

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

# **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

**Massey University Library  
Thesis Copyright Form**

**Title of thesis : Deer Herd Health and Production Profiling**

(1) I do not give permission for my thesis to be made available to readers in Massey University Library under conditions determined by the Librarian until approval from the Game Industry Board of New Zealand.

(2) I do not agree that my thesis, or a copy, may be sent to another institution under conditions determined by the Librarian until approval from the Game Industry Board of New Zealand.

(3) I do not agree that my thesis may be copied for Library use until approval from the Game Industry Board of New Zealand.

Signed 

Date 8/2/95

**NAME AND ADDRESS**

Laurent Audigé

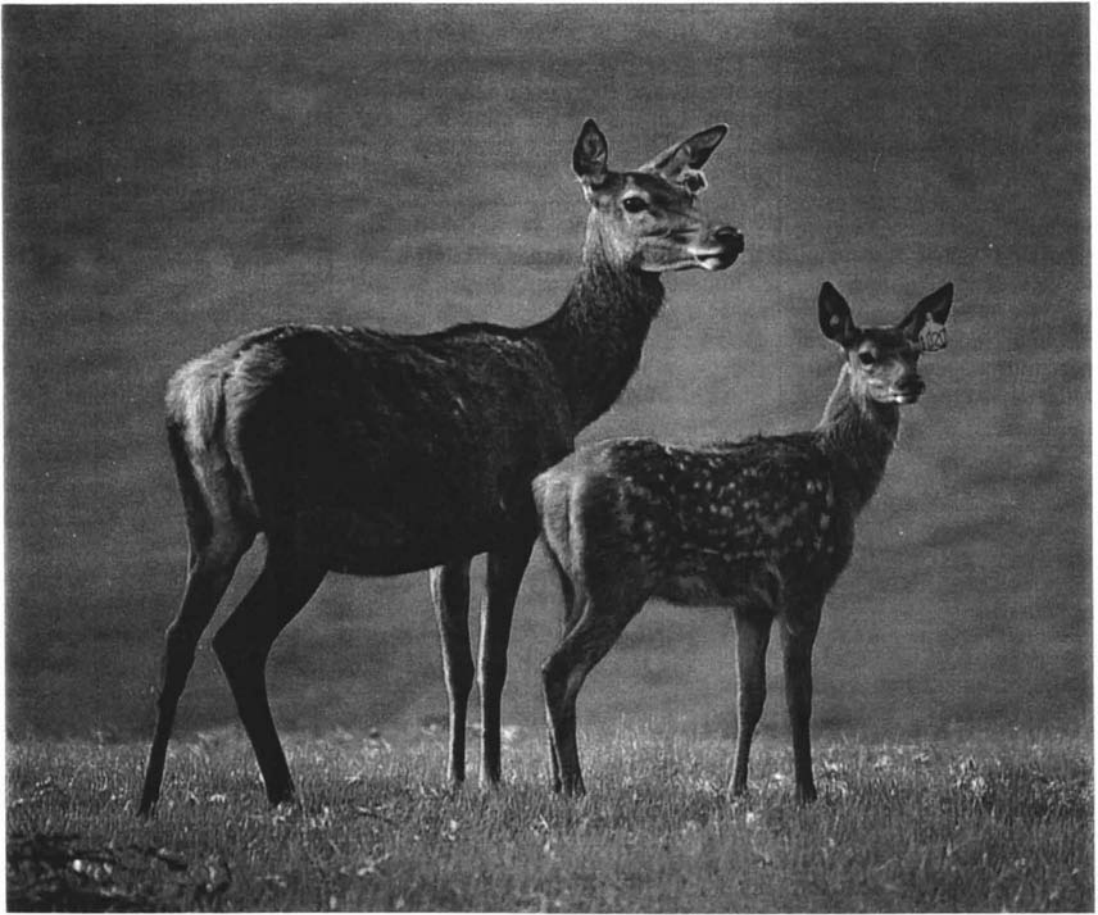
**Professional address**

Institute of Virology and Immunoprophylaxis (IVI)  
PO Box  
CH-3147 Mittelhausern,  
Switzerland  
Ph: +41 (0) 31-848-92-11  
Fax: (+41) 31-848-92-22  
EMail : audige@ivi.ch

**Private address**

Sulgenbachstrasse 25  
3007 Bern  
Switzerland

*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.*



## TABLE OF CONTENTS

TABLE OF CONTENTS.....	I
LIST OF FIGURES.....	XI
LIST OF TABLES.....	XIX
LIST OF APPENDICES.....	XXV
ABSTRACT .....	XXXV
ACKNOWLEDGMENTS .....	XXXIX
TABLE OF ABBREVIATIONS AND UNITS.....	XLI
COMPUTER SOFTWARE USED.....	XLII
ANIMAL REMEDIES USED FOR DISEASE CONTROL.....	XLIII
GLOSSARY : Risk factor codes used for analytical investigations and their descriptions.....	XLV
PUBLICATIONS.....	LI

## CHAPTER 1

### INTRODUCTION

<b>1.1 INTRODUCTION - THE CURRENT STATUS OF DEER FARMING .....</b>	<b>1-1</b>
1.1.1 Deer farming worldwide .....	1-1
1.1.2 The New Zealand deer industry .....	1-3
1.1.2.1 History.....	1-3
1.1.2.2 Industry growth and strategy.....	1-4
1.1.3 Main constraints to New Zealand deer farming .....	1-5
1.1.3.1 Biological constraints : seasonality of red deer.....	1-5
1.1.3.2 New Zealand pastoral systems (seasonality of pasture growth).....	1-6
1.1.3.3 Market requirements.....	1-6
1.1.3.4 Production limiting factors .....	1-7
1.1.3.4.1 Physical and social environment.....	1-7
1.1.3.4.2 Nutritional environment.....	1-8
1.1.3.4.3 Health-related problems .....	1-8

1.1.4 Deer farm management practices.....	1-9
<del>1.1.4.1 Reproductive management.....</del>	<del>1-9</del>
● 1.1.4.2 Nutrition management.....	1-9
● 1.1.4.2.1 Hind nutrition.....	1-10
1.1.4.2.2 Stag nutrition.....	1-10
1.1.4.3 Preventive medicine.....	1-11
1.1.4.4 Animal selection.....	1-11
<b>1.2 HERD HEALTH AND PRODUCTION PROGRAMMES .....</b>	<b>1-12</b>
1.2.1 Objectives and components .....	1-12
1.2.2 The need for reference data to set production targets and investigate management options..	1-12
<b>1.3 HEALTH AND PRODUCTION RESEARCH.....</b>	<b>1-13</b>
1.3.1 Current status of deer research.....	1-13
1.3.2 The holistic approach : herd health and production profiling .....	1-15
1.3.2.1 Definitions and concepts.....	1-15
1.3.2.2 Benefits.....	1-16
1.3.2.2.1 Multivariable approach.....	1-16
1.3.2.2.2 On farm investigations .....	1-17
1.3.2.2.3 Broad investigations.....	1-17
1.3.2.2.4 Generation of hypotheses and identification of research priorities .....	1-18
1.3.2.2.5 Accuracy of data.....	1-18
1.3.2.3 Limitations.....	1-18
1.3.2.4 Statistical analysis of observational data.....	1-19
1.3.2.4.1 Multivariable statistical techniques.....	1-19
1.3.2.4.2 Path analysis .....	1-20
<b>1.4 OBJECTIVES OF THIS DEER HERD HEALTH AND PRODUCTION STUDY1-21</b>	

## CHAPTER 2

### STUDY DESIGN AND METHODS

<b>2.1 SURVEY FARM AND ANIMAL SELECTION.....</b>	<b>2-1</b>
2.1.1 Farm selection - the mail questionnaire.....	2-1
2.1.2 Animal selection.....	2-4
<b>2.2 INDIVIDUAL FARM CHARACTERISTICS .....</b>	<b>2-5</b>
2.2.1 Farmer and farm profile .....	2-5
2.2.2 Farm layout.....	2-5
<b>2.3 FARMER RECORDING .....</b>	<b>2-10</b>
2.3.1 Recording of farm management practices.....	2-10
● 2.3.1.1 Grazing management and sward height.....	2-10
2.3.1.2 Food supplementation.....	2-13
2.3.1.3 Deer work in the yard.....	2-13
● 2.3.1.4 Reproductive management.....	2-14
2.3.1.5 Deer handling.....	2-15

2.3.1.6 Other recording .....	2-15
2.3.2 Health problems .....	2-19
2.3.3 Individual deer.....	2-22
2.3.3.1 Bodyweights and velvet yields .....	2-22
2.3.3.2 Reproduction.....	2-26
2.3.3.3 Mob history.....	2-26
2.3.3.4 Slaughter .....	2-26
2.4 FARM VISITS.....	2-27
2.4.1 Individual deer recording and sample collection .....	2-27
2.4.1.1 Sampling of selected sentinel deer .....	2-27
2.4.1.2 Body condition score .....	2-30
2.4.1.3 Pregnancy testing .....	2-30
2.4.1.4 Deer behaviour.....	2-30
2.4.2 Recording of paddock data.....	2-30
2.5 PROCESSING AND ANALYSIS OF SAMPLES.....	2-31
2.5.1 On farms .....	2-31
2.5.2 Laboratory analyses.....	2-32
2.5.2.1 Haematology.....	2-32
2.5.2.2 Serum biochemistry.....	2-32
2.5.2.3 Serology.....	2-33
2.5.2.4 Parasitology.....	2-33
2.5.2.5 Soil, pasture and food supplements.....	2-33
2.6 COMPUTER DATABASE AND DATA CALCULATIONS .....	2-35
2.6.1 Primary, secondary and master datasets .....	2-35
2.6.2 Description of calculated variables.....	2-36
2.6.2.1 Farm variables .....	2-36
2.6.2.1.1 Mean paddock variables within farms .....	2-36
2.6.2.1.2 Pasture cover measured at farm visits .....	2-36
2.6.2.1.3 Calculated weather variables.....	2-38
2.6.2.2 Calculated mob variables.....	2-38
2.6.2.2.1 Calculated grazing management variables.....	2-38
2.6.2.2.1.1 Calculated pasture and stock variables.....	2-39
2.6.2.2.1.2 Calculated paddock variables.....	2-41
2.6.2.2.1.3 Food supplementation variables.....	2-43
2.6.2.2.1.4 Disease control variables.....	2-43
2.6.2.2.2 Handling management variables.....	2-43
2.6.2.3 Calculation of individual animal variables.....	2-45
2.6.2.3.1 Calculation of bodyweights and growth rates .....	2-45
2.6.2.3.2 Calculation of velvet antler monetary value.....	2-45
2.6.2.4 Calculated health variables and biological markers.....	2-46
2.6.2.5 Measures of health and productivity parameters.....	2-46
2.6.3 Data validation.....	2-49
2.7 STATISTICAL DATA ANALYSES.....	2-50
2.7.1 Selection and rejection of variables .....	2-50
2.7.2 Handling of missing values.....	2-51
2.7.3 Pooling of data .....	2-51
2.7.4 Path analysis .....	2-51
2.7.4.1 Step 1 : Data screening .....	2-51
2.7.4.2 Step 2 : Building of null hypothesis path diagrams.....	2-53



2.7.4.3 Step 3 : Multivariable analysis and estimation of path coefficients .....	2-53
2.7.4.4 Step 4 : Final path diagram and interpretation .....	2-54
<b>2.8 DISCUSSION. ....</b>	<b>2-54</b>
2.8.1 Sample size .....	2-54
2.8.2 Farm selection .....	2-55
2.8.3 Sentinel animal selection .....	2-55
2.8.4 Deer identification .....	2-56
2.8.5 Farm and farmer familiarisation and recording .....	2-56
2.8.6 Information access and availability .....	2-56
2.8.7 Farm visit calendar .....	2-56
2.8.8 Farm management recording .....	2-57
2.8.8.1 Recording sheet utilisation and accuracy of data collection .....	2-57
2.8.8.2 Grazing management and nutrition .....	2-57
2.8.9 Monitoring health and disease .....	2-58
2.8.9.1 Health problems and mortalities .....	2-58
2.8.9.2 Influence of other domestic species on health problems .....	2-58
2.8.9.3 Inspection at deer slaughter premises .....	2-59
2.8.10 Recording during farm visits .....	2-59
2.8.10.1 Sentinel deer .....	2-59
2.8.10.2 Body condition score .....	2-60
2.8.10.3 Pregnancy diagnosis .....	2-60
2.8.11 Laboratory investigations .....	2-61
2.8.11.1 Blood profiles .....	2-61
2.8.11.2 Parasitology .....	2-62
2.8.12 Data management .....	2-62
2.8.12.1 Data validation .....	2-62
2.8.12.2 Missing values .....	2-62
2.8.12.3 Transformation of variables .....	2-63
2.8.13 Statistical analysis .....	2-64
2.8.13.1 Multivariable analyses and the use of path analysis .....	2-64
2.8.13.2 The problem of herd effect .....	2-65
<b>2.9 CONCLUSION .....</b>	<b>2-66</b>

## CHAPTER 3

### DESCRIPTIVE EPIDEMIOLOGY

<b>3.1 FARM CHARACTERISTICS .....</b>	<b>3-2</b>
3.1.1 Farmer profile .....	3-2
3.1.2 Farm characteristics .....	3-2
3.1.2.1 Paddock characteristics .....	3-2
3.1.2.1.1 Individual paddock profile and farm paddock profile .....	3-2
3.1.2.1.2 Interrelationships between paddock variables .....	3-3
3.1.2.2 Soil fertility levels .....	3-5
3.1.2.3 Pasture mineral profile .....	3-7
3.1.3 Stock .....	3-10
3.1.3.1 Deer .....	3-11

3.1.3.1.1 Herd size .....	3-11
3.1.3.1.2 Sex and blood line distributions .....	3-11
3.1.3.2 <i>Other domestic livestock</i> .....	3-14
3.1.4 Deer health problems and disease control in 1991.....	3-14
3.1.5 Weather conditions.....	3-14
<b>3.2 FARM MANAGEMENT PRACTICES .....</b>	<b>3-17</b>
3.2.1 Paddock fertiliser application and weed control.....	3-17
3.2.2 Farmers' deer handling practices .....	3-17
3.2.3 Reproductive management .....	3-18
3.2.3.1 <i>Mating strategies</i> .....	3-18
3.2.3.2 <i>Selection and culling of breeding hinds</i> .....	3-19
3.2.3.3 <i>Pregnancy diagnosis</i> .....	3-20
3.2.3.4 <i>Calving</i> .....	3-21
3.2.3.5 <i>Weaning</i> .....	3-22
3.2.4 Disease monitoring and control .....	3-22
3.2.4.1 <i>Weaners</i> .....	3-25
3.2.4.2 <i>Hinds and stags</i> .....	3-25
3.2.5 Entries and removals.....	3-27
3.2.5.1 <i>Weaners</i> .....	3-27
3.2.5.2 <i>Hinds and stags</i> .....	3-27
3.2.6 Nutrition management.....	3-28
3.2.6.1 <i>Grazing management</i> .....	3-28
3.2.6.1.1 <i>Grazing records</i> .....	3-28
3.2.6.1.2 <i>Mean farm pasture characteristics recorded during visits</i> .....	3-28
3.2.6.2 <i>Food supplementation</i> .....	3-30
3.2.7 Velvet antler harvesting .....	3-31
<b>3.3 DEER AND FARM PERFORMANCE .....</b>	<b>3-33</b>
3.3.1 Hind performance .....	3-33
3.3.1.1 <i>Hind weights</i> .....	3-33
3.3.1.2 <i>Hind condition scores</i> .....	3-35
3.3.1.2.1 <i>Validation of the scoring technique</i> .....	3-35
3.3.1.2.2 <i>Body condition score distribution</i> .....	3-36
3.3.1.3 <i>Reproductive performance</i> .....	3-38
3.3.1.3.1 <i>Hind conception</i> .....	3-38
3.3.1.3.2 <i>Calving dates</i> .....	3-42
3.3.1.3.3 <i>Weaning rates and reproductive efficiency</i> .....	3-42
3.3.1.4 <i>Weaning weights and productivity of breeding hinds</i> .....	3-44
3.3.2 Weaner growth rates and bodyweights .....	3-47
3.3.3 Performance of velvetting stags .....	3-52
3.3.3.1 <i>Stag bodyweights</i> .....	3-52
3.3.3.2 <i>Velvet antler production</i> .....	3-53
3.3.3.2.1 <i>Spike removal of weaner stags (one year old)</i> .....	3-53
3.3.3.2.2 <i>Velvet antler grades and weights</i> .....	3-54
3.3.4 Health problems .....	3-58
3.3.4.1 <i>Mortalities</i> .....	3-58
3.3.4.1.1 <i>Mortalities of deer over 3 months</i> .....	3-58
3.3.4.1.1.1 <i>Overall and seasonal mortality rates</i> .....	3-58
3.3.4.1.1.2 <i>Disease diagnoses</i> .....	3-60
3.3.4.1.2 <i>Progeny loss</i> .....	3-61
3.3.4.2 <i>Clinical diseases</i> .....	3-63
3.3.4.3 <i>Common health problems</i> .....	3-64

3.3.4.3.1 Misadventure .....	3-64
3.3.4.3.2 Yersiniosis and weaner mortality outbreaks .....	3-65
3.3.4.3.3 Osteochondrosis .....	3-65
3.3.4.3.4 Malignant catarrhal fever .....	3-65
3.3.4.3.5 Dystocia .....	3-65
3.3.4.4 <i>Inspection at Deer Slaughter Premises</i> .....	3-66
<b>3.4 SENTINEL DEER AND BIOLOGICAL MARKERS.....</b>	<b>3-67</b>
<b>3.4.1 Physical characteristics of sentinel deer and behavioural observation at sampling.....</b>	<b>3-67</b>
3.4.1.1 <i>Shoulder height</i> .....	3-67
3.4.1.2 <i>Thoracic girth</i> .....	3-67
3.4.1.3 <i>Coat length and density</i> .....	3-70
3.4.1.4 <i>Teeth</i> .....	3-71
3.4.1.5 <i>Ease of blood sampling</i> .....	3-71
3.4.2 Blood markers .....	3-72
3.4.2.1 <i>Individual deer blood characteristics</i> .....	3-72
3.4.2.2 <i>Farm blood markers</i> .....	3-72
3.4.3 Faecal egg and larval counts .....	3-84
3.4.3.1 <i>Sentinel weaners</i> .....	3-84
3.4.3.2 <i>Sentinel hinds and stags</i> .....	3-85
3.4.4 Serological investigations .....	3-87
3.4.4.1 <i>Yersiniosis</i> .....	3-87
3.4.4.2 <i>Leptospirosis</i> .....	3-88
<b>3.5 DISCUSSION .....</b>	<b>3-89</b>
3.5.1 Farm characteristics.....	3-89
3.5.1.1 <i>The farmer profile</i> .....	3-89
3.5.1.2 <i>The deer stock</i> .....	3-89
3.5.2 Farm layout, handling facilities and paddock characteristics .....	3-90
3.5.3 Farm management practices .....	3-90
3.5.3.1 <i>Reproductive management</i> .....	3-90
3.5.3.1.1 Culling and selection of breeding hinds .....	3-90
3.5.3.1.2 Mating, pregnancy diagnosis, calving and lactation.....	3-91
3.5.3.1.3 Weaning procedures .....	3-92
3.5.3.2 <i>Nutrition</i> .....	3-92
3.5.3.3 <i>Health management</i> .....	3-92
3.5.3.4 <i>Velvet antler harvesting</i> .....	3-93
3.5.4 Herd health and production outcomes .....	3-93
3.5.4.1 <i>Hind performance</i> .....	3-93
3.5.4.1.1 Hind weights and condition scores.....	3-93
3.5.4.1.2 Hind conception .....	3-94
3.5.4.1.3 Calving.....	3-95
3.5.4.1.4 Weaning rates and reproductive efficiency .....	3-95
3.5.4.2 <i>Weaner growth and venison production</i> .....	3-96
3.5.4.3 <i>Stag bodyweight and velvet antler production</i> .....	3-97
3.5.4.4 <i>Health problems and mortality rates</i> .....	3-98
3.5.4.4.1 Adult deer.....	3-98
3.5.4.4.2 Weaners .....	3-98
3.5.4.4.3 Progeny loss .....	3-99
3.5.4.4.4 Dystocia .....	3-101
3.5.5 Sentinel deer .....	3-101
3.5.5.1 <i>Deer physical characteristics</i> .....	3-101
3.5.5.2 <i>Biological markers</i> .....	3-102

3.5.5.2.1 Behaviour of deer during blood sampling .....	3-102
3.5.5.2.2 Blood markers .....	3-102
3.5.5.2.3 Parasitology .....	3-103
3.5.5.2.4 Yersiniosis serology .....	3-103
<b>3.6 CONCLUSION.....</b>	<b>3-104</b>

## CHAPTER 4

### ANALYTICAL EPIDEMIOLOGY

<b>4.1 RISK FACTORS FOR HIND CONCEPTION.....</b>	<b>4-9</b>
4.1.1 Introduction.....	4-9
4.1.2 Materials and methods.....	4-10
4.1.3 Results.....	4-13
4.1.3.1 <i>Animal and grazing management risk factors</i> .....	4-13
4.1.3.1.1 Adult hinds.....	4-13
4.1.3.1.2 Yearling hinds.....	4-13
4.1.3.2 <i>Body condition score</i> .....	4-14
4.1.3.3 <i>Back-up mobs</i> .....	4-14
4.1.3.4 <i>Sentinel hind characteristics and biological markers</i> .....	4-14
4.1.4 Discussion.....	4-30
4.1.4.1 <i>Animal management risk factors</i> .....	4-30
4.1.4.1.1 Adult hinds.....	4-30
4.1.4.1.2 Yearling hinds.....	4-33
4.1.4.2 <i>Grazing management and environmental factors</i> .....	4-35
4.1.4.3 <i>Sentinel hinds</i> .....	4-37
4.1.4.4 <i>Blood markers</i> .....	4-38
4.1.5 Conclusion.....	4-42
4.1.5.1 <i>Management of adult hinds</i> .....	4-42
4.1.5.2 <i>Management of yearling hinds</i> .....	4-44
4.1.5.3 <i>Biological markers</i> .....	4-45
4.1.5.4 <i>Identified areas for further research</i> .....	4-45
<b>4.2 RISK FACTORS FOR HIND LACTATIONAL STATUS AT WEANING .....</b>	<b>4-47</b>
4.2.1 Materials and methods.....	4-47
4.2.2 Results.....	4-50
4.2.2.1 <i>Management risk factors</i> .....	4-50
4.2.2.2 <i>Biological markers</i> .....	4-51
4.2.3 Discussion.....	4-60
4.2.3.1 <i>Hind characteristics</i> .....	4-61
4.2.3.2 <i>Nutrition and shelter</i> .....	4-62
4.2.3.3 <i>Human interference</i> .....	4-64
4.2.3.4 <i>Blood markers</i> .....	4-65
4.2.4 Conclusion.....	4-65
4.2.4.1 <i>Management of adult hinds</i> .....	4-66
4.2.4.2 <i>Identified areas for further research</i> .....	4-66

<b>4.3 RISK FACTORS FOR WEANER BODYWEIGHT STANDARDISED TO APRIL 1</b> .....	<b>4-68</b>
4.3.1 Materials and methods .....	4-68
4.3.2 Results .....	4-70
4.3.3 Discussion .....	4-77
4.3.3.1 Dam characteristics .....	4-77
4.3.3.2 Grazing and weaning management .....	4-80
4.3.3.3 Post-weaning management .....	4-81
4.3.3.4 Biological markers .....	4-82
4.3.4 Conclusion .....	4-85
4.3.5 Identified areas for further research .....	4-86
<b>4.4 RISK FACTORS FOR WEANER SEASONAL GROWTH RATES</b> .....	<b>4-88</b>
4.4.1 Materials and methods .....	4-88
4.4.1.1 Results .....	4-92
4.4.1.2 Discussion .....	4-92
4.4.1.2.1 Management risk factors .....	4-92
4.4.1.2.1.1 Autumn growth .....	4-114
4.4.1.2.1.2 Winter growth .....	4-117
4.4.1.2.1.3 Spring growth .....	4-119
4.4.1.2.1.4 Summer growth .....	4-121
4.4.1.2.2 Sentinel weaner characteristics and biological markers .....	4-123
4.4.1.3 Conclusion .....	4-125
4.4.1.4 Identified areas for further research .....	4-127
<b>4.5 RISK FACTORS FOR VELVET ANTLER PRODUCTION</b> .....	<b>4-128</b>
4.5.1 Materials and methods .....	4-128
4.5.2 Results .....	4-132
4.5.3 Discussion .....	4-140
4.5.3.1 Individual stag characteristics .....	4-140
4.5.3.2 Grazing management factors .....	4-142
4.5.3.2.1 Winter grazing management .....	4-143
4.5.3.2.2 Spring grazing management .....	4-144
4.5.3.3 Sentinel stag characteristics and blood markers .....	4-146
4.5.3.4 Conclusion .....	4-149
4.5.3.5 Identified areas for further research .....	4-150
<b>4.6 RISK FACTORS FOR HEALTH PROBLEMS</b> .....	<b>4-151</b>
4.6.1 Risk factors for yersiniosis .....	4-151
4.6.1.1 Materials and methods .....	4-151
4.6.1.2 Results .....	4-153
4.6.1.3 Discussion .....	4-154
4.6.1.4 Conclusion .....	4-159
4.6.1.5 Identified areas for further research .....	4-160
4.6.2 Risk factors for malignant catarrhal fever in hinds and stags over 15 months of age. ....	4-161
4.6.2.1 Materials and methods .....	4-161
4.6.2.2 Results .....	4-163
4.6.2.3 Discussion .....	4-163
4.6.2.4 Conclusion .....	4-167
4.6.3 Risk factors for the occurrence of dystocia .....	4-169
4.6.3.1 Materials and methods .....	4-169
4.6.3.2 Results .....	4-171

4.6.3.3 Discussion.....	4-174
4.6.3.4 Conclusion.....	4-175

## CHAPTER 5

### GENERAL DISCUSSION AND CONCLUSIONS

<b>5.1 STUDY DESIGN AND ANALYSIS .....</b>	<b>5-1</b>
5.1.1 Data recording.....	5-1
5.1.2 Data analysis.....	5-2
5.1.2.1 Selection of outcomes.....	5-3
5.1.2.2 Multivariable analysis using path analysis.....	5-3
5.1.2.3 Multivariable analysis without the use of path analysis.....	5-5
5.1.3 The control for herd effect.....	5-6
5.1.4 Variability explained by path models.....	5-7
<b>5.2 WHAT THIS STUDY HAS SHOWN.....</b>	<b>5-9</b>
5.2.1 The most important associations.....	5-9
5.2.2 The most important areas for potential improvement of productivity.....	5-11
<b>5.3 IMMEDIATE APPLICATIONS OF THESE DATA AND ANALYSES.....</b>	<b>5-13</b>
5.3.1 At the farm level.....	5-13
5.3.1.1 Deer farmers' self evaluation of management options.....	5-13
5.3.1.2 Whole-farm investigations.....	5-14
5.3.2 At the industry level.....	5-15
<b>5.4 FURTHER RESEARCH.....</b>	<b>5-17</b>
5.4.1 Validation of putative epidemiological models.....	5-17
5.4.2 Farm modelling.....	5-17
5.4.3 Further analysis of the database.....	5-18
5.4.4 Serum bank.....	5-19
<b>5.5 CONCLUSION.....</b>	<b>5-19</b>
<b>REFERENCES.....</b>	<b>R-1</b>
<b>APPENDICES .....</b>	<b>A-1</b>
Chapter 1.....	A-2
Chapter 2.....	A-5
Chapter 3.....	A-35
Chapter 4.....	A-119



## LIST OF FIGURES

### CHAPTER 1

#### INTRODUCTION

- Figure 1.1 : Farmed stag before the harvesting of its velvet antlers..... 1-3  
 Figure 1.2 : Actual and projected size of the New Zealand farmed deer herd for the years 1989-2000 1-4

### CHAPTER 2

#### STUDY DESIGN AND METHODS

- Figure 2.1 : Location of selected farms in the Southern part of the North Island ..... 2-2  
 Figure 2.2 : Examples of paddock descriptive variables ..... 2-6  
 Figure 2.3 : Examples of pasture measurements recorded by the farmer ..... 2-11  
 Figure 2.4 : Examples of measurements and observations made on sentinel deer during farm visits.. 2-28  
 Figure 2.5 : Data entry and validation before statistical analyses..... 2-50

### CHAPTER 3

#### DESCRIPTIVE EPIDEMIOLOGY

##### DEER AND FARM CHARACTERISTICS

- Figure 3.1 : Quartiles and range of Olsen phosphate, sulphur, exchangeable potassium and magnesium concentrations on each survey farm in 1992 and 1993..... 3-6  
 Figure 3.2 : Quartiles and range of soil pH on each survey farm in 1992 and 1993..... 3-7  
 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. .... 3-8  
 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. .... 3-9  
 Figure 3.5 : Deer farm size distribution in June 1992 and 1993..... 3-11  
 Figure 3.6 : Age pyramids of hinds and stags individually monitored in 1992 and 1993..... 3-12  
 Figure 3.7 : Distribution of blood line categories within hinds, stags and weaners in 1992 and 1993.3-12  
 Figure 3.8 : Mean maximum temperatures (°C) in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts from March 1992 to March 1994..... 3-15



Figure 3.9 : Mean minimum temperatures (°C) in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts from March 1992 to March 1994.....	3-15
Figure 3.10 : Mean daily rainfall (mm) in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts from March 1992 to March 1994. ....	3-16
Figure 3.11 : Mean daily sunshine score in the Manawatu/Wanganui, Taihape, Bush and Hawkes' Bay districts from March 1992 to March 1994. ....	3-16

## FARM MANAGEMENT PRACTICES

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	3-21
Figure 3.13 : Quartiles and range of mean farm pasture cover, sward height, clover score, and weed score at each farm visit in 1992 and 1993. ....	3-29

## DEER AND FARM PERFORMANCE

### Reproduction

Figure 3.14 : Pre-mating bodyweight distribution of yearling and adult (>2 years) hind in 1992 and 1993. ....	3-34
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. ....	3-34
Figure 3.16 : Mean yearling and adult hind body condition score ( $\pm$ SD) between farms in 1992 and 1993. ....	3-37
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. ....	3-37
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. ....	3-38
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. ....	3-39
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. ....	3-41
Figure 3.21 : Birth date distributions of hind and stag calves in 1992 and 1993. Data from 4 survey farms combined. ....	3-43
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. ....	3-43
Figure 3.23 : Distribution histograms of yearling and adult hind weaning rate and reproductive efficiency within study farms. Data from 1992 and 1993 combined. ....	3-45

### Weaner bodyweights and growth

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. ....	3-47
Figure 3.25 : Mean and standard deviation of bodyweights of weaner hinds and stags. All survey farms and both years 1992 and 1993 combined. ....	3-48

- 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. .... 3-49
- Figure 3.27 : Mean and standard deviation of seasonal growth rates of weaner hinds and stags. Data from 1992 and 1993 combined. .... 3-50
- Figure 3.28 : Median and range of farm mean bodyweights of weaner hinds and stags. Data from 1992 and 1993 combined. .... 3-50

### Velvet antler production

- Figure 3.29 : Bodyweight distribution of yearling (18 months) and adult stags in June 1992 and 1993. 3-52
- Figure 3.30 : Distribution histogram of the time of spike removal in weaner stags (< 15 months)..... 3-53
- Figure 3.31 : Regression line predicting spike removal dates of weaner stags (< 15 months) from their bodyweights standardised to June 1. .... 3-54
- Figure 3.32 : Velvet antler production from yearling (rising 2-year-old) and adult stags in 1992 and 1993. Percentage of each velvet grade (%) and average velvet weight per stag within each grade (kg), and overall mean velvet weight. .... 3-55
- Figure 3.33 : Means ( $\pm$ 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. .... 3-56
- Figure 3.34 : Means ( $\pm$ SD) and ranges of velvet antler weight of stags within each class of age in 1992 and 1993. .... 3-57

### Health problems - Mortalities

- Figure 3.35 : Monthly distribution of weaner (<15 months), hind and stag mortalities from March 1992 to March 1994. .... 3-58
- 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. .... 3-61
- 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. .... 3-64
- 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. .... 3-66

### SENTINEL DEER - BIOLOGICAL MARKERS

- Figure 3.39 : Shoulder height ( $\pm$ 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. .... 3-68
- Figure 3.40 : Thoracic girth ( $\pm$ SD)(cm) of sentinel weaner, yearling and adult stags (a) and hinds (b) at each farm visit in 1992 and 1993. .... 3-68
- Figure 3.41 : Mean ( $\pm$ SD) of coat length of weaner hinds and stags, yearling and adult stags, and yearling and adult hinds, sampled in March, June and September in 1992 and 1993. .... 3-69
- Figure 3.42 : Percentage of sentinel weaners, hinds and stags observed with signs of hair loss on their back (victimisation). .... 3-70
- Figure 3.43 : Percentage of sentinel weaners, hinds and stags that were blood sampled without physical restraint during farm visits. .... 3-71

Figure 3.44 : Means ( $\pm$ SD) and ranges of geometric mean white cell counts ( $10^9/l$ ) and mean haemoglobin concentrations (g/l) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined. ....	3-76
Figure 3.45 : Means ( $\pm$ SD) and ranges of mean packed cell volume (l/l) and geometric mean of mean cell haemoglobin concentrations (g/l) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined. ....	3-77
Figure 3.46 : Means ( $\pm$ SD) and ranges of mean lymphocyte, neutrophil, eosinophil and basophil percentage (%) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.....	3-78
Figure 3.47 : Means ( $\pm$ SD) and ranges of mean serum total protein and albumin concentrations (g/l) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined. ....	3-79
Figure 3.48 : Means ( $\pm$ SD) and ranges of mean serum globulin (g/l) and blood urea nitrogen concentrations (mmol/l) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined. ....	3-80
Figure 3.49 : Means ( $\pm$ SD) and ranges of geometric mean pepsinogen (mU Tyrosine/l) and gamma glutamyl transferase activities (IU) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined. ....	3-81
Figure 3.50 : Means ( $\pm$ SD) and ranges of mean serum copper ( $\mu$ mol/l) and vitamin B12 concentrations (pmol/l) of 10 weaners (3-15 months), 10 hinds and 10 stags within farms. Data from 1992 and 1993 combined.....	3-82
Figure 3.51 : Means, standard deviations ( $\pm$ 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. ....	3-83
Figure 3.52 : Distributions of faecal egg counts (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. ....	3-86
Figure 3.53 : Percentage of sentinel hinds in June and September and stags in June and November-December with positive faecal lungworm larval count and respective overall geometric means of FLC all farms combined. ....	3-86
Figure 3.54 : Distribution of seroprevalence against <i>Yersinia pseudotuberculosis</i> in 10 weaners between farms. Data from 1992 and 1993 combined. ....	3-88

## CHAPTER 4

### ANALYTICAL EPIDEMIOLOGY

#### RISK FACTORS FOR HIND CONCEPTION

Figure 4.1 : Null hypothesis and final path diagrams of animal management risk factors for adult hinds conceiving before May 1. ....	4-16
Figure 4.2 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for adult hinds conceiving before May 1. ....	4-17
Figure 4.3 : Null hypothesis and final path diagrams of animal management risk factors for adult hinds conceiving <i>per se</i> . ....	4-19
Figure 4.4 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for adult hinds conceiving <i>per se</i> . ....	4-20

Figure 4.5 : Overall final path diagram of animal management, grazing management and environmental risk factors for adult hinds conceiving before May 1. ....	4-21
Figure 4.6 : Overall final path diagram of animal management, grazing management and environmental risk factors for adult hinds conceiving <i>per se</i> . ....	4-21
Figure 4.7 : Null hypothesis and final path diagrams of animal management risk factors for yearling hinds conceiving before May 1. ....	4-23
Figure 4.8 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for yearling hinds conceiving before May 1. ....	4-24
Figure 4.9 : Null hypothesis and final path diagrams of animal management risk factors for yearling hinds conceiving <i>per se</i> . ....	4-25
Figure 4.10 : Null hypothesis and final path diagrams of grazing management and environmental risk factors for yearling hinds conceiving <i>per se</i> . ....	4-26
Figure 4.11 : Overall final path diagram of animal management, grazing management and environmental risk factors for yearling hinds conceiving before May 1. ....	4-27
Figure 4.12 : Overall final path diagram of animal management, grazing management and environmental risk factors for yearling hinds conceiving <i>per se</i> . ....	4-27
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. ....	4-39
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. ....	4-41
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. ....	4-41
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. ....	4-42

## RISK FACTORS FOR HIND LACTATIONAL STATUS AT WEANING

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. ....	4-54
Figure 4.18 : Null hypothesis and final path diagrams of calving management risk factors for adult hind lactational status at weaning. ....	4-55
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. ....	4-56
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). ....	4-57
Figure 4.21 : Null hypothesis path diagrams of individual yearling hind characteristics, grazing management (between November 1 and January 1), and calving management risk factors for yearling hind lactational status at weaning. ....	4-58
Figure 4.22 : Relationship between geometric means of pepsinogen concentrations from 5 adult hinds and weaning rates of adult hinds within each survey farm. Data from 1992 and 1993 combined. ....	4-59
Figure 4.23 : Relationship between geometric means of serum gamma glutamyl transferase activities from 5 yearling hinds and weaning rates of yearling hinds within each survey farm. Data from 1992 and 1993 combined. ....	4-59

## RISK FACTORS FOR WEANER BODYWEIGHT STANDARDISED TO APRIL 1

- Figure 4.24 : Null hypothesis path model of individual dam-offspring risk factors for individual weaner bodyweight on April 1 ..... 4-71
- 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. 4-72
- Figure 4.26 : Null hypothesis path diagram of post-weaning grazing management risk factors for individual weaner bodyweight on April 1. .... 4-72
- Figure 4.27 : Final path diagrams of individual dam-offspring risk factors for individual weaner hind and stag bodyweight on April 1. .... 4-73
- 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. 4-74
- Figure 4.29 : Final path diagrams of post-weaning grazing management risk factors for individual weaner hind and stag bodyweight on April 1. .... 4-75
- 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. .... 4-83
- 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..... 4-84
- 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..... 4-84

## RISK FACTORS FOR WEANER SEASONAL GROWTH RATES

- Figure 4.33 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between April 1 and June 1. .... 4-93
- Figure 4.34 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between June 1 and September 1. .... 4-93
- Figure 4.35 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between September 1 and December 1. .... 4-94
- Figure 4.36 : Null hypothesis path diagram of risk factors for weaner stag and hind growth between December 1 and March 1. .... 4-94
- Figure 4.37 : Final path diagrams of risk factors for weaner stag and hind growth rate between April 1 and June 1 (autumn growth). .... 4-96
- 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. .... 4-97
- Figure 4.39 : Final path diagrams of risk factors for weaner stag and hind growth rate between June 1 and September 1..... 4-98
- Figure 4.40 : Final path diagrams of risk factors for weaner stag and hind growth rate between September 1 and December 1. .... 4-100
- Figure 4.41 : Final path diagrams of risk factors for weaner stag and hind growth rate between December 1 and March 1. .... 4-101

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.....	4-105
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.....	4-106
Figure 4.44 : Relationships between individual (a) and mean (b) weaner stag and hind autumn growth rates (g/d) and serum copper concentrations ( $\mu\text{mol/l}$ ) from 10 weaners (5 hinds and 5 stags) randomly selected on each survey farm and sampled in June.....	4-107
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.....	4-108
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. ....	4-109
Figure 4.47 : Relationships between individual weaner stag and hind spring growth rates (g/d) and individual thoracic girth (cm) recorded in September. ....	4-110
Figure 4.48 : Relationships between individual weaner stag and hind spring growth rates (g/d) and individual blood white cell count ( $10^9/\text{l}$ ) recorded in September. ....	4-110
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. ....	4-111
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.....	4-112
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.....	4-113

## RISK FACTORS FOR VELVET ANTLER PRODUCTION

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.	4-134
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. ....	4-135
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. ....	4-136
Figure 4.55 : Null hypothesis path diagram of pre-velvetting (Sept 1 - Velvetting) 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. ....	4-136
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.....	4-137
Figure 4.57 : Final path diagrams of pre-velvetting (Sept 1 - velvetting) 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. ....	4-138

## XVIII

- 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..... 4-147
- 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. .... 4-148

## RISK FACTORS FOR HEALTH PROBLEMS

### Yersiniosis

- Figure 4.60 : Null hypothesis and final path diagrams of risk factors for the occurrence of yersiniosis in individual weaners after April 1..... 4-154
- Figure 4.61 : Null hypothesis and final path diagrams of risk factors for the occurrence of yersiniosis in individual weaners after June 1..... 4-155
- Figure 4.62 : Null hypothesis and final path diagrams of risk factors for the occurrence of yersiniosis in weaner mobs after April 1. .... 4-155

### Malignant catarrhal fever

- Figure 4.63 : Null hypothesis and final path diagrams of risk factors for the occurrence of malignant catarrhal fever in hinds in winter..... 4-164

### Dystocia

- Figure 4.64 : Null hypothesis and final path diagrams of individual hind risk factors for the occurrence of dystocia. .... 4-171
- Figure 4.65 : Null hypothesis and final path diagrams of individual hind and grazing management risk factors for the occurrence of dystocia..... 4-172

## CHAPTER 5

### GENERAL DISCUSSION AND CONCLUSIONS

- Figure 5.1 : Proposed year-round body condition scores of yearling and adult hinds to optimise reproductive performance..... 5-14

## LIST OF TABLES

### CHAPTER 1

#### INTRODUCTION

Table 1.1 : Farned deer species and estimated numbers in the major deer producing countries worldwide .....	1-2
Table 1.2 : Reproductive cycle of farned red deer in New Zealand .....	1-5
Table 1.3 : Examples of achievable mean growth rates of calves and weaners under various environmental and nutritional conditions .....	1-14
Table 1.4 : Examples of veterinary epidemiological studies using path analysis .....	1-21

### CHAPTER 2

#### STUDY DESIGN AND METHODS

Table 2.1 : Location and number of deer farms selected for participation in the mail questionnaire ....	2-1
Table 2.2 : Total and deer-fenced areas and stock numbers of selected farms in each district .....	2-3
Table 2.3 : Total number of deer surveyed and deer individually monitored.....	2-4
Table 2.4 : List of variables used to describe each deer-fenced paddock .....	2-7
Table 2.5 : List of variables used to describe lanes and deer-yards .....	2-9
Table 2.6 : Summary of recording sheets (reports) completed by the farmer .....	2-10
Table 2.7 : List of grazing variables recorded by the farmer .....	2-12
Table 2.8 : Food supplement variables recorded by the farmer .....	2-13
Table 2.9 : Variables used to record the work with deer in yards.....	2-14
Table 2.10 : Mating management variables .....	2-15
Table 2.11 : Calving and weaning management variables .....	2-16
Table 2.12 : Handling management variables .....	2-17
Table 2.13 : Daily weather variables recorded by the farmer.....	2-18
Table 2.14 : Beaufort wind scale.....	2-18
Table 2.15 : Health problem variables.....	2-19
Table 2.16 : Dystocia and calf mortality variables.....	2-20
Table 2.17 : Diagnoses, clinical signs and lesions recorded by farmers or veterinarians. ....	2-21
Table 2.18 : Description of datasets for raw and calculated individual deer variables .....	2-23
Table 2.19 : Annual schedule of deer mob recording and paddock sampling.....	2-26
Table 2.20 : Schedule of measurements and sample collection from selected sentinel deer .....	2-27
Table 2.21 : Description and method for measurements and observations made on individual sentinel deer during farm visits.....	2-29



Table 2.22 : Definition and method of measurements and observations made on paddocks during farm visits.....	2-3
Table 2.23 : Schedule of sample collection and the range of analyses undertaken. ....	2-3
Table 2.24 : List of primary datasets containing raw data.....	2-3
Table 2.25 : Calculated farm mean paddock variables.....	2-3
Table 2.26 : Calculated farm pasture cover variables from each farm visit.....	2-3
Table 2.27 : Calculated weather variables.....	2-3
Table 2.28 : Grazing periods for which grazing mob variables were calculated.....	2-3
Table 2.29 : Calculated grazing management variables.....	2-4
Table 2.30 : Seasonal metabolisable energy requirements of red deer used for calculations of the total daily energy demand per hectare.....	2-4
Table 2.31 : Calculated paddock variables during grazing periods.....	2-4
Table 2.32 : Food supplement variables and calculated supplementary food energy intakes.....	2-4
Table 2.33 : Disease control variables.....	2-4
Table 2.34 : Handling management variables.....	2-4
Table 2.35 : Prices of velvet antler (NZ\$/kg) used for calculation of velvet antler monetary values..	2-4
Table 2.36 : Health problem variables and calculated biological markers.....	2-4
Table 2.37 : Measures of health and productivity of deer farms.....	2-4
Table 2.38 : Summary of outcome variables under investigation in this thesis.....	2-5

## CHAPTER 3

### DESCRIPTIVE EPIDEMIOLOGY

#### DEER AND FARM CHARACTERISTICS

Table 3.1 : Summary of paddock characteristics over all farms in 1992 and 1993.....	3-1
Table 3.2 : Range, mean, median and standard deviation of mean paddock characteristics on each survey farm during the study.....	3-1
Table 3.3 : Statistical significance of factors: year; farm; visit; pasture type; clover score, and sward height in explaining pasture mineral profile variability.....	3-1
Table 3.4 : Summary of farm stock reconciliation in June 1992 and 1993.....	3-1
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.....	3-1
Table 3.6 : Summary results of variability of maximum and minimum temperatures, rainfall and sunshine scores due to year, month and districts.....	3-1

#### FARM MANAGEMENT PRACTICES

Table 3.7 : History of fertiliser application on survey farms during the study.....	3-1
Table 3.8 : Summary of mating management strategies implemented in 1992 and 1993.....	3-1

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.....	3-20
Table 3.10 : Summary of calving management practices in 1992 and 1993. ....	3-22
Table 3.11 : Summary of weaning management practices on each farm in 1992, 1993 and 1994. ....	3-23
Table 3.12 : Animal remedies used by farmers during the study for disease control .....	3-24
Table 3.13 : Summary of disease control practices on hinds and stags (> 15 months) on each farm in 1992, and 1993. ....	3-26
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. ....	3-30
Table 3.15 : List of food supplements used by farmers .....	3-31

## DEER AND FARM PERFORMANCE

### Reproduction

Table 3.16 : Descriptive summary of yearling and adult hind bodyweights (kg) in 1992 and 1993 ...	3-33
Table 3.17 : Model components and calculation formula of the repeatability and reproducibility of hind body condition scoring.....	3-35
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. ....	3-36
Table 3.19 : Summary statistics of farm-level reproductive performance of yearling and adult hinds in 1992, 1993 and both years combined. ....	3-40
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. ....	3-42
Table 3.21 : Overall weaning rate and reproductive efficiency of yearling and adult hinds in 1992, 1993 and both years combined. ....	3-44
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.....	3-45

### Weaner bodyweights and growth

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.....	3-46
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. ....	3-51

### Velvet antler production

Table 3.25 : Summary statistics of farm mean velvet weight of 2-year-old stags, and mean corrected velvet antler weight of adult stags in 1992, 1993 and both years combined. ....	3-57
--	------

**Health problems - Mortalities**

Table 3.26 : Number of hind, stag and weaner (3-15 months) mortalities and mortality rates over autumn, winter, spring, summer (/100 deer-3 months), and all seasons combined (/100 deer-years). Data from 1992 and 1993 combined. ....	3-59
Table 3.27 : Summary statistics of farm mortality rates of weaners (3-15 months), stags and hinds, and progeny loss rates to weaning in yearling and adult hinds. ....	3-60
Table 3.28 : Mortalities of hinds, stags, weaners (3-15 months) and calves, from April 1 1992 to April 1 1994. ....	3-62
Table 3.29: Summary of health problems which did not lead to death from March 1 1992 to April 1 1994. All farms combined. ....	3-63

**SENTINEL DEER - BIOLOGICAL MARKERS**

Table 3.30 : Regression equations predicting the bodyweight of weaners (3-15 months), hinds and stags (kg) from their thoracic girth (cm). ....	3-70
Table 3.31 : Mean, range and standard deviation of individual blood haematological and biochemical characteristics of weaner stags and weaner hinds (3-15 months) at each visit, pooled over all farms and both years 1992 and 1993. ....	3-73
Table 3.32 : Mean, range and standard deviation of individual blood haematological and biochemical characteristics of yearling and adult stags by visit (June and November) and age group, where appropriate. Data pooled over all farms and both years 1992 and 1993. ....	3-74
Table 3.33 : Mean, range and standard deviation of individual blood haematological and biochemical characteristics of yearling and adult hinds by visit (March and September) and age group, where appropriate. Data pooled over all farms and both years 1992 and 1993. ....	3-75
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. ....	3-84
Table 3.35 : Seroprevalence (%) against <i>Yersinia pseudotuberculosis</i> in June and September 1992 and 1993 all farm combined. ....	3-87

**CHAPTER 4****ANALYTICAL EPIDEMIOLOGY****RISK FACTORS FOR HIND CONCEPTION**

Table 4.1 : Summary of multivariable statistical analyses carried out using path analysis. ....	4-2
Table 4.2 : Summary of multivariable statistical analyses carried without the use of path analysis. ....	4-6
Table 4.3 : Potential risk factors for hind conceiving early (before May 1) or hind conceiving <i>per se</i> . ....	4-11
Table 4.4 : Logistic regression coefficient estimates and adjusted odds ratios of animal and grazing management risk factors predicting the probability of adult hinds conceiving before May 1 (direct effects). ....	4-15
Table 4.5 : Logistic regression coefficient estimates and adjusted odds ratios of animal and grazing management risk factors predicting the probability of adult hinds conceiving <i>per se</i> (direct effects). ....	4-18

Table 4.6 : Logistic regression coefficient estimates and adjusted odds ratios of animal and grazing management risk factors predicting the probability of yearling hinds conceiving before May 1 or conceiving <i>per se</i> (direct effects).....	4-22
Table 4.7 : Logistic regression coefficient estimates and adjusted odds ratio of body condition score variables and confounding factors predicting the probability of yearling and adult hinds conceiving before May 1 or conceiving <i>per se</i> .....	4-28
Table 4.8 : Logistic regression coefficient estimates and adjusted odds ratios of back-up risk factors predicting the probability of yearling and adult hinds conceiving before May 1 or conceiving <i>per se</i> .....	4-28
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.....	4-29

### **RISK FACTORS FOR HIND LACTATIONAL STATUS AT WEANING**

Table 4.10 : Potential risk factors for hind rearing a calf to weaning.....	4-48
Table 4.11 : Logistic regression coefficient estimates and adjusted odds ratios of animal and grazing management risk factors predicting the probability of hind rearing a calf up to weaning and goodness of fit of models.....	4-52

### **RISK FACTORS FOR WEANER BODYWEIGHT STANDARDISED TO APRIL 1**

Table 4.12 : Potential risk factors for individual or mean mob weaner bodyweight standardised to April 1.....	4-69
Table 4.13 : Summary of direct effects of risk factors for weaner stag and hind bodyweight within each risk factor block.....	4-76

### **RISK FACTORS FOR WEANER SEASONAL GROWTH RATES**

Table 4.14 : Potential risk factors for weaner seasonal growth rates.....	4-89
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.....	4-95
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.....	4-99
Table 4.17 : Regression coefficients of blood markers significantly associated with individual or mean farm weaner stag and hind growth rates.....	4-102
Table 4.18 : Regression lines of relationships between major individual and mean weaner blood markers for seasonal growth rates as presented from Figure 4.42 to Figure 4.51.....	4-104

### **RISK FACTOR FOR VELVET ANTLER PRODUCTION**

Table 4.19 : Potential risk factors for velvet antler weight, grade and monetary value of 2-year-old and adult stags.....	4-130
Table 4.20 : Summary of direct effects of risk factors for 2-year-old and adult stags velvet antler weight and grade.....	4-133

Table 4.21 : Regression coefficients of sentinel stag characteristics and blood markers significantly associated with individual or mean farm 2-year-old and adult stag velvet antler value corrected for age (NZ\$/AGE), weight (kg) or grade.....	4-139
Table 4.22 : Part of the variability (multiple $r^2$ ) in velvet weight and grade explained by winter and pre-velvetting grazing management risk factors after individual stag characteristics have been taken into account. ....	4-143
Table 4.23 : Correlation coefficients between farm mean haemoglobin concentration, mean packed cell volume and mean serum copper concentration from 10 stags per farm sampled in June.....	4-147

## RISK FACTORS FOR HEALTH PROBLEMS

### Yersiniosis

Table 4.24 : Potential risk factors for weaners dying from yersiniosis. ....	4-152
Table 4.25 : Logistic regression coefficient, adjusted odds ratio of factors predicting the probability of weaners or mobs of weaner to be affected by confirmed or suspected clinical yersiniosis.....	4-156

### Malignant catarrhal fever

Table 4.26 : Potential risk factors for the occurrence of malignant catarrhal fever in hinds in winter and in stags from winter to summer. ....	4-162
Table 4.27 : Logistic regression coefficient estimates and adjusted odds ratios of animal and grazing management risk factors predicting the probability of hinds and stags dying from malignant catarrhal fever.....	4-165

### Dystocia

Table 4.28 : Potential risk factors for the occurrence of hind dystocia. ....	4-170
Table 4.29 : Logistic regression coefficient estimates and adjusted odds ratios of animal and grazing management risk factors predicting the probability of hinds being affected by dystocia at calving. ....	4-173

## CHAPTER 5

### GENERAL DISCUSSION AND CONCLUSIONS

Table 5.1 : Current mean values and proposed targets of farm-level major health and production outcomes.....	5-12
Table 5.2 : Potential financial gain to the deer industry by improvement to proposed target of hind reproductive efficiency alone, the percentage of weaner stag reaching 92 kg by December 1 alone, and both improvements.....	5-16
Table 5.3 : Application of modelling technique to predict weaner hind and stag bodyweights on April 1 with two hinds conforming to a different set of characteristics. ....	5-17
Table 5.4 : Proposed further risk factor analyses from the database .....	5-18

## LIST OF APPENDICES

### CHAPTER 1

#### INTRODUCTION

Appendix 1.1 : New Zealand game industry board guidelines for the removal of velvet antler.....A-1

### CHAPTER 2

#### STUDY DESIGN AND METHODS

Appendix 2.1 : Participation questionnaire sent to 370 deer farmers.....	A-5
Appendix 2.2 : Farmer direct questionnaire .....	A-6
Appendix 2.3 : Questionnaire of deer stock, health problems and disease control programme related to the year 1991 .....	A-7
Appendix 2.4 : Examples of computerised farm maps.....	A-9
Appendix 2.5 : Pasture height and stock report.....	A-10
Appendix 2.6 : Food supplementation reports.....	A-11
Appendix 2.7 : Deer work in yard report .....	A-13
Appendix 2.8 : Reproduction management .....	A-14
Appendix 2.9 : Deer handling questionnaire .....	A-15
Appendix 2.10 : Paddock management report.....	A-16
Appendix 2.11 : Weather report.....	A-17
Appendix 2.12 : Stock reconciliation report.....	A-18
Appendix 2.13 : Health problem sheet.....	A-19
Appendix 2.14 : Disease reports.....	A-20
Appendix 2.15 : Post-mortem report .....	A-23
Appendix 2.16 : Calving problem report .....	A-26
Appendix 2.17 : Calf mortality report .....	A-26
Appendix 2.18 : MAF slaughter report.....	A-27
Appendix 2.19 : Example of computer deer listing.....	A-28
Appendix 2.20 : Velvetting diary.....	A-29
Appendix 2.21 : Body condition chart .....	A-30
Appendix 2.22 : Variables to describe deer-farmer relationships and deer behavioural characteristics .....	A-32

## CHAPTER 3

### DESCRIPTIVE EPIDEMIOLOGY

#### DEER AND FARM CHARACTERISTICS

Appendix 3.1 : Farmer individual characteristics : response to direct questionnaire. ....	A-36
Appendix 3.2 : Farm characteristics : farm areas and altitude, lane, holding paddocks and holding pens. ....	A-37
Appendix 3.3 : Deer-yard characteristics. ....	A-38
Appendix 3.4 : Paddock characteristics on each survey farm in 1992 and 1993. ....	A-39
Appendix 3.5 : Mean paddock characteristics on each survey farm over 1992 and 1993. ....	A-42
Appendix 3.6 : Farm stock reconciliation in June 1992 and 1993. ....	A-43
Appendix 3.7 : Age distribution of hinds and stags on each survey farm in 1992 and 1993. ....	A-44
Appendix 3.8 : Blood line distribution of weaners (<15 months), hinds and stags on each survey farm in 1992 and 1993. ....	A-45
Appendix 3.9 : Deer stock, disease control programme and health problems on survey farms in 1991. ....	A-46
Appendix 3.10 : Monthly average daily minimum and maximum temperatures (°C), total rainfall (mm) and percentage of daily sunshine on each survey farm from March 1 1992 to March 1 1993. ....	A-47
Appendix 3.11 : Monthly average daily minimum and maximum temperatures (°C), total rainfall (mm) and percentage of daily sunshine on each survey farm from March 1 1993 to March 31 1994. ....	A-48

#### FARM MANAGEMENT PRACTICES

Appendix 3.12 : Farmer's deer handling practices and perception of deer behaviour. ....	A-49
Appendix 3.13 : Mating management strategies on each survey farm in 1992. ....	A-50
Appendix 3.14 : Mating management strategies on each survey farm in 1993. ....	A-51
Appendix 3.15 : Culling of yearling and adult hinds (number of hinds and culling percentage) on each survey farm in 1992 and 1993. ....	A-52
Appendix 3.16 : Calving management practices on each farm in 1992 and 1993. ....	A-53
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. ....	A-54
Appendix 3.18 : Entry and removal calendar of yearling hinds on each survey farm in 1992 and 1993. Carcass weights and GR measurements. ....	A-55
Appendix 3.19 : Entry and removal calendar of adult hinds on each survey farm in 1992 and 1993. Carcass weights and GR measurements. ....	A-56
Appendix 3.20 : Entry and removal calendar of yearling stags on each survey farm in 1992 and 1993. Carcass weights and GR measurements. ....	A-58
Appendix 3.21 : Entry and removal calendar of adult stags on each survey farm in 1992 and 1993. Carcass weights and GR measurements. ....	A-59
Appendix 3.22 : Trace element supplementation and vaccination programmes of weaners implemented on each farm in 1992 and 1993. ....	A-60

Appendix 3.23 : Calendar of anthelmintic treatment implemented on weaners (< 15 months) on each farm in 1992. ....	A-61
Appendix 3.24 : Calendar of anthelmintic treatment implemented on weaners (< 15 months) on each farm in 1993 and early 1994. ....	A-62
Appendix 3.25 : Mean pasture cover measurements and paddock observations on each survey farm at each sampling visit during 1992. ....	A-63
Appendix 3.26 : Mean pasture cover measurements and paddock observations on each survey farm at each sampling visit during 1993. ....	A-64
Appendix 3.27 : Calendar of food supplementation given to weaners (3-15 months) from March 1 1992 to April 1 1994. ....	A-65
Appendix 3.28 : Calendar of food supplementation given to hinds (> 15 months) from April 1 to September 1 in 1992 and 1993. ....	A-66
Appendix 3.29 : Calendar of food supplementation given to hinds (> 15 months) from September 1 1992 and 1993 to April 1 the following year. ....	A-67
Appendix 3.30 : Calendar of food supplementation given to stags (> 15 months) from April 1 to September 1 in 1992 and 1993. ....	A-68
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. ....	A-69

## DEER AND FARM PERFORMANCE

### Reproduction

Appendix 3.32 : Bodyweights of yearling hinds mated on each survey farm in 1992 and 1993. ....	A-70
Appendix 3.33 : Bodyweights of adult hinds mated on each survey farm in 1992 and 1993. ....	A-71
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. ....	A-72
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. ....	A-73
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. ....	A-74
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. ....	A-75
Appendix 3.38 : Reproductive performance of yearling hinds on each survey farm in 1992 and 1993. ....	A-76
Appendix 3.39 : Reproductive performance of adult hinds on each survey farm in 1992 and 1993. ....	A-77
Appendix 3.40 : Estimated percentage of blood lines (%), mean and range 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 year 1992 and 1993. ....	A-78

### Weaner bodyweights and growth

Appendix 3.41 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner hinds calculated monthly on each survey farm in 1992. ....	A-79
Appendix 3.42 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner hinds calculated monthly on each survey farm in 1993. ....	A-80



## XXVIII

Appendix 3.43 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner stags calculated monthly on each survey farm in 1992. ....	A-8
Appendix 3.44 : Means, ranges and standard deviations of individual bodyweights (kg) of weaner stags calculated monthly on each survey farm in 1993. ....	A-8
Appendix 3.45 : Means, ranges, standard deviations and quartiles of bodyweights (kg) of weaner hinds and stags, both years 1992 and 1993 combined. ....	A-8
Appendix 3.46 : Growth rates (g/d) of weaner hinds on each survey farm in 1992 and 1993. ....	A-8
Appendix 3.47 : Growth rates (g/d) of weaner stags on each survey farm in 1992 and 1993. ....	A-8
Appendix 3.48 : Mean, ranges and standard deviations, and quartiles of growth rates (g/d) of weaner hinds and stags in 1992, 1993 and both years combined. ....	A-8

### **Velvet antler production**

Appendix 3.49 : Bodyweights (kg) of yearling stags on each survey farm in 1992 and 1993. ....	A-8
Appendix 3.50 : Bodyweights (kg) of adult stags on each survey farm in 1992 and 1993. ....	A-8
Appendix 3.51 : Bodyweight changes (kg) of adult and yearling stags on each survey farm in 1992 and 1993. ....	A-8
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. ....	A-90
Appendix 3.53 : Velvet antler production from adult stags on each survey farm in 1992 and 1993. Percentage of each velvet grade (%), average velvet weight per stag (kg) within each grade and all grade combined, and average corrected velvet weight per stag (kg). ....	A-91

### **Health problems - Mortalities**

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. ....	A-92
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. ....	A-93
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. ....	A-94
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. ....	A-95
Appendix 3.58 : Calculation of progeny loss rates (%) of yearling (<28 months) and adult hinds on each survey farm in 1992, 1993 and both years combined. ....	A-96
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. ....	A-97
Appendix 3.60 : Mortalities due to misadventure from March 1 1992 to April 1 1994. ....	A-98
Appendix 3.61 : Disease history of confirmed or suspected yersiniosis in weaner deer mobs on each survey farm in 1992 and 1993. ....	A-99
Appendix 3.62 : Individual characteristics of deer that died from malignant catarrhal fever and time of occurrence. ....	A-100
Appendix 3.63 : Dystocia occurrences on each survey farm in 1992 and 1993. ....	A-101

## SENTINEL DEER - BIOLOGICAL MARKERS

Appendix 3.64 : Means, ranges and standard deviations of shoulder height (cm), thoracic girth (cm), body condition score, coat length (mm) and coat density (g) of sentinel yearling and adult stags and hinds, and weaner stags and hinds (3-15 months).....	A-102
Appendix 3.65 : Means and standard deviations of the 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. ....	A-103
Appendix 3.66 : Means and standard deviations of the thoracic girth (cm) of sentinel weaners and hinds on each survey farm in 1992 and 1993.....	A-104
Appendix 3.67 : Means and standard deviations of the thoracic girth (cm) and coat length (mm) of sentinel stags on each survey farm. ....	A-105
Appendix 3.68 : Means and standard deviations of the coat length (mm) of sentinel weaners 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. ....	A-106
Appendix 3.69 : Number of sentinel weaners (3-15 months), hinds and stags observed with sign of hair loss and sampled without firm physical restraint, lying, stressed and showing signs of aggression during sampling, respectively, on each survey farm in 1992 and 1993 or both years combined as appropriate. ....	A-107
Appendix 3.70 : Summary of results of statistical analyses of farm, visit and sex effects on blood characteristics of weaner deer (<15 months).....	A-108
Appendix 3.71 : Summary of results of statistical analyses of farm, visit and age effects on blood characteristics of hinds and stags, respectively (>15 months).....	A-109
Appendix 3.72 : Estimates of variance components of blood characteristics of weaners (<15 months) due to year and farm, by visit and by sex (where appropriate). Data from 1992 and 1993 combined. ....	A-110
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. ....	A-111
Appendix 3.74 : Estimates of variance components of blood characteristics of hinds (>15 months) due to year and farm, by visit and by age (where appropriate). Data from 1992 and 1993 combined. ....	A-112
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.....	A-113
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.....	A-114
Appendix 3.77 : Faecal egg and lungworm larval counts (/g) from yearling and adult hinds on each survey farm in March 1992 and 1993. ....	A-115
Appendix 3.78 : Faecal egg and lungworm larval counts (/g) from yearling and adult stags on each survey farm in June 1992 and 1993, and November 1992.....	A-116
Appendix 3.79 : Serological immune response to <i>Yersinia pseudotuberculosis</i> from March to June and from March to September in weaners (3-15 months) on each survey farm in 1992 and 1993. ....	A-117

## CHAPTER 4

### ANALYTICAL EPIDEMIOLOGY

#### RISK FACTORS FOR HIND CONCEPTION

- Appendix 4.1 : Significance level of Chi-square test of association of dichotomous risk factors with the ability of yearling and adult hinds of conceiving early (before May 1) and of conceiving *per se*, respectively, and unadjusted odds ratios (OR).....A-12
- Appendix 4.2 : Range of all values, numbers of cases, means and standard deviations of continuous risk factors screened for association with the ability of yearling hinds of conceiving early (before May 1) and of conceiving *per se*, respectively, in a preliminary univariate analysis, and t-test p values. ....A-12
- Appendix 4.3 : Range of all values, numbers 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) and of conceiving *per se*, respectively, in a preliminary univariate analysis, and t-test p values. ....A-12
- Appendix 4.4 : Range of all values, numbers of cases, means and standard deviations of continuous back-up mob management risk factors screened for association with the ability of yearling and adult hinds of conceiving early (before May 1) and of conceiving *per se*, respectively, in a preliminary univariate analysis, and t-test p values.....A-12
- 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) and of conceiving *per se*, respectively, in a preliminary univariate analysis, and rank sum test p values.....A-125
- 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) and of conceiving *per se*, respectively, in a preliminary univariate analysis, and rank sum test p values.....A-126

#### RISK FACTORS FOR HIND LACTATIONAL STATUS AT WEANING

- 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.....A-127
- 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.....A-128
- 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. ....A-129
- Appendix 4.10 : Range of all values, means and standard deviations of sentinel hind characteristics, and individual 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) and weaning rates of yearling and adult hinds (farm data, Spearman correlation), respectively, in a preliminary univariate analysis. ....A-130

## RISK FACTORS FOR WEANER BODYWEIGHT STANDARDISED TO APRIL 1

- 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.....A-131
- Appendix 4.12 : Means, ranges, standard deviation 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.....A-132
- 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 on April 1 and farm mean weaner stag and hind bodyweight standardised to April 1, respectively, Spearman correlation coefficients and p values. ....A-133

## RISK FACTORS FOR WEANER SEASONAL GROWTH RATES

- 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.....A-134
- 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, Spearman correlation coefficients and p values.....A-135
- 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, Spearman correlation coefficients and p values. ....A-136
- 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, Spearman correlation coefficients and p values. ....A-137
- 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. ....A-138
- 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, Spearman correlation coefficients and p values. ....A-139
- 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, Spearman correlation coefficients and p values. ....A-140
- 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, Spearman correlation coefficients and p values. ....A-141
- 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. ....A-142
- 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, Spearman correlation coefficients and p values. ....A-143

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, Spearman correlation coefficients and p values. ....	A-14
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, Spearman correlation coefficients and p values. ....	A-14
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. ....	A-14
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, Spearman correlation coefficients and p values. ....	A-14
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, Spearman correlation coefficients and p values. ....	A-14
Appendix 4.29 : Interrelationships between mean daily sunshine scores (SUN) and other risk factors potentially associated with weaner hind and stag autumn growth rate. ....	A-14

## RISK FACTORS FOR VELVET ANTLER PRODUCTION

Appendix 4.30 : Means and standard deviations of the velvet antler monetary value of 2-year-old and adult stag (VELV\$) at each level of dichotomous risk factors screened for univariate association with VELV\$ and t-test p values. ....	A-15
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, Spearman correlation coefficients and p values. ....	A-15
Appendix 4.32 : Means, ranges, standard deviations of continuous pre-velvetting grazing management risk factors screened for association with the velvet antler monetary value of 2-year-old and adult stag, Spearman correlation coefficients and p values. ....	A-15
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, Spearman correlation coefficients and p values. ....	A-15
Appendix 4.34 : Means, ranges, standard deviations of mean continuous blood markers screened for association with the farm mean velvet antler monetary value of 2-year-old and adult stag, Spearman correlation coefficients and p values. ....	A-15

## RISK FACTORS FOR HEALTH PROBLEMS

### Yersiniosis

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. ....	A-15
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. ....	A-15

## **Malignant catarrhal fever**

- Appendix 4.37 : Range of all values, means and standard deviations of continuous risk factors screened for association with hind dying from malignant catarrhal fever in winter (June - August) in a preliminary univariate analysis, and rank sum test p values. ....A-158
- Appendix 4.38 : Range of all values, means and standard deviations of continuous risk factors screened for association with stag dying from malignant catarrhal fever from winter to summer (MCF) in a preliminary univariate analysis, and rank sum test p values. ....A-159
- 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. ....A-160

## **Dystocia**

- 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. ....A-161
- Appendix 4.41 : Significance level of univariate Chi-square test of association between dichotomous risk factors and hinds experiencing dystocia and corresponding unadjusted odds ratios. ....A-161



## 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 outcomes 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 bodyweight of weaner standardised on April 1 within 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 faecal 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 have 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.



## ACKNOWLEDGMENTS

I would like to express my sincere appreciation to my chief supervisor Assoc. Prof. P.R. Wilson and co-supervisor Prof. R.S. Morris for their guidance in research and their everwilling co-operation and encouragement throughout the research period. Furthermore, they helped provide all facilities in the Department of Veterinary Clinical Sciences, Massey University, Palmerston North.

As importantly, I express a sincere debt of gratitude to the farmers, their staff and families who have laboured so intensively to help provide the data and physical resources necessary for this study. It has been a major commitment which has been serviced outstandingly. They were: Andy Law, Taihape; Barry Bryant, Dannevirke; Bill Curtis, Palmerston North; Dan von Dadelszen and Paul, Waipukurau; David Johnston, Wanganui; Hugh Williams and Ken Rowe, Waipawa; Ian Walker and Keith Burden, Waipukurau; Joe Fouhy, Pahiatua; John and Robert Bruce, Taihape; John Spiers and John Parrant, Takapau; Leo Hawkins, Eketahuna; Neil Mercer, Pahiatua; Owen Cowie, Pahiatua; Shane Carroll, Pohangina; Stanley Cull, Foxton; Ted Bibby, Onga Onga; Tim Hope, Takapau. I also acknowledge the 92 farmers who responded to the initial survey requesting expression of interest in participating in this study.

I appreciated the excellent technical assistance of Vanessa Tilson, Louise Craigie, Alyson Illingworth, Donna O’Dea, Kate Bertham, Christine McArthur and the help of fellow students, Jos Biemans, Ian Hodge, Jan Spoorenberg, Vera Weilburg and Wallace Wong.

I also thank Dr. Colin Mackintosh, Dr. Jimmy Suttie, Prof. Tom Barry, Dr Sabina Holle, deer farmer John Bruce, deer farmers Leo and Molly Hawkins, and my dear friend Kathy Gibson for their assistance in proof reading part of the manuscript.

I am particularly grateful to Drs. Philippe Chardonnet, Dominique Planchenault and Pierre Charles Lefèvre of the Centre for International Research for Agronomic Development (CIRAD-EMVT), Department of Livestock production and Tropical Veterinary Medicine, Maisons-Alfort, Paris, France, who provided me the moral and financial support to allow me to come to New Zealand and carry out this project.

Service Providers were :

- MAF Animal Health Laboratories for pasture and trace element analyses
- Massey University, Dept. Veterinary Pathology and Public Health for Clinical Pathology, equipment, postmortems and access to the leptospirosis laboratory
- AgResearch Invermay and the Deer Research Laboratory, Otago for yersinia serology
- Massey University Dept. Physiology and Anatomy for pepsinogen assays
- Massey University Animal Science Department for feed nutrient analyses
- Massey University Soil and Lime Research Centre for soil analyses

Funding Providers were :

- Chief Funder : New Zealand Game Industry Board, direct research costs
- Embassy of France, postgraduate scholarship
- CIRAD-EMVT, France, postgraduate expenses
- Rhône Mérieux, research costs
- Deer Branch of the New Zealand Veterinary Association, research costs (leptospirosis)
- Pitman Moore, research costs
- Cyanamid NZ Ltd, research costs
- Massey University Research Fund, research costs (necropsies)

Product and service contributions came from :

- Dr. Colin Mackintosh and Assoc. Prof. Frank Griffin, serology
- Te Pari Products, animal identification
- Allflex New Zealand Ltd, animal identification
- New Zealand Employment Service, technical assistance
- Massey University, study facilities and equipment
- Wanganui Polytechnic, Terry Speake, Jasni Ishak and Rachel Lyons, presentation design and production
- New Zealand Deer Farmers Association, survey mailing lists

Professional assistance and advice were given by :

- Dr. Colin Mackintosh, Ag-research Invermay, New Zealand, advice on study design and deer health
- Dr. Jimmy Suttie, Ag-research Invermay, New Zealand, advice on velvet production
- Barry Butler, BM Computing Ltd, Palmerston North, New Zealand, computing
- Dr. Dirk Pfeiffer, Dept. Veterinary Clinical Sciences, Massey University, New Zealand, data management and analysis
- Dr. Brent Paterson, Dept. Veterinary Clinical Sciences, Massey University, New Zealand, computer setup and data management
- Dr. Hugo Alvarez, Computing Services, Massey University, New Zealand, statistical advice
- Prof. Ian Dohoo, Atlantic Veterinary College, University of Nova Scotia, Prince Edward Island, Canada, epidemiological advice
- Prof. Tom Barry, Animal Science Dept, Massey University, New Zealand, advice on nutrition and weaner production
- Dr. Guy Rosner and staff, Center of Animal Ecopathology, Lyon, France, epidemiological and statistical advice

<b>TABLE OF ABBREVIATIONS AND UNITS</b>
---

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	nmol/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
<b>Anthelmintics</b>		
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 <sup>†</sup>	SMD	Synanthic Mini Dose
	SMS	Synanthic Mini Dose + Selenium
	SYS	Systemex Sheep & Cattle
	SYC	Systemex Low Dose Cattle
SmithKline Beecham Animal Health	VAL	Valbazen
	VMD	Valbazen Mini Dose
<b>Copper supplements</b>		
Pitman-Moore New Zealand Ltd <sup>†</sup>	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)
<b>Vaccines</b>		
Pitman-Moore New Zealand Ltd <sup>†</sup>	LPC	Leptavoid 3
	VAC <sup>‡</sup>	5-in-1 clostridial vaccine
AgVax Developments Ltd	YER	Yersiniavax

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

<sup>†</sup> now Mallinckodt Veterinary New Zealand Ltd

<sup>‡</sup> 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
AVMT	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 $\geq$ 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 $\geq 8 \mu\text{mol/l}$
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
DRENCHI	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 $\geq 3 \text{ kIU/l}$
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 B12 concentration $\geq 185$ 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 $\geq 8$ $\mu\text{mol/l}$
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 $\geq 3$ 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 1 within 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 <i>Yersinia pseudotuberculosis</i> type I, II or III
SEROYERS	2.36	Maximum seroprevalence (increase of 20 Unit OD between March and September) against <i>Yersinia pseudotuberculosis</i> 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 apart ( 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

### Refereed publications

1. Audigé L.; Wilson P.R. and Morris R.S. (1993) Deer herd health and production profiling in New Zealand. 1. Study design. *Veterinary Research*, 25: 126-129
2. Audigé, L.; Wilson, P.R. and Morris, R.S. (1994) Deer herd health and production profiling in New Zealand. 2. Preliminary results. *Veterinary Research*, 25: 258-262
3. Thompson K.G., Audigé L., Arthur D.G., Julian A.F., Orr M.B., McSparran K.D. and Wilson P.R. (1994) Osteochondrosis associated with copper deficiency in young farmed red deer and wapiti x red deer hybrids. *New Zealand Veterinary Journal* 42: 137-143
4. Audigé, L.J.M.; Wilson, P.R.; Morris, R.S., and Pfeiffer, D.U. (1994) Herd health and production profiling as an epidemiologic tool for the study of farmed deer in New Zealand. in: *Proceedings of the 7th International Symposium on Veterinary Epidemiology and Economics*, edited by Rowlands G.J., Kyule M.N. and Perry B.D., Nairobi, Kenya, *The Kenya Veterinarian*, 18 (2) :344-346
5. Audigé L.J.M.; Wilson P.R.; Morris R.S. and Davidson G.W. (1995) Osteochondrosis, skeletal abnormalities associated with copper deficiency in farmed red deer (*Cervus elaphus*). *New Zealand Veterinary Journal*, in press

### Not refereed publications

#### Contributions to the journal "The Deer Farmer"

1. Audigé L. (1992) Fatal disease for farmed deer : should sheep take the blame for MCF ? *The Deer Farmer*, 95: 45-47
  2. Audigé L. (1992) The winter weaner disease : yersiniosis - a high cost illness. *The Deer Farmer*, 96: 49-51
  3. Audigé L. (1992) Lungworm advice coughed up : worm presence may indicate standard of management. *The Deer Farmer*, 97: 72-75
  4. Audigé L. (1993) The inside story on internal parasites : right conditions must prevail. *The Deer Farmer*, 98: 51-54
  5. Audigé L. (1993) Vaccinations for bacterial diseases : one way to improve herd welfare. *The Deer Farmer*, 99: 42-44
  6. Audigé L. (1993) Ticks are the main external parasite problem - New Zealand is relatively safe from the rest. *The Deer Farmer*, 102: 43-45
  7. Audigé L. (1993) Johnes' disease not as common in deer - Sheep and cattle can pass it on. *The Deer Farmer*, 103: 33-37
  8. Audigé L. (1993) Wapiti more susceptible to ryegrass staggers - Disease can be widespread in NZ. *The Deer Farmer*, 104: 33-35
  9. Audigé L. (1993) Sticks and stones. A lack of copper can do much worse than break a few bones - it may lead to an outbreak of osteochondrosis. *The Deer Farmer*, 105: 49-51
- Paper reprinted in the journal *Deer Farming*, 42: 23-24
10. Audigé L. (1993) Facial eczema in deer. *The Deer Farmer*, 106: 49-51
  11. Audigé L. (1993) Leptospirosis. *The Deer Farmer*, 107: 49-53
  12. Audigé L. (1993) Wasting away. *The Deer Farmer*, 109: 43-45

### Conference Proceedings

13. Audigé, L.J.M.; Wilson, P.R.; Morris, R.S., and Davidson, G.W. (1993) A case report : preliminary observations of severe clinical copper deficiency in farmed red deer (*Cervus elaphus*). in: *Proceedings of a Deer Course for Veterinarians*, edited by Wilson P.R., Deer Branch of the New Zealand Veterinary Association, No 10 :66-77
14. Audigé, L.J.M.; Wilson, P.R., and Morris, R.S. (1993) Deer Herd Health and production profiling : the method. in: *Proceedings of a Deer Course for Veterinarians*, edited by Wilson P. R., Deer Branch of the New Zealand Veterinary Association, No 10 :78-100



15. Audigé, L.J.M.; Wilson, P.R., and Morris, R.S. (1993) Deer Herd Health and production profiling : preliminary results. in: *Proceedings of a Deer Course for Veterinarians*, edited by Wilson P. R., Deer Branch of the New Zealand Veterinary Association, No 10 : 101-114
16. Audigé, L.J.M.; Wilson, P.R.; Morris, R.S. and Pfeiffer, D.U. (1994) Deer mortality profile. in: *Proceedings of a Deer Course for Veterinarians*, edited by Wilson P. R., Deer Branch of the New Zealand Veterinary Association, No 11: 251-256
17. Audigé, L.J.M.; Wilson, P.R.; Morris, R.S. and Pfeiffer, D.U. (1994) Risk factor for adult hind conception. in: *Proceedings of a Deer Course for Veterinarians*, edited by Wilson P. R., Deer Branch of the New Zealand Veterinary Association, No 11: 278-293
18. Audigé, L.J.M.; Wilson, P.R. and Morris, R.S., and Pfeiffer, D.U. (1994) Risk Factors for weaner deer bodyweight. in: *Proceedings of a Deer Course for Veterinarians*, edited by Wilson P.R., Deer Branch of the New Zealand Veterinary Association, No 11: 318-326
19. Audigé, L.J.M.; Wilson, P.R. and Morris, R.S. (1994) Deer herd health and production profiling I. The concept. in: *Proceedings of the Third International Congress on the Biology of Deer*, Edinburgh, Scotland, in press
20. Audigé, L.J.M.; Wilson, P.R. and Morris, R.S. (1994) Deer herd health and production profiling II. Risk factors for health problems. in: *Proceedings of the Third International Congress on the Biology of Deer*, Edinburgh, Scotland, in press

### **Poster presentations**

1. Audigé, L.J.M.; Wilson, P.R. and Morris, R.S. (1994) Deer herd health and production profiling. III. Factors affecting growth to weaning. in: *Proceedings of the Third International Congress on the Biology of Deer*, Edinburgh, Scotland, in press
2. Audigé, L.J.M.; Wilson, P.R. and Morris, R.S. (1994) Deer herd health and production profiling. IV. Key factors for reproductive success of adult hinds. In: *Proceedings of the Third International Congress on the Biology of Deer*, Edinburgh, Scotland, in press



L. Aulige  
Jan. 95