VARIANCE COMPONENT ESTIMATES AND RESPONSE TO SELECTION ON BLUP OF BREEDING VALUES IN MERINO SHEEP

J.B van Wyk, G.J. Erasmus
Dept. of Animal Science, University of the Orange Free State, P.O Box 339, Bloemfontein 9300, Republic of South Africa

and

J.J. Olivier
Grootfontein Agricultural Development Institute, Middelburg, Cape 5900, Republic of South Africa

SUMMARY

Direct and maternal variance components and resulting heritabilities were estimated by DFREML-procedures for clean fleece weight (CFW), body weight (BW) and mean fibre diameter (MFD) in the Grootfontein Merino stud. Direct heritabilities were estimated as 0.381, 0.289 and 0.626 for BW, CFW and MFD respectively. The maternal additive variance estimates were low, resulting in heritabilities of 0.013 for BW, 0.027 for CFW and 0.012 for MFD. It is concluded that the maternal component can be ignored due to its relative small effect on these traits. It was found that selection on BLUP of breeding values leads to a marked increase in genetic progress in spite of present practical limitations.

INTRODUCTION

Selection on best linear unbiased prediction (BLUP) of breeding values obtained by Henderson's mixed model methodology is generally recommended for livestock improvement since the correlation between the predicted and true breeding value is optimised. An added advantage is that response to selection can be determined without the use of a control population. For accurate prediction of breeding values at least a good knowledge of the variance components for the traits considered is required.

Estimates of direct additive genetic variance components and resulting heritabilities for Merino sheep, especially for fleece traits and mature body weight, abounds in the literature (Erasmus *et al.*, 1990). Published results on the additive maternal component are, however, very limited for sheep in general (Van Wyk *et al.*, 1993) and especially for important traits in Merino sheep, the most important wool producing breed. Also, very little is known of what the benefits of selection on BLUP of breeding values in practice would actually amount to.

The Grootfontein Merino stud, founded in 1956, is a typical South African Merino stud as far as management and selection procedures (until 1984) are concerned. It was classified as a "parent" stud by Erasmus (1977) and is an important source of genetic material to the stud industry. It is the only known Merino stud in South Africa where extensive production and pedigree records have been kept for a long period (since 1966) and is the source of what could be considered a relevant data-set for practical implicable genetic studies.

The purpose of this study was a) to estimate direct additive and maternal variance components and heritabilities for fleece traits and mature body weight and b) to compare the genetic trends obtained using different selection methods and also slightly different breeding objectives over a period of 26 years.

MATERIAL AND METHODS

Animals

Data from the Grootfontein Merino stud were available from 1966 to 1991. All lambs were first shorn at five to six months of age. The rams remaining after preliminary culling were again shorn at 12 to 14 months of age and the ewes at 16 to 18 months of age. At this second shearing the measurements used in this study were recorded. After editing, the data set consisted of a total of 7151 animal records from 211 sires and 2455 dams. Full pedigree records were available. The following measurements were recorded under the National Woolled Sheep Performance and Progeny Testing Scheme: mature body weight (BW), clean fleece weight (CFW) and mean fibre diameter (MFD). Clean fleece weight was determined by multiplying the clean yield percentage by the pre-adjusted 365-day greasy fleece weight.

The selection procedure followed and objectives can be devided into two periods. 1) 1966 - 1984 : Roughly one third of all candidates were annually rejected for wool and structural faults. The remainder were subjectively selected for "overall excellence" with body size, wool quality and quantity being the most important criteria. Apparently some attention was given to measured performance but this is difficult to quantify.
2) 1985 - 1991 : After culling on wool and structural faults, roughly one-third of the rams were selected for"overall excellence". Final selection was done on animal model BLUP of breeding values for high body weight, low fibre diameter and average fleece weight. Roughly one-third of the ewes were culled on wool and structural faults with final selection the same as the rams.

Statistical analysis

To derive an operational model, an analysis of variance was performed on the effects of sire (nested within year-seasons), year-season of birth, age of dam (maiden or mature), sex and birth status and all two-way interactions using least squares procedures as described by Harvey (1988). Age of dam proved to be significant ($P<0.05$) for CFW but not for BW and MFD and was therefore excluded from the model describing the latter two traits. A highly significant ($P<0.001$) interaction was found between year-season and sex for all three traits and they were subsequently fitted as combined effects.

The model eventually fitted is as follows:

$$\mathbf{y} = X\mathbf{b} + Z_1\mathbf{a} + Z_2\mathbf{m} + \mathbf{e}$$

where **y** is a vector of animal records on BW, CFW and MFD respectively, **b** is a vector of fixed effects consisting of year-season-sex, birth status and age of dam (for CFW), a is a random vector of direct additive genetic effects of animals, **m** is a random vector of maternal additive genetic effects, X, Z_1 and Z_2 are design matrices and **e** is a random vector of residuals.

Estimates were obtained by a derivative-free restricted maximum likelihood algorithm using the programme of Meyer(1989,1991).

Genetic trends were calculated as the regression of mean annual predicted breeding values on year of birth. Two separate linear regressions were fitted viz. from 1966 to 1984 and from 1985 to 1991 to describe the two different selection procedures.

RESULTS AND DISCUSSION

The least squares means ($\bar{X}$), standard deviations (SD), estimates of variance components and heritabilities for direct additive and maternal additive components for the three traits are given in Table 1.

Table 1 Least squares means ($\bar{X}$), standard deviations (SD), variances, heritabilities (h) and standard errors (SE) for direct additive (a) and maternal additive (m) components for BW, CFW and MFD

Parameter	Traits		
	BW	CFW	MFD
$\bar{X}$(kg)	50.39	5.41	23.19
SD	15.73	1.84	2.27
σ^2_a	11.970	0.190	1.879
σ^2_m	0.405	0.018	0.037
σ_{am}	1.255	-0.021	-0.071
σ^2_e	17.748	0.469	1.155
σ^2_p	31.378	0.657	3.000
h^2_a	0.381	0.289	0.626
SE	0.043	0.002	0.021
h^2_m	0.013	0.027	0.012
SE	0.009	0.000	0.015
σ_{am}/σ^2_p	0.040	-0.031	-0.024
SE	0.016	0.001	0.000
r_{Gam}	0.570	-0.352	-0.267

The estimates of maternal additive variances and resulting heritabilities (h^2_m) are very low. This is contrary to the results obtained for staple length, greasy fleece weight and body weight by Trippler (1991) for mutton merino yearlings. However, Woolaston (1993 - personal communication) and Johnson (1993 - personal communication) report similar findings to this study for fine wool Merinos and Romneys, respectively. The present conception seems to be that managerial procedures (shearing) prior to and age at measurement determine the importance of the maternal component. Van Wyk *et al.* (1993) also found that the maternal component decreases in importance with increasing age for growth traits in Dormer sheep.

The genetic trends obtained for the two periods are presented graphically in Figure 1. Prior to 1985, a small positive genetic trend ($P < 0.01$) is observed for all three traits. These results show that, although limited, some genetic progress is possible in measured production traits by indirect selection for visually assessed traits. During this period no attempt was made to reduce fibre diameter (or visually assessed fineness), in fact, preference was normally given to broader

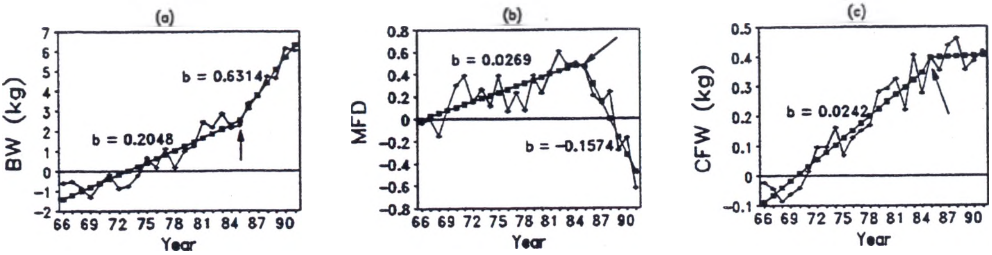

Figure 1 Mean annual genetic values and trends for (a) body weight (BW), (b) mean fibre diameter (MFD) and (c) clean fleece weight (CFW)

crimped wools due to the assumption or belief that it would increase wool production as was generally accepted by stud breeders.

Since 1985 the positive genetic trend for body weight increased more than threefold. The positive trend in MFD was transformed into a highly significant ($P < 0.001$) negative trend. The trend for CFW changed to zero. This was achieved without sacrificing standards in visual appearance.

It is concluded that the additive maternal component of variance can be ignored and that selection on BLUP of breeding values for these traits can improve the response to selection even under the present restrictions of a high culling rate on visual appearance presently applied in the South African stud industry.

ACKNOWLEDGEMENTS

The authors thank the Director and staff, Grootfontein Agricultural Development Institute and the National Woolled Sheep Performance and Progeny Testing Scheme for kind permission to use the data.

REFERENCES

ERASMUS, G.J., DE LANGE, A.O., DELPORT, G.J. & OLIVIER, J.J. (1990) *S.Afr. J. Anim. Sci.* 20,31

ERASMUS, G.J. (1977) MSc-treatise. Univ. OFS., Bloemfontein.

HARVEY, W.R. (1988) User's guide for LSMLMW (PC-1 version). Ohio State Univ., Ohio, USA

MEYER, K. (1989) *Genet. Sel. Evol.* 21,317

MEYER, K. (1991) *Genet. Sel. Evol.* 23,67

TRIPPLER, A. (1991) *Proc. 42nd Annual Meeting of the EAAP.* 8-12 September 1991, Berlin

VAN WYK, J.B., ERASMUS, G.J. & KONSTANTINOV, K.V. (1993) *S. Afr. J. Anim. Sci.* 23,72