**	Number of deer	Mean	SD	Number of deer	Mean	SD	t-test p value**
BLOCK 1 : Stag management														
TINE‡	243	204.84	84.12	316	271.92	95.70	0.000	140	100.42	29.91	102	128.81	45.56	0.000
WINTD	575	272.39	118.84	237	240.17	81.61	0.000	236	110.07	37.56	234	138.66	59.01	0.000
WINCOP	730	262.42	112.78	82	267.99	84.51	0.665	393	124.20	53.30	77	124.83	40.65	0.907
SEPTD‡	761	266.00	110.37	51	218.03	98.44	0.003	407	129.19	52.59	63	92.77	26.63	0.000
BLOCK 2 : Winter grazing management														
RSWH5‡	251	243.42	102.53	561	271.74	112.48	0.001	266	119.13	50.90	204	131.05	51.39	0.013
RSWH10	NP							463	123.96	50.94	7	147.13	78.04	0.463
KALE	803	263.04	110.73	9	257.56	50.03	0.882	NP						
STRIP‡	694	240.90	94.16	118	392.89	108.55	0.000	380	109.88	37.83	90	185.19	56.49	0.000
OSTOCK‡	639	274.99	113.01	173	218.64	86.02	0.000	335	128.62	55.58	135	113.60	37.22	0.004
FSUP‡	126	245.22	85.33	686	266.25	113.96	0.049	178	102.10	33.89	292	137.84	55.44	0.000
BLOCK 3 : Pre-velvetting grazing management														
RSWH5‡	645	266.72	111.76	167	248.56	103.15	0.058	401	126.35	53.28	69	112.42	36.78	0.037
RSWH10‡	657	269.59	114.33	155	234.97	85.55	0.000	314	130.94	57.45	156	110.94	32.54	0.000
STRIP‡	753	253.70	105.02	59	381.44	107.16	0.000	427	117.71	46.13	43	189.75	55.59	0.000
OSTOCK‡	475	283.77	119.88	337	233.69	87.06	0.000	243	134.66	58.65	227	113.22	39.50	0.000
FSUP‡	469	253.87	105.73	343	275.45	115.08	0.006	341	119.92	47.48	129	135.89	59.22	0.003
BLOCK 4 : Sentinel stags and individual blood biological markers														
June visit data														
EASES	28	127.07	43.56	24	116.57	43.27	0.414	48	274.40	101.12	14	227.47	120.39	0.098
GSHPx3	NP							2	165.02	28.66	30	281.95	109.18	0.073
B12185	29	122.81	41.34	27	124.98	45.19	0.208	31	307.58	113.69	31	220.03	78.80	0.002
CU8	10	119.10	39.18	49	123.43	43.19	0.238	3	150.22	32.67	59	269.58	105.87	0.023
November visit data														
B12185	10	133.46	56.27	7	91.36	36.99	0.248	20	280.17	112.58	5	183.65	37.57	0.022
CU8	5	79.66	32.69	12	131.32	52.49	0.026	4	291.33	92.09	21	255.06	112.66	0.280
BLOCK 5 : Mean farm blood markers														
June visit data														
MGSHPx3	2†	228.25	20.76	18†	269.42	52.47	0.314	2†	233.54	65.48	18†	267.31	65.59	0.656
MB12185	7†	281.50	58.68	12†	256.59	49.36	0.447	7†	280.04	82.20	12†	252.33	56.26	0.596
November visit data														
MB12185‡	4†	257.72	52.44	2†	218.97	8.06	0.180	5†	267.34	90.59	3†	208.17	18.18	0.129

* Risk factor codes are described in the glossary and in Table 4.18.

** t-tests were carried out on the ranks (procedure Rank in SAS) in blocks 4 and 5, which is equivalent to the Wilcoxon rank sum test.

NP = Statistical test not possible because of the limited number of farms in one category

† Number of farm-years

‡ Risk factors selected for multivariable analyses.

Appendix 4.31 : Means, ranges, standard deviations of continuous stag individual characteristics and winter grazing management risk factors screened for association with the velvet antler monetary value of 2-year-old and adult stag (VELVS), Spearman correlation coefficients and p values.

		ADULT STAGS							2-YEAR-OLD STAGS						
Risk factor code*	Unit	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
VELVS	NZ$	812	263.04	57.19	723.80	110.17			470	124.30	30.50	317.81	51.40		
BLOCK 1 : Stag management															
Risk factors selected for multivariable analysis															
AGE		803	3.22	2.00	14.00	1.55	0.60	0.000							
NZ	%	797	91.75	0.00	100.00	18.89	-0.18	0.000	449	85.38	0.00	100.00	22.31	-0.43	0.000
CUT	day	812	46.88	0.00	96.00	17.15	-0.50	0.000	470	75.61	37.00	105.00	10.84	-0.28	0.000
WEIGHT	kg	812	2.01	0.75	4.70	0.59	0.97	0.000	470	1.18	0.36	2.25	0.32	0.96	0.000
GRADE	Dis. 1-7;1	812	4.42	2.00	7.00	0.97	0.91	0.000	470	3.27	2.00	5.00	0.76	0.82	0.000
WJUNE	kg	564	137.87	72.50	204.00	21.39	0.69	0.000	291	100.77	66.50	136.00	13.43	0.54	0.000
GRJS	g/d	270	-116.07	-432.43	305.56	85.16	-0.34	0.000	136	-30.89	-222.22	87.84	48.29	0.02	0 842
CHWJV	%	455	9.18	-22.67	70.34	9.41	-0.25	0.000	273	22.03	-4.26	51.43	7.81	-0 18	0.003
BLOCK 2 : Winter grazing management															
Risk factors selected for multivariable analysis															
STOCK		812	2.68	1.00	6.00	1.06	-0.19	0.000	470	2.64	1.00	6.00	1.27	-0.36	0.000
CLOVER	Score 1-3	812	1.17	1.00	2.00	0.20	0.25	0.000	470	1.14	1.00	1.74	0.15	0 27	0 000
DEER		812	69.87	1.46	154.96	31.15	-0.12	0.001	470	58.49	8.11	123.88	22.88	-032	0.000
DEER/Ha	MJME/ha	812	24.90	1.08	87.87	22.43	0.28	0 000	470	17.47	1.87	42.34	12.70	0.32	0 000
FAREA	ha	812	5.94	0.66	25.83	5.39	-0.35	0.000	470	5.94	1.19	14.88	4.35	-0.45	0 000
TOPO	Score 1-3	812	1.43	1.00	2.70	0.57	-0.16	0.000	470	1.53	1.00	2.70	0.41	-0.06	0.163
TREES	Score 0-3	812	1.11	0.00	3.00	0.81	-0.23	0.000	470	0.91	0.00	2.38	0.66	-0.31	0.000
SHELT		812	15.28	2.00	32.00	8.25	-0.17	0.000	470	17.56	7.97	29.77	6.95	-0 19	0.000
AVMIT	°C	812	3.99	1.48	5.51	1.03	0.09	0.013	470	3.86	1.48	5.51	1.05	0.27	0.000
AVMAT	°C	812	9.24	6.43	13.12	1.97	-0.07	0.060	470	9.29	6.43	13.12	2.10	-0.29	0.000
SUN	Score 0-1	812	0.35	0.13	0.70	0.15	-0.25	0.000	470	0.35	0.13	0.59	0.16	-0.45	0.000
Risk factors rejected after univariate screening															
SHIFT		812	6.57	1.00	17.00	3.34	-0.15	0.000	470	7.60	2.00	17.00	4.46	0 20	0.000
ISWH	cm	812	9.25	5.00	17.43	3.44	0.26	0.000	470	8.88	4.29	15.75	2.77	0.02	0 671
PASTT	Score 1-3	812	1.92	1.00	2.99	0.56	-0.09	0.015	470	1.93	1.07	3.00	0.47	-0.04	0 336
SUR	%	812	52.16	0.00	100.00	38.02	-0.21	0.000	470	54.08	0.00	100.00	38.17	0.41	0.000
AVWIND		812	1.27	0.36	3.36	0.79	0.23	0.000	470	0.99	0.44	1.84	0.43	-0.07	0 144
AVMAT	°C	812	13.26	10.10	15.88	1.76	0.03	0 342	470	13.19	10.10	15.88	1.74	-0.13	0.005
RAIND	mm/d	812	4.02	1.59	8.38	1.62	-0.12	0.001	470	4.12	1.59	6.62	1.46	0.08	0 094

* Risk factor codes are described in the glossary and in Table 4.19.
Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.
Note on units :
"Score 0-1" means "Score ranging from 0 to 1"
"Dis. 1-7;1" means "discrete variable from 1 to 7 with 1 unit increments"

Appendix 4.32 : Means, ranges, standard deviations of continuous pre-velvetting grazing management risk factors (BLOCK 3) screened for association with the velvet antler monetary value of 2-year-old and adult stag (VELV$), Spearman correlation coefficients and p values

		ADULT STAGS							2-YEAR-OLD STAGS						
Risk factor code*	Unit	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
VELV$	NZ$	812	263.04	57.19	723.80	110.17			470	124.30	30.50	317.81	51.40		
Risk factors selected for multivariable analysis															
SHIFT		812	7.79	1.00	27.00	5.12	0.06	0.081	470	9.41	1.00	25.00	7.21	0.21	0.000
STOCK		812	4.09	1.00	13.00	2.04	-0.24	0.000	470	3.43	1.00	8.00	1.39	-0.27	0.000
ISWH	cm	812	9.41	3.00	15.05	2.50	0.12	0.001	470	10.30	4.00	14.43	3.11	0.12	0.008
DEER/Ha	Deer/ha	812	16.97	1.02	66.96	13.44	0.26	0.000	470	17.89	3.26	57.18	14.39	0.30	0.000
FAREA	ha	812	4.64	0.66	11.40	2.96	-0.25	0.000	470	4.80	1.18	8.90	2.61	-0.36	0.000
TREES	Score 0-3	812	0.75	0.00	3.00	0.57	-0.30	0.000	470	0.49	0.00	1.64	0.41	-0.13	0.004
AVWIND		812	1.29	0.33	2.79	0.50	0.17	0.000	470	1.22	0.52	2.67	0.41	0.08	0.070
AVMAT	°C	812	16.98	12.90	20.51	1.65	-0.25	0.000	470	17.61	14.80	20.74	1.35	-0.26	0.000
AVMMT	°C	812	10.74	7.47	13.22	1.57	-0.19	0.000	470	10.74	8.19	13.22	1.55	-0.30	0.000
SUN	Score 0-1	812	0.43	0.16	0.69	0.10	-0.15	0.000	470	0.42	0.20	0.65	0.10	-0.10	0.027
Risk factors rejected after univariate screening															
CLOVER	Score 1-3	812	1.72	0.98	2.95	0.45	0.03	0.405	470	1.84	1.00	2.65	0.41	-0.12	0.008
DEER		812	47.29	2.00	149.00	21.52	0.16	0.000	470	50.85	10.30	83.24	19.36	-0.26	0.000
TOPO	Score 1-3	812	1.28	1.00	2.60	0.40	-0.15	0.000	470	1.36	1.00	2.36	0.41	0.04	0.339
PASTT	Score 1-3	812	1.84	1.00	3.00	0.48	-0.09	0.012	470	1.94	1.00	2.76	0.44	-0.02	0.663
SUR	%	812	45.31	0.00	100.00	34.79	-0.17	0.000	470	51.44	0.00	100.00	38.11	0.06	0.199
SHELT		812	11.66	1.69	32.00	6.67	-0.14	0.000	470	13.36	1.94	27.77	7.23	-0.01	0.770
AVMIT	°C	812	6.14	2.94	8.57	1.23	0.02	0.663	470	6.73	3.80	8.57	1.18	0.21	0.000
RAIND	mm/d	812	3.67	1.10	8.90	1.34	-0.07	0.033	470	3.92	2.02	6.41	1.29	0.20	0.000

* Risk factor codes are described in the glossary and in Table 4.19.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Note on units : "Score 0-1" means "Score ranging from 0 to 1"

Appendix 4.33 : Means, ranges, standard deviations of sentinel deer risk factors and continuous blood markers screened for association with the velvet antler monetary value of 2-year-old and adult stag (VELV$), Spearman correlation coefficients and p values.

Risk factor code*		ADULT STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	2-YEAR-OLD STAGS Number of deer	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
JUNE VISIT DATA															
VELV$		62	276.66	132.64	618.98	100.25			59	122.69	57.19	268.38	42.24		
Individual characteristics															
Risk factors rejected after univariate screening															
SIZE	cm	17	107.43	101.60	114.30	3.36	0.08	0.759	44	101.92	95.25	111.76	4.04	0.21	0.170
GIRTH	cm	18	125.89	117.00	136.00	4.79	-0.26	0.301	45	114.84	105.00	127.00	4.73	0.10	0.523
BCS	Dis. 1-5;0.5	62	3.00	1.50	4.50	0.58	0.09	0.511	59	3.12	2.00	4.00	0.51	0.01	0.966
COATL	mm	61	52.56	30.00	65.00	5.87	0.06	0.650	59	54.22	44.00	67.00	5.22	-0.09	0.493
TEETH	Dis. 1-3;1	44	2.75	1.00	3.00	0.49	0.19	0.221							
Blood markers															
Risk factors selected for multivariable analysis															
NP	%	62	40.42	19.00	67.00	10.44	-0.25	0.047	58	35.07	7.00	71.00	12.52	-0.23	0.081
B12	pmol/l	62	266.89	65.00	3000.00	376.53	-0.20	0.119	56	201.68	90.00	540.00	91.70	-0.20	0.134
Risk factors rejected after univariate screening															
WCC	10E9/l	61	5.27	2.40	18.90	2.92	0.12	0.366	58	6.39	2.70	22.60	3.96	0.04	0.759
HB	g/dl	61	17.53	11.80	27.20	3.37	0.28	0.031	58	16.72	11.70	23.00	2.12	0.15	0.256
PCV	l/l	61	0.44	0.33	0.56	0.05	0.20	0.113	58	0.44	0.32	0.53	0.04	0.07	0.611
EOP	%	62	8.21	1.00	30.00	7.11	0.06	0.639	58	7.02	0.00	27.00	4.64	0.05	0.684
LP	%	62	48.55	25.00	70.00	10.18	0.15	0.247	58	54.05	23.00	90.00	12.65	0.16	0.239
TP	g/l	62	77.12	63.20	90.00	5.37	-0.04	0.731	58	73.44	58.60	85.00	5.13	0.20	0.128
ALB	g/l	62	36.03	27.80	44.30	3.59	-0.08	0.540	58	35.67	29.90	42.10	2.93	0.14	0.303
P	mmol/l	62	2.49	1.54	3.68	0.47	-0.01	0.939	58	2.80	1.42	4.33	0.46	-0.02	0.889
GGT	IU	62	49.08	23.00	177.00	24.27	-0.07	0.581	58	45.38	22.00	91.00	13.18	-0.02	0.856
BUN	mmol/l	62	12.94	9.22	16.94	2.05	-0.23	0.068	58	12.54	8.33	16.35	1.73	0.03	0.813
CU	µmol/l	62	15.71	3.10	26.00	4.75	0.17	0.195	59	13.47	1.90	25.00	5.23	-0.11	0.396
GSHPx	kIU/l	32	9.38	1.80	24.40	6.23	0.26	0.154	6	14.58	3.50	35.20	11.13	0.26	0.623
PEPS	mU Tyrosine/l	62	634.11	78.00	2150.00	453.95	-0.16	0.207	57	621.42	78.00	1574.00	308.29	0.12	0.363

* Risk factor codes are described in the glossary and in Table 4.19.

(Cont'd)

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Note on units :

"Dis. 1-7; 1" means "discrete variable from 1 to 7 with 1 unit increments"

Appendix 4.33 (Cont'd)

Risk factor code*	Unit	ADULT STAGS Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	2-YEAR-OLD STAGS Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	p value
NOVEMBER VISIT DATA															
VELV$		25	275.66	132.01	655.42	117.09			17	116.12	38.13	244.36	52.44		
Individual characteristics															
Risk factors selected for multivariable analysis															
Risk factors rejected after univariate screening															
SIZE	cm	10	109.22	100.33	116.84	4.23	0.21	0.564	17	101.97	80.01	110.49	7.07	0.22	0.398
GIRTH	cm	8	127.38	121.00	137.00	5.29	-0.58	0.133	17	115.41	106.00	122.00	5.56	0.38	0.138
BCS	Dis. 1-5;0.5	25	4.04	2.50	5.00	0.52	-0.02	0.921	17	3.03	2.00	4.00	0.67	0.34	0.182
Blood markers															
Risk factor selected for multivariable analysis															
B12	pmol/l	25	172.24	65.00	380.00	75.42	-0.34	0.098	17	199.47	65.00	630.00	133.37	-0.51	0.035
Risk factors rejected after univariate screening															
WCC	10E9/l	25	4.29	2.70	6.20	0.94	0.06	0.773	17	4.08	2.70	6.30	0.98	-0.26	0.314
HB	g/dl	25	19.18	15.40	27.70	3.52	0.32	0.119	17	17.20	14.20	21.30	1.81	-0.23	0.375
PCV	l/l	25	0.45	0.39	0.55	0.03	-0.05	0.795	17	0.43	0.36	0.51	0.04	-0.24	0.343
NP	%	25	48.64	25.00	73.00	12.85	-0.06	0.792	17	35.00	17.00	53.00	10.80	-0.78	0.000
EOP	%	25	4.76	0.00	12.00	3.33	0.29	0.166	17	7.88	1.00	20.00	4.58	0.15	0.558
LP	%	25	45.80	22.00	71.00	12.30	0.01	0.961	17	55.94	40.00	73.00	9.97	0.81	0.000
TP	g/l	25	75.63	68.20	83.50	5.16	-0.36	0.077	17	66.96	61.90	78.60	4.55	0.10	0.702
ALB	g/l	25	39.02	32.80	44.10	2.72	-0.21	0.310	17	34.61	31.10	39.80	2.81	-0.20	0.444
P	mmol/l	25	2.30	1.20	3.53	0.60	0.00	0.985	17	2.42	1.84	3.11	0.35	0.43	0.086
GGT	IU	25	34.12	23.00	61.00	8.52	0.04	0.862	17	37.53	23.00	145.00	28.52	-0.16	0.534
BUN	mmol/l	25	9.99	6.82	14.57	1.79	-0.11	0.602	17	10.65	7.96	13.48	1.61	0.43	0.088
CU	µmol/l	25	16.30	3.20	33.00	6.86	0.29	0.166	17	12.64	1.00	21.00	6.02	0.26	0.323
GSHPx	kIU/l	17	11.73	2.80	22.90	5.43	0.18	0.498							
PEPS	mU Tyrosine/l	25	498.13	0.00	1940.56	389.37	0.36	0.077	17	602.21	305.60	1222.40	232.18	-0.37	0.146

* Risk factor codes are described in the glossary and in Table 4.19.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Note on units :

"Dis. 1-7;1" means "discrete variable from 1 to 7 with 1 unit increments"

Appendix 4.34 : Means, ranges, standard deviations of mean continuous blood markers recorded in June and November screened for association with the farm mean velvet antler monetary value of 2-year-old and adult stag (MVELV$), Spearman correlation coefficients and p values.

		ADULT STAGS							2-YEAR-OLD STAGS						
Risk factor code*	Unit	Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef.	p value	Number of farm-years	Mean	Min	Max	SD	Spearman Corr. Coef	p value
JUNE VISIT DATA															
MVELV$		20	265.31	192.75	353.89	51.45			20	122.10	57.19	189.75	35.31		
Risk factors selected for multivariable analysis															
MHB	g/dl	20	17.23	13.96	21.52	2.14	0.44	0.054	20	16.86	14.56	20.06	1.60	0.47	0.038
MPCV	l/l	20	0.44	0.37	0.50	0.03	0.45	0.048	20	0.44	0.37	0.50	0.03	0.67	0.001
MCU	µmol/l	20	14.03	5.15	20.20	3.52	0.40	0.078	20	14.03	5.15	20.20	3.52	0.49	0.030
MPEPS	mU Tyrosine/l	20	538.00	299.01	1043.41	183.09	0.33	0.158	20	538.00	299.01	1043.41	183.09	0.37	0.107
Risk factors rejected after univariate screening															
MWCC	10E9/l	20	4.73	3.30	10.10	1.52	0.13	0.596	20	5.63	3.60	9.20	1.52	0.08	0.724
MNP	%	20	41.01	22.00	57.75	7.53	-0.11	0.659	20	35.54	24.20	52.40	7.90	-0.19	0.412
MEOP	%	20	7.45	4.13	14.66	2.56	-0.15	0.539	20	7.45	4.13	14.66	2.56	0.10	0.668
MLP	%	20	47.50	37.00	65.00	7.68	-0.12	0.624	20	53.75	41.20	68.00	6.49	0.02	0.945
MTP	g/l	20	76.47	70.07	82.72	4.08	0.18	0.443	20	72.82	66.86	80.00	3.59	0.24	0.318
MALB	g/l	20	35.35	32.53	40.32	2.04	0.22	0.349	20	35.35	32.53	40.32	2.04	0.40	0.083
MP	mmol/l	20	2.54	2.09	3.09	0.27	-0.34	0.139	20	2.77	2.04	3.26	0.36	-0.10	0.663
MGGT	IU	20	45.53	37.56	61.40	6.96	0.21	0.366	20	45.53	37.56	61.40	6.96	-0.29	0.217
MBUN	mmol/l	20	13.49	10.44	17.25	1.87	-0.24	0.313	20	12.55	8.88	14.92	1.46	-0.05	0.840
MB12	pmol/l	19	208.87	95.13	361.33	64.20	-0.25	0.297	19	208.87	95.13	361.33	64.20	-0.22	0.375
MGSHPx	kIU/l	20	9.29	2.03	32.10	7.31	0.22	0.361	20	9.29	2.03	32.10	7.31	0.21	0.380
NOVEMBER VISIT DATA															
MVELV$		8	243.19	178.94	304.61	44.63			6	139.78	76.42	189.75	40.28		
Risk factors rejected after univariate screening															
MWCC	10E9/l	8	4.63	3.45	5.84	0.82	0.14	0.736	6	4.28	3.72	5.71	0.75	-0.20	0.704
MHB	g/dl	8	18.83	16.78	24.14	2.24	0.61	0.108	6	17.34	16.26	18.84	1.15	-0.14	0.787
MPCV	l/l	8	0.44	0.42	0.46	0.01	0.08	0.843	6	0.44	0.42	0.46	0.02	-0.23	0.658
MNP	%	8	52.20	38.20	65.00	9.76	-0.05	0.911	6	37.67	27.60	44.00	6.72	-0.43	0.397
MEOP	%	8	5.46	1.73	7.98	2.03	0.62	0.102	6	7.07	5.13	9.67	1.68	0.09	0.872
MLP	%	8	42.39	29.60	54.40	9.47	-0.10	0.823	6	53.29	47.33	65.00	6.68	0.31	0.544
MTP	g/l	8	75.25	70.62	82.00	3.94	-0.12	0.779	6	68.13	63.68	72.20	2.86	0.26	0.623
MALB	g/l	8	37.95	33.98	40.88	2.60	0.07	0.867	6	36.64	33.98	39.47	2.39	-0.14	0.787
MP	mmol/l	8	2.29	1.66	3.02	0.43	-0.21	0.610	6	2.39	2.14	2.68	0.23	0.31	0.544
MGGT	IU	8	33.47	24.91	41.76	5.88	-0.43	0.289	6	31.87	24.91	41.76	6.30	-0.37	0.468
MBUN	mmol/l	8	10.11	8.41	13.14	1.51	-0.05	0.911	6	10.47	8.93	11.63	0.97	0.71	0.111
MCU	µmol/l	8	16.02	4.60	22.20	6.38	0.48	0.233	6	15.84	4.60	22.20	6.57	0.54	0.266
MB12	pmol/l	8	177.31	95.57	253.96	49.60	-0.60	0.120	6	175.26	95.57	252.41	57.53	-0.49	0.329
MGSHPx	kIU/l	8	10.96	3.83	19.95	5.41	0.33	0.420	5	10.99	5.70	16.77	4.15	0.30	0.624
MPEPS	mU Tyrosine/l	7	488.87	264.66	615.20	117.84	0.18	0.702	6	530.76	436.04	615.20	65.71	0.09	0.872

* Risk factor codes are described in the glossary and in Table 4.19.

Min = minimum; Max = maximum; SD = standard deviation; Corr.Coef. = correlation coefficient.

Appendix 4.35 : Ranges of all values, means and standard deviations of continuous risk factors screened for association with weaners dying from confirmed or suspected yersiniosis after April 1 in a preliminary univariate analysis, and rank sum test p values.

					Weaner deer dying from Yersiniosis			Apparently healthy weaners		
Risk factor code*	Unit	Rank sum test p value	Range of all values Min	Max	Number of deer	Mean	SD	Number of deer	Mean	SD
BLOCK 1 : Individual hind variables										
Analysis including all weaners present on farms on April 1										
NZ	%	0.932	0.00	100.00	74	88.18	21.59	3390	89.19	19.56
NZ†	%	0.162	6.40	100.00	26	76.44	30.69	2460	88.85	19.04
W4	kg	0.003	19.93	69.11	26	43.74	7.12	2657	47.88	7.65
PERCW4	%	0.025	0.51	98.10	26	37.14	28.03	2226	50.31	28.47
MAXW4	kg	0.003	0.00	44.57	26	18.02	6.85	2226	14.08	7.19
Analysis including all weaners present on farms on June 1										
NZ	%	0.062	0.00	100.00	31	78.23	28.68	2274	88.73	20.60
W6	kg	0.033	26.55	82.03	23	48.90	10.27	2107	53.51	8.48
PERCW6	%	0.202	0.76	99.24	16	38.80	33.52	1752	49.95	28.47
MAXW6	kg	0.079	0.00	42.49	16	19.68	9.58	1752	15.29	8.44
GR46	g/d	0.265	-66.19	330.77	23	72.71	83.88	1779	103.05	54.23
BLOCK 2 : Mob analysis of grazing management variables										
Analysis including all weaners present on farms on April 1										
Mean weaner deer characteristics										
MW4	kg	0.593	33.76	55.49	7	46.70	4.77	16	47.32	6.43
MNZ	%	0.049	47.36	100.00	8	74.19	23.17	22	93.09	12.42
Environment and grazing management										
Variables selected for multivariable analysis										
AVMIT	°C	0.001	3.28	7.82	8	6.72	0.88	26	4.97	1.12
AVMMT	°C	0.022	6.93	14.28	8	8.50	1.74	26	10.00	1.54
M%WS	%	0.113	32.13	89.91	8	48.33	4.05	26	53.83	12.27
AVWIND		0.141	0.28	2.70	8	1.30	0.35	25	1.13	0.56
PASTT	Score 1-3	0.158	1.00	2.77	8	1.58	0.40	26	1.82	0.44
SHELT		0.194	3.72	37.00	8	17.48	3.92	26	15.56	7.47
Variables rejected after univariate screening										
CLOVER	Score 1-3	0.228	1.00	2.74	8	1.50	0.36	26	1.77	0.52
DEER		0.330	17.92	220.54	8	103.19	35.52	26	91.62	46.94
FAREA	ha	0.350	0.72	20.20	8	3.91	1.21	26	3.82	3.81
TREES	Score 0-3	0.416	0.00	3.00	8	0.77	0.38	26	1.03	0.81
TOPO	Score 1-3	0.463	1.00	2.54	8	1.61	0.58	26	1.51	0.48
RAIND	mm/d	0.514	1.26	4.39	8	2.67	1.13	26	2.61	0.45
SUN	Score 0-1	0.568	0.23	0.65	8	0.40	0.20	26	0.41	0.08
STOCK		0.619	1.00	8.00	8	3.00	1.51	26	3.58	2.14
AVMAT	°C	0.684	12.54	19.42	8	15.24	1.09	26	14.97	1.86
DEER/Ha	Deer/ha	0.776	6.44	134.81	8	37.21	21.39	26	37.01	24.14
SUR	%	0.791	0.00	100.00	8	55.62	24.68	26	52.38	38.54
ISWH	cm	0.887	7.00	28.00	8	13.48	2.65	26	14.60	6.09
SHIFT		0.984	1.00	9.00	8	4.38	2.26	26	4.50	2.40
handling and disease control										
NANTH		0.222	2.00	6.00	8	3.38	1.06	26	2.92	0.89
YARDED		0.002	2.00	15.00	8	9.50	3.74	26	5.04	2.11
WEAND		0.106	59.00	95.00	8	68.88	4.12	26	74.92	10.09

* Risk factor codes are described the glossary and in Table 4.24.

Min = minimum; Max = maximum; SD = standard deviation

Note on units : "Score 0-1" means "Score ranging from 0 to 1"

"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

† includes only weaners for which April 1 bodyweight (W4) was recorded. NZ was forced into the null hypothesis path diagram from this univariate analysis.

Appendix 4.36 : Significance level of Chi-square test of association of dichotomous individual and mob risk factors with weaners dying from confirmed or suspected yersiniosis (YER)(after April 1 and June 1, respectively) and the occurrence of YER after April 1, respectively, and unadjusted odds ratios (OR).

Risk factor code*	Number of deer	Chi-square** p value	Unadjusted odds ratio*** OR	95%CI
BLOCK 1 : Individual weaner characteristics				
Analysis including all weaners present on farms on April 1				
HIND	3226	0.673		
HIND†	2683	0.060	2.19	0.95 5.04
Analysis including all weaners present on farms on June 1				
HIND	2305	0.091	1.90	0.89 4.05
GR46<0	2305	0.004	2.71	1.33 5.53
BLOCK 2 : Mob analysis of grazing management variables				
STRIP	34	0.131	8.33	0.64 107.85
RSWH10	34	1.000		
ODEER	34	1.000		
FS P	34	1.000		
OSTOCK	34	0.131	8.33	0.64 107.85

* Risk factor codes are described in the glossary and in Table 4.24.

** Mob analysis were carried out using the Fisher exact test

*** Odds ratio (OR) and 95% confidence interval (95%C) are presented if $p < 0.20$

† includes only weaners for which April 1 bodyweight was recorded. HIND was forced into the null hypothesis path diagram from this univariate analysis.

Appendix 4.37 : Range of all values, means and standard deviations of continuous risk factors screened for association with hinds dying from malignant catarrhal fever in winter (June - August)(MCF) in a preliminary univariate analysis, and rank sum test p values.

Risk factor code*	Unit	Rank sum test p value	Range of all values Min	Max	HIND dying from MCF Number of deer	Mean	SD	HIND not dying from MCF Number of deer	Mean	SD
INDIVIDUAL RISK FACTOR ANALYSIS										
Individual hind variables										
Risk factors selected for multivariable analysis										
MARW	kg	0.094	44.00	144.50	3	84.3	10.2	3503	95.88	12.28
BCSM	Dis. 1-5;0.5	0.130	1.00	5.00	3	2.7	0.8	3725	3.31	0.68
Environment and grazing management from May 1 to July 1										
Risk factors selected for multivariable analysis										
AVMMT	°C	0.028	5.83	12.39	7	6.94	1.01	4716	8.48	1.89
FAREA	ha	0.052	0.79	28.30	7	4.37	4.62	4716	7.32	6.02
DEER/Ha	deer/ha	0.102	3.93	112.34	7	52.17	31.36	4716	29.00	23.15
SUN	Score 0-1	0.134	0.02	0.70	7	0.22	0.15	4716	0.33	0.18
SHELT		0.139	2.00	34.73	7	12.01	9.24	4716	17.23	8.10
AVMIT	°C	0.150	1.33	7.13	7	5.04	1.44	4716	4.18	1.70
TOPO	Score 1-3	0.191	1.00	3.00	7	1.49	0.73	4716	1.83	0.65
CLOVER	Score 1-3	0.198	1.00	2.57	7	1.40	0.50	4716	1.16	0.34
Risk factors rejected after univariable screening										
STOCK		0.212	1.00	5.00	7	2.14	0.69	4716	1.83	0.83
SHIFT		0.271	1.00	9.00	7	4.43	3.46	4716	2.74	1.76
SHEEP	%	0.302	0.00	100.00	7	77.14	28.77	4716	61.83	39.05
AVWIND		0.356	0.33	3.88	7	1.78	1.48	4443	1.12	0.83
AVMAT	°C	0.512	8.70	17.04	7	11.98	1.59	4716	12.67	1.80
SUR	%	0.569	0.00	100.00	7	34.76	46.10	4716	21.80	35.48
TREES	Score 0-3	0.620	0.00	3.00	7	0.73	1.11	4716	1.11	1.22
PSHEEP	%	0.640	0.00	73.33	7	0.00	0.00	4716	2.15	11.04
PASTT	Score 1-3	0.659	1.00	3.00	7	2.21	0.56	4716	2.26	0.55
ISWH	cm	0.675	2.92	21.67	7	8.28	3.43	4678	8.85	3.16
DEER		0.776	4.47	195.47	7	123.66	53.10	4716	118.16	47.53
RAIND	mm/d	0.838	1.83	8.75	7	4.11	1.66	4716	4.07	1.75
M%AH	%	0.850	0.00	100.00	7	85.86	19.33	4716	82.58	29.09
MOB RISK FACTOR ANALYSIS										
Mob analysis of environment and grazing management from May 1 to July 1										
Risk factors selected for multivariable analysis										
AVMMT	°C	0.016	5.83	12.39	6	6.83	1.07	80	8.55	1.70
M%AH	%	0.091	0.00	100.00	6	87.68	20.51	80	66.55	35.74
DEER		0.104	4.47	195.47	6	117.00	54.87	80	81.66	48.11
BSHEEP	%	0.106	0.00	100.00	6	80.00	30.40	80	52.78	40.74
SUN	Score 0-1	0.110	0.02	0.70	6	0.20	0.15	80	0.34	0.19
AVMAT		0.129	8.70	17.04	6	11.77	1.64	80	13.02	1.69
DEER/Ha	deer/ha	0.186	3.93	112.34	6	50.08	33.82	80	24.44	20.15
Risk factors rejected after univariable screening										
AVMIT	°C	0.503	1.33	7.13	6	4.93	1.54	80	4.47	1.71
FAREA	ha	0.519	0.79	28.30	6	4.67	4.98	80	5.10	4.72
SHELT		0.564	2.00	34.73	6	12.84	9.82	80	14.88	7.50
ISWH	cm	0.600	2.92	21.67	6	8.87	3.34	79	9.89	3.77
RAIND	mm/d	0.678	1.83	8.75	6	4.17	1.80	80	3.92	1.81
PASTT	Score 1-3	0.732	1.00	3.00	6	2.24	0.60	80	2.11	0.61
SUR	%	0.736	0.00	100.00	6	40.56	47.63	80	30.31	39.46
SHIFT		0.739	1.00	9.00	6	3.67	3.08	80	2.74	1.38
TREES	Score 0-3	0.769	0.00	3.00	6	0.85	1.16	80	1.05	1.14
AVWIND		0.780	0.33	3.88	6	1.81	1.61	75	1.20	0.78
TOPO	Score 1-3	0.792	1.00	3.00	6	1.57	0.76	80	1.67	0.61
STOCK		0.837	1.00	5.00	6	2.17	0.75	80	2.14	0.92
CLOVER	Score 1-3	0.844	1.00	2.57	6	1.29	0.46	80	1.19	0.35

*Risk factor codes are described in the glossary and in Table 4.26.

Min = minimum; Max = maximum; SD = standard deviation

Note on units : "Score 0-1" means "Score ranging from 0 to 1"

"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Appendix 4.38 : Range of all values, means and standard deviations of continuous risk factors screened for association with stags dying from malignant catarrhal fever from winter to summer (MCF) in a preliminary univariate analysis, and rank sum test p values.

Risk factor code*	Unit	Rank sum test p value	Range of all values Min	Max	STAG dying from MCF Number of deer	Mean	SD	STAG not dying from MCF Number of deer	Mean	SD
INDIVIDUAL RISK FACTOR ANALYSIS										
Individual stag characteristics										
Risk factor selected for multivariable analysis										
JUNEW	kg	0.044	57.00	242.00	7	143.64	22.48	1475	123.39	26.17
Environment and grazing management from June 1 to September 1.										
Risk factor selected for multivariable analysis										
BSHEEP	%	0.134	0.00	100.00	11	72.23	34.00	1934	58.75	36.61
Risk factors rejected after univariable screening										
SUN	Score 0-1	0.249	0.13	0.70	11	0.34	0.19	1934	0.40	0.17
DEER		0.249	1.46	154.96	11	60.63	42.47	1934	69.31	33.42
DEER/Ha	Deer/ha	0.311	1.08	87.87	11	15.63	16.75	1934	19.00	17.43
RAIND	mm/d	0.321	1.59	8.38	11	4.18	1.11	1934	3.67	1.60
AVWIND		0.354	0.34	3.36	11	1.44	1.07	1934	1.09	0.70
SHIFT		0.364	1.00	17.00	11	5.82	4.53	1934	6.38	3.51
ISWH	cm	0.397	4.29	17.43	11	8.91	3.54	1922	9.56	3.24
AVMMT	°C	0.571	5.79	13.12	11	9.20	2.59	1934	9.45	1.98
FAREA	ha	0.578	0.66	25.83	11	8.21	7.54	1934	6.68	5.44
STOCK		0.639	1.00	6.00	11	2.64	1.29	1934	2.74	1.04
TREES	Score 0-3	0.689	0.00	3.00	11	1.26	1.03	1934	1.06	0.80
PASTT	Score 1-3	0.758	1.00	3.00	11	1.94	0.41	1922	1.98	0.53
AVMAT	°C	0.814	8.96	15.88	11	12.95	2.02	1934	13.19	1.77
CLOVER	Score 1-3	0.833	1.00	2.00	11	1.11	0.11	1922	1.15	0.20
TOPO	Score 1-3	0.851	1.00	2.70	11	1.55	0.57	1934	1.53	0.52
SUR	%	0.871	0.00	100.00	11	43.18	41.01	1934	46.39	39.44
SHELT		0.876	2.00	37.66	11	17.65	8.98	1934	17.93	8.68
AVMIT	°C	0.979	1.48	5.51	11	3.70	1.25	1934	3.72	1.08
MOB RISK FACTOR ANALYSIS										
Mob analysis of environment and grazing management from June 1 to September 1.										
Risk factor selected for multivariable analysis										
FAREA	ha	0.156	0.66	25.83	10	8.25	7.95	65	4.06	2.68
Risk factors rejected after univariable screening										
RAIND	mm/d	0.218	1.59	8.38	10	4.14	1.16	65	3.44	1.76
TREES	Score 0-3	0.224	0.00	3.00	10	1.34	1.05	65	0.95	0.90
TOPO	Score 1-3	0.271	1.00	2.70	10	1.60	0.57	65	1.42	0.45
SHEEP	%	0.333	0.00	100.00	10	74.24	35.15	65	62.75	38.05
DEER		0.374	1.46	154.96	10	59.37	44.54	65	45.35	33.93
SUR	%	0.383	0.00	100.00	10	37.50	38.39	65	50.36	38.24
SHELT		0.431	2.00	37.66	10	18.76	8.63	65	16.29	8.16
SUN	Score 0-1	0.487	0.13	0.70	10	0.34	0.20	65	0.36	0.15
STOCK		0.488	1.00	6.00	10	2.70	1.34	65	3.02	1.24
PSHEEP	Score 0-1	0.508	0.00	1.00	10	0.20	0.42	65	0.12	0.33
SHIFT		0.515	1.00	17.00	10	5.70	4.76	65	5.83	3.27
CATTLE		0.615	0.00	100.00	10	62.17	35.72	65	58.80	38.38
AVMAT	°C	0.640	8.96	15.88	10	12.79	2.05	65	12.60	1.84
AVWIND		0.815	0.34	3.36	10	1.25	0.91	65	1.10	0.64
ISWH	cm	0.847	4.29	17.43	10	9.22	3.58	63	9.34	3.19
CLOVER	Score 1-3	0.877	1.00	2.00	10	1.11	0.11	63	1.19	0.27
AVMMT	°C	0.888	5.79	13.12	10	9.03	2.68	65	8.82	1.64
AVMIT	°C	0.913	1.48	5.51	10	3.72	1.32	65	3.77	1.09
PASTT	Score 1-3	0.955	1.00	3.00	10	1.94	0.43	63	1.89	0.61
DEER/Ha	deer/ha	0.975	1.08	87.87	10	15.99	17.61	65	14.64	13.65

*Risk factor codes are described in the glossary and in Table 4.26.

Min = minimum; Max = maximum; SD = standard deviation

Note on units : "Score 0-1" means "Score ranging from 0 to 1"

Appendix 4.39 : Significance level of univariate Chi-square test of association between dichotomous risk factors and hind and stag dying from malignant catarrhal fever (MCF) , respectively, and unadjusted odds ratios.

	HINDS					STAGS	
Risk factor code*	Number of hinds	Fisher exact p value	Unadjusted odds ratio** OR	95%CI		Number of stags	Fisher exact p value
BLOCK 1 :							
Individual deer variables							
ADULT	4735	0.353				2654	0.47
AGE4	4735	0.255	0.25	0.03	2.08	2654	0.63
NZ100	4696	0.050	0.20	0.04	0.88	2601	0.70
ADVC	4161	0.004	0.08	0.01	0.43		
Body condition score analysis							
BCSM2	3728	0.100	8.21	0.74	90.62		
BCSM4	3728	0.561					
Grazing management							
RSWH5	4645	0.707				1933	0.56
RSWH10	4645	1.000				1933	1.00
STRIP						1945	0.36
OTHERST	4723	1.000				1945	0.72
OSHEEP	4723	1.000				1945	0.38
FSUP						1945	1.00
BLOCK 2 : Mob analysis of grazing management factors							
RSWH5	83	1.000				73	1.00
RSWH10	83	1.000				73	1.00
STRIP						73	0.08†
OTHERST	86	1.000				73	1.00
OSHEEP	86	1.000				73	0.61
FSUP						73	1.00

* Risk factor codes are described in the glossary and in Table 4.26.

** Unadjusted odds ratios (OR) and their 95% confidence interval (95%CI) are presented if $P < 0.20$, except AGE4 that was forced into the null hypothesis path diagram.

† Unadjusted odds ratio and 95%CI were 7.88 (0.97 - 63.89)

Appendix 4.40 : Range of all values, means and standard deviations of continuous risk factors screened for association with hinds experiencing dystocia, in a preliminary univariate analysis, and t-test p values.

Risk factor		t-test	Range of all values		DYSTOCIA Number			NO DYSTOCIA Number		
code*	Unit**	p value	Min	Max	of deer	Mean	SD	of deer	Mean	SD
BLOCK 1 : Hind individual characteristics										
Risk factors selected for multivariable analysis										
NZ	%	0.005	0.00	100.00	20	86.25	22.18	3412	94.15	16.59
CHW9C	kg	0 019	-7.50	34.00	13	15.23	5.21	909	11.16	4.72
BCSS	Dis. 1-5;0.5	0.080	1.00	5.00	21	3.60	0.83	3416	3.33	0.72
Risk factors rejected after univariable screening										
BCSD	Dis. 1-5;0.5	0.428	-3.00	2.50	13	0.27	0.86	2731	0.02	0.80
WD6	kg	0.871	64.41	140.32	14	97.81	10.64	2225	97.61	10.45
BLOCK 2 : Pre-calving environmental factors and grazing management										
Risk factors selected for multivariable analysis										
FAREA	ha	0.000	0.96	25.36	19	3.30	1.26	3386	7.30	5.70
TOPO	Score 1-3	0.000	1.00	2.91	19	1.32	0.38	3386	1.86	0.55
SHIFT		0.000	1.00	27.00	19	14.21	4.94	3386	10.13	7.38
SHELT		0.000	4.05	38.99	19	12.52	6.03	3386	20.79	8.71
AVW ND		0 000	0.32	3.26	19	1.21	0.44	3386	0.87	0.51
M%AH	%	0.003	0.00	100.00	19	78.57	14.72	3386	84.19	22.87
DEER/Ha	Deer/ha	0.007	4.79	61.92	19	32.74	12.30	3386	25.46	16.05
AVMMT	°C	0.011	8.50	13.12	19	11.50	1.56	3386	10.45	1.61
RAIND	mm/d	0 034	1.53	6.56	19	3.28	1.14	3386	3.88	1.31
ISWH	cm	0.047	3.33	20.40	19	8.39	1.20	3354	7.61	2.14
AVMAT	°C	0.083	12.98	19.64	19	17.47	1.36	3386	16.96	1.28
DEER		0.162	14.77	185.42	19	95.40	44.28	3386	111.70	40.66
Risk factors rejected after univariable screening										
CLOVER	Score 1-3	0.203	1.00	2.41	19	1.66	0.27	3218	1.60	0.37
PASTT	Score 1-3	0.224	1.00	3.00	19	2.21	0.48	3386	2.10	0.51
STOCK		0.228	1.00	15.00	19	4.00	1.76	3386	3.56	2.06
SUR	%	0 273	0.00	100.00	19	31.29	28.26	3386	25.67	30.36
AVMIT	°C	0 283	3.52	8.06	19	5.97	1.37	3386	6.45	1.08
TREES	Score 0-3	0.439	0.00	3.00	19	1.03	1.00	3386	1.18	0.97
SUN	Score 0-1	0 606	0 20	0.63	19	0.46	0.12	3386	0.44	0.10

Min = minimum; Max = maximum; SD = standard deviation

* Risk factor codes are described the glossary and in Table 4.28.

Note on units : "Score 0-1" means "Score ranging from 0 to 1"
"Dis.1-5;0.5" means "Discrete variable from 1 to 5 with 0.5 unit increments".

Appendix 4.41 : Significance level of univariate Chi-square test of association between dichotomous risk factors and hinds experiencing dystocia and corresponding unadjusted odd ratios

Risk factor	Number	Chi-square	Unadjusted odds ratio**	
code*	of deer	p value	OR	95%CI
BLOCK 1 : Individual hind variables				
ADULT	3782	0.126	0.48	0 19 1.25
ADVC	3528	0.571		
Body condition score analysis				
BCSS2	3782	0 492		
BCSS4	3782	0.010	2 97	1 25 7.06
BLOCK 2 : Pre-calving environmental factors and grazing management				
RSWH5	37-13	0.609		
RSWH10	3743	0.121	0 89	0 88 0.90
OTHERST	3743	0.237		
FSUP	3743	0.069	2.28	0 91 5.68

** Unadjusted odds ratios and their 95% confidence interval (95%CI) are presented if P < 0.20
Number of hinds with dystocia : Block 1 : 21 ; Block 2 : 19