A STUDY OF REGIONAL DIFFERENCES IN WITHIN-FLOCK SOURCES OF VARIATION IN SHEEPLAN RECORDS OF PRODUCTION TRAITS FOR COOPWORTH SHEEP

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ABSTRACT

Performance records on 219,000 ewes and 231,000 lambs from 48 Coopworth flocks were obtained from Sheeplan files. The flocks were divided into 5 climatologically similar regions: Northland; north of Taupo excluding Northland; remainder of the North Island; the South Island north of Palmerston, excluding the West Coast; the South Island south of Palmerston. Flock records were edited in an effort to remove recording errors.

Within-flock environmental estimates were obtained using ordinary least squares procedures for continuous characters or iterative weighted least squares for binomial characters. The within-flock estimates were weighted by the inverse of their standard error's and weighted means of the regional and national fixed effects were obtained. Paternal half-sib heritability estimates were obtained for each flock.

There were few significant differences in the environmental estimates between regions.

The traits examined (with the average of the heritability estimates) were: weaning weight (0.17); ram autumn liveweight (0.24); ewe autumn liveweight (0.26); ram winter liveweight (0.26); ewe winter liveweight (0.31); ram spring liveweight (0.29); ewe spring liveweight (0.34); ram hogget fleece weight (0.29); ewe hogget fleece weight (0.33); survival of all lambs (0.04); single lamb survival (0.05) and multiple lamb survival (0.05); proportion of a ewe's lambs surviving (0.04); number of lambs born to a ewe present at mating (0.12); number of lambs weaned per ewe lambing (0.07); given a ewe lambed, did she bear multiples (0.14); weight of lamb weaned per ewe rearing lambs (0.10). Selection and non-random mating may have biased the estimates.

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CHAPTER ONE

INTRODUCTION

The analyses of the effects of various environmental and genetic effects leads to a greater understanding of factors that underlie variation in animal performance. Correcting records for non-genetic sources of variation can improve the accuracy of estimates of genetic effects. Heritabilities estimated after correction should be larger than would otherwise be the case.

There has been a world wide upsurge in sheep recording schemes (Owen, 1971). These schemes involve sheep breeders forwarding data on their flocks to a central processing facility. The data are adjusted for known sources of environmental variation. Breeding values for important traits and an overall estimate of the animals' aggregate breeding value are predicted from the adjusted data.

With the New Zealand flock recording scheme, Sheeplan, the majority of environmental adjustments are overall corrections (i.e. across all flocks and years), as opposed to within-year-within-flock corrections. This assumes that adjustment factors for dual purpose sheep are constant across locations, breeds, flocks and years.

The objective of this study is to compare environmental factors and heritabilities for productive traits estimated within some Coopworth flocks, with Sheeplan adjustments and other published estimates. These estimates will also be compared to ascertain if region should affect the magnitude of the adjustments.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 INTRODUCTION

In terms of control of unwanted variation correction factors may be regarded as "statistical controls" as distinct from "physical control" (Lush and Shrode, 1950) where the endeavour is to keep the environment constant. Both these types of control are intended to eliminate variation caused by circumstances thought not to be important to the question being investigated. Physical control is expensive, frequently impossible and far from perfect. Statistical control can also be imperfect and can only correct for known sources of environmental variation (Lush and Shrode, 1950). Not all the variation from a given source may be removed by statistical control. If, for example, the effect varies from one observation to the next, only the average effect will be removed (Koch and Clarke, 1955). But, as Koch and Clark (1955) noted, any variation eliminated increases the accuracy with which real differences between animals can be assessed.

Turner and Young (1969) stated that if no corrections were made for environmental effects a lower genetic selection differential may result. This may occur as genetically superior animals may be culled because of their lowered phenotypic value due to environmental handicaps (for example, being reared as a multiple or reared by a young dam). Turner and Young (1969) noted that if those animals culled on their phenotype are multiples, and a selection objective includes increasing the incidence of multiple births, then multiples are effectively being selected against. Similarly, the rejection of progeny from young dams will tend to increase the generation interval and decrease the genetic merit, as those animals culled may have a higher generation number for the trait required than progeny of older dams (Turner and Young, 1969).

2.2 METHODS OF ESTIMATING CORRECTION FACTORS

The procedures used for the estimation of environmental adjustment factors should have several desirable features. These are (Eikje and Johnson, unpub.):-

"i) the effects adjusted for should be completely environmental in origin.

ii) provided there is no confounding between environmental and genetic effects the adjustments should make the means of the adjusted groups (age-of-dam, sex groups etc) equal.

iii) the adjustments should also equalize variances in the different adjusted groups provided differences in variance are not due to genetic effects.

iv) the adjustments should take into account possible between flock and year variation in the magnitude of environmental effects.

v) the adjustments should take into account possible within flock and year interactions among environmental effects.

vi) the records made in different environmental subclasses should genetically express the same trait: interactions between genotype and environmental effects must be unimportant" and the same genes should control the traits - in the different environments.

2.2.1 Statistical Procedures

The majority of authors have used least squares procedures to estimate environmental effects (for example, Ch'ang and Rae, 1961; Eikje, 1971a,b; Hight and Jury, 1971; Baker *et al* 1974a,b; Gregory *et al*, 1977; Nicoll and Rae, 1977, 1978).

Ordinary least squares (OLS) procedure was first utilized for animal breeding analysis by Yates (1934, cited by Hazel, 1946) and Hazel (1946). Harvey (1960) popularized the methodology. The procedure, summarized by Searle (1971) involves choosing an estimator that minimizes the sum of squares of deviations from their expected values.

For the model,

$$\underset{\sim}{y} = \underset{\sim}{X}\underset{\sim}{b} + \underset{\sim}{e}$$

where $\underset{\sim}{y}$ is an N x 1 vector of observations

$\underset{\sim}{b}$ is a p x 1 unknown vector of fixed effects

$\underset{\sim}{X}$ is an N x p design matrix

$\underset{\sim}{e}$ is a N x 1 vector of random residual terms distributed with mean $\underset{\sim}{0}$ and variance $\sigma^2\underset{\sim}{I}$

$(\underset{\sim}{y} - \underset{\sim}{X}\underset{\sim}{b})' (\underset{\sim}{y} - \underset{\sim}{X}\underset{\sim}{b})$ is minimized with respect to $\underset{\sim}{b}$. The resulting solution is

$$\underset{\sim}{b}^o = (\underset{\sim}{X}'\underset{\sim}{X})^- X'y$$

where

$\underset{\sim}{X}'$ is the transpose of $\underset{\sim}{X}$

$(\underset{\sim}{X}'\underset{\sim}{X})^-$ is a generalised inverse of $\underset{\sim}{X}'\underset{\sim}{X}$.

Henderson (1972) illustrated the use of generalized least squares (GLS) procedures for estimating environmental effects. The GLS procedures (as summarized by Searle, 1971) assumes that the variance-covariance matrix of the residual terms is $\underset{\sim}{V}$. The term $(\underset{\sim}{y} - \underset{\sim}{X}\underset{\sim}{b})' \underset{\sim}{V}^{-1} (\underset{\sim}{y} - \underset{\sim}{X}\underset{\sim}{b})$ is minimized with respect to $\underset{\sim}{b}$. The resulting solution vector is

$$\tilde{\underset{\sim}{b}}^o = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^- \underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{y}$$

Clearly when $\underset{\sim}{V} = \sigma^2\underset{\sim}{I}$, OLS and GLS are equal.

The major advantage of least squares estimation procedures is that no assumption is made about the form of the distribution of the random residual terms in the model (Searle, 1971).

Miller _et al_ (1966) were among the first to use maximum likelihood procedures to estimate environmental effects. Maximum likelihood procedures (as summarized by Searle, 1971) require an assumption be made about the distribution of the residual errors (usually that they are normally distributed). The parameters are then estimated by maximizing the $\log_e$ of the likelihood function. Thus, assuming the $\underset{\sim}{e}$'s are normally distributed with mean zero and variance-covariance matrix $\underset{\sim}{V}$ the likelihood is

$$L = (2\pi)^{-\frac{1}{2}N} / \underset{\sim}{V} /^{-\frac{1}{2}} \exp\{-\tfrac{1}{2}(\underset{\sim}{y}-\underset{\sim}{X}\underset{\sim}{b})' \underset{\sim}{V} (\underset{\sim}{y}-\underset{\sim}{X}\underset{\sim}{b})\}$$

Maximising $\log_e L$ with respect to $\underset{\sim}{b}$ gives the solution as

$$\underset{\sim}{b}^o = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^- \underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{y}$$

which is the same as the GLS solution (Searle, 1971). In situations where repeated observations are collected and selection on the basis of the magnitude of earlier performance has occurred, maximum likelihood techniques are appropriate (Henderson, 1949). Maximum likelihood techniques make use of both within-animal and among-animal differences, thus being more efficient than the least squares estimates (Miller _et al_, 1966).

Miller _et al_ (1966) noted that for age effects on both milk and fat yields in dairy cows, maximum likelihood estimates (MLE) were theoretically more accurate than least squares procedures in data where culling on the basis of early performance occurred. Neville _et al_ (1974) reported OLS and maximum likelihood procedures gave similar estimates for milk production of Hereford cows, but the MLE had smaller standard errors. Both procedures gave similar age-of-dam estimates and standard errors for the sex of calf effect.

Henderson (1972) showed that solutions to mixed model equations results in best linear unbiased estimates (BLUE) of the fixed effects. Several authors have estimated BLUE's of fixed effects (e.g. Nicoll and Rae, 1978; Blair, 1981; Tait, 1983). Searle (1971), in summarizing the methodology, shows that the

$$\text{b.l.u.e. of } \underset{\sim}{b} \text{ is } \tilde{\underset{\sim}{b}}^{o} = (\underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{X})^{-} \underset{\sim}{X}'\underset{\sim}{V}^{-1}\underset{\sim}{y}.$$

This is identical to the GLS estimator and the MLE (assuming normality) of $\underset{\sim}{b}$.

The majority of authors, when estimating environmental effects, fit age of the animal (in days) as a covariate, and the remainder of the effects in discrete categories (for example, Koch and Clark, 1955; Koch et al 1959; Brinks et al 1961; Bosman and Harwin, 1966; Cundiff et al 1966 ; Eikje, 1971a,b; Nicoll and Rae, 1977, 1978; Baker et al 1979; Newman et al 1983). Marlowe et al (1965) subdivided age-of-calf effects into seven 30 day periods, when assessing non-genetic influences on average daily gain and type score and fitted age-of-calf in discrete categories.

2.2.2 Multiplicative and Additive Adjustments

Once the environmental estimates are obtained they can be formed into either additive or multiplicative adjustments. Records are additively adjusted to a common base "by adding the differences between the mean values" of the base and remaining subclasses (Brinks et al, 1961). Multiplicative adjustments are the ratios of the mean value of a subclass to a base subclass (Brinks et al, 1961). Jury et al (1979) and Bosman and Harwin (1966) analysed logarithmic values of lamb weaning weight and beef cattle pre-weaning traits, respectively, to obtain multiplicative adjustments.

Additive correction factors are used when the differences between subclass means are constant over time (Schaeffer and Wilton, 1974b). The phenotypic records are adjusted to a common environmental influence by adding the correction factor.

When the difference between the subclass means changes proportionally with changes in the means, multiplicative corrections should be used (Schaeffer and Wilton, 1974). The phenotypic record is multiplied by the correction factor, adjusting the records to a common environmental influence.

Additive correction factors will not alter the variance of the subclasses, whereas multiplicative factors do alter the subclass variances (Brinks *et al*, 1961; Cundiff *et al*, 1966b; Eikje, 1971a).

Lush and Shrode (1950) noted that age correction factors for milk fat production could be either gross age comparisons (averages of all records made at each age) or successive age comparisons (records made by the same cows at two successive ages are compared). They suggested that the former procedure may underestimate the age effect because some of the animals with a low producing ability would normally be culled at each age. A disadvantage of the latter is that it will overestimate the age effect if concurrent selection is occurring (Lush and Shrode, 1950). Koch and Clark (1955) suggested the two procedures could be combined by weighing the estimates by p/(1-p), where p is the repeatability of adjacent records.

2.3 EVALUATING METHODS OF ESTIMATING CORRECTION FACTORS

2.3.1 Equalize Means and Variances

The equalization of the means of the subclasses and the within-subclass variances are common criteria for assessing the effectiveness of correction factors (Nicoll and Rae, 1977).

Cundiff *et al* (1966) and Linton *et al* (1968) utilized this criterion to assess whether to adjust beef cattle weaning weights additively or multiplicatively. They found that additive adjustments for season of birth equalized variances within subclasses, as did multiplicative adjustments for sex. Nicoll and Rae (1977) found multiplicative adjustment for sex of calf was satisfactory for Hereford animals, but failed to fully equalize variances for Angus animals. Cundiff *et al* (1966) noted neither additive nor multiplicative adjustments for age-of-dam equalized the within subclass variances but additive adjustments did not result in large divergence as did multiplicative. Nicoll and Rae (1977) reported similar findings. Linton *et al* (1968) found multiplicative adjustments for age-of-dam most satisfactory using this criterion.

To assess the most accurate adjustment of the nine they proposed for lamb weaning weight Eikje and Johnson (unpublished) used as one of their criteria, the equalization of means and variances. They noted an adjustment that corrected for lamb age at weaning, deviated the corrected weight from the corresponding flock x year x age-of-dam x sex x birth-rearing rank subclass, and "multiplied by the ratio between the standard deviation in the base group and the standard deviation in the group to which the animal belongs" equalized the subclass means perfectly. It also gave the "smallest coefficient of variation (CV) of subclass variances."

Searle and Henderson (1960) stated that the use of CV as criterion for judging age correction factors can be questioned. If the CV is to be a criterion of judgment, then the question, "is retaining a constant CV one of the purposes of age-correcting factors?" must be answered "yes." Searle and Henderson (1960) note that the same criterion should apply to other types of corrections, for example environmental trends. This they thought to be "unreasonable."

2.3.2 Heritabilities

The heritability of a trait can be defined as (Rae, 1982):

$$h^2 = \frac{Vg}{Vx}$$

where

Vg is the additive genetic variance

Vx is the total observed variance.

Assuming a completely additive model,

$$Vx = Vg + Ve$$

where

Ve is the environmental variance.

Thus, by minimizing the non-genetic sources of variation, the heritability estimate of a trait should be increased.

Several authors have noted an increase in the estimated heritability of traits adjusted for known environmental effects (for example, Shelton and Campbell, 1962; Baker et al, 1979). Eikje and Johnson (unpublished) suggested that higher paternal half-sib heritability estimates may arise due to the adjustment method not removing possible systematic differences among progeny groups. These systematic differences are more likely to arise in commercial flocks than in research flocks kept to estimate genetic differences (Eikje and Johnson, unpublished). Lower heritability estimates after adjustment may indicate the adjustment method reduced the genetic variation present, the heritability estimate then being biased downwards (Eikje and Johnson, unpublished). If correction factors involve expressing the records as deviations from contemporary averages, the heritability estimates may also be biased downwards (Eikje, 1974).

Eikje and Johnson (unpublished) and Gregory et al (1977) reported heritability estimates calculated on unadjusted records were greater than estimates obtained from adjusted data.

2.3.3 Intra-Class Regression and Correlation Coefficients

Searle and Henderson (1960) stated that if age correction factors are expected to remove herd x year interaction, then individual within herd-year regression of butter fat production on cow age (in months) will vary little about their means for records so corrected. They reported that the mean weighted regression was significantly different from zero for actual and multiplicatively corrected records, but for additive adjustments and adjustments taking into account the level of herd production, the regressions were not significantly different from zero.

Nicoll and Rae (1978) regressed within herd-year-age-of-dam adjusted beef cattle 18 month weights on age at weaning to evaluate three adjustment procedures. They noted that both additive and multiplicative within subclass regression coefficients of age on weight were most effective in reducing the dependence of weight on age. The corrections used by the National Beef Recording Scheme (MAF, 1973, cited by Nicoll and Rae, 1978) were least effective.

The intra-class regression of beef calf weaning weight on age at weaning was used by Minyard and Dinkel (1965) to assess the effectiveness of additive and multiplicative corrections and compare these to non-adjusted weights. Multiplicative and additive corrections showed substantial reductions in the regression coefficient over no adjustment. The greatest reduction was shown by multiplicative adjustment of age weaned, but the difference was small.

Gregory _et al_ (1977) estimated a "genetic" correlation coefficient between age of lamb and corrected weight, expecting the coefficient to be zero if the data had been corrected satisfactorily and random mating had occurred.

Eikje and Johnson (unpublished) reasoned that if lamb weaning weight was not adequately adjusted for environmental effects, there may still be variation present among years within sires which may arise from correlations among mates and from sire x year interaction. Eikje and Johnson (unpublished) estimated the within sire correlation among half-sibs born in the same year as:

$$r_1 = \frac{Vy}{Vy + Ve}$$

where

Vy is the between years within sire variance component

Ve is the between progeny within sires and years variance component.

The correlations were then averaged over flocks and compared, the smallest correlation being optimum. Eikje and Johnson (unpublished) reported that the procedure of additively correcting for age of lamb and expressing the weights as deviations from the mean of the corresponding flock x year x age-of-dam x sex x birth-rearing rank subclass was the optimum lamb weaning weight adjustment procedure using this criterion.

2.3.4 Repeatability

Searle and Henderson (1960) studied the effect of different age correction factors on repeatability of dairy production records. They noted that as repeatability is a measurement of the relationship of an animals production from one year to the next, it is unconnected with the true purpose of age correction factors. The true purpose of age-correction factors is estimating what a young animal would have produced had she been mature, not with what a young animal will produce when she eventually is mature, as repeatability suggests (Searle and Henderson, 1960).

Eikje and Johnson (unpublished) evaluated the effectiveness of correction factors using the repeatability of progeny performance. The repeatability was estimated as the correlation between half sibs in different years. This correlation was calculated as:

$$r_2 = \frac{Vs}{Vs + Vy + Ve}$$

where

Vy and Ve have been described previously

Vs is the between sires variance component.

Using this method of evaluation, combined additive and multiplicative, and straight multiplicative (except for weaning weight) correction factors were the most effective. Multiplicative adjustment, including multiplicative adjustment for weaning age, was the least effective. (Eikje and Johnson, unpublished).

In an effort to overcome possible correlations among environmental effects, and to combine the information provided by r_1 and r_2 , Eikje and Johnson (unpublished) calculated the ratio r_2/r_1. They reported, using this criterion, that when lamb weaning weights were first adjusted additively for weaning age, then a combination additive-multiplicative adjustment was applied or straight multiplicative adjustment was applied, the ratio of r_2/r_1 was maximized.

2.3.5 Herd-by-Age Variance Components

Searle and Henderson (1960) proposed this evaluation procedure as it was thought desirable that age correction factors should take into account any interaction that may exist between herd environment and the effect of age on production. Searle and Henderson (1960) reported, using this criterion, that herd-level age adjustments are a little better than multiplicative age adjustments in reducing the herd x age interaction variance. Searle and Henderson (1960) noted that, "the suggested criterion, while being a desirable adjunct for any set of age-correction factors, is not sufficient as a role method of judging between sets of factors."

Eikje and Jury (unpublished) reported that, "it seemed difficult to establish a single criterion which would be markedly better than any other criterion. However, it was thought that the results from a number of different evaluation methods taken together might enable some conclusions to be drawn."

2.4 ENVIRONMENTAL ESTIMATES FOR NEW ZEALAND DUAL PURPOSE BREEDS

2.4.1 Weaning Weight

The environmental estimates across breeds for weaning weight (Table 2.1) appear to be in general agreement. Within the Romney breed, Wewala's (1984) estimate for sex is greater than previous estimates. The estimates for dam age appear to be of similar magnitude except for estimates by Wewala (1984) and Newman *et al* (1983). Wewala (1984) included a maternal component in the model, which may explain why the results obtained differ from other estimates.

2.4.2 Later Liveweights

The environmental estimates of later liveweight traits (Table 2.2) appear to be quite variable across authors and thus across flocks. When the estimates are compared within authors the effect of BRR decreases with age and the sex difference increases with age. The effect of dam age is variable across the month weighed, but it appears to decrease with age, albeit slowly. The date of birth/age weighed covariates appear to be in general agreement with the exception of Tait's (1983) ram November weight estimate, which is extremely large. There appears to be sex differences in the environmental estimates, with the rams generally having larger estimates than the ewes.

Table 2.1: Environmental Estimates for the New Zealand Romney and Romney based breed

Breed	Romney							
Author	1	2[b,c]	3[b]	4	6	7	8	8
BRR								
SS - TwS	3.03	1.3	1.64	2.5	2.0	1.45	1.43	1.93
SS - TwTw	4.64	4.2	4.41	4.2	4.2	3.59	3.55	3.90
SS - TrS								
SS - TrTw								
SS - TrTr								
Dam Age								
4-2 year old	2.01	2.0	2.04	1.3	1.3	2.13	0.53	-0.36
4-3	0.75	0.4	0.59	0.2	0.3	0.19	0.04	-1.04
4-5	-0.15		0.22		-0.2	0.45		
4-6					0.6			
3-2								
Sex								
M-F	1.38[a]		1.58	1.9	2.1	1.68	1.61	1.30
Age at Weaning (kg/d)	0.13	0.12		0.12	0.17		0.18	0.16
Date of birth			0.17			-0.16[d]		

a. wether-ewe b. converted from lbs to kgs c. ewe lambs only
d. pooled over years e. rearing rank - Single-Twin

S = Single Tw = Twin Tr = Triplet M = Male F = Female

1. Ch'ang and Rae (1961); 2. Ch'ang and Rae (1970); 3. Lundie (1971);
4. Baker et al (1974a); 5. Elliott (1975); 6. Jury et al (1979);
7. Tait (1983); 8. Newman et al (1983); 9. Wewala (1984);
10. Gregory (unpublished)

Table 2.1 (continued)

Breed	Romney	Perendale			Coopworth		
Author	9	5	7	8	8	8	10
BRR							
SS - TwS	1.98		2.23	2.88	2.20	1.69	2.53
SS - TwTw	4.20	4.20[e]	4.19	4.70	4.34	5.06	4.94
SS - TrS							3.95
SS - TrTw							6.32
SS - TrTr							7.35
Dam Age							
4-2 year old	1.19	1.44	0.71	1.26	1.58	0.25	
4-3	-0.22	0.53	1.08	0.22	0.22	1.08	
4-5	-0.01	0.0					
4-6							
3-2							1.72
Sex							
M-F	3.61[a]		2.15	2.05	1.64	1.84	2.23
Age at weaning (kg/d)	0.16		0.18	0.13	0.07	0.09	0.22
Date of birth							

Table 2.2: Liveweight environmental estimates for the New Zealand Romney and Romney based breeds

Breed	Romney																Peren.
Month weighed	Feb.	Mar.	April		June			July	August		October			November			Oct.
Author	3	2[a]	6[a]	6[b]	2[a]	6[a]	6[b]	3	6[a]	6[b]	1[a]	2[a]	5[c]	3	6[a]	6[b]	4
BRR																	
SS-TS	2.3	1.3	1.10	0.65	1.3	0.80	0.30	1.4	0.90	0.43	0.35	1.8	-	1.4	0.52	0.03	
SS-TT	3.1	3.1	2.24	3.09	2.7	1.75	2.27	2.1	1.74	2.18	2.22	2.2	1.16[d]	2.1	1.05	1.62	2.12[e]
Dam Age																	
4-2	1.3	1.9	0.96	2.33	2.4	0.74	1.66	0.9	1.13	1.46	1.71	2.4		1.2	-0.69	1.3	0.98
4-3	0.2	0.5	-0.13	0.31	0.9	-0.24	0.25	0.1	-0.02	0.30	0.81	1.0	-	0.2	-1.70	0.43	0.35
4-5	-	-	0.49	1.02	-	0.67	0.67	-	0.88	0.74	-	-	-	-	-1.01	0.38	-0.13
Sex																	
R-E	3.7	-	-	-	-			4.4	-	-	-		-	10.8	-	-	-
Age weighed	0.13	0.10	-	-	0.19	-	-	0.08	-	-	-	0.18	-	0.05	-	-	-
DOB[f]	-	-	-0.13	-0.19	-	-0.13	-0.18	-	-0.12	-0.20	-0.23	-	-	-	-0.10	-1.11	-

a. Ewes only
b. Rams only
c. Pooled across sire groups
d. Birth rank
e. Rearing rank
f. Date of birth

1. Tripathy (1966); 2. Ch'ang & Rae (1970); 3. Baker *et al* (1974a); 4. Elliott (1975); 5. Chopra (1978); 6. Tait (1983).

Barnicoat, Logan and Grant (1949, cited by Ch'ang and Rae, 1970) noted that the estimates of age of dam and type of birth and rearing effects are thought to be essentially reflections of the magnitude of pre-weaning nutritional handicap resulting from a lower milk production of the younger dams or, in the case of twins, having to share pre-natal uterine environment and post-natal milk supply. Ch'ang and Rae (1970) suggest that the effect of being born or reared as a twin was sufficient to trigger post weaning compensatory growth, whereas the effect of being born to a young dam was insufficiently severe to invoke compensatory growth.

2.4.3 Hogget Fleece Weight

There is good agreement between estimates for greasy HFW (Table 2.3). The exception is that of Lundie (1971) BRR estimates which are larger than those of other authors. Also, the DOB estimate made by Lundie (1971) is of reverse order to that of other authors.

2.4.4 Reproductive Traits

The estimates for reproductive performance are difficult to compare as so many different traits are used to evaluate the reproductive performance of ewes (Table 2.4). A general pattern to emerge is that reproductive performance increases with ewe age, there being little difference between ewes classified as mature at 4 or 5 years of age.

Table 2.3: Hogget greasy fleece weight environmental estimates for the New Zealand Romney and derived breeds

Breed	Romney								Peren.
Author	1	2[b]	3	3	4	5	6[b]	6[c]	7
BRR									
SS - TS	0.16	0.24	-	-	0.1	0.06[a]	0.06	0.04	
SS - TT	0.17	0.21	0.14[d]	0.18[d]	0.1	-	0.02	0.09	0.12[d]
Dam Age									
4-2	0.23	0.22	0.04	-0.19	0.0	-	-	-	0.07
4-3	0.07	0.04	0.02	0.04	0.0	-	-	-	0.03
4-5		-0.07	-0.03	-0.17	-	-	-	-	0.02
Sex R-E					0.5	-			-
Age shorn (kg/d)	-		0.009	0.014	0.1		-	-	-
Date of birth (kg/d)	-0.02	0.008	-	-	-		-0.01	-0.01	-

a. Birth rank
b. Ewes only
c. Rams only
d. Rearing rank

1. Tripathy (1966); 2. Lundie (1971); 3. Hight & Jury (1971)
4. Baker _et al_ (1974a); 5. Chopra (1978); 6. Tait (1983);
7. Elliott (1975).

Table 2.4: Environmental estimates of reproductive performance for the New Zealand Romney

Trait	Barren	NLB	NLW			Multiple Births			Triplet Births	LW/LB		Wt.L.W.
Author	2[a]	2[b]	1[c]	1[c]	2[d]	1[e]	1[e]	2[f]	2[g]	1[L]	1[1]	2[i]
Age of Ewe												
4-2	0.12	0.39	0.26	0.24	0.37	12.6	13.0	0.26	-0.002	5.9	9.9	12.77
4-3	0.03	0.18	0.06	0.02	0.18	1.4	3.7	0.15	-0.011	1.9	0.6	6.01
4-5	0.0	-0.05	-0.04	-0.02	-0.03	-7.6	0.9	-0.05	-0.007	-3.8	2.7	-1.34

1 = Hight and Jury (1970); 2 = Lundie (1971)

a. Barrenness. Dry ewes = 0 ewes that have a lamb(s) = 1

b. Number of lambs born/ewe mated and present at lambing

c. Ratio of lambs weaned/ewe present at lambing

d. Number of lambs weaned/ewe mated and present at lambing

e. Percent ewes lambing multiples /ewes lambing

f. Ewes with 2 or more lambs born = 1, those with 1 or 0 = 0

g. Ewes with 3 lambs at birth = 1, those with 2, 1, or 0 = 0

h. Percentage of lambs weaned/ lambs born

i. Weight of lamb weaned per ewe mated and present at lambing (kg)

CHAPTER THREE

MATERIALS AND METHODS

3.1 SOURCE OF DATA

The Sheeplan recording scheme was introduced in 1976 (Clarke and Rae, 1977) and has as its objectives (Clarke and Rae, 1976):

(a) the measurement or assessment of the traits of economic importance on individual animals

(b) the processing and presentation of the records in a way which will assist the breeder to make effective selection decisions.

Sheeplan is based on four measures of productivity (Clarke and Rae, 1977):

(a) number of lambs born (NLB) or reared (NLR)

(b) lamb weaning weight (WWT)

(c) hogget liveweights taken in the autumn (ALW), winter (WLW) and/or spring (SLW)

(d) hogget fleece weight (HFW).

The breeder supplies the pedigree (i.e. parentage) and record(s) of the trait(s) they are recording. For dual purpose breeds NLB is the only character that is mandatory for all breeders to record.

The breeder receives breeding values, calculated using selection index procedures, for each of the traits the breeder records and for various combinations of them. These are revised and presented annually for the selection of two-tooth replacement ewes and rams and for the culling of ewes already in the flock. Breeding values are also presented to summarize the performance of the progeny of each sire used in the flock. Sheeplan is a within flock recording scheme, and thus comparisons of breeding values across flocks are not valid (Clarke and Rae, 1977).

The data were extracted from Sheeplan files. The criteria used for selecting Coopworth flocks to be included in the study were that they:

(i) recorded on Sheeplan at least from 1978,

(ii) recorded at least 400 ewes in 1983,

(iii) recorded all lamb production traits, hogget fleece weight and at least one later liveweight.

The records of approximately 219,000 ewes and 231,000 lambs were made available from 48 flocks throughout New Zealand. A maximum of 8 years data were available on the lamb production traits including weaning weight, and a maximum of 6 years data on hogget fleece weight and later liveweights.

3.2 PRELIMINARY EDITING

The flocks were divided into 5 climatologically similar regions, based on the first two digits of the Sheeplan flock code which indicates the geographical location of the flock. The regions are:

North (1)	=	Northland
N.North (2)	=	North of Taupo excluding Northland
S.North (3)	=	remainder of the North Island
N.South (4)	=	the South Island north of Palmerston, excluding the West Coast
S.South (5)	=	the South Island south of Palmerston.

Records from unknown dams and sires were dropped from the study, as were hogget dams and records relating to fostered animals. Records pertaining to sires that had less than 6 progeny in any one year were dropped, for each trait, in an effort to remove recording errors.

Animals that were not born between days 170 and 290 (where day 1 is the 1st January) i.e. mid June to late October, were not included in analyses of weight traits. Similarly, ewes that did not lamb between days 166 and 304 were not included in reproductive traits analyses (with the exception of traits related to barrenness). These animals were removed to avoid autumn lambing ewes, and exceptionally early or late lambing ewes.

The final requisite for flocks to be included in analyses for environmental and heritability estimates was that the edited flock comprize of at least 30 sires nested within-years (referred to as sire years) and 1000 records. Where traits were divided into differing sexes or age groups the stipulation was relaxed to at least 500 records, but still requiring 30 sire years to be represented.

3.3 TRAITS

3.3.1 Weight Traits

The weight traits studied were weaning weight (WWT), autumn liveweight (ALW), winter liveweight (WLW), spring liveweight (SLW) and hogget greasy fleece weight (HFW). Sheeplan (1984) defines; WWT as lamb weights taken before 31st January in any year; ALW as weights taken from the 1st January to 30th April; WLW as weights taken from 1st May to 31st August; SLW as weights taken from 1st September to 30th November; and HFW can be a weight taken as early as 1st March. Animals that were weaned after 150 days of age were not included in the WWT analysis, and data from animals not shorn as lambs were left out of the HFW analyses.

Male and female hoggets were analysed separately for the later liveweights (i.e. ALW, WLW and SLW) and HFW, due to animals of different sexes being in separate mobs and the traits being recorded at different times.

3.3.2 Reproductive Traits

Several reproductive traits were studied in order to derive an understanding of the factors influencing the reproductive performance of ewes.

Barrenness was studied as a measure of the factors influencing post-mating infertility in flocks. In this study barrenness was defined as ewes that were joined but did not have a lamb allocated to them. Barrenness was subdivided into two traits, namely two-tooths only (BAR2TH) and all ewe ages (BAR). BAR2TH was treated as a separate trait in order to avoid the influence of selection against barren ewes that would have probably occurred in older ewes.

The trait lamb survival (LSURV) is a measure of survival from the lambs point of view. LSURV was defined as: given a lamb was born, was it alive at weaning. Due to the possibility of different genetic pathways controlling survival of singles and multiples, the traits lamb survival of singles (LSURV1) and multiples (LSURV2) were also included.

As a measure of the ewes influence on lamb survival, the proportion of lambs surviving (ESURV) was included for analysis. This trait was defined as; given at least one lamb was born to the ewe, what proportion of those lambs were alive at weaning.

Number of lambs born to a ewe present at mating (NLB) and number of lambs weaned per ewe lambing (NLW) were two measures of the ewes fecundity. Two further measures of the ewes fecundity that were studied were given a ewe lambed, did she bear multiples (MULT) or did she bear triplets and higher order multiples (TRIP).

As a measure of the overall reproductive performance of the ewe the weight of lamb weaned per ewe (provided she reared at least one lamb, Wt.L.W.) was a trait investigated. This trait was modified by adjusting for the birth and rearing rank of the lambs (Wt.L.W.BR.)

3.4 STATISTICAL METHODS

3.4.1 Estimates of Environmental Effects for Continuous Traits

For all weight traits and Wt.L.W., Wt.L.W.BR, ESURV, NLB and NLW, ordinary least squares (OLS) analyses were performed on a within region basis to identify which fixed effects should be included in the linear models. The analyses identified flocks and years as being important for all continuous traits, and flock x year interaction being important for all traits except ESURV, where flock x year interaction was important in only some regions. No other first order interactions between the main effects controlled more than 2% of the variation (estimated as sum of squares attributable to that factor divided by the total sum of squares).

For the weight traits, dam's age, birth-rearing rank and age at weighing were all important factors, as well as sex for WWT. It was found that for the weight traits age at weighing generally controlled a greater portion of variation than did fitting date of birth. For HFW, age at hogget shearing was found to control more variation than days between lamb and hogget shearing. Ewe's age was important in all the continuous reproductive traits. Age at weaning was important for Wt.L.W. and Wt.L.W.BR. with birth-rearing rank being important in Wt.L.W.BR. For ESURV, the number of lambs born to the ewe was of importance.

To estimate the environmental effects, OLS analyses were undertaken on a within-flock basis. Due to the data having unequal subclass numbers (i.e. unbalanced) the order of fitting of the effects, affects the sums of squares. Thus the within-flock models were fitted in the order shown. For WWT the following model was fitted:-

$$Y_{ijklm} = \mu + t_i + d_j + f_k + r_l + bx_{ijklm} + e_{ijklm} \qquad 3.1$$

where

Y_{ijklm} is the observation on the mth individual recorded in the i^{th} year, of the k^{th} sex, l^{th} birth-rearing rank and born to a ewe of the j^{th} dam age

μ is the general mean

t_i is the fixed effect of the i^{th} record year ($i = 1, \ldots, 8$)

d_j is the fixed effect of the j^{th} dam age ($j = 1,2,3$, where 1 is a 2 year old dam, 2 is a 3 year old dam and 3 is a 4 year old or older dam)

f_k is the fixed effect of the k^{th} sex ($k = 1,2$ where 1 is a male, and 2 a female)

r_l is the fixed effect of the l^{th} birth rearing rank ($l = 1, \ldots, 6$) - see Table 3.1

b is the regression coefficient of the animals age (x_{ijklm}) in days, on its weight (Y_{ijklm}), in kilogrammes

e_{ijklm} is a random residual effect unique to the m^{th} individual of the i^{th} year, k^{th} sex, l^{th} birth rearing rank and born to a ewe of the j^{th} dam age. The residual effects are assumed to be normally distributed with mean zero and variance σ^2_e.

Table 3.1: Definition of the Birth Rearing rank subclasses

Value	Birth Rank	Rearing Rank
1	Single	Single
2	Twin	Single
3	Twin	Twin
4	Triplet	Single
5	Triplet	Twin
6	Triplet	Triplet

The fixed effects model fitted to estimate the environmental effects for the weight traits except WWT (i.e. ALW, WLW, SLW and HFW for rams and ewes separately) was the same as model 3.1 except the model did not contain a factor for sex, and only years 1,...,6 were present.

For Wt.L.W.BR. the following model was fitted:

$$Y_{ijkl} = \mu + t_i + a_j + r_k + b\,x_{ijkl} + e_{ijkl} \qquad 3.2$$

where

Y_{ijkl} is the observation on the l^{th} ewe recorded in the i^{th} year, of the j^{th} age, bearing lambs of the k^{th} birth rearing rank

μ is a general mean

t_i defined in model 3.1

a_j is the fixed effect of the j^{th} age of the ewe ($j = 1,\ldots,4$, with 1 = 2 year old, 2 = 3 year old, 3 = 4 year old, and 4 = 5 year old and older)

r_k defined in model 3.1

b is the regression coefficient of the ewe's progenys age at weaning (x_{ijkl}) in days, on the total weight of lamb weaned by the ewe (Y_{ijkl})

e_{ijkl} is a random residual effect unique to the l^{th} ewe recorded in the i^{th} year, of the j^{th} age, bearing lambs of the k^{th} birth rearing rank. The residual effects are assumed to be normally distributed with mean zero and variance σ^2_e.

For Wt.L.W. the model fitted was the same as model 3.2 except it did not contain a birth-rearing rank effect. The models fitted for the traits NLB and NLW were the same as 3.2 except they contained no effect due to birth rearing rank and no covariate for progeny age.

The fixed effects model fitted to estimate the environmental effects for ESURV was:

$$Y_{ijkl} = \mu + t_i + a_j + n_k + e_{ijkl} \qquad 3.3$$

where

Y_{ijkl} is an observation on the l^{th} ewe, in the i^{th} year, of the j^{th} age, bearing k^{th} number of lambs

μ is a general mean

t_i defined in model 3.1

a_j defined is model 3.2

n_k is the fixed effect of the k^{th} number of lambs born to the ewe ($k = 1,\ldots,3$, where 1 = single, 2 = twins, 3 = triplets or greater)

e_{ijkl} is a random residual effect unique to the l^{th} ewe of the i^{th} record year, j^{th} ewe age, bearing k^{th} number of lambs. The residual effects are assumed to be normally distributed with mean zero and variance σ^2_e.

3.4.2 Estimation of Environmental Effects for Binomial Data

With binomial data the mean is related to the variance (Snedecor and Cochran, 1982), thus violating the assumptions of constant error variance and zero covariance between error terms, required for OLS.

The logit transformation was applied to the BAR, BAR2TH, MULT, TRIP, LSURV, LSURV1 and LSURV2 data. The transformed data were then analysed using an iterative weighted least squares procedure (see Berkson, 1957; Nelder and Wedderburn, 1972; Bock, 1975; and Gilmour, 1983), and estimates of the fixed effects obtained.

Models were fitted to the transformed binomial traits within region to assess which factors were of importance. Flock and year effects were found to be important in all traits with the ewe's dam's age or dam's dam's age being to be of little importance. Interactions were not fitted due to the nature of the computing program used. For traits BAR, MULT and TRIP the ewes age was an important factor. Dam's age was important for the traits LSURV, LSURV1 and LSURV2, with the number of lambs born by the ewe important for the trait LSURV.

The fixed effects models fitted to estimate the environmental effects for BAR, MULT and TRIP were the same as model 3.3 except they did not contain a term for the number of the lambs born to the ewe. The model fitted to BAR2TH was model 3.3 without the terms number of lambs born to the ewe and age of the ewe.

The model fitted to estimate the environmental effects for LSURV was

$$Y_{ijkl} = \mu + t_i + d_j + n_k + e_{ijkl} \qquad 3.4$$

where

Y_{ijkl} is an observation on the l^{th} individual, in the i^{th} year, of the k^{th} birth rank and born to a ewe of the j^{th} age

μ is a general mean

d_j as defined for model 3.1

n_k is the fixed effect of the k^{th} birth rank of a lamb (k = 1, ...3, where 1 = single, 2 = twin and 3 = triplet or higher order multiple).

e_{ijkl} is a random residual effect unique to the l^{th} individual of the i^{th} year, k^{th} birth rank and born to a ewe of the j^{th} dam age. The residual effects are assumed normally distributed with mean zero and variance σ^2_e.

The models fitted to estimate the environmental effects for LSURV1 and LSURV2 are the same as model 3.4 except they do not contain a term for the birth rank of the lamb.

3.4.3 Analysis of Regional Differences

The within-flock estimates were themselves subjected to analysis of variance procedures to ascertain if regional differences in the effects do exist. The fixed effects for the binomial traits were analysed on the logit scale. Bartletts test of homogeniety was used to test constant variance across regions. To assess if the effects were distributed normally a test for skewness was also undertaken (see Snedecor and Cochran, 1982). The model fitted was:

$$Y_{ij} = \mu + r_i + e_{ij} \qquad 3.5$$

where

Y_{ij} is the j^{th} observation from the i^{th} region of the fixed effect

μ is an overall mean

r_i is the fixed effect due to regions (i = 1,...,5, where 1 = North, 2 = N.North, 3 = S.North, 4 = N.South, 5 = S.South)

e_{ij} is a random residual effect unique to the j^{th} observation in the i^{th} region, assumed to be distributed normally, with mean zero and variance σ^2_e.

The within-flock estimates were weighted by the inverse of their standard error's, and weighted means of the regional and national fixed effects were obtained.

3.4.4 Heritability Estimates

Paternal half-sib heritability estimates were calculated within each flock. Henderson's Method 3 was used to calculate sire and error variance components for the weight traits. The models fitted for the weight traits were the same as for the environmental estimates except they contained a random effect for sires nested within years. Standard errors of these estimates were estimated using the methodology outlined by Swiger et al (1964).

The heritabilities for the reproductive traits ESURV, NLB, NLW, Wt.L.W. and Wt.L.W.BR were also estimated by the paternal half-sib method. The variances were estimated using Henderson's Method 3 after correcting the data for year. The model fitted was the same as for the environmental estimates except that the random effect of sires nested within years was fitted. For the traits LSURV, LSURV1 and LSURV2 the lambs sire was the appropriate random effect; with the remaining reproductive traits (i.e. BAR, BAR2TH, MULT and TRIP) the ewes sire was appropriate.

The intra-class correlations from which heritabilities of binomial traits were derived were obtained by the logistic linear mixed models procedure, as discussed by Gilmour (1983). The procedure involves setting up mixed model equations, absorbing the random effects and obtaining solutions by iteration. The random effects were obtained by back-solution using the final fixed effects.

Standard errors were not obtained for the heritabilities of the reproductive traits.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 ENVIRONMENTAL ESTIMATES

4.1.1 Weight Traits

4.1.1.1 Regional Comparisons

The within-flock within-region estimates of environmental effects and numbers of observations in each regional and national subclass are shown in Tables 4.1 to 4.10. Tests of homogeniety of variance and skewness were significant only for rams HFW. The subclasses SS-TrS and SS-TrTw had significantly skewed distributions across regions. This is probably due to the relatively low numbers of observations in the subclasses TrS and TrTw (218 and 1507 observations, respectively). For this reason skewness was thought not to be important.

The ram HFW subclass Mat-2yr showed significant non-homogeniety of variance. A difference between regions in age of shearing as lambs and as hoggets may be an explanation. All environmental subclasses would be expected to have non-homogenous variances between regions if time between shearing was the cause. As the influence of the sub-class Mat-2yr is small (a maximum value of 0.02 kg compared with the general mean of 2.97 kg for the N.North region) this deviation from normality was thought not important.

Ewes SLW was the only trait to show significant regional differences with the BRR subclass SS-TrTw being significantly different between regions. Using orthogonal contrasts (see Snedecor and Cochran, 1982) the S.North region was found to have significantly smaller ($p < 0.008$) estimates for SS-TrTw than other regions. Preferential treatment of triplet borne animals would not be a suitable explanation as ram hoggets as well as ewe hoggets would be expected to be affected, and also earlier liveweights would be expected to show regional differences.

Table 4.1: Within-flock Within-region Estimates of Environmental Effects on WWT (kg)

	North-land	N.North	S.North	N.South	S.South
Dam Age					
Mat-2 year	1.1414	1.2575	1.1474	1.1865	1.3675
Mat-3 year	-0.0778	0.0335	-0.3018	-0.1463	-0.1012
Sex					
R-E	1.8143	1.8372	2.1428	1.8207	1.8005
BRR					
SS-TwS	1.8798	2.1089	2.1582	2.1278	1.8510
SS-TwTw	5.2029	5.0931	5.3110	5.5118	5.0122
SS-TrS	2.9846	3.3872	3.1044	4.0031	3.0717
SS-TrTw	5.2964	5.9666	6.3173	6.7123	6.0962
SS-TrTr	6.5426	7.1439	8.2459	8.1638	7.7937
Age weaned (kg/d)	0.1546	0.1757	0.1944	0.1565	0.1670
General mean[a]	22.7391	23.1386	26.5946	24.5799	24.4609

a. at mean weaning age.

Table 4.2: Numbers of WWT Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Dam Age						
2 year	2921	9800	21315	8319	7991	50346
3 year	1511	7287	18488	7188	6492	40966
Mat	1897	10915	30404	16744	9143	69103
Sex						
M	3181	14026	34917	16203	11752	80079
F	3148	13976	35290	16048	11874	80336
BRR						
SS	1513	6312	13746	3976	3514	29061
TwS	264	1247	2971	1785	1422	7689
TwTw	4277	19040	46929	22571	16171	108988
TrS	14	82	294	241	133	764
TrTw	74	592	2588	1339	917	5510
TrTr	187	729	3679	2339	1469	8403
Age weaned	6329	28002	70207	32251	23626	160415
Flocks	2	5	15	4	5	31

Table 4.3: Within-flock Within-region Estimates of Environmental Effects on ALW (kg)

		North-land	N.North	S.North	N.South	S.South
Dam Age						
Mat-2 year	R	-	0.6377	0.3178	0.6959	0.5991
	E	-	-	-0.1295	0.7295	-
Mat-3 year	R	-	-0.4181	-0.9026	0.0699	-0.4382
	E	-	-	-0.7515	-0.2067	-
BRR						
SS-TwS	R	-	1.2993	2.0597	1.5727	0.6067
	E	-	-	1.9654	1.2330	-
SS-TwTw	R	-	4.0829	4.1875	3.5697	3.2200
	E	-	-	3.4969	3.5575	-
SS-TrS	R	-	-1.8963	2.8599	3.0697	0.0187
	E	-	-	3.7304	3.8338	-
SS-TrTw	R	-	3.7371	5.3949	4.5186	4.6254
	E	-	-	4.8529	4.3389	-
SS-TrTr	R	-	5.1004	6.9483	5.0115	4.3890
	E	-	-	6.8954	5.8043	-
Age of Weighing	R	-	0.1285	0.2178	0.0977	0.1416
(kg/d)	E	-	-	0.1834	0.0884	-
General mean[a]	R	-	35.6752	40.4053	39.1315	37.3886
	E	-	-	34.6002	34.7217	-

a. at mean weighing age

Table 4.4: Number of ALW Records in Subclasses and Flocks

		North-land	N.North	S.North	N.South	S.South	National
Dam Age							
2 year	R	-	679	437	1470	437	3023
	E	-	-	406	749	-	1155
3 year	R	-	453	521	1322	421	2717
	E	-	-	565	897	-	1462
Mat	R	-	621	1040	3879	627	6167
	E	-	-	1003	2856	-	3859
BRR							
SS	R	-	427	211	868	84	1590
	E	-	-	163	647	-	810
TwS	R	-	46	115	382	187	730
	E	-	-	83	266	-	349
TwTw	R	-	1192	1325	4596	1136	8249
	E	-	-	1393	3152	-	4545
TrS	R	-	2	7	63	12	94
	E	-	-	12	33	-	45
TrTw	R	-	24	148	286	37	495
	E	-	-	153	152	-	305
TrTr	R	-	62	182	476	29	749
	E	-	-	170	252	-	422
Age weighed	R	-	1753	1998	6671	1485	11907
	E	-	-	1974	4502	-	6476
Flocks	R	-	1	1	2	1	5
	E	-	-	1	2	-	3

Table 4.5: Within-flock Within-region Estimates of Environmental Effects on WLW (kg)

		North-land	N.North	S.North	N.South	S.South
Dam age						
Mat-2 year	R	-	0.8548	0.8417	0.3466	-
	E	-	1.0312	-	-	0.2979
Mat-3 year	R	-	-0.1398	0.2039	0.0203	-
	E	-	0.4474	-	-	-0.6355
BRR						
SS-TwS	R	-	1.0095	1.0109	1.4514	-
	E	-	1.2926	-	-	1.8840
SS-TwTw	R	-	3.1836	2.4423	2.5344	-
	E	-	2.7794	-	-	2.1890
SS-TrS	R	-	3.6845	3.1390	2.6655	-
	E	-	1.5445	-	-	2.0546
SS-TrTw	R	-	3.7433	2.7789	3.6282	-
	E	-	3.6479	-	-	3.9676
SS-TrTr	R	-	3.7421	3.7479	3.9563	-
	E	-	3.7981	-	-	4.1694
Age at weighing	R	-	0.1336	0.0914	0.0541	-
	E	-	0.1212	-	-	0.0972
General mean[a]	R	-	42.8413	50.9374	41.9775	-
	E	-	38.4383	-	-	32.2389

a. at mean weighing age

Table 4.6: Number of WLW Records in Subclasses and Flocks

		North-land	N.North	S.North	N.South	S.South	National
Dam Age							
2 year	R	-	1151	2961	1106	-	5218
	E	-	632	-	-	404	1036
3 year	R	-	906	2647	1032	-	4585
	E	-	489	-	-	356	845
Mat	R	-	1173	4283	3363	-	8819
	E	-	593	-	-	259	852
BRR							
SS	R	-	710	2145	727	-	3582
	E	-	369	-	-	172	541
TwS	R	-	129	446	295	-	870
	E	-	73	-	-	77	150
TwTw	R	-	2164	6371	3744	-	12279
	E	-	1138	-	-	682	1820
TrS	R	-	14	32	59	-	105
	E	-	11	-	-	6	17
TrTw	R	-	118	362	240	-	720
	E	-	81	-	-	38	119
TrTr	R	-	95	535	436	-	1066
	E	-	42	-	-	44	86
Age weighed	R	-	3230	9891	5501	-	18622
	E	-	1714	-	-	1019	2733
Flocks	R	-	2	7	1	-	10
	E	-	1	-	-	1	2

Table 4.7: Within-flock Within-region Estimates of Environmental Effects on SLW (kg)

		Northland	N.North	S.North	N.South	S.South
Dam Age						
Mat-2 year	R	-	0.4670	0.6263	0.8881	0.8201
	E	-	0.3155	0.42i5	0.5972	1.0412
Mat-3 year	R	-	-0.2520	-0.4341	-0.1464	-0.5355
	E	-	-0.3558	-0.0164	-0.1268	-0.2023
BRR						
SS-TwS	R	-	2.6928	1.2788	2.1758	2.8465
	E	-	1.2559	1.3802	1.8841	1.2219
SS-TwTw	R	-	3.7661	3.5842	3.3815	2.2764
	E	-	2.7126	2.0744	3.3095	2.6134
SS-TrS	R	-	1.2302	0.6163	3.3363	-0.8674
	E	-	3.2587	2.1134	4.2365	1.3203
SS-TrTw	R	-	4.0033	4.1223	4.5751	5.8752
	E	-	4.2569	2.5466	4.0723	3.2026
SS-TrTr	R	-	6.3368	5.3164	4.7800	4.8685
	E	-	3.8018	3.5682	5.1689	4.8734
Age at weighing	R	-	0.1279	0.1056	0.0673	0.0279
(kg/d)	E	-	0.0861	0.0713	0.0716	0.0670
General mean[a]	R	-	49.2717	59.5262	56.5525	48.6084
	E	-	38.9460	42.7951	46.0449	43.9377

a. at mean weighing age

Table 4.8: Number of SLW Records in Subclasses and Flocks

		North-land	N.North	S.North	N.South	S.South	National
Dam Age							
2 year	R	-	1060	653	1689	322	3724
	E	-	1932	3357	1810	1672	8771
3 year	R	-	772	529	1659	256	3216
	E	-	1432	3102	1983	1392	7909
Mat	R	-	1138	1092	4605	514	7349
	E	-	2078	4538	4868	1851	13335
BRR							
SS	R	-	520	298	846	224	1888
	E	-	1171	2288	873	802	5134
TwS	R	-	167	95	466	64	792
	E	-	228	438	496	311	1473
TwTw	R	-	2101	1733	5604	730	10168
	E	-	3807	7412	6326	3441	20986
TrS	R	-	5	7	75	5	92
	E	-	17	37*	56	20	130*
TrTw	R	-	80	64	342	27	513
	E	-	80	330	300	146	856
TrTr	R	-	97	77	620	42	836
	E	-	139	492	610	195	1436
Age weighed	R	-	2970	2274	7953	1092	14289
	E	-	5442	10997	8661	4915	30015
Flocks	R	-	2	2	4	1	9
	E	-	3	7	5	4	19

* Subclass contained 1 less flock than indicated.

Table 4.9: Within-flock Within-region Estimates of Environmental Effects on HFW

		North-land	N.North	S.North	N.South	S.South
Dam Age						
Mat-2 year	R	-0.0033	0.0190	-0.0085	-0.0112	0.0023
	E	0.0984	0.0072	-0.0101	-0.0189	0.0033
Mat-3 year	R	0.0144	-0.2004	-0.0130	-0.0400	-0.0084
	E	0.0417	0.0017	-0.0243	-0.0502	-0.0229
BRR						
SS-TwS	R	0.0289	0.0825	0.0451	0.0535	0.0675
	E	-0.0773	0.0484	0.0554	0.0641	0.0462
SS-TwTw	R	0.0640	0.1106	0.0607	0.0443	0.0651
	E	0.0626	0.1200	0.0917	0.0511	0.0939
SS-TrS	R	-0.0511	0.1046	0.0581	0.1380	0.1302
	E	0.2992	0.1473	0.1230	0.1632	0.1913
SS-TrTw	R	0.1818	0.1271	0.0698	0.0966	0.1371
	E	0.2958	0.2424	0.1527	0.1274	0.1611
SS-TrTr	R	0.1098	0.1734	0.1290	0.1237	0.1456
	E	0.2057	0.1570	0.1800	0.1640	0.2262
Age at Shearing (kg/d)	R	0.0085	0.0095	0.0074	0.0061	0.0082
	E	0.0060	0.0078	0.0061	0.0056	0.0067
General mean[a]	R	2.5470	2.9702	3.2202	2.6203	3.0531
	E	2.3171	2.8987	3.4365	2.8219	2.9525

a. at mean shearing age

Table 4.10: Number of HFW Records in Subclasses and Flocks

		North-land	N.North	S.North	N.South	S.South	National
Dam Age							
2 year	R	612	2285	5430	2204	1098	11629
	E	592	2640	5569	2671	1964	13436
3 year	R	346	1722	4688	2218	974	9948
	E	286	1960	5012	2648	1731	11637
Mat	R	396	2369	7903	5689	1574	17931
	E	375	2721	8307	6005	2334	19742
BRR							
SS	R	248	1280	3318	1036	430	6312
	E	226	1583	3728	1222	954	7713
TwS	R	66	303	820	606	259	2054
	E	60	307	737	639	384	2127
TwTw	R	987	4376	12114	7220	2562	27259
	E	923	5058	12887	8187	4169	31224
TrS	R	5	19	81	85	28	218
	E	5	28	68*	69	32	202*
TrTw	R	10	206	718	420	153	1507
	E	13	164	612	410	203	1402
TrTr	R	38	192	970	744	214	2158
	E	26	181	856	797	287	2147
Age Shorn	R	1354	6376	18021	10111	3646	39508
	E	1253	7321	18888	11324	6029	44815
Flocks	R	1	4	12	5	4	26
	E	1	4	12	5	5	27

* Subclass contained 1 less flock than indicated.

Preferential treatment of lighter ewe hoggets during late winter may be responsible, as triplet borne animals would be expected to be the lightest.

The estimates of the environmental effects between flocks were highly variable. This may offer an explanation as to why more regional differences in environmental estimates were not significant. The large variability between flocks may be a reflection of climatological and managerial differences. It may also be a reflection of recording errors in flocks and/or breeders pre-adjusting records before they leave the farm.

The general means were not analysed for regional differences. For WWT there appears to be a regional trend in the general means. The S.North region had, on average, lambs that were 2 kg heavier than N.South and S.South regions. Compared with S.North region lambs from N.South and S.South regions were weaned, on average, 5 and 2 days younger, respectively. Lambs from the regions North and N.North were lighter than lambs from S.North region by 4 and 3 kg respectively. The average age difference from S.North region was 5 days in both instances. The differences between the regions in average WWT appears not to be due to the effect of NLW. The North region had a lower general mean for NLW than the other 4 regions. The regions N.North, S.North, N.South and S.South had similar mean NLW (Table 4.15).

Ewe ALW general means showed little difference between the 2 regions represented (S.North and N.South). Similarly ram ALW showed little difference between S.North and N.South regions. The S.South region was, on average, 3 kg lighter than S.North. This may be due to the S.South ram hoggets being weighed at an earlier average age than those from S.North (203 and 222 days of age, respectively). Ram hoggets from N.North were, on average, 5 kg lighter than S.North ram hoggets, although they were on average 10 days older when weighed.

The WLW general mean for ewe hoggets was 6 kg greater for N.North region than for the S.South region. As there was 12 days difference in average age at weighing between the 2 regions, age appears unimportant in explaining this difference. As there was only 1 flock in each region, this difference may be a reflection of between-flock variability as opposed to between-region variability. The ram WLW general means were larger in S.North region than in either N.North or N.South regions (by 8 and 9 kg respectively). This difference is too large to be explained by differences in ages at weighing (S.North ram hoggets were older than N.North and N.South ram hoggets by an average of 15 and 19 days respectively).

There is a small difference in ewe hogget SLW between the regions S.North, N.South and S.South. Ewe hoggets from N.South region were 2 kg heavier, on average, than S.South region ewe hoggets, and 3 kg heavier than S.North hoggets. N.North ewe hoggets were 7 kg lighter, on average, than N.North hoggets. The differences do not appear to be explained by differences in ages at weighing. The ram hogget SLW was, on average, largest for S.North region, with N.South region ram hoggets being 3 kg lighter. The differences between S.North region and N.North and S.South regions were larger still (10 and 11 kg respectively). These differences appear not to be explained by age at weighing.

The trend in HFW between-regions is the same for both ewe and ram hoggets. Ewe hoggets from S.North region produced, on average, 0.5 kg more wool than those from S.South and N.North regions. N.South and North ewe hoggets, on average, produced 0.6 kg and 1.1 kg less wool than S.North ewe hoggets. These differences cannot be explained by between-region age differences at shearing. The differences between regions in ram HFW is smaller than that of ewe hoggets, probably due to ram hoggets being shorn at an earlier age than ewe hoggets. Ram hoggets from the regions S.South and N.North produced, on average, 0.2 kg less wool than ram hoggets from the S.North region. Animals from the N.South and North regions produced 0.6 and 0.7 kg respectively, less wool than those from the S.North.

As there was only a 14 day difference in average ram hogget shearing age between regions, age would appear to offer little explanation of the regional differences.

The trends in the general mean in HFW between regions that are not explainable by age of the animal, are probably due to differences in climate and management. Flocks in the S.South region would be subjected to a harsher winter and early spring than, say, animals from N.North region. But animals from N.North region may be subjected to facial eczema, whereas animals in the 2 South Island regions would not be subjected to this effect.

4.1.1.2 National Estimates

The national environmental estimates are presented in Table 4.11. The effect on liveweight of being born a multiple and reared as either a single or multiple decreases with age. The exception is for the subclass SS-TwS for rams where there is little difference in the environmental estimates for WWT and SLW, although the estimates for ALW and WLW are smaller than for WWT. The largest reduction in the BRR effect occurs between weaning and autumn liveweight. This reduction is possibly due to the decreased dependance of the lamb on the dam for feed supply, and the decreased competition for milk supply with full-sibs. The New Zealand Romney estimates obtained by Ch'ang and Rae (1970), Baker et al (1974a) and Tait (1983) for the BRR subclasses SS-TwS and SS-TwTw (Tables 2.1 and 2.1) also decrease with age and likewise the largest reduction in the effect of BRR occurs between WWT and the equivalent of ALW.

The effect of dam-age on liveweight appears to decrease with age in the Mat-2yr subclass, but little change occurs with the Mat-3yr subclass. This may indicate that the greater suppression of liveweight in progeny of 2 year old dams leads to compensatory growth.

Table 4.11: National Estimates of Environmental Effects of Weight Traits

	WWT[a]	ALW[b]	WLW[b]	SLW[b]	HFW[b]
Dam Age					
Mat-2 year	1.2084	0.5951 0.4063	0.7600 0.6891	0.7258 0.5675	-0.0034 -0.0031
Mat-3 year	-0.1707	-0.3070 -0.4138	0.0976 0.0721	-0.2636 -0.1476	-0.0187 -0.0231
Sex					
R-E	1.9626	-	-	-	-
BRR					
SS-Tw S	2.0741	1.4799 1.4766	1.1271 1.5944	2.1749 1.4385	0.0546 0.0502
SS-TwTw	5.2451	3.6831 3.5226	2.6045 2.7632	3.4161 2.6210	0.0625 0.0857
SS-TrS	3.2983	2.0616 3.7877	3.0755 1.7901	2.2164 2.7627	0.0944 0.1563
SS-TrTw	6.2447	4.6393 4.5244	3.1850 3.8015	4.4833 3.3681	0.0962 0.1653
SS-TrTr	7.8984	5.3833 6.2177	3.8148 3.9817	5.1177 4.3193	0.1342 0.1826
Age weighed	0.1788	0.1306 0.1196	0.0925 0.1098	0.0875 0.0740	0.0076 0.0064
General mean[c]	24.9597	38.4436 34.8433	46.9459 35.4039	54.2988 43.0691	2.9986 3.0955

a. ram and ewe lamb weights combined

b. ram estimates above, ewe estimates below

c. at mean weighing age

There was no consistent trend in the differences between dam-age effects estimated from Romney data collected at different ages (Ch'ang and Rae, 1970; Baker et al, 1974a; Tait, 1983).

The effect on liveweight due to the animal's age at weighing decreases with age. Declining growth rate with age would lead to this observation.

The decrease in the influence of environmental effects on liveweight as sheep age is emphasized when environmental estimates are presented as percentages of the general mean (Table 4.12).

4.1.1.2.1 Weaning Weight

The estimates of the environmental effects on WWT obtained in this study are similar to other estimates (Table 2.1). The 1.2 kg depression due to 2 year old dams is similar to that found for Coopworths by Newman et al (1983) and similar to the 1.3 kg disadvantage assumed by Sheeplan (Clarke and Rae, 1976). The effect of being born and raised by a 3 year old dam is small and similar to the estimate published by Newman et al (1983). The effect was opposite in magnitude to that of 0.2 kg assumed by Sheeplan (Clarke and Rae, 1976). A possible reason for the estimate from this study and Newman et al (1983) being of opposite magnitude to the Sheeplan assumed value is that the mature group may contain ewes that are older than those flocks from which the Sheeplan estimates were derived, thus decreasing the handicap of 3 year old ewes relative to the Mat group. Also, the estimates from Newman et al and the current study are from commercial flocks which may tend to preferentially feed younger ewes.

Table 4.12: National Estimates of Environmental Effects on Weight Traits as Percentages of the General Mean of each Trait

	WWT[a]	ALW[b]	WLW[b]	SLW[b]	HFW[b]
Dam Age					
Mat-2 year	4.84	1.55 1.17	1.62 1.95	1.34 1.32	-0.11 -0.10
Mat-3 year	0.68	-0.80 -1.19	0.21 0.20	-0.49 -0.34	-0.62 -0.75
Sex					
R-E	7.86	-	-	-	-
BRR					
SS-TwS	8.31	3.85 4.24	2.40 4.50	4.01 3.34	1.82 1.62
SS-TwTw	21.01	9.58 10.11	5.55 7.80	6.29 6.09	2.08 2.77
SS-TrS	13.21	5.36 10.87	6.55 5.06	4.08 6.41	3.15 5.05
SS-TrTw	25.02	12.07 12.98	6.78 10.74	8.26 7.82	3.21 5.34
SS-TrTr	31.64	14.00 17.84	8.13 11.25	9.43 10.03	4.48 5.90

a. Ram and ewe lamb weights combined

b. ram estimates above, ewe estimates below.

The Coopworth estimates of dam-age made by Gregory (unpublished) were not derived in a comparable way. The Mat-2yr effects fall approximately in the middle of the published New Zealand Romney estimates and Perendale estimates (Table 2.1). The Mat-3yr estimates fall at the lower end of the published results.

The disadvantage of 2.1 kg due to being born a twin and reared a single is similar to estimates produced by Newman _et al_ (1983), Gregory (unpublished) and that assumed by Sheeplan (2.0 kg, Clarke and Rae, 1976). The handicap of being born and reared as a twin (5.2 kg) is greater than estimated for Coopworths by Newman _et al_ (1983) and the 4.2 kg assumed by Sheeplan (Clarke and Rae, 1976). It is also similar to the published New Zealand Romney estimates and Perendale estimates (Table 2.1).

The handicap of being born a triplet and reared as either a single, twin or triplet (3.3, 6.2, 7.9 kgs, respectively) is similar to that estimated by Gregory (unpublished) of 3.95, 6.32 and 7.35 kgs, respectively. The Sheeplan adjustments are 4.2, 5.4 and 6.8 kgs, respectively. Some of these estimates are based on small numbers.

The female effect (a disadvantage of 2.0 kg) was similar to the 1.82 and 2.23 kg disadvantages obtained by Newman _et al_ (1983) and Gregory (unpublished), respectively,and about the middle of published New Zealand Romney and Perendale estimates (Table 2.1). Sheeplan deviates the adjusted weaning weights from the within-flock within-sex mean (Clarke and Rae, 1976). Thus, no correction factors are used.

The age-at-weaning regression coefficient (0.18 kg/d) was at the upper end of those obtained for New Zealand Romney and Perendale lambs (Table 2.1), and similar to that of 0.17 kg/d estimated for Coopworths by Newman _et al_ (1983) and that assumed by Sheeplan (0.17 kg/d).

4.1.1.2.2 Autumn Liveweight

The estimates of the dam-age effects on ALW (Mat-2yr, 0.6 and 0.4 kg; Mat-3yr, -0.3 and -0.4 kg for ram and ewe hoggets respectively) were less than those published for the New Zealand Romney (Table 2.2), and those assumed by Sheeplan for both sexes (Clarke and Rae, 1976). The lower estimates may be due to the Mat dam-age group containing ewes older than those in the research flocks from which Sheeplan and other published estimate are based. The commercial flocks in this study may have tended to feed younger ewes better, thus minimizing the effect of being born to a 3 year old ewe. The sex of the hoggets also appear to have an influence on age-of-dam estimates, with ewes having smaller estimates than rams, an effect also noted by Tait (1983). As the sex difference is still present when the effects are presented as a percentage of the general mean (Table 4.12) liveweight is not the only factor influencing the difference.

The effect of being born a twin and reared as either a single (1.5 kg handicap for both sexes) or twin (3.7 and 3.5 kg for ram and ewe hoggets, respectively) are at the large end of those reported for the New Zealand Romney (Table 2.2) and similar to Sheeplan estimates (1.8 kg for twins reared as singles and 3.1 kg for twins reared as twins, for both ewe and ram hoggets). Hoggets born as triplets have larger environmental estimates than those assumed by Sheeplan (3.1, 3.8 and 4.5 kg singles, twins, and triplets respectively for ewe and ram hoggets) except for triplet ewe lambs reared as singles. This difference from Sheeplan assumed values may be due to the relatively low numbers in the TrS and TrTw subclasses (94 and 495 ewe hogget and 45 and 305 ram hogget estimates respectively) or to the research flocks from which Sheeplan estimates were derived having a low incidence of triplets. The BRR estimates tend to be larger for ewe hoggets, an effect which is magnified when the estimates are presented as percentages of the general mean (Table 4.12). The reason for the opposite trends occuring between dam-age and BRR effects in sex differences is not clear.

The age-at-weighing regression coefficients (0.13 and 0.12 kg/d for ram and ewe hoggets, respectively) were at the upper end of the published estimates for the New Zealand Romney and slightly larger than the estimates assumed by Sheeplan (Clarke and Rae, 1976) of 0.10 kg/d for ewe and ram hoggets.

4.1.1.2.3 Winter Liveweights

The WLW handicap of being born to a young dam (0.8 and 0.7 kg for ram and ewe hoggets, respectively, borne to a 2 year old dam, and 0.1 kg for both sexes borne to a 3 year old dam) is at the low end of those estimated for the New Zealand Romney. The effect is less than that assumed by Sheeplan of 2.4 and 0.9 kg for 2 and 3 year old dams, respectively and for both sexes (Clarke and Rae, 1976). A possible explanation for the lower estimates in this study is the hoggets are being fed at a higher level thus enabling them to overcome the handicap to a greater extent.

The disadvantage of being born a twin and raised as a single (1.1 and 1.6 kg for ram and ewe hoggets respectively) or twin (rams 2.6 and ewes 2.8 kg) are at the upper end of the estimates published for the New Zealand Romney and similar to the handicap assumed by Sheeplan (1.5 and 2.7 kg). The effect of being born a triplet and reared a single (3.1 and 1.8 kg for rams and ewes respectively) differs from the 2.7 kg effect (for both sexes) assumed by Sheeplan (Clarke and Rae, 1976). This is probably due to the very low numbers of animals in the TrS subclass. The influence of being born a triplet and reared as a twin (rams 3.1; ewes 3.8 kg) or triplet (rams 3.8; ewes 4.0 kg) is similar to those assumed by Sheeplan (twins 3.3 kg; triplets 3.8 kg, for both ewe and ram hoggets). There also appears to be a small sex difference in the BRR estimates with the ewe hoggets tending to have larger estimates than the ram hoggets. Expressing the BRR effects as percentages of the general mean magnifies the sex difference. Thus, influences other than weight differences appear to be mediating the sex difference.

The age-at-weighing regression coefficients (0.07 and 0.11 kg/day for ram and ewe hoggets respectively) are at the low end of those estimated for the New Zealand Romney, and similar to the effect assumed by Sheeplan of 0.09 kg/d for both sexes (Clarke and Rae, 1976).

4.1.1.2.4 Spring Liveweight

The influence of dam-age on SLW is at the low end of the New Zealand Romney and Perendale estimates and are smaller than the values assumed by Sheeplan (2.4 and 1.0 kg for 2 and 3 year old dams, respectively for both sexes). The estimates may be lower due to higher feeding levels in commercial flocks as compared to research flocks.

The handicap of being born a twin and reared as either a single (2.2 and 1.4 kg for ram and ewe hoggets, respectively) or twin (rams 3.4; ewes 2.6 kg) is larger than estimates reported for the New Zealand Romney and Perendale, as well as being larger than assumed by Sheeplan (0.4 and 2.2 kg respectively, for both sexes). Also, animals born as triplets and reared as either singles, twins or triplets have larger estimates than assumed by Sheeplan (2.2, 2.6 and 3.0 kg respectively, for both sexes). This indicates that BRR effects may influence hogget liveweight for a longer period of time than originally estimated. A sex difference between the estimates is apparent with ewe hoggets having smaller estimates for BRR effects than ram hoggets (except for TrS subclass). The difference is not as distinct when the estimates are presented as percentages of the general mean, indicating weight differences may be mediating the effect.

The age-at-weaning regression coefficients (0.09 and 0.07 kg/day for ram and ewe hoggets respectively) are midway between the values estimated for New Zealand Romneys and are similar to the values assumed by Sheeplan (0.09 and 0.08 kg/d for ram and ewe hoggets, respectively).

4.1.1.2.5 Hogget Fleeceweight

The effect on HFW due to being born to a young dam is small (Table 4.11). The effect is towards the lower end of the published estimate for the New Zealand Romney and Perendale (Table 2.3).

The handicap of HFW due to an animal being born a twin and reared a single (0.05 kg for both sexes) or twin (0.06 and 0.09 kg for ram and ewe hoggets, respectively) are lower than most New Zealand Romney and Perendale estimates. The effect on HFW of being born a triplet and reared as either a single (rams 0.09; ewes 0.16 kg), twin (0.10 and 0.17 kg) or triplet (0.13 and 0.18 kg) is quite large. A sex difference is also apparent in BRR effects with ewe hoggets having larger estimates than rams. The sex difference is not entirely due to the different weight of wool shorn by ewe and ram hoggets, as when the BRR adjustments are expressed as percentages of the mean fleece weight (Table 4.12) sex differences are still apparent.

The regression of age-at-shearing on HFW is small (0.008 and 0.006 kg /d for ram and ewe hoggets, respectively) and lies midway between published estimates for the New Zealand Romney.

Sheeplan adjusts HFW for environmental influences by expressing the record as a deviation from the average fleece weight of individuals of the same sex and same age-of-dam class (yearling or older ewes). Estimates of the effect of BRR would suggest that a BRR subclass also be included.

4.1.2 Reproductive Traits

4.1.2.1 Regional Comparisons

The regional and national estimates and numbers of observations per subclass for the reproductive traits are given in Table 4.13 to 4.30. Due to the low incidence of triplets, TRIP estimates are not presented. Also because of the culling policies of breeders for barrenness traits (BAR2TH and BAR) and the possibility of not only barren ewes being recorded as zero NLB, the barrenness traits are not presented.

ESURV had significantly skewed distributions ($p < 0.01$) across regions for the subclasses Mat-2yr and Mat-3yr. Similarly, NLW showed significant skewness across regions for the subclass Mat-3yr. As these subclasses were not significant for Bartlett's test of homogeniety of variance, analysis of variance procedures were used to ascertain if regional differences did exist. Wt.L.W.BR had significantly skewed distributions ($p < 0.01$) across regions for the subclasses SS-TwS and SS-TrS. These subclasses were also significant for Bartlett's test of homogeniety of variance. The low number of observations in the TrS subclass (268 observations from 21 flocks) could be partly responsible. No explanation can be offered as to why the subclass SS-TwS showed non-homogenous variance and was skewed across regions. No corrective measures were applied to these subclasses.

Significant differences between the estimates from different regions for NLW, MULT and ESURV were found for the dam-age subclass Mat-3yr. Orthogonal contrasts showed the North region to have significantly greater estimates of Mat-3yr effects for NLW and MULT ($p < 0.0003$ and 0.02 respectively) and N.North region to have significantly greater estimates than the 3 more southern regions ($p < 0.05$ and 0.04 respectively). The North region had significantly greater estimates of the Mat-3yr effect than other regions ($p < 0.01$) for ESURV.

Table 4.13: Within-flock Within-region Estimates of Environmental Effects on NLB

	Northland	N.North	S.North	N.South	S.South
Ewe Age					
Mat-2 year	0.2896	0.2679	0.2047	0.2719	0.2360
Mat-3 year	0.2119	0.1762	0.0941	0.1505	0.0737
Mat-4 year	0.0464	0.0694	0.0142	0.0235	-0.0210
General mean[a]	1.4989	1.8293	1.7499	1.8767	1.8504

a. mean of mature ewe age.

Table 4.14: Number of NLB Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Ewes Age						
2 year old	1034	5398	10867	6412	2529	26240
3 year old	664	3256	7653	4627	1737	17937
4 year old	251	1550	4401	3093	869	10164
Mat	196	986	3782	4811	695	10470
Flocks	2	5	12	5	4	28

Table 4.15: Within-flock Within-region Estimates of Environmental Effects on NLW

	Northland	N.North	S.North	N.South	S.South
Ewes Age					
Mat- 2 year	0.3323	0.2355	0.1828	0.2513	0.2186
Mat- 3 year	0.4622	0.1380	0.0427	0.0651	0.0147
Mat- 4 year	0.0593	-0.0074	-0.0138	-0.0359	-0.0480
General mean[a]	1.4060	1.4782	1.5276	1.5504	1.5365

a. mean of mature ewe age.

Table 4.16: Number of NLW Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Ewes Age						
2 year old	586	5397	10859	6409	2529	25780
3 year old	323	3256	7639	4627	1736	17581
4 year old	120	1549	4398	3088	868	100231
Mat	105	986	3776	4809	695	10371
Flocks	1	5	12	5	4	27

Table 4.17: Within-flock Within-region Estimates of Environmental Effects on MULT

	Northland	N.North	S.North	N.South	S.South
Ewes Age					
Mat-2 year	0.3259	0.2000	0.1487	0.2102	0.1756
Mat-3 year	0.2604	0.1370	0.0718	0.1198	0.0519
Mat-4 year	0.1000	0.0554	0.0067	0.0115	-0.0249
General mean[a]	0.6416	0.7274	0.6690	0.7798	0.7402

a. mean of mature ewes (0 = singles; 1 = multiples)

Table 4.18: Number of MULT Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Ewes Age						
2 year old	586	5397	10844	6384	2529	25740
3 year old	323	3256	7634	4627	1736	17576
4 year old	120	1549	4398	3088	868	10023
Mature	105	986	3776	4809	695	10371
Flocks	1	5	12	5	4	27

Table 4.19: Within-flock Within-region Estimates of Environmental Effects on ESURV

	North-land	N.North	S.North	N.South	S.South
Ewe Age					
Mat-2 year	-0.0120	0.0214	0.0269	0.0434	0.0355
Mat-3 year	0.2026	0.0199	-0.0104	-0.0131	-0.0166
Mat-4 year	-0.0139	-0.0275	-0.0120	-0.0185	-0.0121
NLB					
S-Tw	-0.1019	-0.0093	0.0016	-0.0078	0.0149
S-Tr	0.1243	0.2188	0.1895	0.1664	0.1700
General mean[a]	0.6775	0.6106	0.7123	0.6895	0.6965

a. mean of mature ewe bearing 2+ lambs.

Table 4.20: Number of ESURV Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Ewe Age						
2 year old	586	5397	10859	6409	2529	25780
3 year old	323	3256	7639	4627	1736	17581
4 year old	120	1549	4398	3088	868	10023
Mat	105	986	3776	4809	695	10371
NLB						
S	556	4402	9406	4600	1827	20801
Tw	544	6396	15571	12722	3557	38790
Tr	24	390	1695	1611	444	4164
Flocks	1	1	5	12	5	4

Table 4.21: Within-flock Within-region Estimates of Environmental Effect on LSURV

	Northland	N.North	S.North	N.South	S.South
Dam Age					
Mat-2 year	-0.0360	0.0278	0.0446	0.0751	0.0368
Mat-3 year	0.0304	-0.0096	-0.0398	-0.0278	-0.0230
Mat-4 year	-0.0706	-0.0534	-0.0336	-0.0501	-0.0134
BR					
S-Tw	-0.0577	-0.0043	0.0033	-0.0425	0.0019
S-Tr	0.1783	0.2721	0.2773	0.2014	0.2426
General mean[a]	0.7119	0.5844	0.6970	0.6626	0.6685

a. mean of triplet lamb born to a mature dam

BR birth rank of lamb; S = single birth, Tw = twin birth; Tr = Triplet or greater birth.

Table 4.22 : Number of LSURV Records and Flocks in Subclasses

	North-land	N.North	S.North	N.South	S.South	National
Dam Age						
2 year old	3388	12127	25400	13959	10194	65068
3 year old	1853	8730	21552	11936	8039	52110
4 year old	1089	5830	14928	9017	5153	36017
Mature	1188	7403	21484	19057	6589	55721
BR						
S	1841	7674	16035	6754	4377	36681
Tw	5286	24190	57501	39518	21568	148063
Tr	391	2226	9828	7697	4030	24172
Flocks	2	5	15	6	6	34

Table 4.23: Within-flock Within-region Estimates of Environmental Effects on LSURV1

	Northland	N.North	S.North	N.South	S.South
Dam Age					
Mat-2 year	0.0308	0.0108	0.1048	0.1279	-0.0096
Mat-3 year	0.3119	0.1086	0.0142	0.0868	-0.0450
Mat-4 year	-0.1651	0.0133	-0.0045	0.0475	-0.0499
General mean[a]	0.8656	0.8692	0.9032	0.8956	0.8663

a. mean of mature dam age.

Table 4.24: Numbers of LSURV1 Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Dam Age						
2 year old	381	2083	5446	1939	1478	11327
3 year old	301	1056	3967	1253	1011	7588
4 year old	142	447	2238	710	436	3973
Mature	167	457	3076	1473	616	5789
Flocks	1	3	13	4	4	25

Table 4.25: Within-flock Within-region Estimates of Environmental Effects on LSURV2

	Northland	N.North	S.North	N.South	S.South
Dam Age					
Mat-2 year	-0.0883	0.0049	-0.0149	0.0182	-0.0019
Mat-3 year	-0.0641	-0.0559	-0.0660	-0.0716	-0.0461
Mat-4 year	-0.0760	-0.0646	-0.0395	-0.0626	-0.0193
General mean[a]	0.8027	0.7992	0.8459	0.8105	0.8248

a. mean of mature dam age.

Table 4.26: Numbers of LSURV2 Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Dam Age						
2 year old	1628	8535	19328	11494	8136	49121
3 year old	862	6720	17251	10364	6555	41752
4 year old	531	4856	12512	8163	4442	30504
Mat	703	6301	18196	17177	5451	47828
Flock	1	5	15	6	5	32

Table 4.27: Within-flock Within-region Estimates of Environmental Effects on Wt.L.W.

	North-land	N.North	S.North	N.South	S.South
Ewe Age					
Mat-2 year	-	5.3407	4.0784	4.9246	5.2211
Mat-3 year	-	1.1426	-0.1959	0.3833	0.2198
Mat-4 year	-	-0.1804	-1.3608	-1.8715	-2.7228
Age weaned (kg/d)	-	0.2765	0.3195	0.3178	0.2612
General mean[a]	-	33.8004	40.6769	41.4519	40.7690

a. mean of mature ewe age group at mean weaning age

Table 4.28: Number of Wt.L.W. Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Ewe Age						
2 year old	-	4138	9379	5178	1760	20455
3 year old	-	2542	6923	4034	1254	14753
4 year old	-	1247	4005	2718	580	8550
Mature	-	762	3407	4192	462	8823
Age weaned	-	8689	23714	16122	4056	52581
Flocks	-	4	12	4	3	23

Table 4.29 : Within-flock Within-region Estimates of Environmental Effects on Wt.L.W.BR.

	North-land	N.North	S.North	N.South	S.South
Ewe Age					
Mat-2 year	-	2.7166	1.6030	1.9204	2.7843
Mat-3 year	-	0.1736	-1.0950	-0.8790	0.0533
Mat-4 year	-	-0.1580	-1.3698	-1.8208	-1.4217
BRR					
SS-TwS	-	3.8335	2.3820	2.6915	2.9703
SS-TwTw	-	-13.3789	-17.5620	-17.2773	-16.4924
SS-TrS	-	3.7478	5.0958	4.9285	4.4999
SS-TrTw	-	-10.9233	-14.7255	-13.6428	-13.1874
SS-TrTr	-	-22.9776	-27.6718	-27.7647	-26.5636
Age weaned (kg/d)	-	0.2533	0.3096	0.3148	0.2108
General mean[a]		46.9698	56.2018	57.0606	56.7930

a. mean of mature ewes and TrTr BRR.

Table 4.30: Number of Wt.L.W.BR. Records in Subclasses and Flocks

	North-land	N.North	S.North	N.South	S.South	National
Ewe Age						
2 year old	-	4138	9379	5178	1760	20455
3 year old	-	2542	6923	4034	1254	14753
4 year old	-	1247	4005	2718	580	8550
Mat	-	762	3407	4192	462	8823
BRR						
SS	-	3143	7810	3518	1218	15689
TwS	-	364*	1298	1313	329	3304
TwTw	-	4890	13064	9879	2265	30098
TrS	-	25*	100*	125	18	268**
TrTw	-	103*	437	452	52	1044
TrTr	-	164	1005	835	174	2178
Age weaned	-	8689	23714	16122	4056	52581
Flocks		4	12	4	3	23

* subclass contained 1 less flock than indicated

** subclass contained 2 less flocks than indicated.

If the differences occured because of North being represented by only 1 flock with relatively few observations, other traits would be expected to show differences between regions. Similarly, if the differences were due to management differences, why didn't other traits and other subclasses show significant differences between regions?

The general means for each region were not analysed for regional differences. For the lamb production traits NLB, NLW and MULT the North region had the lowest overall means with there being little difference between the other 4 regions. For the remaining reproductive traits there was little difference between the regions.

4.1.2.2 National Estimates

4.1.2.2.1 NLB, NLW and MULT

These traits are measures of the lamb producing ability of ewes. There is an upward trend in lamb producing ability with ewe's age (Table 4.31), peak production (relative to mature ewes) appearing to occur at 4 years of age. A similar trend has been noted by Hight and Jury (1970a), Lundie (1971) and Lewer et al (1983). Dalton and Rae (1978) noted that peak production appears to be reached at approximately 5 years of age.

4.1.2.2.2 ESURV, LSURV, LSURV1 and LSURV2

These traits are measures of lamb survival either from the ewe's (ESURV) or lamb's (LSURV, LSURV1 and LSURV2) viewpoints (Tables 4.31 and 4.32). The effect of the ewe's or dam's age on lamb survival decreases with the ewes's or dam's age.

Table 4.31: National Estimates of Environmental Effects on NLB, NLW, MULT and ESURV

	NLB	NLW	MULT	ESURV
Ewe Age				
Mat-2 year	0.2383	0.2149	0.1805	0.0302
Mat-3 year	0.1239	0.0695	0.0977	-0.0031
Mat-4 year	0.0227	-0.0203	0.0154	-0.0159
NLB				
S-Tw				-0.0017
S-Tr				0.1844
General mean	1.7934[a]	1.5232[a]	0.7157[a]	0.6901[b]

a. mean of mature ewe age

b. mean of mature ewes bearing triplets or greater

Table 4.32: National Estimates of Environmental Effects on LSURV, LSURV1 and LSURV2

	LSURV	LSURV1	LSURV2
Dam Age			
Mat-2 year	0.0437	0.0782	-0.0043
Mat-3 year	-0.0266	0.0451	-0.0624
Mat-4 year	-0.0383	-0.0060	-0.0464
BR			
S-Tw	-0.0088		
S-Tr	0.2517		
General mean	0.6686[a]	0.8907[b]	0.8253[b]

Ewe's or dam's 2 years of age have the lowest rates of lamb survival, except for multiple births where there is little difference between age groups. The influence of BR is larger than dam-age with triplet borne animals having the lowest survival rates (18% and 25% lower rate than singles for ESURV and LSURV respectively). This lower survival rate can probably be attributed to the lighter birthweight of triplets.

4.1.2.2.3 Wt.L.W. and Wt.L.W.BR

These traits are measures of the overall ewe productivity (excluding wool) up to weaning, incorporating reproductive rate and maternal ability.

The estimates of ewe's age effects on Wt.L.W. and Wt.L.W.BR (Table 4.33) decrease with age. The estimates for Wt.L.W.BR are lower than for Wt.L.W. indicating some of the difference attributed to ewe-age is due to the BRR of the animal. Mature ewes appear to be out-produced by 4 year old ewes, indicating peak production may occur at 4 years of age. This peak at a younger age than noted by Dalton and Rae (1978) and Lundie (1971) could be due to the Mat group containing very old ewes which are past their peak production.

The number of lambs born and reared by the ewe has a large influence on the weight of lamb weaned by a ewe. Ewes that have twins and rear twins weaned 17 kg more lamb than those that have and rear singles. Similarly ewes that rear triplets weaned 10 kg more lamb than those that had and reared twins.

Table 4.33 : National Estimates of Environmental Effects on Wt.L.W. and Wt.L.W.BR.

	Wt. L.W.	Wt.L.W.BR.
Ewe Age		
Mat-2 year	4.6097	1.9717
Mat-3 year	0.2148	-0.7300
Mat-4 year	-1.4006	-1.2883
BRR		
SS-TwS		2.7801
SS-TwTw		-16.7711
SS-TrS		4.8461
SS-TrTw		-13.6938
SS-TrTr		-26.9050
Age lambs weaned (kg/d)	0.3044	0.2908
General mean	39.2523[a]	54.4686[b]

a. mean of mature ewe at mean weaning age

b. mean of mature ewe bearing and rearing triplet progeny.

4.2 HERITABILITY ESTIMATES

As the data was from commercial flocks, selection for economically important traits should be occuring in these flocks. The Coopworth Breed Society puts strong emphasis on early conception and lambing percentage as shown by ewe deregistration criteria:-

"(a) Any ewe (other than a hogget) which is barren.
(b) Any ewe which on more than one occasion fails to lamb in the first 38 days.
(c) Any ewe which does not rear a set of her own twins at or before her four-tooth lambing.
(d) Any ewe which does not lamb naturally, has a faulty udder, or has bearing trouble.
(e) Any ewe which prematurely develops poor wool or loses constitution.

Inclusive of the above, the culling at the hogget stage and after the two-tooth lambing shall be such that 40% of any age group must be culled between weaning as ewe lambs and mating as four-tooths." (Coopworth Flock Book, 1983).

Similarly, the selection of rams puts emphasis on early conception, lambing percentage and wool weight. To qualify for single entry, which is required for their progeny to gain registration, a ram must:-

"(i) Pass inspection and be out of a registered ewe.
(ii) Be in the top 25% of index (based on number of lambs weaned as shown on the 2-TH selection list).

(iv) Ram lambs shall be in the top 25% on index (based on number of lambs weaned...) and have positive BV NLB. Their dams must have positive BV HFW" (Coopworth Flock Book, 1983).

Selection on traits of interest or on traits correlated with those of interest alters the means, variances and covariances of records (Henderson, 1982), thus biasing the genetic parameter estimates. The size of the bias will also be influenced by the selection intensity. All genetic parameter estimates in this study may be influenced by selection of parents. Traits expressed at later ages may be biased by selection occuring on traits expressed earlier in life, especially if these traits are genetically correlated.

A fundamental assumption invoked when estimating heritabilities using paternal half-sib methods is that sires are randomly mated to ewes. This assumption was violated in some traits as ewe's were allocated to sires according to the ewe's age.

4.2.1 Weight Traits

The within-flock heritability estimates for WWT, ALW, SLW and HFW are given in Tables 4.34 to 4.38. The mean's of the estimates are also given but this should be interpreted with caution as it is unlikely the heritability estimates are distributed normally. Also, as different flocks contain differing numbers of sires-nested-within-years and progeny per sire-nested-within-years, a weighted mean would be more desirable. To the authors knowledge there has been no methods developed to weight genetic parameters from different flocks to give an overall population estimate.

The heritability estimates for WWT cover a larger range than that of New Zealand published estimates (Table 4.39), with the mean of the estimates (0.17) falling at the lower end of the published estimate. The range of the estimates (0.02 to 0.74) may be a result of differing levels of selection or recording accuracy in flocks.

Table 4.34. Within-flock Heritability Estimates, Standard Errors of Heritability Estimates, Number of Observations and Sires Nested Within-years for WWT

h^2 (Standard Error)	Number of Observations	Number of Sireyears
0.1490 (0.0406)	3843	44
0.1244 (0.0454)	2486	30
0.1029 (0.0291)	5142	44
0.0815 (0.0242)	4965	50
0.1352 (0.0285)	6335	83
0.1731 (0.0332)	8421	71
0.0726 (0.0293)	3139	31
0.1096 (0.0323)	3716	52
0.5451 (0.0802)	6525	83
0.1688 (0.0324)	7174	83
0.0728 (0.0253)	4089	42
0.0561 (0.0236)	3268	43
0.0558 (0.0229)	3466	56
0.0189 (0.0227)	2077	40
0.1648 (0.0326)	7529	73
0.1185 (0.0294)	5601	60
0.1000 (0.0224)	7976	72
0.2321 (0.0496)	5308	56
0.3966 (0.1083)	1581	33
0.0372 (0.0183)	3933	46
0.2010 (0.0656)	2264	30
0.7455 (0.1077)	5700	73
0.2910 (0.0255)	23633	312
0.1474 (0.0444)	2840	42
0.0929 (0.0314)	3208	46
0.0786 (0.0339)	2570	32
0.1343 (0.0381)	3452	48
0.0901 (0.0219)	6289	87
0.1657 (0.0365)	4760	71
0.1023 (0.0255)	5752	67
0.2614 (0.0571)	3373	64
mean 0.1686		

Table 4.35: Within-flock Heritability Estimates, Standard Errors of Heritability Estimates, Number of Observations and Sires Nested Within-years for ALW

h^2 (Standard Error)		Number of Observations		Number of Sireyears	
Rams	Ewes	Rams	Ewes	Rams	Ewes
0.2375 (0.0727)	-	1753	-	35	-
0.1551 (0.0496)	0.3543 (0.0813)	1998	1974	55	56
0.2620 (0.0364)	0.1673 (0.0378)	5825	3488	235	126
0.3036 (0.1090)	0.2635 (0.0941)	846	1014	30	31
0.2483 (0.0728)	-	1485	-	51	-
mean 0.2413	mean 0.2617				

Table 4.36: Within-flock Heritability Estimates, Standard Error of Heritability Estimates, Number of Observations and Sires Nested Within-years for WLW

h^2 (Standard Error)		Number of Observations		Number of Sireyears	
Rams	Ewes	Rams	Ewes	Rams	Ewes
0.2240 (0.0718)	-	1602	-	35	-
0.1846 (0.0604)	0.2306 (0.0674)	1628	1714	47	47
0.1603 (0.0631)	-	1393	-	31	-
0.1175 (0.0641)	-	960	-	45	-
0.3839 (0.0782)	-	2567	-	63	-
0.2881 (0.0781)	-	1685	-	46	-
0.2349 (0.0848)	-	1116	-	33	-
0.2354 (0.0938)	-	876	-	31	-
0.5369 (0.1269)	-	1294	-	43	-
0.2579 (0.0370)	-	5501	-	234	-
-	0.3939 (0.1077)	-	1019	-	50
mean 0.2624	mean 0.3123				

Table 4.37: Within-flock Heritability Estimates, Standard Error of Heritability Estimates, Number of Observations and Sires Nested Within-years for SLW

h^2 (Standard Error)		Number of Observations		Number of Sireyears	
Rams	Ewes	Rams	Ewes	Rams	Ewes
-	0.0451 (0.0314)	-	1697	-	35
0.4928 (0.1192)	0.4138 (0.1058)	1617	1665	38	37
0.3110 (0.0869)	0.4682 (0.1019)	1353	2080	47	48
-	0.3772 (0.1075)	-	1305	-	34
0.2301 (0.0933)	0.7887 (0.1461)	836	1437	30	53
-	0.1408 (0.0725)	-	876	-	44
-	0.3311 (0.0680)	-	3063	-	63
0.2217 (0.0728)	-	1438	-	40	-
-	0.4330 (0.1089)	-	1448	-	42
-	0.0964 (0.0584)	-	985	-	31
-	0.8123 (0.1439)	-	1883	-	53
0.3541 (0.1036)	0.4400 (0.0908)	948	1603	54	78
0.2775 (0.0387)	0.2104 (0.0427)	5418	3444	233	126
0.3063 (0.0974)	0.2714 (0.0705)	944	1601	52	78
0.3003 (0.1204)	0.4826 (0.1415)	643	895	30	31
-	0.1617 (0.0685)	-	1118	-	36
0.1585 (0.0678)	0.2087 (0.0762)	1092	1154	36	37
-	0.2776 (0.0802)	-	1331	-	54
-	0.3227 (0.1011)	-	952	-	45
-	0.2171 (0.0694)	-	1478	-	43
mean 0.2947	mean 0.3420				

Table 4.38: Within-flock Heritability Estimates, Standard Error of Heritability Estimates, Number of Observations and Sires Nested Within-years for HFW

h^2 (Standard Error)		Number of Observations		Number of Sireyears	
Rams	Ewes	Rams	Ewes	Rams	Ewes
0.4923 (0.1280)	0.2590 (0.0856)	1354	1253	34	34
0.2243 (0.0718)	0.2177 (0.0692)	1603	1698	35	35
0.2683 (0.0789)	0.1958 (0.0641)	1608	1653	38	37
0.3986 (0.0884)	0.3284 (0.0772)	1792	1879	60	61
0.1762 (0.0628)	0.1878 (0.0562)	1373	2091	49	49
0.1863 (0.0793)	0.4664 (0.1239)	942	1308	33	34
0.3061 (0.0750)	0.2558 (0.0694)	1898	1746	53	54
0.2218 (0.0643)	0.2088 (0.0658)	1714	1493	54	53
0.4621 (0.1262)	- -	1393	-	31	-
0.1761 (0.0705)	0.1996 (0.0730)	1116	1201	35	36
0.2258 (0.0828)	0.2289 (0.0787)	979	1117	45	46
- -	0.2387 (0.1149)	-	555	-	30
0.2600 (0.0601)	0.2552 (0.0569)	2595	3052	63	63
0.1538 (0.0586)	0.2367 (0.0722)	1493	1675	42	40
0.4540 (0.0968)	0.4412 (0.0915)	2039	2425	53	54
0.4765 (0.1181)	0.5636 (0.1291)	1361	1453	41	42
0.5105 (0.1475)	0.3203 (0.1072)	879	986	31	31
0.2088 (0.0645)	0.7296 (0.1346)	1612	1877	53	53
0.1297 (0.0561)	0.5285 (0.1007)	1413	1601	78	78
0.2857 (0.0390)	0.3094 (0.0393)	5526	6106	234	234
0.2983 (0.0794)	0.4166 (0.0881)	1366	1604	77	78
0.2832 (0.1119)	0.3996 (0.1260)	714	892	30	31
0.2595 (0.0889)	0.2915 (0.0943)	1092	1121	36	36
0.2538 (0.0869)	0.1702 (0.0698)	1095	1154	36	37
0.2431 (0.0792)	0.4421 (0.1051)	1190	1319	50	53
- -	0.3955 (0.1083)	-	1008	-	50
0.3276 (0.1096)	0.4060 (0.0929)	783	1788	48	52
0.2143 (0.1096)	0.2291 (0.0975)	578	760	32	35
mean 0.2883	mean 0.3304				

Table 4.39: New Zealand Heritability Estimates for WWT

Heritability	Method[a]	Sex[b]	Breed	Author
0.35	D-0	M + F[c]	Romney	Ch'ang and Rae (1961)
0.30	P.H-S	F	Romney	Ch'ang and Rae (1970)
0.23	D-0	F	Romney	Ch'ang and Rae (1970)
0.348	P.H-S	M + F[c]	Romney	Lundie (1971)
0.18	P.H-S	M + F	Romney	Baker et al (1974a)
-0.05	P.H-S	M + F	Romney	Baker et al (1974a)
-0.06	P.H-S	M	Romney	Baker et al (1979)
0.20	P.H-S	F	Romney	Baker et al (1979)
0.08	P.H-S	M + F	Romney	Baker et al (1979)
0.22	D-0	M + F	Romney	Baker et al (1979)
0.20	P.H-S	F	Perendale	Elliott et al (1979)
0.16	D-0	F	Perendale	Elliott et al (1979)
0.35[d]	P.H-S	F	Romney	Blair (1981)
0.24[e]	P.H-S	F	Romney	Blair (1981)
0.19[f]	P.H-S	M	Romney	Blair (1981)
0.10	P.H-S	M + F	Romney	Tait (1983)
0.20	P.H-S	M + F[c]	Romney	Wewala (1985)
0.13	P.H-S	M	Coopworth	Gregory (unpublished)
0.20	P.H-S	F	Coopworth	Gregory (unpublished)
0.16	P.H-S	M + F	Coopworth	Gregory (unpublished)

a. D-0 = Dam-offspring regression
   P.H-S = Paternal half-sib analysis
b. M = Male; F = Female; M + F = Males and Females pooled
c. Wethers and ewes pooled
d. Control group
e. Fleece weight group
f. Face cover group

The ALW heritability estimates for ram hoggets are larger than those for ewe hoggets in 2 out of the 3 flocks (Table 4.35), although the overall means are similar. The mean ALW estimate for ewe hoggets (0.26) is smaller than previously estimated, whereas the ram hogget mean estimate (0.24) is larger than previous ram estimates. The estimates are similar to the larger, published pooled male and female estimates (Table 4.40).

The estimates of WLW heritability (Table 4.36) are similar to published New Zealand estimates (Table 4.41). Insufficient flocks recorded ewe hogget WLW to allow a between sex comparison of the means.

The heritability estimates of SLW (Table 4.37) are in reasonable agreement with the New Zealand published estimates (Table 4.42). The mean heritability estimates of the ewe hoggets are larger than the ram hogget estimates. In 5 of the 8 flocks that have estimates from both sexes, heritabilities for ewe hoggets were larger than for ram hoggets.

Heritability estimates for HFW (Table 4.38) are in reasonable agreement with New Zealand published estimates (Table 4.43). The mean heritability for ewe hoggets is larger than for ram hoggets (0.33 and 0.29, respectively). In 15 of the 25 flocks having both ewe and ram hogget fleeceweights recorded, ewe hoggets had a larger heritability.

Sex differences in heritability estimates have been noted by Baker et al (1979) for liveweights and HFW with ewe hoggets having larger estimates than ram hoggets. The estimates made by Blair (1981) suggest a similar trend. Baker et al (1979) noted a lower genetic variance in ram hoggets when compared with ewe hoggets and a larger environmental variance in ram hoggets.

Table 4.40: New Zealand Heritability Estimates for the Equivalent of ALW

Heritability	Method[a]	Sex[b]	Breed	Author
0.45	P.H-S	F	Romney	Ch'ang and Rae (1970)
0.35	D-O	F	Romney	Ch'ang and Rae (1970)
0.24	P.H-S	M + F	Romney	Baker *et al* (1974a)
0.24	P.H-S	M + F	Romney	Baker *et al* (1974a)
0.13	P.H-S	M	Romney	Baker *et al* (1979)
0.14	P.H-S	M	Romney	Baker *et al* (1979)
0.36	P.H-S	F	Romney	Baker *et al* (1979)
0.34	P.H-S	F	Romney	Baker *et al* (1979)
0.22	P.H-S	M + F	Romney	Baker *et al* (1979)
0.22	P.H-S	M + F	Romney	Baker *et al* (1979)
0.33	D-O	M + F	Romney	Baker *et al* (1979)
0.28	D-O	M + F	Romney	Baker *et al* (1979)
0.13	P.H-S	M + F	Romney	Tait (1983)

a. D-O = Dam-offspring regression
P.H-S = Paternal half-sib analysis

b. M = Male; F = Female; M + F = Males and Females pooled.

Table 4.41: New Zealand Heritability Estimates for the Equivalent of WLW

Heritability	Method[a]	Sex[b]	Breed	Author
0.39	P.H-S	F	Romney	Ch'ang and Rae (1970)
0.42	D-O	F	Romney	Ch'ang and Rae (1970)
0.38	P.H-S	M + F	Romney	Baker *et al* (1974a)
0.32	P.H-S	M + F	Romney	Baker *et al* (1974a)
0.21	P.H-S	M	Romney	Baker *et al* (1979)
0.46	P.H-S	F	Romney	Baker *et al* (1979)
0.34	P.H-S	M + F	Romney	Baker *et al* (1979)
0.28	D-O	M + F	Romney	Baker *et al* (1979)
0.14	P.H-S	M + F	Romney	Tait (1983)
0.15	P.H-S	M + F	Romney	Tait (1983)
0.65	P.H-S	M + F	Coopworth	Gregory (unpublished)
0.18	D-O	M + F	Coopworth	Gregory (unpublished)

a. D-O = Dam-offspring regression
P.H-S = Paternal half-sib analysis

b. M = Male; F = Female; M + F = Males and Females pooled.

Table 4.42: New Zealand Heritability Estimates for the Equivalent of SLW

Heritability	Method[a]	Sex[b]	Breed	Author
0.46	D-O	F	Romney	Tripathy (1966)
0.51	P.H-S	F	Romney	Ch'ang and Rae (1970)
0.46	D-O	F	Romney	Ch'ang and Rae (1970)
0.22	P.H-S	M + F	Romney	Baker et al (1974a)
0.22	P.H-S	M + F	Romney	Baker et al (1974a)
0.27	P.H-S	F	Romney	Chopra (1978)
0.23	P.H-S	M	Romney	Baker et al (1979)
0.31	P.H-S	F	Romney	Baker et al (1979)
0.27	P.H-S	M + F	Romney	Baker et al (1979)
0.26	D-O	M + F	Romney	Baker et al (1979)
0.27	P.H-S	F	Perendale	Elliott et al (1979)
0.44	D-O	F	Perendale	Elliott et al (1979)
0.34[c]	P.H-S	F	Romney	Blair (1981)
0.06[d]	P.H-S	F	Romney	Blair (1981)
0.52[e]	P.H-S	F	Romney	Blair (1981)
0.26[d]	P.H-S	M	Romney	Blair (1981)
0.42[e]	P.H-S	M	Romney	Blair (1981)
0.25	P.H-S	M + F	Romney	Tait (1983)

a. D-O = Dam-offspring regression
P.H-S = Paternal half-sib analysis.

b. M = Male; F = Female; M + F = Male and Female pooled.

c. Control line

d. Face cover group

e. Fleeceweight group

Table 4.43: New Zealand Heritability Estimates for HFW

Heritability	Method[a]	Sex[b]	Breed	Author
0.46	D-O	F	Romney	Tripathy (1966)
0.225	P.H-S	F	Romney	Lundie (1971)
0.29	P.H-S	M + F	Romney	Baker *et al* (1974a)
0.57	P.H-S	M + F	Romney	Baker *et al* (1974a)
0.39	P.H-S	F	Romney	Chopra (1978)
0.32	P.H-S	F	Perendale	Elliott *et al* (1979)
0.30	D-O	F	Perendale	Elliott *et al* (1979)
0.29	P.H-S	M + F	Romney	Baker *et al* (1979)
0.27	P.H-S	M	Romney	Baker *et al* (1979)
0.41	P.H-S	F	Romney	Baker *et al* (1979)
0.34	D-O	M + F	Romney	Baker *et al* (1979)
0.28[c]	P.H-S	F	Romney	Blair (1981)
0.34[d]	P.H-S	F	Romney	Blair (1981)
0.34[e]	P.H-S	F	Romney	Blair (1981)
0.07[d]	P.H-S	M	Romney	Blair (1981)
0.15[e]	P.H-S	M	Romney	Blair (1981)
0.14	Realised	F	Romney	Blair (1981)
0.17	Realised	M	Romney	Blair (1981)
0.30	P.H-S	M + F	Romney	Tait (1983)
0.67	P.H-S	M + F	Coopworth	Gregory (unpublished)
0.31	D-O	M + F	Coopworth	Gregory (unpublished)

a. D-O = Dam-offspring regression
P.H-S = Paternal half-sib analysis

b. M = Male; F = Female; M + F = Males and Females pooled

c. Control group

d. Fleece weight group

e. Face cover group.

4.2.2 Reproductive Traits

The heritability estimates of the reproductive traits (Tables 4.44 to 4.52) have overall means close to zero, except for NLB, MULT, Wt.L.W. and Wt.L.W.BR. This indicates that lamb survival is largely environmental.

The mean heritability estimate for NLW (0.12) is large when compared with New Zealand estimates (Table 4.53). The mean NLW estimate (0.07) falls in the middle of New Zealand estimates (Table 4.54). The estimates for MULT have a range from nearly zero to 1.0, with the mean value (0.14) being larger than New Zealand estimates (Table 4.55). Comparing within-flock heritability estimates for MULT and NLB shows 14 of the 23 flocks have higher heritabilities for NLB than MULT. The mean MULT heritability (0.14) is slightly larger than the mean NLB estimate (0.12).

The mean Wt.L.W. estimate (0.10) lies in the middle of New Zealand estimates (Table 4.56). Within-flock estimates in 14 of the 23 flocks were larger for Wt.L.W.BR than Wt.L.W.

Table 4.44 : Within-flock Heritability Estimates, Number of Observations and Sires Nested Within-years for NLB

h^2	Number of Observations	Number of Sireyears
0.0130	1007	52
0.2239	1138	47
0.1302	2602	128
0.0755	2549	105
0.1080	2546	157
0.0720	2271	69
0.0399	1222	35
0.1439	1508	74
0.1052	2933	146
0.0929	1844	135
0.1170	1282	57
0.0248	1794	115
0.0457	3832	161
0.3079	1456	85
0.1295	3557	164
0.1235	2661	93
0.0788	1805	85
0.0639	1283	53
0.1165	2748	146
0.2131	3026	199
0.0484	11740	534
0.1271	2011	136
0.0877	1025	76
0.2620	1141	38
0.1519	1853	84
0.1228	1169	77
0.0280	1657	77
0.1667	1151	83
mean 0.1150		

Table 4.45: Within-flock Heritability Estimates, Number of Observations and Sires Nested Within-years for NLW

h^2	Number of Observations	Number of Sireyears
0.1614	1134	47
0.0891	2601	128
0.0299	2549	105
0.0325	2545	157
0.0487	2271	69
0.0556	1222	35
0.0960	1508	74
0.0686	2933	146
0.0602	1844	135
0.0948	1274	57
0.0322	1794	115
0.0380	3831	161
0.1331	1454	85
0.0361	3549	164
0.0249	2661	93
0.0612	1805	85
0.1033	1283	53
0.0398	2736	146
0.0753	3019	198
0.0396	11738	534
0.0553	2011	136
0.0231	1025	76
0.0000	1140	38
0.0790	1852	84
0.0271	1657	77
0.1642	1151	83
0.1313	1168	77
mean 0.0667		

Table 4.46 : Heritability Estimates, Number of Observations and Sires Nested Within-years for MULT

h^2	Number of Observations	Number of Sireyears
0.2228	1134	47
0.1195	2601	128
0.0373	2549	105
0.1088	2545	157
0.0023	1222	35
0.0918	2271	69
0.1218	2933	146
0.0782	1844	135
0.1519	1274	57
0.0431	3831	161
0.0694	3549	164
0.1278	2661	93
0.0990	1805	85
0.0396	1283	53
0.1150	2736	146
0.1567	1488	72
0.0033	1794	115
1.0359	1454	85
0.3041	3019	198
0.0287	11738	534
0.0804	2011	136
0.0033	1025	76
0.2889	1115	38
0.1679	1852	84
0.0158	1168	77
0.0026	1657	77
0.1719	1151	83
mean 0.1366		

Table 4.47: Within-Flock Heritability Estimates, Number of Observations and Sires Nested Within-years for LSURV

h^2	Number of Observations	Number of Sireyears
0.0021	2790	30
0.0694	4728	44
0.0309	5935	44
0.0064	5953	50
0.0019	7676	83
0.0106	10395	69
0.0010	4131	31
0.0179	4318	52
0.0196	7404	83
0.0217	8930	86
0.0012	5003	42
0.0443	3923	44
0.0025	3942	56
0.0657	2483	40
0.0824	8715	74
0.0190	6432	60
0.0544	9187	72
0.0314	6012	58
0.1278	2142	33
0.0067	5206	46
0.0022	2606	30
0.1522	7061	74
0.0023	7047	108
0.0316	29147	315
0.0864	6886	105
0.0206	4267	46
0.0085	3048	32
0.0884	3574	43
0.0017	4201	49
0.0307	7239	88
0.0316	5887	74
0.0123	7138	71
0.0705	4351	65
0.0229	1159	36
mean 0.0364		

Table 4.48 : Within-flock Heritability Estimates, Number of Observations and Sires Nested Within-years for LSURV1

h^2	Number of Observations	Number of Sireyears
0.0027	991	31
0.0032	1429	43
0.0026	1009	48
0.0155	1605	71
0.0037	543	36
0.0821	999	64
0.1344	618	36
0.0030	971	41
0.0026	1316	49
0.0033	882	39
0.1200	1499	188
0.0034	962	37
0.0033	1537	66
0.0034	1254	47
0.0882	1120	42
0.1905	2103	63
0.0034	923	57
0.0035	833	75
0.0706	3261	232
0.0037	749	76
0.4890	523	34
0.0145	876	42
0.0036	528	45
0.0034	789	59
0.0034	1348	61
mean 0.0503		

Table 4.49 : Within-flock Heritability Estimates, Number of Observations and Sires Nested Within-years for LSURV2

h^2	Number of Observations	Number of Sireyears
0.0863	3724	44
0.0200	4501	44
0.0275	4937	50
0.0156	6029	82
0.0130	7803	69
0.0011	3142	31
0.0024	3750	52
0.0204	6354	82
0.0244	7872	84
0.0012	4371	42
0.0530	2569	54
0.1279	1597	40
0.0562	7195	74
0.0284	5448	60
0.0790	7637	72
0.1116	4735	56
0.2058	1686	33
0.0110	4076	46
0.0029	2117	30
0.1979	4942	72
0.0023	6090	107
0.0332	25643	313
0.1051	6020	105
0.0350	3746	46
0.0020	2728	32
0.0321	2971	42
0.0099	3322	49
0.0658	6620	88
0.0522	5069	70
0.0198	5756	69
0.0511	3817	63
mean 0.0482		

Table 4.50: Within-flock Heritability Estimates, Number of Observations and Sires Nested Within-years for ESURV

h^2	Number of Observations	Number of Sireyears
0.0495	1134	47
0.0288	2601	128
0.0000	2545	157
0.0432	2271	69
0.0361	1222	35
0.0221	2549	105
0.0554	1508	74
0.0565	2933	146
0.0000	1844	135
0.0000	1274	57
0.0359	1794	115
0.0799	3831	161
0.0023	1454	85
0.0000	3549	164
0.0102	2661	93
0.0370	1805	85
0.0637	1283	53
0.0025	2736	146
0.0040	3019	198
0.0132	11738	534
0.0072	2011	136
0.1911	1025	76
0.0000	1140	38
0.0769	1852	84
0.0471	1168	77
0.0546	1657	77
0.0767	1151	83
mean 0.0368		

Table 4.51: Within-Flock Heritability Estimates, Number of Observations, and Sires Nested Within-years for Wt.L.W.

h^2	Number of Observations	Number of Sireyears
0.1459	2338	124
0.0715	2209	103
0.0794	2217	145
0.0337	1925	68
0.3427	1441	74
0.0396	2658	140
0.0903	1567	126
0.0646	1182	56
0.0300	1589	106
0.0536	3537	160
0.1842	1306	80
0.0760	3277	162
0.0942	2362	87
0.0000	1463	79
0.1331	1206	53
0.2344	2126	127
0.0875	2655	184
0.0653	10597	514
0.0989	1805	132
0.0401	1065	38
0.0488	1572	81
0.1442	1053	71
0.0521	1431	76
mean 0.0961		

Table 4.52: Within-Flock Heritability Estimates, Number of Observations, and Sires Nested Within-years for Wt.L.W.BR.

h^2	Number of Observations	Number of Sireyears
0.0638	2338	124
0.1671	2209	103
0.0538	2217	145
0.0680	1925	68
0.2047	1441	74
0.0346	2658	140
0.1480	1567	126
0.0000	1182	56
0.0000	1589	106
0.1118	3537	160
0.1833	1306	80
0.1754	3277	162
0.0423	2362	87
0.0156	1463	79
0.1350	1206	53
0.3370	2126	127
0.0933	2655	184
0.1002	10597	514
0.1749	1805	132
0.1120	1065	38
0.0000	1572	81
0.0516	1053	71
0.0981	1431	76
mean 0.1031		

Table 4.53: New Zealand Heritability Estimates for NLB

Herita-bility	Method[a]	Age of Ewe	Breed	Author
0.053	P.H-S	2 yr old	Romney	Ch'ang and Rae (1970)
0.045	D-O	2 yr old	Romney	Ch'ang and Rae (1979)
0.0409	P.H-S	2 yr old	Romney	Lundie (1971)
0.0106	P.H-S	3 yr old	Romney	Lundie (1971)
0.0164	P.H-S	4 yr old	Romney	Lundie (1971)
0.0363	P.H-S	5 yr old	Romney	Lundie (1971)
0.17	P.H-S	2 yr old	Coopworth	Gregory (unpublished)
-0.13	D-O	2 yr old	Coopworth	Gregory (unpublished)

a. D-O = Dam-offspring regression
P.H-S = Paternal half-sib analysis

Table 4.54: New Zealand Heritability Estimates for NLW

Herita-bility	Method[a]	Age of Ewe	Breed	Author
0.0583	P.H-S	2 yr old	Romney	Lundie (1971)
0.0663	P.H-S	3 yr old	Romney	Lundie (1971)
0.0262	P.H-S	5 yr old	Romney	Lundie (1971)
0.14	P.H-S	2 yr old	Perendale	Lewer (1978)
0.02	P.H-S	3 yr old	Perendale	Lewer (1978)
0.24	P.H-S	4 yr old	Perendale	Lewer (1978)
0.04	P.H-S	5 yr old	Perendale	Lewer (1978)
0.14	P.H-S	2 yr old	Coopworth	Gregory (unpublished)
-0.05	D-O	2 yr old	Coopworth	Gregory (unpublished)

a. D-O = Dam-offspring regression
P.H-S = Paternal half-sib analysis.

CHAPTER FIVE

SUMMARY

The regional analyses of the fixed effects highlighted S.North as having significantly different estimates for SS-TrTw effects on spring liveweight. For NLW, MULT and ESURV the North region was shown to have significantly larger estimates than other regions for Mat-3 yr effect. The N.North region had significantly larger estimates of Mat-3 yr effects on NLW and MULT, than the 3 more southern regions. A feature of all the environmental estimates was the large between flock variation within traits.

The national environmental estimates for the liveweight traits differ from those assumed by Sheeplan especially for the BRR subclasses. The effect of the under-estimation of the effects by Sheeplan is that animals born as multiples (especially triplets) will tend to be penalized unduly relative to single born and reared animals. The HFW environmental estimates suggest that dam-age is of little importance and BRR is of importance especially for animals born as triplets.

Differences between the sexes in environmental estimates for ALW, WLW and HFW were apparent with ewe hoggets having larger estimates for the BRR effects than ram hoggets. The sex differences for SLW appeared to be mediated though liveweight differences, whereas the other sex differences appeared not to be due to weight differences.

Dam or ewe age was of importance in the reproductive traits. The young ewes were worse, with there being little difference between 4 year old and mature ewes. In Wt.L.W.BR, ewes rearing multiples weaned a greater amount of lambs than those rearing singles.

The heritability estimates may be biased by within-flock selection and non-random mating. For the weight traits the majority of the heritability estimates were larger for the ewe hoggets. The mean heritabilities (and range) are: WWT 0.17 (0.02 - 0.75); ram ALW 0.24 (0.16 - 0.30); ewe ALW 0.26 (0.17 - 0.35); ram WLW 0.26 (0.12 - 0.54); ewe WLW 0.31 (0.23 - 0.39); ram SLW 0.29 (0.16 - 0.49); ewe SLW 0.34 (0.04 - 0.81); ram HFW 0.29 (0.13 - 0.51); ewe HFW 0.33 (0.17 - 0.73). The traits assessing lamb survival (LSURV, LSURV1, LSURV2 and ESURV) had heritabilities close to zero (mean(and range); 0.04 (0.00 - 0.15); 0.05 (0.00 - 0.49); 0.05 (0.00 - 0.21); 0.04 (0.00 - 0.19), respectively). Traits measuring the ewes' lamb producing ability (NLB, NLW and MULT) and overall production (Wt.L.W. and Wt.L.W.BR) had low to medium heritabilities (mean (and range): 0.12 (0.01 - 0.31); 0.07 (0.00 - 0.16); 0.14 (0.00 - 1.04); 0.10 (0.00 - 0.34); 0.10 (0.00 - 0.34), respectively). Large between-flock within-trait variation was evident.

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