A MIXED MODEL EVALUATION FOR GROWTH AND REPRODUCTION PARAMETERS IN A SA MUTTON MERINO FLOCK

by

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SUMMARY

Records of the La Rochelle S.A. Mutton Merino stud were analysed to determine the importance of possible contributing non-genetic sources of variation on growth and reproductive traits. Growth traits analysed were pre-weaning weight (42dW), weaning weight (100dW), 205d weight, ADG's and Kleiber Ratio's (KR) for both 42d and 100d. All the included effects, i.e. year, sex, birth status, season, age of dam and the year x sire interaction, were highly significant (P<0.001) for the growth traits. Reproduction traits measured were mean number of lambs born per ewe per year, mean Kg lamb weaned per ewe per year, percentage twins and fecundity. Year was the only significant effect (P<0.001) for all four reproduction traits.

Data of records between 1974 and 1995 were used to estimate additive direct and additive maternal heritabilities for seven growth traits. The estimates of the direct heritabilities varied between 0.166 for 42dW and 0.513 for 205dW. The estimates of the maternal heritabilities were within the 0.042 (42dW) to 0.370 (100dADG) range. Estimates of the covariance between the direct additive and maternal additive components were generally negative and of a substantial size (-0.215 to -0.674).

Additive direct and additive maternal heritabilities for four reproductive traits were also estimated. The estimates for direct additive heritabilities varied between 0.039 for fecundity and 0.177 for Kg lamb weaned per ewe per year. Estimates for the maternal additive heritabilities were correspondingly low, varying from 0.007 for lambs born per ewe per year to 0.197 for percentage twins. Estimates of covariance between the additive direct and additive maternal components were negative.

Genetic trends of the flock were studied. The main objective of the breeder was to improve the reproductive efficiency of the flock, whilst decreasing the incidence of very large lambs. Selection pressure on reproductive performance hasn't yet attained the desired effect as three of the four reproductive traits measured, showed very little or no improvement. Lambs do however have lower body weights, while the 100dADG and 100dKR have improved.

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1. GENERAL INTRODUCTION

Genetic change can readily be accomplished by crossbreeding two existing breeds. This practise should result in a fast rate of genetic improvement. It is also necessary however, to utilise the genetic properties of the new or an existing breed in order to attain further genetic change and improvement within a specific breed, as selection within a breed could sometimes even be more efficient than crossbreeding. This genetic change can be accomplished by the selection of parents and by controlling the way in which they are mated.

Clarke (1988) and Fogarty & Gilmour (1993) stated that it is of the utmost importance to clearly separate breeding objectives from selection criteria. The breeding objectives should first be determined on purely economical grounds, where after genetic qualifications and selection criteria to achieve this goal should be introduced. The profit of sheep production for mutton depends greatly on the number and live weight of the sheep, and selection objectives should concentrate on these traits (Tosh & Kemp, 1994). As the sale of lambs is the major source of income for SA Mutton breeders, traits influencing both reproductive efficiency of the flock and growth of lambs is of crucial importance to the profitability of the enterprise.

In order to determine the breeding strategy that will be followed in a specific breed or flock, certain genetic parameters (i.e. variance components and heritabilities) of certain traits must be estimated. Genetic changes should be monitored over time to check the validity of the predictions made.

The La Rochelle SA Mutton Merino stud was started in 1972 by Mr. Collett. The purpose of this study was to describe some important genetic properties and dynamics of the La Rochelle S.A. Mutton Merino stud. It is hoped that this document will both be useful to the specific breed and that it will contribute to the general knowledge of the application of modern genetic principles.

2. NON-GENETIC FACTORS INFLUENCING GROWTH AND REPRODUCTION TRAITS.

Summary

Records of the La Rochelle S.A. Mutton Merino stud were analysed to determine the importance of possible contributing non-genetic sources of variation on both growth and reproductive traits. Growth traits analysed were pre-weaning weight (42dW), weaning weight (100dW), 205d weight, ADG's and Kleiber Ratio's (KR) for both 42d and 100d. All the effects that were included, i.e. year, sex, birth status, season, age of dam and the year x sire interaction, were highly significant (P<0.001) for these growth traits. Reproduction traits measured were mean number of lambs born per ewe per year, mean kg lamb weaned per ewe per year, percentage twins and fecundity. Year was found to be the only significant effect (P<0.001) for all four the reproduction traits.

2.1 Introduction

Genetic improvement to a large extent depends on the accuracy of identifying genetically superior animals. Identifying genetically superior animals requires that non-genetic factors (fixed effects) which influence the accuracy of predicted breeding values be controlled either experimentally or accounted for statistically (Van Wyk, 1992).

In order to be able to estimate breeding values, a mathematical model must be specified to accurately describe the biological processes that influence the specific measured trait. The magnitude of non-genetic sources of variation must be quantified to construct this model in a way that will best describe the data. Wilson *et al* (1996) has shown that the significance of interactions between sex, birth and rearing type and age of dam varies across breeds. The apparently inconsistent pattern of interactions highlights the need for breed-specific, and in some cases even within-breed-specific, adjustment factors. Information on the magnitude of these effects is limited in the S.A. Mutton Merino, with research mainly done by Vosloo (1967), Kotze (1976) and Fourie & Cloete (1993).

The objective of this study was to analyse the records of the La Rochelle S.A. Mutton Merino stud in order to investigate the importance of possible contributing non-genetic sources of variation on growth traits as well as on reproductive traits.

2.2 Materials and Methods

2.2.1 Animals and environment

The data used in this study were obtained from the registered La Rochelle stud of Mr C. Collett situated between Venterstad and Bethulie in the Free State province. The farm is situated in the summer rainfall region, at an altitude of approximately 1291 m above sea level (φ 30° 32' S λ 25° 59' E). The farm has an average annual rainfall of 422 mm, which falls mainly during the summer months. During the summer months (September - April) the average maximum (minimum) temperatures are 27° C (12° C) and during the winter 18° C (3° C).

Mr Collett started the current La Rochelle stud in 1972, but data from the previous owners were also obtained.

All the ewes and their progeny are kept under extensive circumstances. Since 1985 they don't receive any supplementary feed during the summer or winter, except for a salt lick. Twin born lambs are fed supplemental roughage after weaning, while triplet lambs are hand-raised, as they won't survive the extensive conditions otherwise. To prepare ram lambs for auctioning, they are fed concentrates *ad lib* from 270 days of age. A dosing and inoculation programme suited for the farm was followed.

2.2.2 Management and selection

Lambs were weaned on the veld at approximately 100 days. Due to the extensive conditions, ewes were mated for the first time at 18 months. Accelerated mating systems were practised during the first few years of the La Rochelle flock's existence, mainly 1976 to 1982. This practise was stopped due to the adverse effect of the accelerated mating system on the general condition of the ewes. Only one lambing

season per year (either spring or autumn) occurred onwards from 1983. Lambing season therefore had to be included as a fixed effect.

Adaptation to the natural environment was the collective most important selection objective. Selection emphasis was primarily on reproductive performance for the ewes. Lambing interval, date of first lambing and mass of lamb produced at 100 days of age were the major traits considered. The rams were not selected on reproductive performance, as they were bred from the ewes mentioned above. Growth, functional characteristics and wool production were the selection criteria for rams. All the animals had to comply with the breed standards of the SA Mutton Merino Breed Society. A very high replacement rate of 70% per annum was practised for the ewes.

2.2.3   Data

The data, before editing, consisted of 4577 individual lamb records that were collected over the period 1962 to 1995. Most of the data collected before 1990 were incomplete, as almost no weights for any age were recorded. Fifty-eight percent of the animals whose records were used, were born during 1990 to 1995. The remaining 42% were born between 1962 and 1989. The variance components estimated from the period 1962-1989 were compared to those estimated from the group 1990-1995. The objective was to ascertain if the same effects should be included in the model for both groups. Interestingly, almost no differences in the variance components were found between the two analyses.

As no records of birth weights were kept, a standard birth weight was allocated to lambs irrespective of the age of dam, but dependent on birth status. It can however be assumed that the older ewes would give birth to heavier lambs than younger ewes, as indicated in literature (Kotze, 1976, Schoeman, 1990 and Nugent & Jenkins, 1993).

Traits analysed in this study were pre-weaning weight (42dW), weaning weight (100dW), 205d weight, ADG's and Kleiber ratio's (KR) for both 42d and 100d. Records for birth weights were not available.

Age variation occurred at the measurement of 42d and 100d weights. The lambs were weighed between days 26 and 77 for the 42dW records, and between days 75 and 129 for the 100dW records. It was thus decided to use the ADG's and KR (ADG / $WW^{0.75}$) for both these periods in addition to the weight traits, as ADG and KR take into account the period over which the weight change occurred. The Kleiber ratio has been suggested as an indirect selection criterion for efficiency of feed conversion under field conditions (Van Wyk, 1992).

The data for 100d ADG en KR were only available for two years (1991 and 1993). Year or season of birth effects could therefore not be estimated accurately for these traits.

Reproduction traits measured were mean number of lambs born per year per ewe, mean kg lamb weaned per year per ewe, percentage twins and fecundity. While the percentage twins trait only measured a ewe's ability to produce twins, the fecundity trait also included other multiple births and accounted for the frequency with which the ewe lambed (i.e. whether the ewe lambed every year).

2.2.4   *Statistical analysis*

Preliminary analysis was performed by analysing the effects of age of dam, birth status, birth season, sex, two-way interactions between sire and year, sire and season and age of dam and birth status on all measurements. The sire x year interaction was included as a fixed effect. The General Linear Model Procedure (Scheffe's test) was used as this test controls the Type I experiment wise error and was chosen because the number of animals differed drastically between years.

The various models fitted for the growth and reproductive traits will be discussed.

- The following model was fitted for 42dW, 42dADG and 42dKR:

$$Y_{ijklmn} = \mu + r_i + h_j + a_k + s_l + p_m + f_n + b_o \times h_j + e_{ijklmn}$$

Where Y_{ijklmn} = an observation of a trait on the ith animal of the mth birth status of the lth sex of the kth dam age group born in the jth year and the nth season,

μ = least squares mean

r_i = random effect of the ith animal with zero mean and variance $I\sigma^2_r$,

h_j = fixed effect of the jth year,

a_k = fixed effect of the kth age of dam (k= 2 to 9),

s_l = fixed effect of the lth sex (l = 1 or 2),

p_m = fixed effect of the mth birth status (m = 1,2,3, or 4),

f_n = fixed effect of the nth season (n = 1 or 2),

$b_o \times h_j$ = the interaction between the oth sire and the jth year,

e_{ilklmn} = random error with zero mean and variance $I\sigma^2_e$.

- A similar model was used for 100dW (where only the effect of season was omitted) and 205dW (effect of age of dam and the interaction was omitted).

- The following model was fitted for 100dADG and 100dKR:

$$Y_{ijklmn} = \mu + r_i + a_k + s_l + p_m + e_{ijklmn}$$

Where Y_{ijklmn} = an observation of a trait on the ith animal of the mth birth status of the lth sex.

μ = least squares mean

r_i = random effect of the ith animal with zero mean and variance $I\sigma^2_r$,

a_k = fixed effect of the kth age of dam (k= 2 to 9),

s_l = fixed effect of the lth sex (l = 1 or 2),

p_m = fixed effect of the mth birth status (m = 1,2,3, or 4),

e_{ilklmn} = random error with zero mean and variance $I\sigma^2_e$.

For the reproduction traits the following model was fitted:

- The following model was fitted for mean number of lambs born/year/ewe and for mean kg lamb weaned/year/ewe:

$$Y_{ijklmn} = \mu + r_i + h_j + e_{ijklmn}$$

Where Y_{ijklmn} = an observation of a trait on the ith animal born in the jth year,

μ = least squares mean

r_i = random effect of the ith animal with zero mean and variance $I\sigma^2_r$,

h_j = fixed effect of the jth year,

e_{ilklmn} = random error with zero mean and variance $I\sigma^2_e$.

- A similar model was fitted for fecundity, where age of dam was included.

- For percentage twins the following model was fitted:

$$Y_{ijklmn} = \mu + r_i + h_j + a_k + s_l + p_m + f_n + b_o \text{ x } h_j + e_{ijklmn}$$

Where Y_{ijklmn} = an observation of a trait on the ith animal of the mth birth status.

μ = least squares mean

r_i = random effect of the ith animal with zero mean and variance $I\sigma^2_r$,

p_m = fixed effect of the mth birth status (m = 1,2,3, or 4),

$b_o \text{ x } h_j$ = the interaction between the oth ram and the jth year,

e_{ilklmn} = random error with zero mean and variance $I\sigma^2_e$.

2.3 Results and discussion

Analysis of variance indicated that all the effects included, were highly significant (P < 0.001) for the production traits analysed (Table 2.1). Year was the only significant effect (P < 0.001) for reproduction traits analysed, as could be expected (see Table 2.2).

Table 2.1. Analysis of variance for production traits (F-values).

Trait	Year	Sex	Birth status	Season	Age of dam	Year x Sire Interaction
42d weight	50.33*	26.68*	46.51*	52.46*	2.49*	6.04*
100d weight	8.70*	42.92*	2.63*	1.12	2.34*	2.65*
205d weight	11.82*	136.69*	4.89*	86.42*	3.48	_____
42d ADG	28.30*	4.85	24.60*	15.33*	3.02*	1.81*
42d KR	17.70*	133.48*	0.54	0.10*	2.32*	5.14*
100d ADG	_____	3.51*	2.76*	_____		_____
100d KR	_____	1.87	8.48*	_____		_____

* Significant effect (P < 0.001)

Table 2.2. Analysis of variance for reproduction traits (F-values).

Trait	Year	Birth status	Season	Age of dam	Year x Sire Interaction
Mean number of lambs born/y/ewe	1.72*	0.23	1.45	1.95	1.12
Mean kg lamb weaned/y/ewe	2.01*	0.28	2.33	1.19	1.03
Percentage twins	1.04	2.35*	0.19	0.51	1.47*
Fecundity	2.10*	1.36	0.36	2.12*	1.09

* Significant effect (P < 0.001)

The sex of the lamb had a significant effect on all traits except 42d ADG and 100d KR, which is probably caused by the incomplete nature of the data, as it doesn't conform to the normal trend. The male lambs were consistently heavier than the females and had higher Kleiber ratios, which confirmed studies done by Hall *et al* (1995).   Cantet *et al* (1988) showed that the sex of lambs is significant, but account for a small portion of the total variation in weaning weight. The general conclusion of published researched is that male lambs grow faster than their female counterparts and thus have higher weaning weights (Kotze, 1976; Boujenane & Kerfal, 1990; Wilson *et al*, 1996), as is confirmed in Tables 2.3 and 2.4.

Single lambs were significantly heavier than twins, triplets and quadruplets (2.16 kg, 4.06 kg and 8.21 kg respectively) at 42d weight. The ranking of 42d ADG's for birth status followed the same tendency. 42d KR will most probably also be significantly affected by birth status, its exclusion is most probably a fixed effect caused by the nature of the data. This ranking for birth status had changed drastically for 100d weight, with the triplets weighing the most, then singles, quadruplets and lastly the twins as shown in Tables 2.3 and 2.4. This is due to the hand raising of litters with more than two lambs. Triplets were on average 4.4 kg heavier than twins. The 100d ADG however showed that twins had the second highest ADG's after the triplets, while the quadruplets had the lowest. The 100d KR again followed the same tendency, triplets having the highest figures and the twins second. Although still weighing less than singles at weaning, twin born lambs thus had higher 100dADG's and 100dKR's than the single born lambs.

Although the rankings for birth status may differ, it is clear that number of lambs born does have a significant effect on growth traits, as ascertained by Annala *et al* (1995) on the Segureña sheep breed in Spain and Kotze (1976) on the S.A. Mutton Merino. Thorgeirsson & Thorsteinsson (1989) indicated that singles had a better chance of expressing their genetic potential than lambs born in larger litters. Fogarty & Hall (1995) confirmed this by stating that the average birth weight of 4 to 5 kg is the weight at which a maximum lamb survival rate among highly fecund Poll Dorset ewes can be found. Few triplet and higher order birth lambs can attain this ideal weight for survival.

According to Wilson *et al* (1996), the type of birth and birth and rearing type accounted for a larger amount of variation than sex or age of dam. This was confirmed for 42d traits in this study, as shown in Table 2.1.

Schoeman (1990) showed that season and year of birth significantly affected birth weight, weaning weight and 100d weight. In this study, lambs born in spring weighed consistently more at 42 days (20.32 kg vs. 17.79 kg), had higher 42d ADG's (0.323 vs. 0.299) and higher 42d Kleiber ratio's (0.0346 vs. 0.0344), as shown in Table 2.3. However, they had lower 205d masses than the autumn born lambs (45.08 vs. 48.01). Due to a lack of data the effect of season on 100d growth traits could not be estimated.

Table 2.3. Least square means (LSMeans) and standard errors (SE) estimates for 42d weights (42dW), 42d average daily gain (42dADG) and 42d Kleiber ratio (42dKR) by sex, birth status, season of birth and age of dam.

Effect	42dW LSMean (SE)	42dADG LSMean (SE)	42dKR LSMean (SE)
Sex			
• Female	17.8504 (0.745)	0.30243 (0.012)	0.034425 (0.001)
• Male	18.9523 (0.751)	0.29845 (0.012)	0.032536 (0.001)
Birth status			
• Single	21.7644 (0.599)	0.33768 (0.009)	0.033765 (0.001)
• Twin	18.7040 (0.611)	0.30191 (0.009)	0.033772 (0.001)
• Triplet	17.5276 (0.763)	0.28406 (0.012)	0.032930 (0.001)
• Quadruplet	15.6093 (1.814)	0.27811 (0.31)	0.033456 (0.002)
Season of birth			
• Autumn	17.4969 (0.759)	0.28717 (0.012)	0.032935 (0.001)
• Spring	19.3057 (0.744)	0.31371 (0.012)	0.034027 (0.001)
Age of dam			
• 2 (n=418)	17.5654 (0.673)	0.28914 (0.011)	0.033134 (0.001)
• 3 (351)	19.5232 (0.684)	0.32018 (0.011)	0.034500 (0.001)
• 4 (253)	19.9658 (0.684)	0.32136 (0.011)	0.034141 (0.001)
• 5 (236)	19.6881 (0.692)	0.32014 (0.011)	0.034177 (0.001)
• 6 (162)	18.5420 (0.695)	0.30493 (0.011)	0.033577 (0.001)
• 7 (2)	13.9198 (2.507)	0.24182 (0.038)	0.032010 (0.002)

Table 2.4. Least square means (LSMeans) and standard errors (SE) estimates for 110d weights (100dW) by sex, birth status, season of birth and age of dam.

Effect	100dW LSMean (SE)
Sex	
• Female	28.9659 (1.488)
• Male	31.3747 (1.499)
Birth status	
• Single	32.1144 (0.818)
• Twin	28.6968 (0.850)
• Triplet	31.7418 (1.178)
• Quadruplet	28.1283 (4.974)
Season of birth	
• Autumn	30.4204 (1.489)
• Spring	29.9203 (1.497)
Age of dam	
• 2 (n=190)	27.7955 (1.376)
• 3 (220)	29.7834 (1.374)
• 4 (200)	30.9578 (1.382)
• 5 (156)	29.4835 (1.381)
• 6 (90)	30.0549 (1.389)
• 7 (19)	31.8476 (1.740)

The age of dam had a significant effect on 42d weight, 42d ADG, 42d KR and 100d weight. Thorgeirsson & Thorsteinsson (1989) found that the greatest increase in birth weight was found between yearling and two-year-old ewes. A gradual increase in the birth weight of lambs continued up to six-year-old ewes. Kotze (1976) found that this difference in weight was not significant by the time that the lambs were weaned. In this study it was found that ewes between the ages of three and five years had the lambs with the highest 42d W, 42d ADG and 42d KR. Both younger and older ewes had lambs with lower performances. This corresponds with Boujenane & Kerfal (1990) who found that D'man ewes that were younger than 1.5 years had the lambs with the lowest performance level for growth traits, while lambs from ewes older than 3.5 years had the highest performance levels.

Year was found to be the only significant effect influencing all four reproduction traits, as shown in Table 2.2. Age of dam only had a significant effect on the kilograms of lamb weaned per year per ewe. Schoeman (1990) found that number of ewes lambed / number of ewes mated was significantly influenced by year, age of dam and the pre-mating body mass of the ewe in the Döhne Merino breed. Lambs born / ewes lambed was significantly influenced by year, lambing season, pre-mating mass of ewe and a year x season interaction. Dimsoski *et al* (1994) added age of dam to these effects. Schoeman (1990) stressed that the higher production rate of heavier ewes were the result of higher fertility and fecundity and not due to heavier lambs born and weaned.

2.4 Conclusion

It is interesting to note that the management practise of hand-raising triplets led to an inverse ranking order in 100d weight, as compared to 42d weights. The heavier weights recorded for triplet lambs were thus not due to better natural adaptability, but to an external influence. Not adjusting for this fixed effect would lead to selection practises not conforming to the breeding objective (i.e. adaptation to the natural environment) for the flock.

These results stress the importance of adjusting for known non-genetic fixed effects that will influence production traits. In order to conduct a meaningful statistical analysis it is imperative to specify the fixed and random effects correctly.

3.   HERITABILITY ESTIMATES OF GROWTH TRAITS.

Summary

Data of records between 1974 and 1995 of the La Rochelle S.A. Mutton Merino flock were used to estimate additive direct and additive maternal heritabilities for seven growth traits. The estimates of the direct heritabilities varied between 0.166 for 42dW and 0.513 for 205dW. The estimates of the maternal heritabilities were within the 0.042 (42dW) to 0.370 (100dADG) range. Estimates of the covariance between the direct additive and maternal additive components were generally negative and of a substantial size (-0.215 to –0.674). The influence of the sire x year interaction was found to be significant for most growth traits and accounted for a large portion of the variation. These high values indicated a genotype x environment interaction. It was concluded that no selection pressure should be put on live weight in this extensive production system.   The Kleiber Ratio could however be used to improve the biological efficiency of the flock.

3.1 Introduction

Various growth traits have been recommended as selection criteria for mutton production in sheep. It should be kept in mind however, that if genetic improvement of growth traits don't lead to increased efficiency of production, it seldom is of any economic value or consequence. Lamb weight is however an important component in the profitability of sheep and is an important objective in selection strategies (Martin *et al*, 1980). Estimates of genetic parameters are needed in order to decide upon characters to select for in a selection program (Boujenane & Kerfal, 1990). Accurate estimates of the variance components and heritabilities are also required to include these traits into a breeding program whereby breeding values will be estimated.

As the estimates of genetic parameters vary widely across breeds, it is imperative that data-specific figures should be estimated. Information on the magnitude of genetic variance and covariance figures is limited in the SA Mutton Merino and also varies widely (Table 3.1). Estimates of the maternal and additive components of heritability

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for some other breeds are summarised in Table 3.2. Unfortunately, for sheep breeds, very little literature exists in which the different components of heritability are listed.

Table 3.1. Heritability (h^2) estimates of growth traits in SA Mutton Merino lambs, according to literature.

Trait	n	h^2	Reference
Birth weight	802	0.21	Vosloo (1967)
	1241	0.21	Kotze (1976)
	8909	0.1205	Van Wyk (1992) – Sire model
	8909	0.4217	Van Wyk (1992) – Animal model
Weaning weight	805	0.08	Vosloo (1967)
	1241	0.09	Kotze (1976)
	7740	0.1195	Van Wyk (1992) – Sire model
	7740	0.3405	Van Wyk (1992) – Animal model
ADG	805	0.08	Vosloo (1967)
	1241	0.09	Kotze (1976)
	7740	0.1258	Van Wyk (1992) – Sire model
	7740	0.3124	Van Wyk (1992) – Animal model
Kleiber Ratio	7740	0.1321	Van Wyk (1992) – Sire model
	7740	0.2613	Van Wyk (1992) – Animal model

Table 3.2. Estimates of maternal (h^2_m) and additive (h^2_d) heritabilities and the correlation between direct and maternal effects (r_{dm}) of growth traits in different breeds.

Breed	Trait	h^2_d	h^2_m	r_{dm}	Reference
Hampshire	50dW	0.16	0.14	-0.57	Tosh & Kemp (1994)
	100dW	0.39	0.19	-0.74	
Polled Dorset	50dW	0.21	0.19	-0.42	Tosh & Kemp (1994)
	100dW	0.25	0.08	-0.31	
Romanov	50dW	0.05	0.06	-0.39	Tosh & Kemp (1994)
	100dW	0.14	0.02	-0.43	
Segureña	45dW	0.43	0.06	-0.63	Analla *et al* (1995)
	90dW	0.35	0.12	-0.61	
	0-45d ADG	0.34	0.07	-0.62	

In this study, different components of genetic variation could be estimated because of the maternal additive genetic values that were taken into account. According to Van Wyk (1992) the effect of a dam W on an individual X can be illustrated by the path diagram in Figure 3.1.
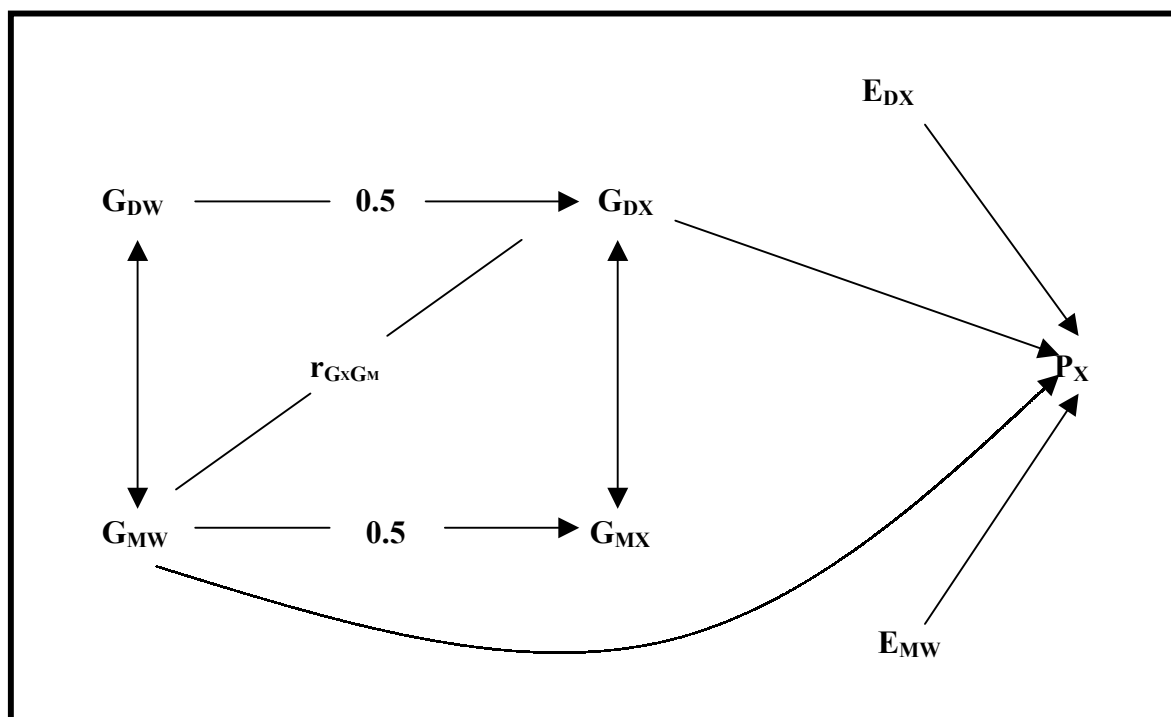

Figure 3.1. A path diagram describing a phenotypic value influenced by a maternal effect (Van Wyk, 1992).

The symbols in the figure denotes the following:

- P_X - the phenotype of the individual
- E_{DX} – the non-maternally caused environmental effect
- G_{DX} – the direct additive genetic effect of X
- G_{MX} – the genetic maternal ability of X which is not measured
- G_{MW} – the genetic maternal effect of X
- G_{DW} – the direct genetic effect associated with the dam of X
- E_{MW} – the maternally caused environmental effect on X.
- r_{GXGM} – the genetic correlation between the direct and maternal additive components.

The purpose of this study was to estimate both the maternal and additive components of heritability for growth traits in the SA Mutton Merino flock.

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3.2 Materials and Methods

3.2.1   Data

After editing, a total of 4036 42dW and 100dW records of the original 4577 records were available for analysis. These records contained 402 base animals, and 4036 non-base animals. The sheep used in the analysis were born during 1982 to 1993 (42d records), 1974 to 1995 (100d records) and 1989 to 1995 (205d records). A total of 139 incomplete data records were excluded from the data set.

The data analysed consisted of records on 42 day weight (42dW), 100d weight (100dW), ADG (birth – 42dW), ADG (42dW – 100dW) and Kleiber Ratio's for the same two periods as well as 205 day weight (205dW).

3.2.2   Statistical analysis

The VCE program (Neumaier & Groeneveld, 1997) was used to estimate all the variance components and genetic parameters, while PEST (Groeneveld *et al*, 1990) was used to estimate breeding values.

A single trait animal model was used to analyse the data.

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z_1a}\ \mathbf{Z_2m} + \mathbf{e}$$

where:

- y is a vector of progeny records for 42dW, 100dW, 205dW, the two ADG periods and the two KR periods respectively,
- b is a vector of fixed effects depending on the specific model used for the trait (see Chapter 2, par 2.2.3),
- the matrix $Z_1 = Z_2 = I$,
- a is a vector which denotes a random vector for the animals' own additive genetic effect, and m is a random vector of the maternal additive genetic values, and
- e is a random vector associated with residual errors.

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It was assumed that

$Var(a) = Z_1 \ AZ'_1 \sigma^2_a$,

$Var(m) = Z_2 AZ'_2 \sigma^2_m$,

$Cov(a,m) = Z_1 AZ'_2 \sigma_{am}$,

$Var(e) = I\sigma^2_e$, and

$Var(y) = Z_1 AZ'_1 \sigma^2_a + Z_2 AZ'_2 \sigma^2_m + Z_1 AZ'_2 \sigma_{am} + I\sigma^2_e$,

Where σ_{am} is the covariance between additive direct and additive maternal effects .

The different heritabilities which were estimated for the purpose of this study, were established as follows:

1. Heritability for direct additive genetic effect:

    $h^2_a = \sigma^2_a \, / \, \sigma^2_p$

2. Heritability for the additive maternal effect:

    $h^2_m = \sigma^2_m \, / \, \sigma^2_p$

3.3 Results and Discussion

The estimates of the genetic parameters are presented in Table 3.3. The estimates of the direct heritabilities for 42dW (0.166), 100dW (0.182) and 42dADG (0.215) and the maternal heritabilities of 100dW (0.146) and 42dADG (0.091) all fell within the range of estimates reported in literature (see Table 3.2). The estimate of the maternal heritability for 42dW (0.042) was however lower than reported values in literature. There was also a bigger difference in magnitude between the additive and maternal components for the 42dW than was expected.

The estimate of the direct heritability of the 205dW trait was higher than reported in literature. Boujenane & Kerfal (1990) reported an estimated value of 0.43 for 180dW and Mavrogenis & Constantinou (1990) estimated a heritability of 0.3 for mature weight.

Table 3.3. Estimates of heritabilities for additive direct (h^2_a) and additive maternal (h^2_m) effects for growth traits, covariance between additive direct and maternal effects (r_{hm}), as well as the influence of the Sire x Year interaction and the environment.

Trait	h^2_a	h^2_m	r_{hm}	Sire x Year effect	Environmental effect
42dW	0.166	0.042	-0.215	0.343	0.449
42d ADG	0.215	0.091	-0.330	0.128	0.566
42d KR	0.073	0.077	-0.300	0.064	0.787
100dW	0.182	0.146	-0.674	0.185	0.487
100d ADG	0.078	0.370	-0.481	_	0.552
100d KR	0.241	0.344	0.169	_	0.415
205dW	0.513	_	_	_	0.487

The large difference between the different components of heritability for the 42dW trait could be explained by the nature of the data. As stated in Chapter 2, the 42d weights were recorded over a period varying from 26 to 77 days. The processed data (corrected for age) used for the other two 42d traits have more accurate estimates of the components with estimates more closely related to literature.

The maternal effects for 42d traits as well as for 100d traits are of both genetic and environmental origin. Cantet *et al* (1988) suggested that the additive maternal effects are less important for birth weights than for weaning weight. The maternal effects are however important in determining the results of selection for pre-weaning growth rate. The genetic correlation between the direct and maternal components of the growth traits tended to be negative, with values that varied between –0.31 and –0.74 (Table 3.2). This negative correlation implies that improvement in one of the components will hinder performance in the other, and will thus decrease the overall rate of progress. The response to selection on phenotype would thus also be slow.

The estimates of the covariance between the direct and maternal additive components are generally negative and of a substantial size (-0.215 to -0.674), although the values are quite variable (see Table 3.3). Other authors listed in Table 3.2 have reported a negative correlation between these additive components. This negative correlation indicates that improvement in one of the components would hinder performance in the other and would thus slow the rate of progress.

The sire x year interaction is significant for most of these traits and accounts for a large portion of the variation. The high values of this effect (in the same order as the heritability estimates) indicate a genotype x environment interaction. The influence of this interaction declines with age, therefore rendering the attainment of the objective of adaptation less effective.

The environmental influence is very high on the 42d traits, as could be expected. This influence also declines drastically as the lambs grow older.

Morris *et al* (1996) found that selection for increased live weight led to larger litter sizes, but that lamb survival until weaning decreased significantly. They also reported greater absolute responses in ewe live weight than in lamb live weight. A nett increase per year for lambs weaned per ewe lambing were however reported. Lasslo *et al* (1985) however found no nett increase in the weights of lambs weaned in a line selected for 120d weight. Lamb survival was consistently lower in this line than in the control. This reduction in live weight occurred over the whole range of birth weights. The increase in 120d weight was offset by a decrease in lamb survival.

Martin *et al* (1980) stated that the genetic correlations between weights at various stages suggest that selection for one weight would result in considerable positive change in all weights. Selection for birth or pre-weaning weight could possibly increase the frequency of dystocia, and selection would best be directed towards weight at later stages. Unfortunately, selection for weights at later stages would be expected to lead to increased mature weights and greater maintenance requirements. Sakul *et al* (1994) confirmed this and stated that adaptation to the specific environment is crucial when selecting for increased live weight. If adaptation is not taken into account, output per ewe will be adversely affected.

In an extensive production system where adaptation to the natural environment is very important, it is recommended that no selection pressure be put on live weight, as larger animals have higher maintenance requirements. To improve nett output per ewe, selection pressure could rather be put on reproductive traits.

Mavrogenis & Constantinou (1990) stated that selection for weights following weaning are likely to cause undesired positive correlated responses in mature weight. This was stressed by Sakul *et al* (1994), who stated that the success of selection for weaning weight depended not only on the improvement made in this trait, but also on the fitness traits correlated to weaning weight.

Shresta *et al* (1985) stated that selection for ADG(50-100d) had no advantage over selection based on lamb weight at 100d, because of the high correlation (0.80 ± 0.02) between the two traits. Although the estimate of maternal heritability for 100dADG was moderate, the estimate for the direct additive component was low. A slow rate of progress could thus be expected if selection is based on this trait and selection for ADG might not improve the biological efficiency of animals.

Feed conversion ratio and the ratio of growth rate to metabolic mass (the Kleiber ratio) are however unrelated to fertility. Selection for feed conversion is a suitable criterion for breeds used in maternal lines, but the measuring thereof is not always practical because of costs and labour involved. The Kleiber ratio is however highly correlated with feed conversion ratios (Scholtz & Roux, 1988) and is also moderately heritable (see Table 3.3). The results show that the 100dKR trait had the highest estimate of direct additive heritability (0.241) of all the growth traits, and the second highest for maternal heritability (0.344). This trait can thus be used successfully as a selection criterion.

3.4 Conclusion

1. The estimates of the various components of heritability for growth traits corresponded largely with literature.

2. Selection for growth rate and ADG's has no advantage over selection based on lamb weight, and should be carefully considered in a breeding program.

3. In an extensive production system, like the La Rochelle flock where adaptation to the natural environment is very important, it is recommended that no selection pressure be put on live weight, as larger animals have higher maintenance requirements. To improve nett output per ewe, selection pressure could rather be put on reproductive traits.

4. The Kleiber Ratio is highly correlated with feed efficiency and an improved KR will have no adverse effect on fertility or reproduction. This trait's moderate heritability indicates that it could successfully be used as a selection criterion to increase the biological efficiency of a flock.

4.   HERITABILITY ESTIMATES OF REPRODUCTION TRAITS.

Summary

Data of records from the La Rochelle S.A. Mutton Merino flock for sheep born between 1974 and 1995 were studied in order to estimate the direct additive and additive maternal heritabilities for four reproductive traits.   All the estimated heritabilities were of low magnitude. The estimates for direct additive heritabilities varied between 0.039 for fecundity and 0.177 for Kg lamb weaned per ewe per year. Estimates for the maternal additive heritabilities were correspondingly low, varying from 0.007 for lambs born per ewe per year to 0.197 for percentage twins. Estimates of covariance between the additive direct and additive maternal components were negative as was expected.   The higher heritability estimates of Kg lambs weaned per ewe per year indicated that this trait could be used to improve the reproductive performance of the flock.

4.1 Introduction

Schoeman (1990) stated that the major factor that affects the profitability of sheep production in South Africa is the number of lambs born per ewe in a given interval. The efficiency of a lamb production system will thus improve with an increase in the number of lambs marketed per year (Schoeman (1990), Iman & Slyter (1993)). Fogarty *et al* (1995) expressed this reproduction productivity as the weight of lamb weaned per ewe per year. This trait includes components of fertility, prolificacy, lamb survival and early lamb growth.

Lee & Atkins (1996) suggested that selection criteria for improved reproduction rate should be reassessed. They stated that selection with emphasis on fertility and survival will achieve a significant response in the nett reproduction rate of the breeding flock, but that this is at odds with current recommendations to improve reproduction rate through selection for increased litter size. Selection for a single reproduction trait will however not necessarily lead to increased total herd efficiency (Ap Dewi *et al*, 1996). Fogarty *et al* (1994) stated that an overall measure of the profitability of a sheep system can be expressed as Productivity = weight of lamb

weaned/ewe/year. The fertility component of a production system includes the ability to conceive at different mating periods during the year and the ability to conceive again soon after lambing. It was thus decided to estimate genetic parameters both for singular traits (fecundity and percentage twins) and complex traits (number of lambs born per year per ewe (L_b/e) and kilogram lamb weaned per year per ewe (L_w/e)).

Estimates of genetic parameters and variances of these traits are required to provide a basis for the prediction of response to selection. Considerable genetic variation for reproduction traits exist between and within breeds (Land *et al*, 1988 and Fogarty & Hall, 1995), as can be seen in Table 4.1. Although the estimates of heritability for reproduction traits are generally low, genetic improvement in reproduction and overall lamb production can thus be achieved.

Table 4.1. Heritability estimates of reproduction traits, according to literature.

Trait	h^2	Reference
Percentage twins	0.19	Fogarty *et al* (1994)
Fecundity	0.03	Fogarty *et al* (1994)
	0.08	Morris *et al* (1996)
Number of lambs born per year per ewe	0.19	Fogarty *et al* (1994)
	0.04	Morris *et al* (1996)

Aboul-Naga & Monsour (1988) stated that the between breed variation in reproduction performance among three Egyptian breeds were mainly due to managerial conditions and breed x location interactions, rather than the breeds' differences in performance. Estimates of genetic parameters are however required to provide a basis for the prediction of response to selection. It is thus necessary to estimate data-specific genetic parameters, as information on the magnitude of these values is limited for the South African Mutton Merino.

The purpose of this study was to estimate heritabilities for reproduction traits in the LA Rochelle SA Mutton Merino flock.

4.2 Materials and Methods

4.2.1 Data

After editing, a total of 4036 records of the original 4577 records were available for analyses. These records contained 402 base animals and 4036 non-base animals. The sheep used in the analyses were born between 1974 to 1995. Incomplete data were excluded from the data set.

The data analysed consisted of records on fecundity, percentage twins, mean number of lambs born per ewe per year (L_b/e) and mean kg of lamb weaned per ewe per year (L_w/e).

4.2.2 Statistical analysis

The VCE program (Neumaier & Groeneveld, 1997) was used to estimate all the variance components and genetic parameters, while PEST (Groeneveld *et al*, 1990) was used to estimate breeding values.

A single trait animal model was used to analyse the data.

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Z_1a}\ \mathbf{Z_2m} + \mathbf{e}$$

where:

- y is a vector of progeny records for fecundity, percentage twins, L_b/e and L_b/e respectively,
- b is a vector of fixed effects depending on the specific model used for the trait (see Chapter 2, par 2.2.3),
- the matrix $Z_1 = Z_2 = I$,
- a is a vector which denotes a random vector for the animals' own additive genetic effect, and m is a random vector of the maternal additive genetic values, and
- e is a random vector associated with residual errors.

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It was assumed that

$\text{Var (a)} = Z_1 \, AZ'_1 \sigma^2_a$,

$\text{Var(m)} = Z_2 AZ'_2 \sigma^2_m$,

$\text{Cov(a,m)} = Z_1 AZ'_2 \sigma_{am}$,

$\text{Var(e)} = I\sigma^2_e$, and

$\text{Var(y)} = Z_1 AZ'_1 \sigma^2_a + Z_2 AZ'_2 \sigma^2_m + Z_1 AZ'_2 \sigma_{am} + I\sigma^2_e$,

Where σ_{am} is the covariance between additive direct and additive maternal effects.

Both maternal and direct additive heritabilities were estimated because the maternal additive genetic values were taken into account.

The different heritabilities were established as follows:

1. Heritability for direct additive genetic effect:

$\quad h^2_a = \sigma^2_a / \sigma^2_p$

2. Heritability for the additive maternal effect:

$\quad h^2_m = \sigma^2_m / \sigma^2_p$

4.3 Results and discussion

The estimates of the heritabilities presented in Table 4.2 are closely related to those found in literature. Estimates of heritabilities for reproductive traits are usually very low (generally under 0.09) and this was confirmed by this study.

Table 4.2. Estimates of heritabilities for additive (h^2_a) and maternal (h^2_m) effects for reproductive traits, covariance between additive direct and maternal effects (r_{hm}), as well as the influence of the environment.

Trait	h^2_a	h^2_m	r_{hm}	Environmental effect
Percentage twins	0.062	0.197	-0.027	0.741
Fecundity	0.039	0.049	-0.807	0.911
L_b/e	0.062	0.007	-0.492	0.931
L_w/e	0.177	0.047	-0.786	0.775

The low magnitude of the estimated heritabilities was expected, as these values very seldomly exceeds 0.1 in literature. These traits usually also have correspondingly low repeatabilities (Fogarty *et al*, 1994).

The estimated heritabilities (both direct additive and maternal) for fecundity was very low, while both those for twinning were higher. This was not unexpected, as the fecundity trait included the ewe's ability to lamb regularly. A much larger environmental variation can thus be expected in this trait, leading to lower heritability estimates. The maternal and direct components for fecundity were in the same range. For twinning however, the maternal component was almost double the value of the direct additive component. The genetic maternal effect is thus of great importance in this trait. Selection for this trait will possibly lead to an improvement in the twinning rate of the flock.

Both L_b/e and L_w/e had very small maternal heritability components. The lower heritabilities for L_b/e than for L_w/e were not unexpected, because higher environmental variation is usually present for maternal lamb survival. L_w/e is also influenced by and associated with unpredictable factors such as weather, predators

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etc. The reason for the relatively high heritability estimates for L_w/e could be that twin and triplet lambs are hand-raised in this system. The environmental influence is thus increased, while the variation for maternal lamb survival is possibly decreased.

L_w/e takes into account other important reproductive traits, i.e. mothering ability, milk production, lamb survival and early growth of the lamb. The main components of L_b/e, namely ovulation rate and embryonic survival (Hanrahan, 1989) are also included into the former trait. The number of lambs weaned by a ewe in a specific period, and the kilograms weaned will thus give a good indication of the ewe's overall reproductive efficiency. The heritability estimates for L_w/e (0.177 and 0.047) indicate that the genetic variation for this trait can be used to improve reproductive performance.

The estimates of covariance between the additive direct and additive maternal components of all the reproduction traits were negative and of a substantial size (Table 4.2). No comparable estimates were found in the literature. These very low covariance values indicate that it would be difficult to improve the traits through selection.

The low repeatability and heritability estimates of reproductive traits can be improved on by using repeated records. The use of repeated records will improve the accuracy of selection and will lead to an increased rate of genetic improvement. Lee & Atkins (1996) however stated that reproduction performance of ewes in their early life might be used to identify ewes with potentially lower nett reproduction rates in later life. As early and later life nett reproduction rates are positively correlated, a ewe's first reproduction record should give an indication of the reproductive efficiency that can be expected of her in later life. Fogarty *et al* (1994) found that the high heritability estimates for overall performance (number of lambs born, weaned and weight weaned) based on the first mating record were higher than those based on all the mating records. If selection is thus based on overall nett reproduction rate in early life, improvement in all the components of nett reproduction rate may follow.

The failure of an ewe to lamb is a major source of reproductive wastage and is also the major factor limiting lifetime productivity and the rate of genetic improvement in a breeding program (Beck *et al*, 1996). Fourie & Cloete (1993) suggested that these ewes should be marked as ewes with reproductive failure records. Culling of these ewes should enhance the reproduction in a flock. Lee & Atkins (1996) agreed with this, and added that the extent to which culling will improve the nett reproduction rate of future generations will depend on the level of genetic variation in and the co-variation among traits. Both Fourie & Cloete (1993) and Lee & Atkins (1996) suggested that selection for twinning as well as against reproduction failure might result in an overall increase in the reproduction efficiency of a flock. Selection for L_w/e encompasses these factors and can be implemented in large commercial flocks who record the necessary records.

Although it has been suggested that an accelerated breeding system be implemented in order to improve the overall profitability of reproduction performance, this largely depends on increased managerial inputs. In an extensive sheep producing system like the La Rochelle flock, this won't be possible without changing the entire managerial policy. It may therefore thus be more suitable under these conditions to maintain the current breeding system (i.e. one lambing season per year per ewe) and put more emphasis on selection for overall reproductive efficiency.

4.4 Conclusion

1. The heritability estimates for all the reproductive traits were relatively low, as was expected.

2. The fecundity trait includes a large portion of environmental variation and should, because of the low heritability estimates, not be used as a selection criterion to improve the reproduction efficiency of the flock. Selection for twinning should however lead to an advanced rate of improvement in reproductive efficiency.

3. The higher heritability estimates for L_w/e indicate that it can be used to improve the reproductive performance of the flock. Selection for L_w/e is an indirect selection method against failure to reproduce as well as a selection criterion to improve nett reproduction rates.

4. An accelerated lambing system is not recommended for this specific flock. General managerial inputs should rather be optimised to improve the overall efficiency of the flock. Care should however be taken not to create an artificial environment.

5. GENETIC AND ENVIRONMENTAL TRENDS OF THE LA ROCHELLE FLOCK.

Summary

Genetic trends were studied in the La Rochelle S.A. Mutton Merino flock. The main objective of the breeder was to improve the reproductive efficiency of the flock, whilst decreasing the incidence of very large, heavy lambs. Records in this study were collected from 1962 to 1995. Genetic trends were estimated over two periods for each trait, i.e. the period before 1985 and the period thereafter, as a new selection program was implemented in 1985. It was found that selection pressure on reproductive performance hasn't yet attained the desired effect as three of the four reproductive traits measured, showed very little or no improvement. Selection should rather be based on BLUP estimates of breeding values. Lambs do however have lower body weights, while the 100dADG and 100dKR have improved.

5.1 Introduction

The primary goal of animal breeders is to maximise the rate of genetic improvement. As was already stated, reproduction rate as well as the growth rate of lambs is the major factors affecting financial returns in a mutton sheep production system. The maximising of the genetic improvement of the sheep flock's reproductive efficiency will depend mainly on the accuracy of selecting superior parents for the next generation. However, both growth rate and reproductive performance are markedly influenced by the environment, and advantages in genetic potential for these traits may be more than offset by lack of adaptation (Bradford *et al*, 1994). To determine how effective the genetic selection was performed in the past, the genetic and environmental trends in the relevant population should be considered.

The main objective of the breeder's selection program was to improve the reproductive efficiency of the ewe flock. He emphasised the following traits: lambing interval, the date of first lambing and the lamb weight produced per ewe per year. Growth rate was selected for in the ram flock. The breeder also experienced some problems with very large, heavy lambs and wanted to address this situation.

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The purpose of this study was to assess the genetic change in both growth and reproductive traits in the La Rochelle SA Mutton Merino flock.

5.2 Material and methods

Records used in this study were obtained from the La Rochelle SA Mutton Merino stud, collected over the period 1962 to 1995. Most of the data collected before 1990 were incomplete, as very few records were kept.

The animals were kept under an extensive husbandry system. Since 1985 they didn't receive any supplementary feed during the summer or winter, except for a salt lick. Ewes were mated for the first time at 18 months and lambed in either the autumn or spring. Lambs were weaned on the veld at approximately 100 days.

 All the growth and reproductive traits were considered. Breeding values have been estimated with PEST (Groeneveld *et al*, 1990), using single trait animal models as described in Chapter 2. The annual means were then estimated for both the reproductive and growth traits.

Genetic trends were estimated over two periods for every trait, i.e. the period before 1985 and the period thereafter. In 1985 a new selection program was implemented. The ewes were selected on reproductive performance, while adaptation to the natural environment was the collective most important selection objective. The genetic trends were estimated in order to see if the breeder was making any genetic progress with the new selection method.

Environmental trends were also estimated, as these could be informative to a commercial breeder in order to monitor management effects and / or climatic changes. Unfortunately too few records were available to estimate two separate environmental trends for the traits. All trends were estimated using linear regressions.

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5.3 Results and Discussion

5.3.1 Environmental trends

The environmental trends of growth traits are presented in Figures 5.1 to 5.4. The traits could only be estimated for 42-day traits from 1982 and for 100dW from 1974. Data before these dates were too incomplete to be included.

As can be seen in Figures 5.1 to 5.3, the environmental influence on 42d traits was very small. This could be the result of the lambs still suckling; environmental changes would thus have a greater influence on the dams than on the lambs.

Environmental changes have however a much larger effect on the 100dW trait (Figure 5.4) as the lambs are by then dependent on grazing veld. The effect of the environment could only be seen from 1985 onwards, as the artificial environmental conditions that were created before then were discontinued. From 1985 no more supplementary feed was given to the sheep. Droughts and abnormal weather conditions' adverse effects on this trait can be seen clearly after 1985. During the droughts of 1986 and 1990, the 100dW of the lambs fell drastically. The abnormal high rainfall that was measured in 1994 also had a negative effect on this trait because of the adverse weather conditions as well as the very high moisture content of the pastures. The droughts before 1985 didn't manifest in lower 100dW, as the negative impact thereof were offset by supplementary feed.

No specific trend of the environment's influence on 205d traits or on the reproductive traits could be ascertained.
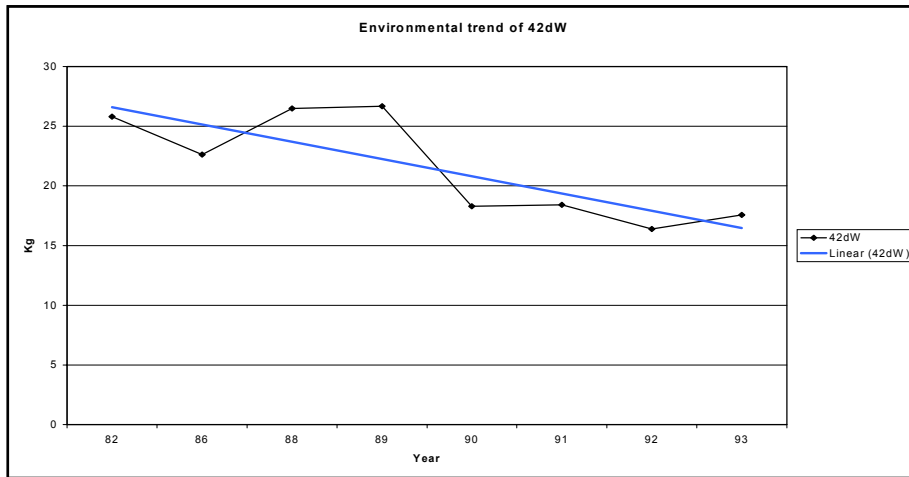
Figure 5.1 Environmental trend of 42dW
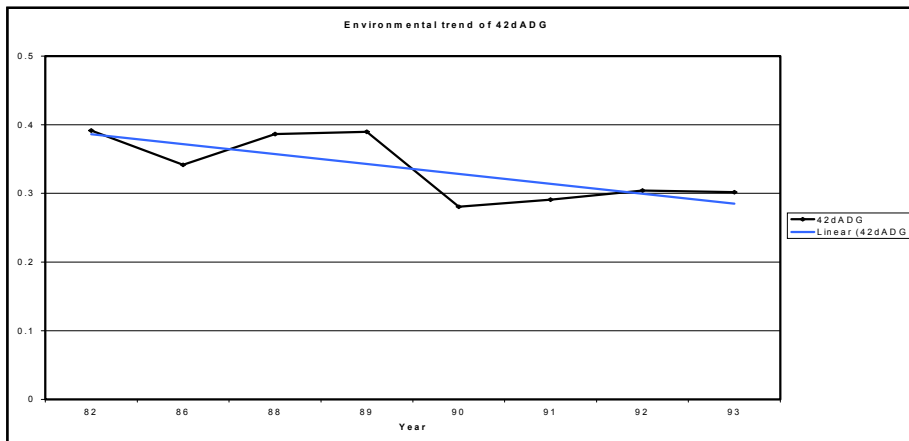
Figure 5.2 Environmental trend of 42dADG
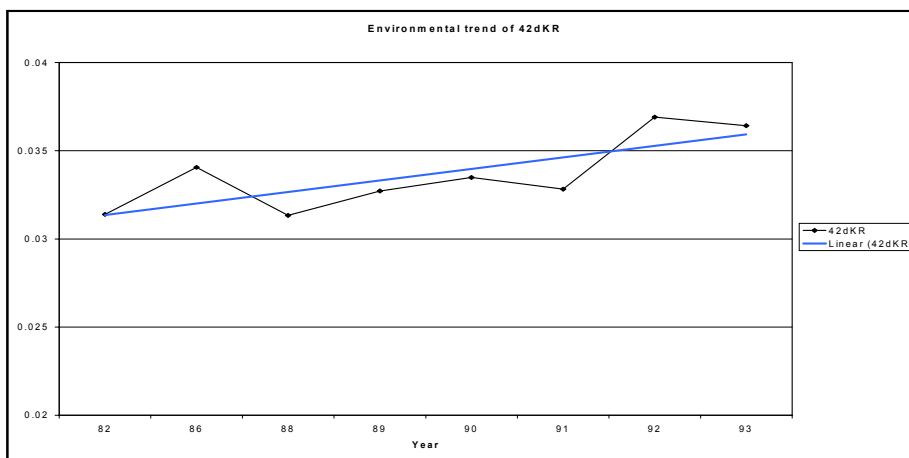
Figure 5.3 Environmental trend of 42dKR

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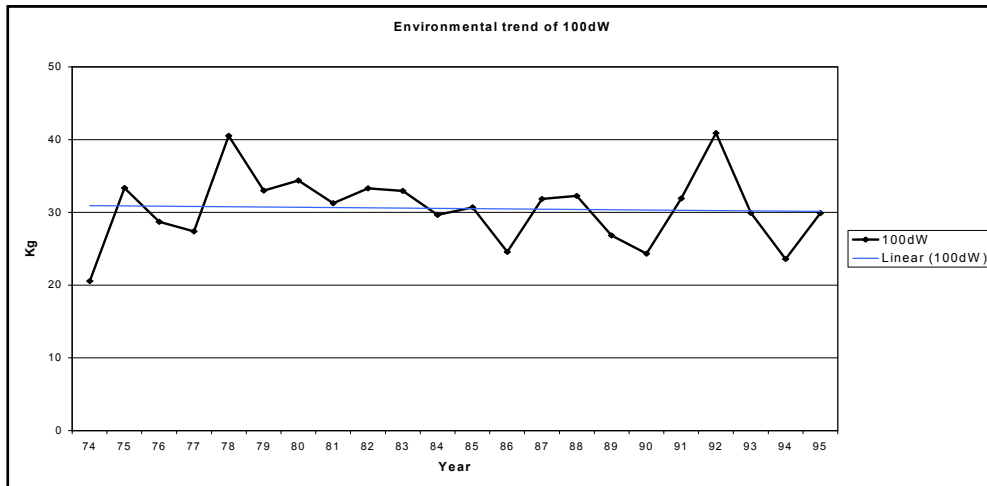
Figure 5.4 Environmental trend of 100dW

It should be borne in mind that certain unexplained fluctuations in the trends could be contributed to several people being responsible for the management of the flock and the record keeping over the periods described, as well as to the small number of records obtained in certain years.

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5.3.2   Genetic trends

The genetic trend (Figure 5.5) shows a steady increase in lambing interval from 1985. This could possibly be the result of ewes lambing at a younger age.   These ewes would have longer recovery periods before having a second lamb.   The R^2 value of the trendlines decreased from 0.5776 (Trend 1) to 0.2083 (Trend 2).
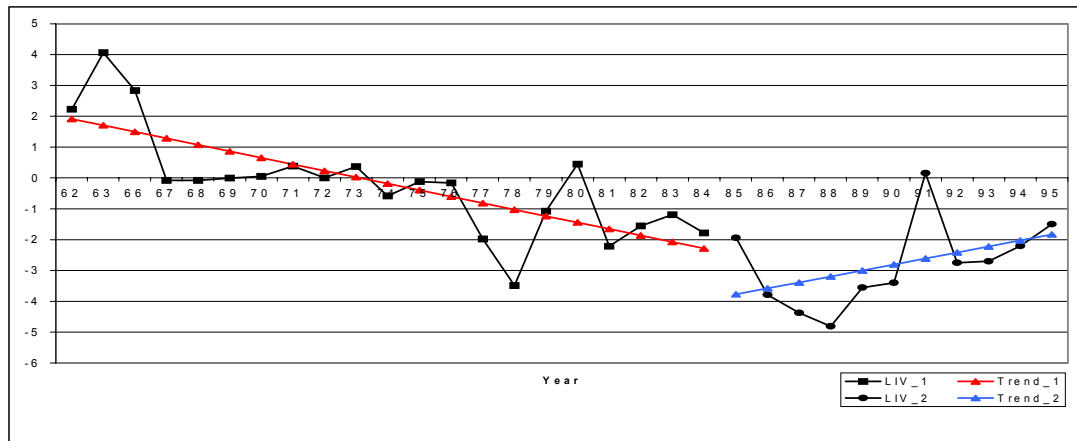
Figure 5.5 Mean annual estimated breeding values of Lambing interval

The genetic trend for twinning rate, followed a downward trend (Figure 5.6).   This wasn't unexpected, as no selection pressure was applied to the trait.   No difference in trend was found between the two periods measured, although the R^2 value of the second trendline (0.708) indicated a much better fit than that of the first trendline (0.1043).
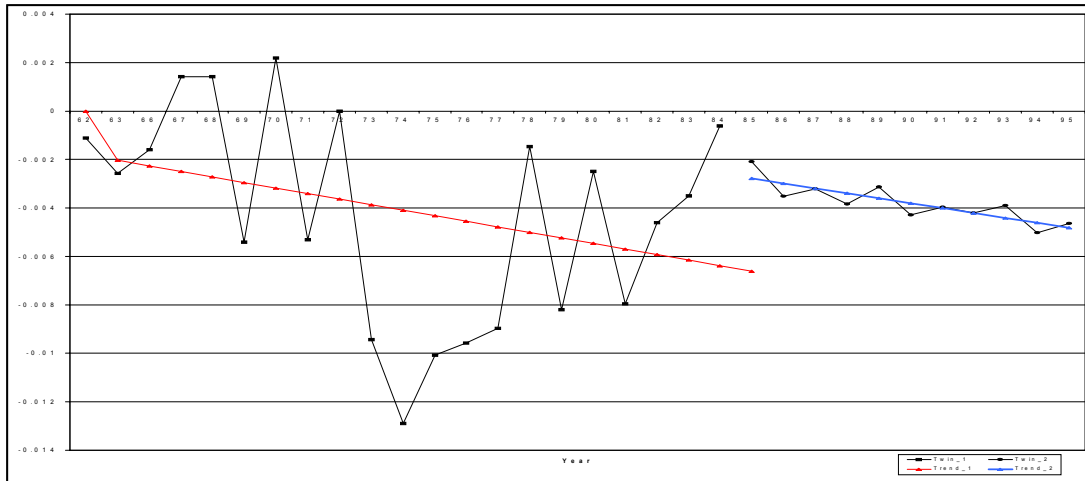
Figure 5.6 Mean annual estimated breeding values of Twinning rate

The genetic trend of fecundity (Figure 5.7) shows a steady improvement over the last decade. The R^2 values of the two trendlines remained in the same range (0.1302 vs. 0.1958). Although the rate of response is slow, it is not uncommon to see temporary selection plateaus in long term selection experiments in livestock. The low heritability estimates and especially the small additive variance for this trait would also hinder selection response. Natural selection could be responsible for the steady improvement in this trait.
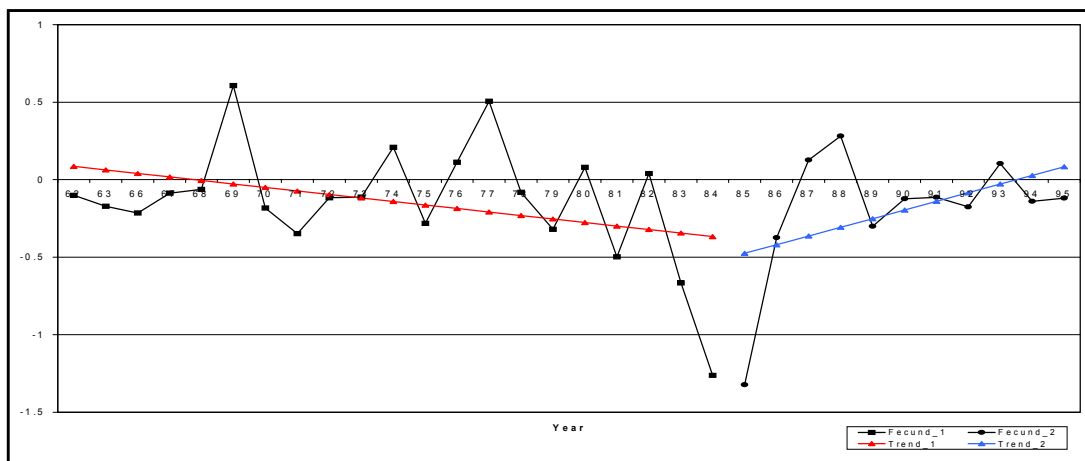
Figure 5.7 Mean annual estimated breeding values of Fecundity
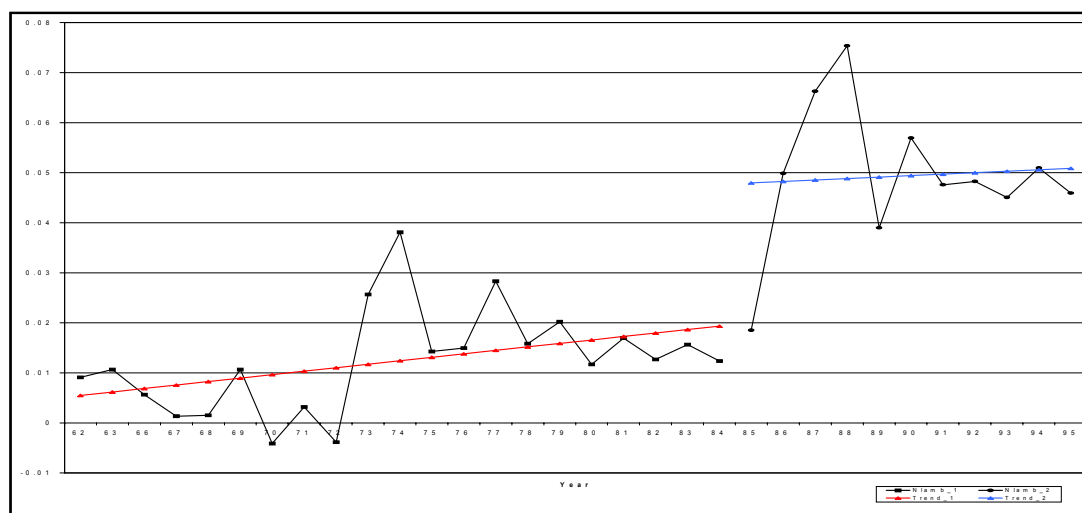
Figure 5.8 Mean annual estimated breeding values of L$_b$/e

The genetic trend of Number of lambs born per ewe per year (L$_b$/e) doesn't differ much between the two periods (Figure 5.8), although the second periods' y-axis values are much higher than the first. The R^2 value of the second trendline (0.0044) showed a marked decreased from that of the first trendline (0.1736), although both values are low. Genetic improvement in this trait could be hindered by the increase in lambing interval and a plateau would be expected in this trait.

The genetic trends of Kilograms of lamb weaned per ewe per year (L$_w$/e) show a slight negative trend (Figure 5.9) after 1985. This was unexpected, as high selection pressure was put on this trait. This could possibly be attributed to the fact that 100dW decreased significantly over the same period. It should also be kept in mind that the selection was based on phenotypic values and not genetic values. The R^2 value of the first trendline indicates a better fit than that of the second trendline (0.0156).

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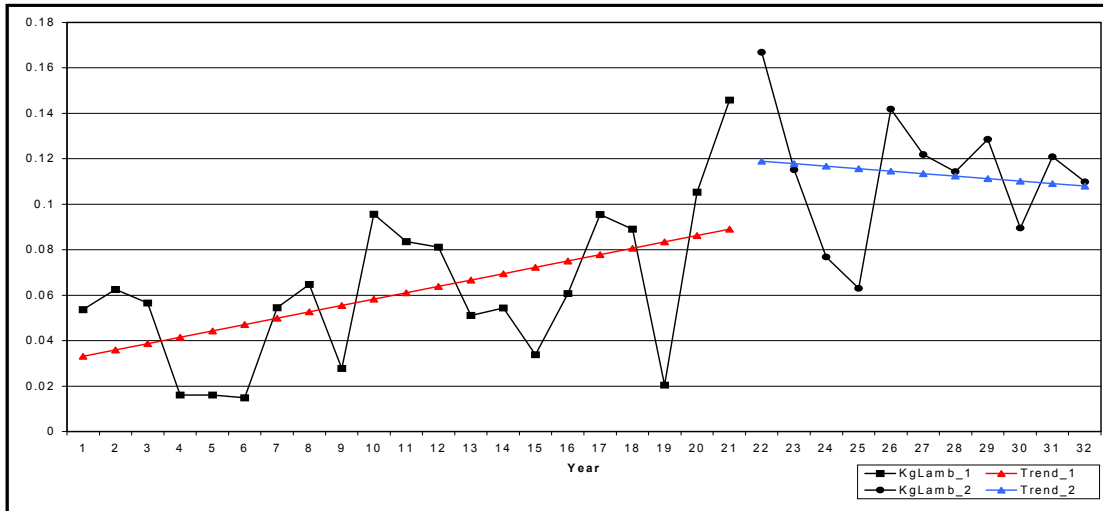
Figure 5.9 Mean annual estimated breeding values of L_w/e

No specific trend could be estimated from the available estimates of the maternal breeding values for any of the reproductive traits, as can be seen in Figure 5.10. Only lambing interval show some variation over time, but no trend could be estimated. The lack of trends for these traits could be due to the small number of available records.
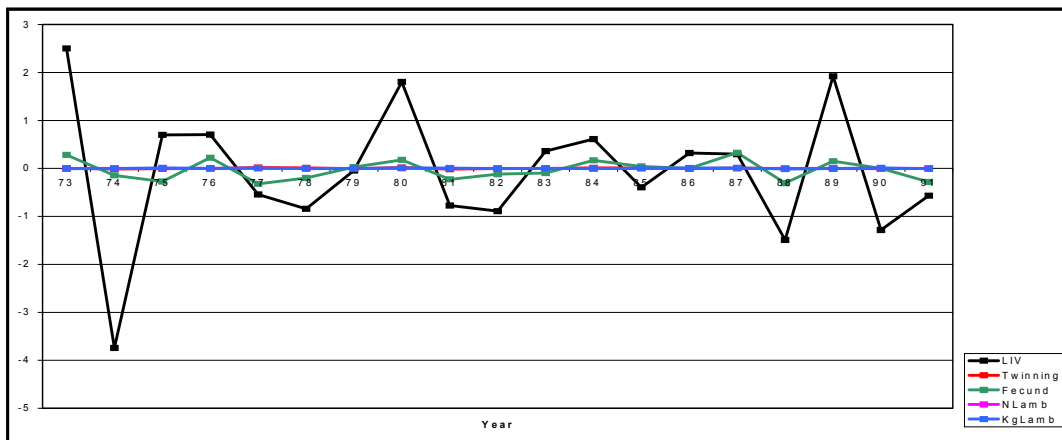

Figure 5.10 Mean annual estimated maternal breeding values of reproductive traits

The genetic trends for the two periods of the 42dW and 42dADG traits didn't vary significantly (Figure 5.11 and 5.12). All the R^2 values of these trendlines were very low (0.202 and 0.0886 for 42dW, and 0.0566 and 0.1146 for 42dADG respectively). The y-axis values of the second periods were however much lower than those of the former periods. This could be the result of high selection emphasis that was placed on the reproductive performance of the ewes. This normally leads to smaller lambs, which would still have low weights at 42d age, as compensatory growth wouldn't have taken place yet. The lower 42dW could also be caused by ewes lambing at a younger age, and thus giving birth to lighter lambs.
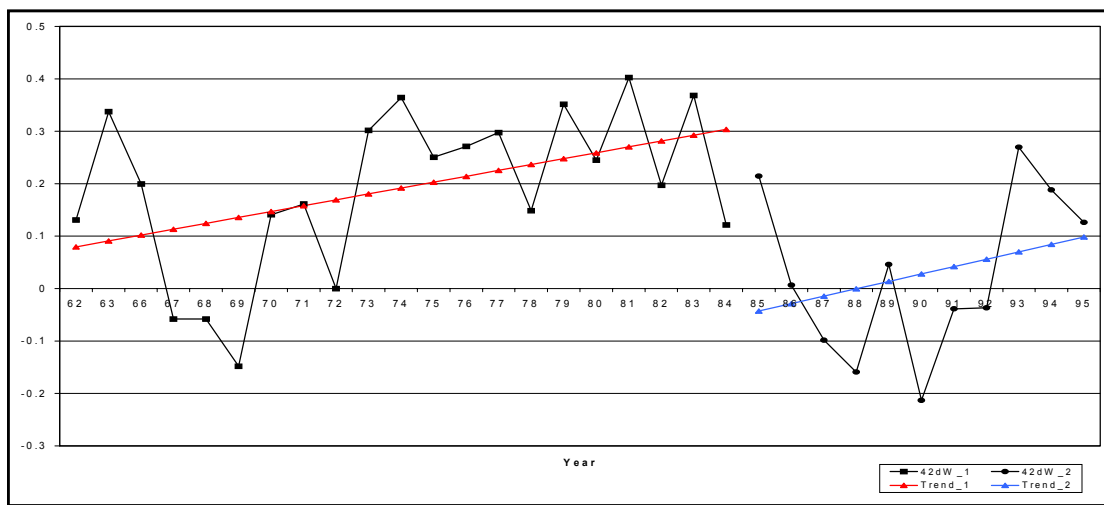
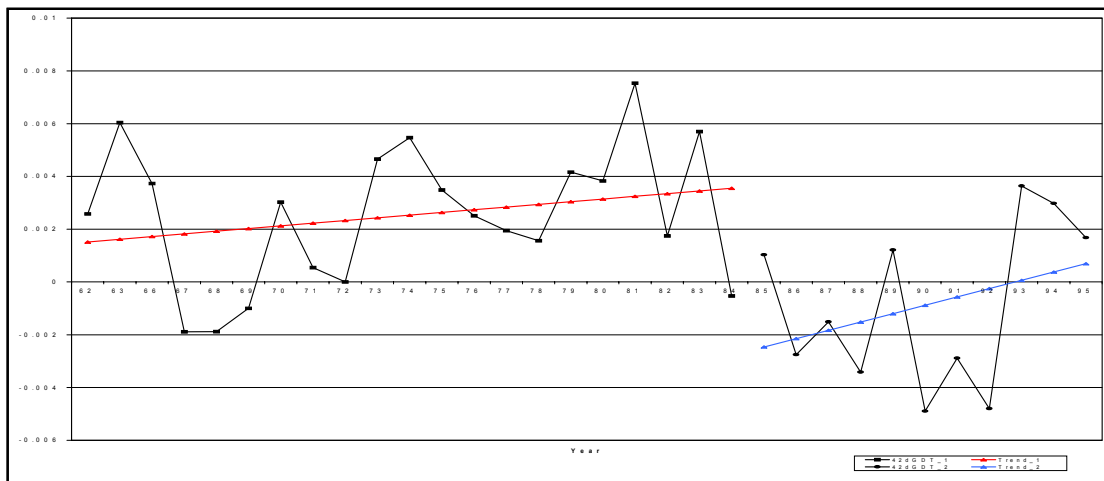

Figure 5.11 Mean annual estimated breeding values of 42dW

Figure 5.12 Mean annual estimated breeding values of 42dADG

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The negative trends of 42dKR (Figure 5.13) was however unexpected. The R^2 value of the second trendline (0.0362) also indicates a worse fit than that of the first trendline (0.3233). The estimated breeding values for this trait were quite erratic over the past decade, which could have been caused by the small number of animals with relevant records until 1990.
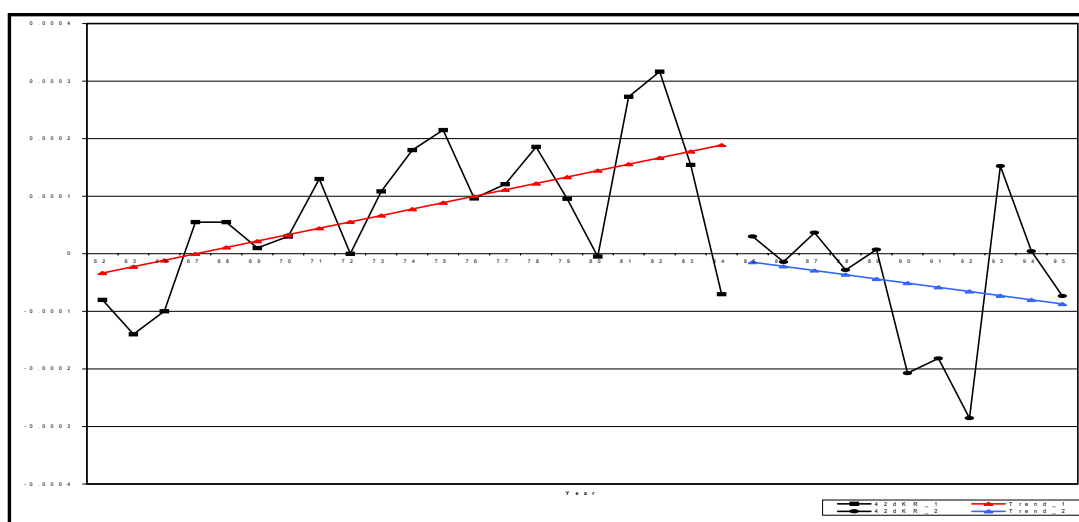

Figure 5.13 Mean annual estimated breeding values of 42dKR

All the genetic trends of the 100d traits conformed to expectations. The 100dW (Figure 5.14) followed a negative trend for both periods, similar to the 42dW trait. The R^2 values of the two trendlines of this trait (0.1633 and 0.0638) were both very low. As very little or no selection pressure was placed on this trait, due to emphasis on other traits, a negative response was expected.

The 100dADG and 100dKR both showed a drastic positive change in trend over the last decade (Figures 5.15 and 5.16). The R^2 values of both these traits increased markedly from the first to the second periods (100dADG: 0.3054 vs. 0.8146 and 100dKR: 0.0085 vs. 0.8146). Very few records were available for the first period. These positive trends indicate that although lighter lambs were weaned, they were more efficient and faster growing. These lambs are therefore fit and adapted for this specific extensive environment.
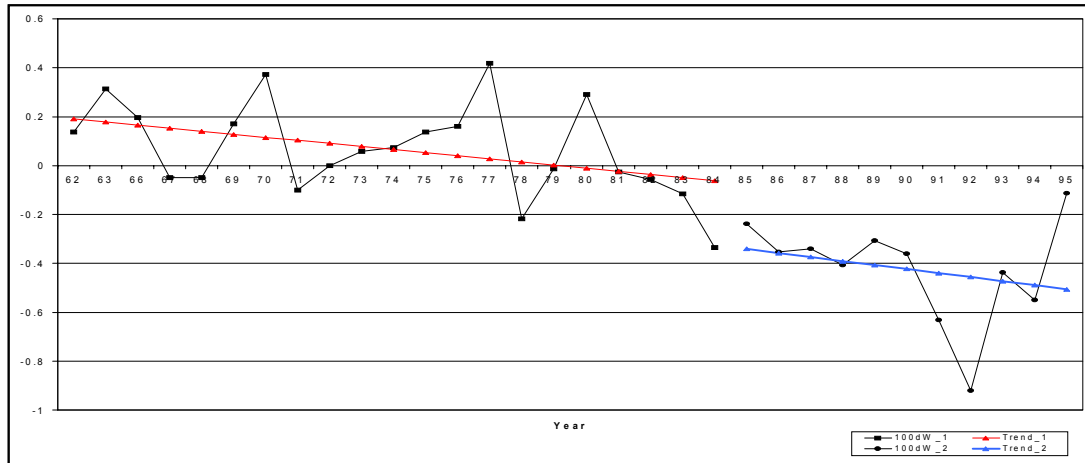
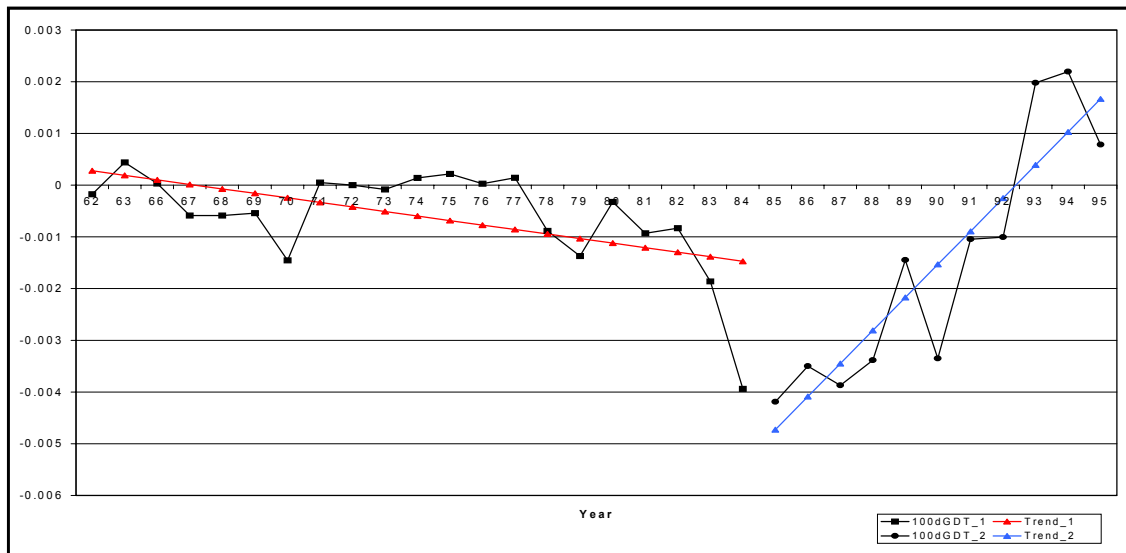**Figure 5.14 Mean annual estimated breeding values of 100dW**

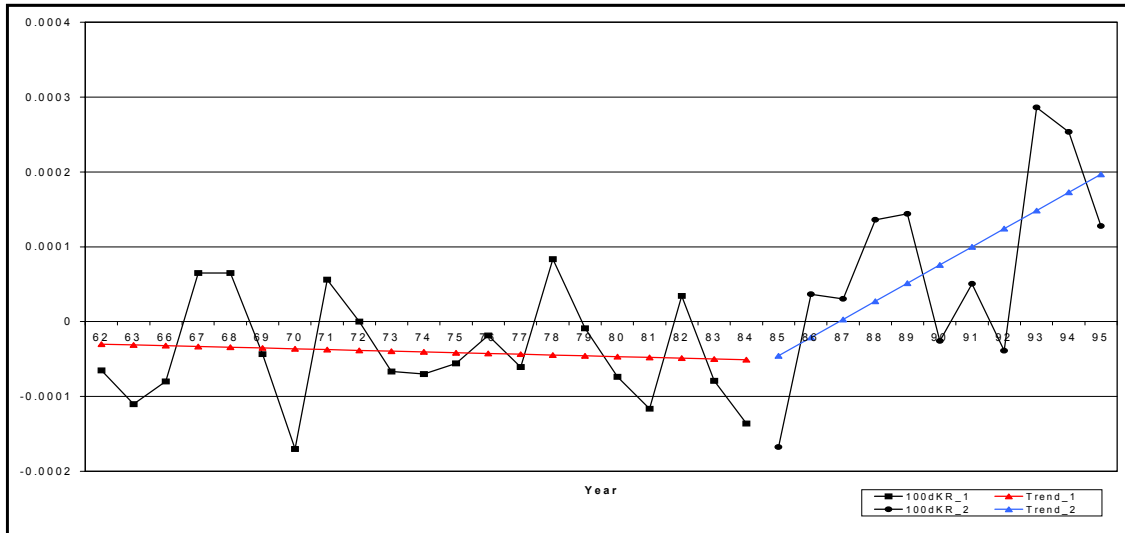**Figure 5.15 Mean annual estimated breeding values of 100dADG**

Figure 5.16 Mean annual estimated breeding values of 100dKR

Very few records were available for the estimation of the additive maternal breeding values for the 42d and 100d traits. As can be seen in Figures 5.17 and 5.18, no trend could be estimated for the ADG or KR components of both periods. The selection response has evidently reached a plateau. The estimated maternal breeding values show a negative trend for 42dW and a positive trend for100dW. This confirms the known negative correlation between direct additive and maternal additive breeding values.
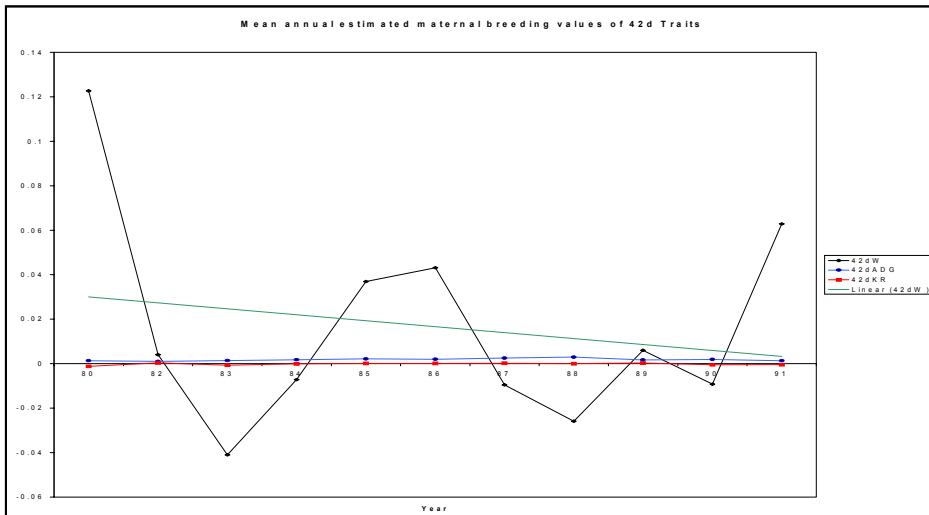

Figure 5.17 Mean annual estimated maternal breeding values of 42d traits
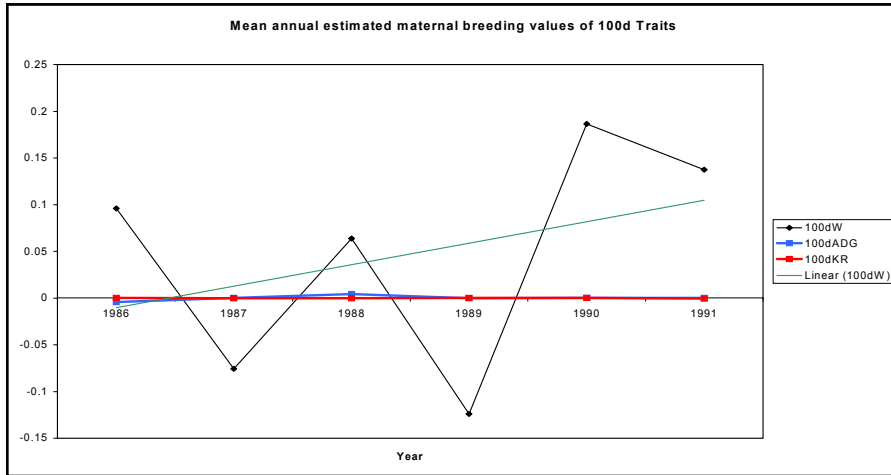
Figure 5.18 Mean annual estimated maternal breeding values of 100d traits

The genetic trend of 205dW (Figure 5.19) shows a steady downward trend from 1985. The R^2 values of both the trends were very low (0.002 and 0.0852). Very few records were available for this trait. The low selection differential on this trait would have hindered any positive response in increasing the 205d weight of the animals.
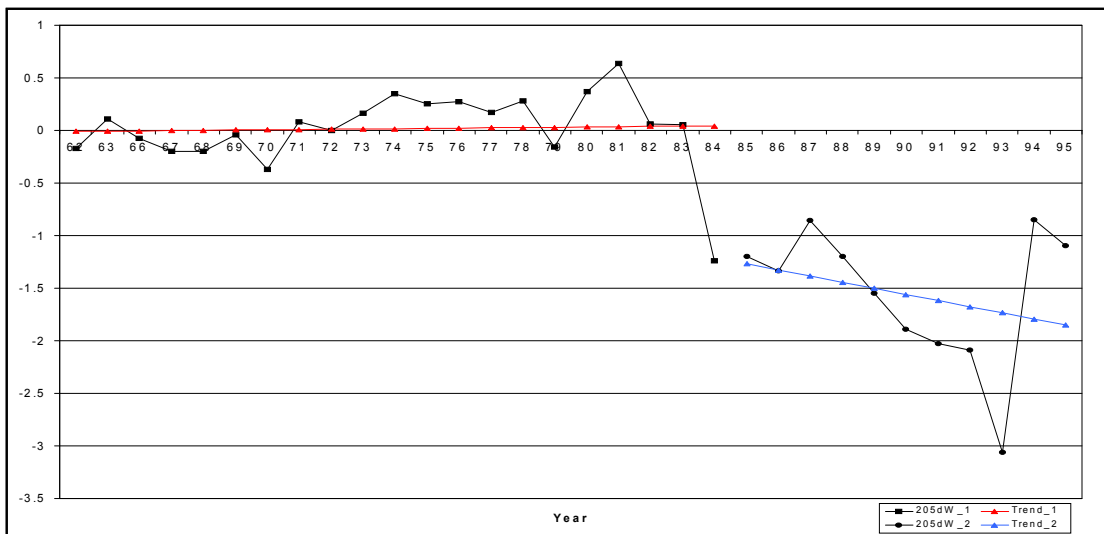

Figure 5.19 Mean annual estimated breeding values of 205dW

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5.4 Conclusions

1. It should be borne in mind that the data used were not obtained from an experimental design that was pre-determined. Raw field data obtained from records kept by various managers was revised and edited in order to compile the graphs and trendlines. Due to this, trendlines did not always conform to expectations and various R^2 values were exceptionally low.

2. Selection was performed purely on phenotypic data. If genetic values (i.e. BLUP of breeding values) were used, genetic improvement would be achieved at a much higher rate. Selection differentials could then be optimised and genetic improvement accurately measured over time.

3. Reproduction traits with low heritabilities could be optimally utilised as selection criteria, as long as the selection differentials for these traits are maximised. Positive responses on selection pressure based on BLUP estimation of the breeding values would be obtained if the selection pressure were continued over time, irrespective of low heritabilities and poor environmental conditions.

4. Selection pressure on reproductive performance has not yet attained the desired effect. Although fecundity has improved, both number of lambs born per ewe and kilograms of lambs weaned per ewe has shown very little or no improvement. Selection should rather be based on BLUP estimates of breeding values, which should lead to faster genetic improvement, by optimising selection differentials.

5. Although lambs might have lower body weights due to selection pressure on reproductive performance, their ADG's and Kleiber Ratio's were increased.

6. The selection objective of lower live weight is being attained. The 100dW of lambs has been markedly reduced, with an increase in both 100dADG and 100dKR. The selection policy of putting no selection pressure on live weight traits should be continued.

7. Animals that are adapted to an extensive farming system could be bred by discontinuing the creation of an artificial environment, and selecting efficiently for improved reproductive performance of the flock.

6.   GENERAL CONCLUSIONS

1.   The identification of the possible contributing non-genetic sources of variation on both growth and reproductive traits was the first important aspect of this study. It was found that age of dam, birth status, birth season, sex and the sire x year interaction all had a significant effect on growth traits. Year and birth status were the only non-genetic factors influencing reproductive traits.

2.   Results from this study show that direct selection for growth rate and ADG's has no advantage over selection based on lamb weight. Selection for increased live weight would also possibly cause undesired positive responses in mature weight, leading to increased maintenance requirements. This would be particularly unfavourable in an extensive production system and would increase the breeder's current concerns.

3.   The Kleiber Ratio, which was included as a measure of efficiency of production, does not have the same adverse effects on flock efficiency. This trait with its moderate heritability can be used effectively as a selection criterion that will lead to improved biological efficiency of a flock. The utilising of this specific trait will also counteract the difficulties experienced in the specific flock, where too large animals were becoming a problem.

4.   The kilograms of lamb weaned by a ewe per year is recommended as an effective selection trait to improve reproduction performance.   This trait has high heritability estimates and can be used as an indirect selection method against failure to reproduce. Selection for the trait should also lead to an improved nett reproduction rate.

5.   The implementation of an accelerated lambing system is not recommended for this extensive flock. General managerial inputs should rather be optimised in order to improve the overall efficiency of the flock.

6. Selection for increased reproductive performance has thus far not been very successful, with limited improvement in reproductive traits being achieved. Selection should rather be based on BLUP estimates of breeding values. Selection differentials could then be optimised and genetic improvement should be achieved at a faster rate.

7. The selection objective of raising smaller, lighter lambs was reached, with a marked decrease in 100d live weights being recorded. These lambs have increased ADG's and Kleiber ratio's, indicating increased effectiveness. The selection policy of putting no selection pressure on increased live weights has thus been successful.

8. Animals adapted to an extensive farming system could thus be bred by discontinuing an artificial environment and by placing high selection pressure on the reproductive performance of the flock.

LITERATURE

Aboul-Naga, A.M. & Monsour, H., 1988. Evaluating reproductive performance of sheep breeds as ram criteria. *3rd Wrld congr sheep and beef cattle breeding.* 2, 641-643. Paris, France.

Analla, M., Muñoz-Serrano, A., Cruz, J.M. & Serradilla, J.M., 1995. Estimation of genetic parameters of growth traits in Segureña lambs. *J. Anim. Breed. Genet*. 112, 183-190.

Ap Dewi, M., Owen, J.B., El-Seikh, A., Axford, R.F.E. & Beigi-Nassiri, M., 1996. Variation in ovulation rate and litter size of Cambridge sheep. *Anim. Sci.* 62, 489-495.

Beck, N.F.G., Davies, M.C.G. & Davies, B., 1996. A comparison of ovulation rate and embryonic mortality in ewe lambs and ewes and the rôle of late embryo loss in ewe lamb subfertility. *Anim. Sci.* 62, 79-83.

Boujenane, I. & Kerfal, M., 1990. Estimates of genetic and phenotypic parameters for growth traits of D'man lambs. *Anim. Prod*. 51, 173-178.

Bradford, G.E., Sakul, H., Neira, R., Famula, T.R., Dally, M.R. & Finley, C.M., 1994. *Proc. 5th Wrld Congr Genet Appl Livest Prod.* 18, 95-98. Ontario, Canada.

Cantet, R.J.C., Kress, D.D., Anderson, D.C., Doornbos, D.E., Burfening, P.J. & Blackwell, R.L., 1988. Direct and maternal variances and covariances and maternal phenotypic effects on pre-weaning growth of beef cattle. *J. Anim. Sci.* 66, 648-660.

Clarke, J.N., 1988. Recent developments and prospects of selection for wool and meat production in dual-purpose sheep. *3rd Wrld Congr sheep and beef cattle breeding.* 2, 429-433. Paris, France.

Dimsoski, P., Irvin, K.M. & Clay, J., 1994. Effects of management, breed and ewe age on litter size born and weaned in sheep. *Proc. 5th Wrld Congr Genet Appl Livest Prod.* 18, 119-122. Ontario, Canada.

Fogarty, N.M., Brash, L.D. & Gilmour, A.R., 1994. Genetic parameters for reproduction and lamb production and their components and live weight, fat depth and wool production in Hyfer sheep. *Aust. J. Agric. Res*. 45, 443-457.

Fogarty, N.M. & Gilmour, A.R., 1993. Sensitivity of breeding objectives to prices and genetic parameters in Australian Corriedale and Polwarth dual-purpose sheep. *Aust. J. Exp. Agric*. 33, 259-268.

Fogarty, N.M. & Hall, D.G., 1995. Performance of crossbred progeny of Trangie fertility Merino and Booroola Merino rams and Poll Dorset ewes. 3. Reproduction, live weight and wool production of adult ewes. *Aust. J. Exp. Agric*. 35, 1083-1091.

Fogarty, N.M., Hall, D.G. & Gilmour, A.R., 1995. Performance of crossbred progeny of Trangie fertility Merino and Booroola Merino rams and Poll Dorset ewes. 2. Reproductive activity, live weight and wool production of ewe lambs. *Aust. J. Exp. Agric.* 35, 1075-1082.

Fourie, A.J. & Cloete, S.W.P., 1993. Reproductive performance of commercial Merino, Döhne Merino and SA Mutton Merino flocks in the Southern Cape. *S. Afr. J. Anim. Sci.* 23 (3/4), 104-110.

Groeneveld, E., Kovac, M. & Wang, T., 1990. PEST, a general purpose BLUP package for multivariate prediction and estimation. *Proc. 5th Wrld Congr Genet Appl Livest Prod.* 488-491. Edinburgh, Scotland.

Hall, D.G., Fogarty, N.M. & Gilmour, A.R., 1995. Performance of crossbred progeny of Trangie fertility Merino and Booroola Merino rams and Poll Dorset ewes. 1. Lamb birth weight, survival and growth. *Aust. J. Exp. Agric.* 35, 1069-1074.

Hanrahan, J.P., 1989. Altering reproductive rate in sheep: Some genetic and non-genetic options. In *Reproduction, growth and nutrition in sheep* (ed. O.R. Dyrmundsson & S. Thorgeirsson), 45-55.

Iman, N.Y. & Slyter, A.L., 1993. Production of yearling Targhee or Finn-Dorset-Targhee ewes managed as a farm or range flock. *J. Anim. Sci.* 71, 3206-3210.

Kotze, F de K., 1976. Die teelstruktuur en 'n genetiese analise van die S.A. Vleismerino in Suid Afrika. D.Sc. Thesis, University of Pretoria.

Land, R.B., Bodin, L., Driancourt, M.A., Haley, C.S. & McNeilly, J.R., 1988. Physiological prediction of genetic merit for female reproduction in the sheep. *3rd Wrld Congr sheep and beef cattle breeding.* 2, 611-613. Paris, France.

Lasslo, L.L., Bradford, G.E., Torell, D.T. & Kennedy, B.W., 1985. Selection for weaning weight in Targhee sheep in two environments. II. Correlated effects. *J. Anim. Sci.* 61 (2), 387-397.

Lee, G.J. & Atkins, K.D., 1996. Prediction of lifetime reproductive performance of Australian Merino ewes from reproductive performance in early life. *Aust. J. Exp. Agric.* 36, 123-128.

Martin, T.G., Sales, D.I., Smith, C. & Nicholson, D., 1980. Phenotypic and genetic parameters for lamb weights in a synthetic line of sheep. *Anim. Prod.* 30, 261-269.

Mavrogenis, A.P. & Constantinou, A., 1990. Relationships between pre-weaning growth, post-weaning growth and mature body size in Chios sheep. *Anim. Prod.* 50, 271-275.

Morris, C.A., Johnson, D.L., Sumner, R.M.W., Hight, G.K., Dobbie, J.L., Jones, K.R., Wrigglesworth, A.L. & Hickey, S.M., 1996. Single trait selection for yearling fleece weight or live weight in Romney sheep - correlated responses in live weight, fleece

traits, and ewe reproduction. *New Zealand Journal of Agricultural Research*. 39 (1), 95-106.

Neumaier, A. & Groeneveld, E., 1997. Restricted Maximum Likelihood of covariances in sparse linear models. *Genet. Sel. Evol.* in print.

Nugent, R.A. & Jenkins, T.G., 1993. Simulated effects of culling ewes for age and failure to conceive on biological efficiency of an annual lambing production system. *J. Anim. Sci.* 71, 310-320.

Sakul, H., Bradford, G.E., Dally, M.R., Famula, T.R. & Finley, C.M., 1994. Growth rate in sheep selected for weaning weight or litter size in a range environment. *Proc. 5th Wrld Congr Genet Appl Livest Prod.* 18, 59-62. Ontario, Canada.

Schoeman, S.J., 1990. Production parameters for Döhne Merino under an accelerated, intensive lambing system. *S. Afr. J. Anim. Sci.* 20 (4), 174-179.

Scholtz, M.M. & Roux, C.Z., 1988. The Kleiber ratio (growth rate / metabolic mass) as possible selection criterion in the selection of beef cattle. *3rd Wrld Congr sheep and beef cattle breeding.* 2, 373-375. Paris, France.

Shresta, J.N.B., Veseley, J.A. & Chesnais, J.P., 1985. Genetic and phenotypic parameters for daily gain and body weights in Suffolk lambs. *Can. J. Anim. Sci.* 65, 575-582.

Thorgeirsson, S. & Thorsteinsson, S., 1989. Growth, development and carcass characteristics. In *Reproduction, growth and nutrition in sheep* (ed. O.R. Dyrmundsson & S. Thorgeirsson), 169-175.

Tosh, J.J. & Kemp, R.A., 1994. Estimation of variance components for lamb weights in three sheep populations. *J. Anim. Sci.* 72, 1184-1190.

Van Wyk, J.B., 1992. A Genetic evaluation of the Elsenburg Dormer stud. Ph.D. dissertation, University of Orange Free State.

Vosloo, L.P., 1967. Faktore wat die produksie van die Elsenburg Duitsemerino vleisskaapkudde beïnvloed. D.Sc. dissertation, University of Stellenbosch.

Wilson, D.E., Rothschild, M.F., Boggess, M.V. & Morrical, D.G., 1996. Adjustment factors for birth weight and 30-day, 60-day, and 90-day weaning weight in sheep. *J. Anim. Breed. Genet.* 113, 29-41.