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GENETIC RELATIONSHIPS BETWEEN OBJECTIVELY MEASURED AND SUBJECTIVELY ASSESSED TRAITS IN THE SOUTH AFRICAN DORPER SHEEP BREED

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SUMMARY

Breed improvement in the Dorper sheep breed is based on subjectively assessed traits as determined in the show ring. Little information is available about the genetic relationships between these visually assessed traits and objectively measured growth traits in the breed. Against this background, genetic analyses were conducted to determine the magnitude of additive direct and maternal effects as well as correlations between average daily weight gains from weaning to yearling age with fat distribution and colour scores. The growth traits were moderately to highly heritable and maternal effects were significant although of low magnitude. Heritabilities of fat distribution and colour scores were low. A series of two-trait analyses between all the five trait combinations confirmed the existence positive genetic and environmental correlations between subjective and objective traits. It was concluded that, despite favourable correlations of fat distribution scores with growth traits, greater genetic gains will be achieved if more emphasis is put on objectively measured traits during breed improvement.

INTRODUCTION

The Dorper breed was developed as a culmination of the need for a sheep breed suitable for the production of slaughter lambs under South African adverse arid environments (Cloete *et al*. 2000). The Dorper breed is the most common meat sheep in South Africa and constitutes the vast majority of ~6.1 million non-wool sheep out of the national sheep population of ~22 million (Abstract of Agricultural Statistics 2009). Dorper rams have been proven to be outstanding terminal meat sires whose lamb growth rate, feed conversion efficiency and carcass characteristics are comparable to those of Suffolk crossbred lambs and Columbia purebred lambs (Snowder and Duckett 2003). Traditionally the breed development of the Dorper has been mainly based on subjective assessment in the show ring with little emphasis on objectively measured production traits (Olivier and Cloete 2006). The South African National Small Stock Improvement Scheme (NSIS) records live weight traits such as weaning weights, post-weaning weights up to slaughter age and average daily live weight gain to yearling age (Olivier and Cloete 2006).

Despite a preliminary study having been undertaken by Olivier and Cloete (2006) in which they validated the need for further investigations, there is a paucity of information on the genetic basis of subjectively assessed traits and their correlation with objectively measured traits in the Dorper breed. There is a dearth in the literature of estimates of genetic parameters in the breed (Cloete *et al*. 2000). The hypothesis by Olivier and Cloete (2006) in which they attributed the slow genetic gains in Dorper production traits to an over-accentuation of type traits needs to be validated further.

The objectives of this study were therefore to extract average daily gain performance as well as subjectively assessed score data from the NSIS database and estimate genetic parameters for all the recorded traits as well as computing some genetic correlations between subjectively assessed and objectively measured traits.

MATERIALS AND METHODS

Data were retrieved from the NSIS database, and performance records accumulated by a single breeder over a period of 21 years (1983 to 2003) were utilized. The data came from progeny of 104 sires and 2558 dams. The objectively measured production traits considered were average daily weight gain to weaning, average daily live weight gain during the post-weaning phase, and average daily live weight gain up to yearling age. The subjectively assessed traits scored on a 5 point scale close to weaning stage were fat distribution (1=excessive localization, 2=localized fat, 3=reasonable amount of localized fat, 4= good with slight localization and 5=good over the entire body with no fat localization) and colour (1=excessive, to 5=ideal). A white sheep with a black head is regarded as ideal (South African Dorper Sheep Breeders Society 2011). Additional pigment on the body and legs is discriminated against. Descriptive statistics of the data after editing are summarized in Table 1.

Data analysis. The Shapiro-Wilk test, Kolmogorov-Smirnov test, Cramer-von Mises test and the Anderson-Darling test all confirmed that the 5 traits assumed a normal distribution. The decision to utilize linear methods to analyze the data was therefore justified. Data were rigorously edited by assessing the number of progeny per sire and dam, pooling twins and triplets (as multiples) because the incidence of triplets was low, maintaining dams between two and eight years of age and other criteria. The ASREML program (Gilmour *et al*. 2002) was used for the estimation of (co)variance components using single-trait analyses and also a series of two-trait analyses. The significant ($P < 0.05$) fixed effects were incorporated into the operational models. Random terms were added to analytical models sequentially. Likelihood Ratio Tests (LRT) were performed to assess the significance of the contribution of each random term to improvements in the model of analysis. The LRT is based on testing twice the increase in Log-likelihood resulting from adding a random term to the model of analysis as a Chi-square statistic. Alternatively, for two models with the same number of different random terms, and assuming identical fixed effect modelling, the model with the higher value for the Log-likelihood fits the data. Only the animal random effect was fitted in the series of two-trait analyses to estimate genetic and environmental correlations between all trait combinations.

Table 1. Description of the raw data after editing (n = number of records, CV% = coefficient of variation and SD = standard deviation)

Parameter	Weaning ADG (g/day)	Post Weaning ADG (g/day)	Yearling ADG (g/day)	Fat Distribution	Colour
Records	7773	1859	1475	6609	6609
Mean	195	110	102	4.67	3.67
SD	50	21	22	0.51	0.86
CV %	26	19	22	11	23
Range	83-307	62-166	47-158	1-5	1-5

RESULTS AND DISCUSSION

Analysis of variance indicated that year of birth (1983-2003), month of birth (January-December), sex of the lamb (male or female), birth status (single or multiples) and ewe age (2 to 8 years) treated as fixed effects were all highly significant ($P < 0.001$) for all traits analyzed. The genetic parameter estimates using single-trait analyses for all 5 traits are presented in Table 2. The heritabilies (h^2) of average daily gains to weaning and yearling ages were higher than expected, but nevertheless consistent with a few literature estimates available (Notter and Hough 1997; Mousa *et al* 1999; Bromley *et al*. 2000; Rao and Notter 2000 and Matika 2003). The h^2 of post-weaning average daily weight gain was consistent with estimates in the previously cited literature. However, it could have been biased because the model failed to partition the variation further into direct additive maternal effects and dam permanent environmental effects due to excessive data erosion and loss of genetic links. The moderate to high m^2 estimates for average daily gain weight to weaning and yearling age were consistent with some estimates in the previously cited literature. However, the estimate for average daily weight gain to yearling age could be biased due of the erosion of data because carcasses of Dorper lambs tend to get over fat at an early age, so they are rarely slaughtered as yearlings (Cloete *et al*. 2000).

The correlation between direct additive effects and maternal effects (r_{am}) was high and negative when fitted to average daily weight gain to weaning and average daily weight gain to the yearling stage. Although these correlations were within the range of estimates in the literature, more recent research indicated that such correlations may not always be a function of the underlying biological processes, and may rather be caused by not fitting all the relevant terms in the model (Robinson, 1996; Maniatis and Pollot 2003; Heydarpour *et al*. 2008). It was attempted to fit a sire by year interaction as an additional random term in an effort to counteract this attribute but it resulted in no significant change in the LRT, hence it was dropped from the model.

The dam permanent environmental effect was significant in the models for average daily gain to weaning and for colour. In the case of average daily gain to weaning the low estimate was consistent with literature estimates (Mousa 1999; Bromley *et al*. 2000; Duguma *et al*. 2002 and Matika *et al*. 2003). There were no literature comparisons for the c^2 estimate for colour. The h^2 of fat distribution and colour were low. No literature values for comparison with these estimates could be found. These subjective traits are thus lowly heritable and genetic progress to be achieved will likely be slow when considered in association with the modest CV % of these traits.

Table 2. REML estimates of variance components and ratios from single-trait analysis for objectively measured and subjectively assessed traits in Dorper sheep

Parameters	Weaning ADG	Post-weaning ADG	Yearling ADG	Fat Distribution	Colour
σ_a^2	840.39	59.15	99.45	0.024	0.063
σ_m^2	288.04	-	52.43	-	-
σ_c^2	104.50	-	-	-	0.027
σ_p^2	1814.59	242.51	193.75	0.176	0.717
σ_{am}	-364.94	-	-52.45	-	-
σ_e^2	946.60	183.35	94.32	0.152	0.627
$h^2 \pm$ s.e.	0.46±0.06	0.24±0.06	0.51±0.15	0.13±0.02	0.09±0.02
$m^2 \pm$ s.e.	0.16±0.03	-	0.27±0.09	-	-
$c^2 \pm$ s.e.	0.06±0.02	-	-	-	0.04±0.01
$r_{am} \pm$ s.e.	-0.74±0.06	-	-0.73±0.12	-	-

The genetic and environmental correlations from a series of two-trait analyses between all the trait combinations are presented in Table 3. The genetic correlations between fat distribution and the three objectively measured average daily weight gain traits were positive and varied from moderate to high. There are no literature estimates for comparison of these estimates. These positive correlations indicate that selecting Dorper sheep on the basis of the fat distribution score will have a positive impact on their growth traits.

The correlations between fat distribution and growth traits could also infer that selecting animals that have good average daily gains to weaning, post-weaning and yearling stage will result in animals that have a reasonable fat distribution. It is also critical to mention that fat distribution scores should be treated with caution as animals that are too fat may be undesirable although they may have desirable growth patterns. It would be prudent to penalize animals that are too fat as they would have poor carcass characteristics. It was apparent that environments supporting high levels of growth would also result in a better fat distribution of Dorpers. The genetic and environmental correlations between colour and objectively measured average daily live weight gains ranged from lowly negative to lowly positive. These estimates indicate that selecting Dorper sheep on the basis of colour has very little or no effect on average daily weight gains. It is therefore clear that this trait is measured purely for aesthetical reasons in selection programs for Dorper sheep.

Table 3. REML estimates (SE in brackets) of genetic (above diagonal) and environmental (below diagonal) correlations between objective and subjective traits in Dorper sheep using bivariate analyses

Traits	Fat Distribution	Colour	Weaning ADG	Post-weaning ADG	Yearling ADG
Fat Distribution	-	0.30(0.12)	0.66(0.07)	0.43(0.14)	0.50(0.12)
Colour	0.13(0.01)	-	0.16(0.10)	0.20(0.15)	-0.05(0.16)
Weaning ADG	0.42(0.01)	0.13(0.01)	-	0.62(0.09)	0.74(0.06)
Post-weaning ADG	0.22(0.03)	0.09(0.02)	0.47(0.02)	-	0.96(0.08)
Yearly ADG	0.28(0.03)	0.06(0.03)	0.64(0.02)	0.35(0.05)	-

CONCLUSIONS

It can be concluded that an over-emphasis on breed standards (subjective scores) in the South African Dorper breed will not necessarily contribute to better growth. This is particularly the case for colour score. Low heritability estimates for subjective traits suggest that genetic progress in such traits is feasible, although it may be slow. However, more emphasis should be given to recording objective traits having a larger impact on profitability. There is a need to unravel relationships of the studied subjective scores with reproductive traits, as this could also affect overall profitability.

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