Estimated genetic trends for weaning weight in three Dorper lines with different selection criteria

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A study was undertaken to compare the effectiveness of three different selection strategies in increasing weaning weight of a Dorper flock under natural conditions. Data were analysed by mixed model procedures. Direct selection for weaning weight under natural conditions proved to be effective. Selection on breed standards and selection on weaning weight under natural conditions combined with feedlot performance were not successful in increasing weaning weight. Only direct selection for weaning weight under natural conditions is therefore recommended.

'n Studie is onderneem om die doeltreffendheid van drie verskillende seleksieprosedures vir die verhoging van speenmassa in 'n Dorperkudde onder ekstensiewe toestande, te ondersoek. Gemengde modelprosedures is gebruik vir die vergelyking van die verskillende seleksiemetodes. Direkte seleksie vir speenmassa onder ekstensiewe toestande was die effektiefste metode om speenmassa te verhoog. Seleksie op grond van rasstandaarde en seleksie vir speenmassa onder ekstensiewe toestande gekombineer met voerkraalprestasie was nie suksesvol nie. Slegs direkte seleksie vir speenmassa onder natuurlike toestande word dus aanbeveel.

Keywords: Dorper sheep, selection, mixed model procedures, weaning weight.

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Introduction

The Dorper is a synthetic sheep breed developed in South Africa for mutton production under harsh natural conditions. Since the lambs are marketed as soon as possible after weaning (Campbell, 1974), weaning weight appears to be a very important trait. The objective of this study was to estimate the genetic trends relating to weaning weight in a selection experiment conducted from 1966 to 1982, where three different selection policies were applied. These policies closely represent the different breeding strategies in Dorper studs in South Africa. The data used by Els *et al.* (1985) were re-analysed, using mixed model methodology.

Material and methods

Data

A detailed description of the data and experimental design is given by Els *et al.* (1985). The three selection groups were derived from one parent Dorper flock. Each group consisted of about 150 ewes until 1970, after which it was reduced to 120 ewes.

Replacement ewes and rams were chosen according to the following criteria:

Group 1: Both ewe and ram replacements were selected for weaning weight under natural conditions.

Group 2: Ewes were selected for weaning weight under natural conditions. The highest ranking 20 rams on weaning weight were finally selected on the basis of the following index:

$$(W \times 60 + G \times 20 + E \times 20)$$

where

W = Weaning weight as a percentage of the mean of the group

G = Post-weaning daily gain in the feedlot as a percentage of the mean

E = Feed efficiency in the feedlot as a percentage of the mean. (Els *et al.*, 1985)

Group 3: Animals were selected according to breed standards (Dorpers Sheep Breeder's Association of South Africa, 1965).

Annual ewe replacement was maintained at 20% and breeding ewes were culled on the basis of age, poor teeth and defective udders. A fresh set of rams was used each year. The percentage rams used throughout the trail was a constant 3.3%. The data consisted of a total of 1576 weaning weight records for selection Group 1, 1474 records for selection Group 2 and 1 660 records for selection Group 3. Complete pedigree information for all animals was available.

Two mating systems were applied during the experimental period. During 1966 to 1972 ewes were mated once a year in spring; after 1972, it was changed to mating every eight months. In 1973 age at weaning changed from 100 days to 60 days. The authors were compelled to consider the weight at different ages as being the same trait. From 1966 to 1973 rams and ewes were first mated at approximately 18 months of age. From 1974 onwards age at first mating was set at approximately 11 months. Ewe lambs were placed on natural grazing after weaning. A phosphate lick was made available throughout.

No animals born in 1974 were used as parents and no records were available for the 1981 lambing season.

Statistical methods

A mixed model analysis of variance, using Harvey's (1988) LSMLMW program, showed the following fixed effects to be highly significant ($P < 0.01$) in all groups: Sires, year/season, sex and birth status. Age at weaning was a significant ($P <$

0.01) covariable. The following mixed model was used to estimate breeding values in the analysis of all three selection Groups:

$$y = Xb + Z_1a + Z_2m + e$$

where

y = vector of observations

b = vector of fixed effects

a = vector of additive genetic effects

m = vector of additive maternal genetic effects

e = vector of residual errors

X, Z_1 and Z_2 = incidence matrices

The three selection Groups were analysed separately since sires were nested within groups and no genetic link existed between the groups. The authors were also interested in comparing the fixed effects estimates from each flock.

Although there was no selection for maternal ability, it was decided to include additive maternal effects in the analysis for weaning weight in order to ascertain possible correlated responses with the different methods of selection. The importance of the inclusion of additive maternal effect in the analysis for early growth traits in mutton sheep was discussed in detail by van Wyk *et al.* (1993) and Neser (1992).

Mixed model methodology requires that the different variance components be known, at least to proportionality (Henderson, 1973). Since no estimates for Dorper sheep could be found, it was decided to estimate genetic parameters for each of the three groups. Blair & Pollak (1984) showed how the estimated genetic response to selection varies with different assumed heritability estimates. Reasonably good estimates for each selection Group are therefore essential. Estimates for the genetic parameters were done using the DFREML program of Meyer (1991) while breeding value estimates were obtained using the program of Tess (1989).

Results and discussion

The estimates of the genetic parameters used for the estimation of breeding values in the groups are presented in Table 1.

The results of the estimates for year/season effects, additive breeding value, maternal breeding value and adjusted phenotypic value for each selection group are presented in Tables 2 and 3.

Table 1 Estimates of the genetic parameters for each group

	Selection Group 1	Selection Group 2	Selection Group 3
Additive variance	2.167	1.434	4.409
Maternal variance	0.989	2.730	2.084
Cov animal effects	−0.055	−0.016	−0.070
SE	0.049	0.048	0.064
Error variance	10.733	9.530	9.389
Phenotypic variance	13.807	13.48	14.842
h_a^2	0.157	0.106	0.297
SE	0.071	0.082	0.089
h_m^2	0.072	0.203	0.140
SE	0.042	0.058	0.056

By comparing the differences between the estimated year/season effects (r_i) it could be determined if differences existed in the year/season effects between the three selection groups. The quantity $\hat{r}_1 - \hat{r}_2$, $\hat{r}_1 - \hat{r}_3$ and $\hat{r}_2 - \hat{r}_3$ is expected to deviate from zero only due to sampling. If the estimated year/season effects were the same for all groups, it would indicate that the data could be combined to estimate one set of year/season effects. However, if these differences are consistently positive or negative, or if a trend in the differences occurs, it might be suggested that the selection groups were subjected to different environments (Blair & Pollak, 1994). Since differences existed, separate analyses were warranted and indeed necessary.

In Figure 1 the estimated average additive breeding values for each selection group within each year/season are presented.

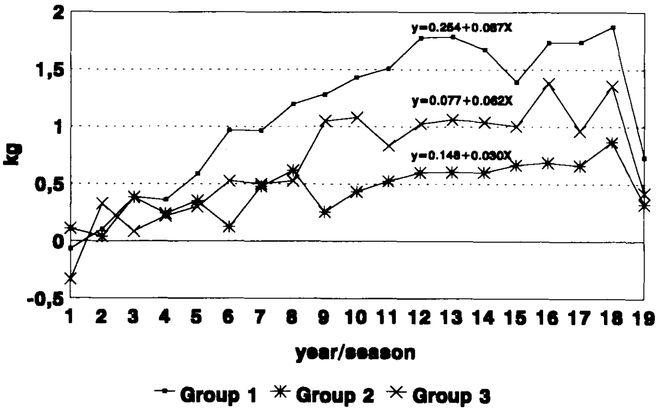

Figure 1 Annual mean estimated direct additive breeding values for weaning weight in each selection group

As expected, the estimated genetic trend for weaning weight in selection Group 1 was the highest, since selection was for weaning weight. It would be expected of the genetic trend in selection Group 2 to closely represent that of Group 1, since the selection index used in Group 2 included weaning weight and initial selection was on weaning weight. Although the ewes in Group 2 were selected on weaning weight, less emphasis was placed on this trait in the selection of sires. The correlation between weaning weight under natural conditions and the index used for selection in Group 2 is unknown. This

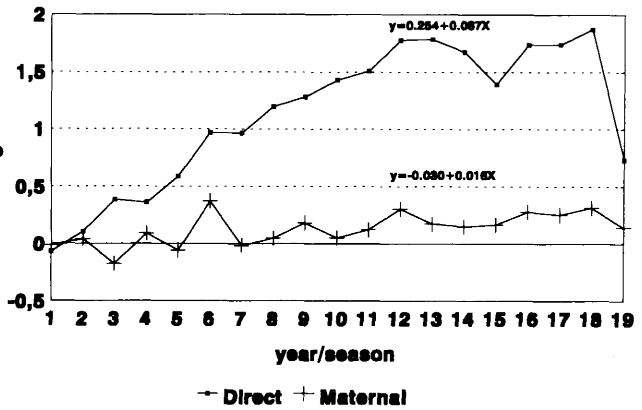

Figure 2 Annual mean estimated direct and maternal breeding values for selection group 1

Table 2 Estimates for year/season effects ($\hat{r}$), average yearly additive breeding value ($\hat{BV}$) and adjusted yearly phenotypes ($\hat{P}$) for each selection group (1, 2, 3)

J	$\hat{r}_1$	$\hat{BV}1$	$\hat{P}1$	$\hat{r}_2$	$\hat{BV}2$	$\hat{P}2$	$\hat{r}_3$	$\hat{BV}3$	$\hat{P}3$
1	0.00	−0.07	−0.07	0.00	0.11	0.11	0.00	−0.33	−0.33
2	0.55	0.10	0.66	2.04	0.04	2.08	−1.15	0.33	−0.83
3	0.69	0.38	1.08	3.16	0.38	3.54	1.62	0.08	1.70
4	0.44	0.36	0.80	2.55	0.24	2.79	−5.11	0.22	−4.89
5	2.06	0.59	2.65	4.83	0.35	5.18	1.71	0.30	2.01
6	−0.94	0.97	0.03	3.30	0.12	3.43	1.31	0.52	1.83
7	4.52	0.96	5.48	6.68	0.48	7.16	4.36	0.50	4.86
8	0.69	1.20	1.89	1.98	0.62	2.59	0.26	0.53	0.78
9	−2.54	1.28	−1.25	−2.19	0.26	−1.93	−6.08	1.05	−5.03
10	−1.58	1.43	−0.15	0.68	0.43	1.11	−2.03	1.08	−0.94
11	−5.66	1.51	−4.16	−2.89	0.52	−2.36	−8.32	0.83	−7.49
12	−4.99	1.78	−3.21	−3.47	0.60	−2.88	−7.79	1.02	−6.76
13	−7.40	1.79	−5.62	−2.81	0.60	−2.21	−10.20	1.06	−9.14
14	−3.31	1.68	−1.64	0.66	0.60	1.26	−7.05	1.04	−6.01
15	−6.86	1.39	−5.47	−4.11	0.66	−3.44	−9.36	1.00	−8.35
16	−5.38	1.74	−3.64	−0.61	0.69	0.08	−6.66	1.38	−5.28
17	−4.28	1.74	−2.54	−0.83	0.66	−0.17	−7.17	0.86	−6.31
18	−7.97	1.87	−6.10	−4.09	0.87	−3.22	−10.89	1.36	−9.53
19	−3.81	0.73	−3.08	2.80	0.32	3.13	−1.27	0.42	−0.85

correlation could play a major role in the response to selection in Group 2. The estimated genetic trend for selection Group 3 was higher than that of Group 2.

A possible explanation for the positive trend in Group 3 is that indirect selection for weaning weight could have occurred. Some of the traits used for selection on breeding standards must have had a positive correlation with weaning weight. It is, however, difficult to explain the sudden increase from the 9th to the 18th year/season. It is possible that the Dorper Breed Association judges concentrated more on size as a selection criterium in those particular years. It is also difficult to explain the sudden decline in the genetic trend for weaning weight in all three groups in the 19th year/season.

Figures 2, 3, and 4 show the correlated response for each selection method in average maternal breeding value. Of interest is the results of Group 1, represented in Figure 2.

From Figure 2 it can be seen that selection for weaning weight in Group 1 had a small but positive effect on maternal

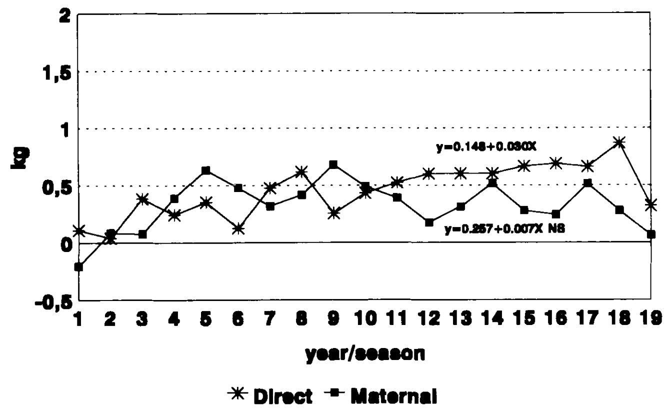

Figure 3 Annual mean estimated direct and maternal breeding values for selection group 2

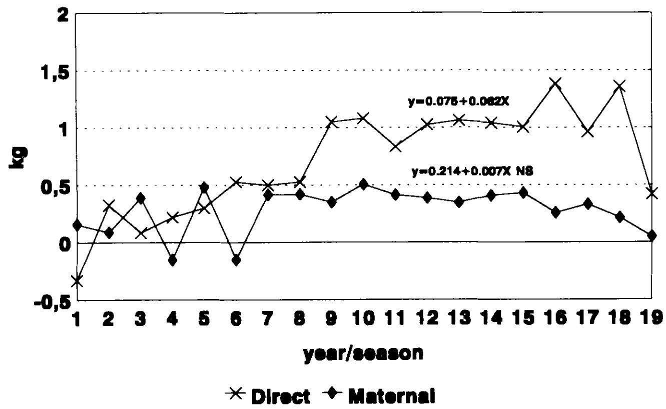

Figure 4 Annual mean estimated direct and maternal breeding values for selection group 3

Table 3 Estimates for year/season effects ($\hat{r}$), average yearly maternal breeding value ($M\hat{B}V$) and adjusted yearly phenotypes ($\hat{P}$) for each selection group (1, 2, 3)

J	$\hat{r}_1$	$M\hat{B}V1$	$\hat{P}1$	$\hat{r}_2$	$M\hat{B}V2$	$\hat{P}2$	$\hat{r}_3$	$M\hat{B}V3$	$\hat{P}3$
1	0.00	–0.01	–0.01	0.00	–0.20	–0.20	0.00	0.16	0.16
2	0.55	0.04	0.59	2.04	0.09	2.13	–1.15	0.09	–1.06
3	0.69	–0.18	0.52	3.16	0.08	3.23	1.62	0.39	2.01
4	0.44	0.09	0.53	2.55	0.39	2.94	–5.11	–0.15	–5.26
5	2.06	–0.06	2.00	4.83	0.63	5.46	1.71	0.48	2.19
6	–0.94	0.37	–0.57	3.30	0.48	3.78	1.31	–0.15	1.16
7	4.52	–0.02	4.50	6.68	0.32	7.00	4.36	0.42	4.78
8	0.69	0.05	0.74	1.98	0.42	2.39	0.26	0.42	0.68
9	–2.54	0.18	–2.35	–2.19	0.68	–1.51	–6.08	0.35	–5.73
10	–1.58	0.05	–1.53	0.68	0.49	1.17	–2.03	0.50	–1.52
11	–5.66	0.12	–5.54	–2.89	0.39	–2.50	–8.32	0.41	–7.91
12	–4.99	0.30	–4.69	–3.47	0.17	–3.30	–7.79	0.39	–7.40
13	–7.40	0.17	–7.23	–2.81	0.31	–2.50	–10.20	0.35	–9.85
14	–3.31	0.15	–3.16	0.66	0.51	1.17	–7.05	0.40	–6.65
15	–6.86	0.17	–6.69	–4.11	0.28	–3.83	–9.36	0.43	–8.93
16	–5.38	0.28	–5.10	–0.61	0.24	–0.37	–6.66	0.26	–6.40
17	–4.28	0.25	–4.03	–0.83	0.51	–0.31	–7.17	0.33	–6.84
18	–7.97	0.31	–7.66	–4.09	0.28	–3.81	–10.89	0.22	–10.67
19	–3.81	0.14	–3.67	2.80	0.07	2.87	–1.27	0.05	–1.22

breeding values.

In Group 2 the improvement in direct additive breeding values coincided with an improvement in maternal breeding values. However, after nine year/seasons of selection, the mean maternal breeding values started decreasing, while a positive trend in direct additive breeding values was maintained. The additive maternal variance was higher than the direct additive variance. It is also interesting to note that up to the 9th year/season, the average maternal breeding value was higher than the direct additive breeding value. This could possibly be explained by the fact that up to year/season nine, sires with low direct additive breeding values were used.

The maternal trend in selection Group 3 remained more or less constant with a slight decline in year/seasons 10 to 14. This decline coincided with a significant increase in the average direct additive breeding value.

Conclusions

The second and third selection Groups represent what is currently happening in many Dorper sheep studs in South Africa. Selection is done on breeding standards, sometimes combined with feedlot performance (phase C tests). It is then expected of the progeny of these animals to perform under natural extensive and sometimes harsh conditions. More emphasis should be placed on important traits in the selection process, in this case weaning weight under natural conditions. Genetic change would then be more rapid (selection Group 1 vs. selection Groups 2 and 3). The later diversion shown in Figures 3 and 4, between the direct additive and maternal breeding values, suggests that the covariance between the two genetic effects could be higher than estimated in the Dorper population. However, more data is needed to assess this covariance from a population level. The effect of increased weaning weight on viability and fertility should also be investigated.

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