Direct and maternal variance component estimates for clean fleece weight, body weight and mean fibre diameter in the Grootfontein Merino stud

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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 heritability estimates of 0.013 for BW, 0.027 for CFW and 0.012 for MFD. The estimated covariances between direct additive and maternal additive effects (σ_{am})were positive for BW and negative for CFW and MFD. The proportion of σ_{am} to the phenotypic variance was 4.0%, –3.1% and –2.4% for BW, CFW and MFD, respectively. It is concluded that the maternal component can be ignored due to its relative small effect on these traits.

Direkte en maternale variansie-komponente en oorerflikhede is deur DFREML-prosedures beraam vir skoonvaggewig (SVG), liggaamsgewig (LG) en gemiddelde veseldikte (GVD) in die Grootfonteinse Merinostoet. Direkte oorerflikhede is beraam as 0.381, 0.289 en 0.626 vir LG, SVG en GVD, respektiewelik. Die beramings van maternale additiewe variansie was laag met gevolglike oorerflikheidsberamings van 0.013 vir LG, 0.027 vir SVG en 0.012 vir GVD. Die beraamde kovariansies tussen direkte additiewe en maternale additiewe effekte (σ_{am}) was positief vir LG en negatief vir SVG en GVD. Die bydrae van σ_{am} tot die fenotipiese variansie was 4.0%, –3.1% en –2.4% vir LG, SVG en GVD, respektiewelik. Daar word tot die gevolgtrekking gekom dat die maternale komponent weens die relatiewe klein effek op hierdie eienskappe, geïgnoreer kan word.

Keywords: Merino sheep, maternal variance, variance components.

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Introduction

The estimation of genetic and environmental components of variance and their ratios forms an integral part of animal breeding research. Knowledge of these parameters is essential in the genetic improvement of livestock.

Estimates of direct additive genetic variance components and resulting heritabilities for Merino sheep, especially for fleece traits and mature body weight, abound 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.

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 genetic studies.

Clean fleece weight and body weight, at about 18 months of age, are generally regarded as the best measures of wool and mutton production and are generally recommended as selection criteria for the breed. Mean fibre diameter is by far the most important trait affecting the processing performance (Hunter, 1980) and price (Erasmus & Delport, 1987) of wool. The aim of this study was to estimate direct and maternal additive variance components and associated parameters for these traits in the Grootfontein Merino stud. The estimation of the relative importance of the maternal component was of particular interest, since this information is lacking for important traits of Merino sheep in South Africa and elsewhere. The maternal component is important since it can cloud the expected improvement from direct selection as was recently illustrated by Van Wyk *et al.* (1993). Since wool follicle development starts before birth, fleece traits could be maternally influenced.

Material and Methods

Data

Data from the Grootfontein Merino stud were available from 1966 to 1990. All lambs still alive were first shorn at five to six months of age. The rams remaining after preliminary culling were again shorn at 12 – 14 months of age and the ewes at 16 – 18 months of age. The measurements used in this study were recorded at this second shearing. A detailed description of the management of the stud, replacement and selection procedures, is given by Olivier (1989). After editing, the data set consisted of at 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:

Body weight (BW) – taken immediately after shearing

Clean fleece weight (CFW) – Greasy fleece weight was first adjusted to an exact 365-days wool growth by multiplying with the appropriate constant. Clean yield percentage was determined on a mid-rib fleece sample by normal scouring procedures and expressed on a 16% moisture regain basis. Clean fleece weight was determined by multiplying this percentage by the adjusted greasy fleece weight.

Mean fibre diameter (MFD) – determined on the fleece sample by the air-flow procedure using a WIRA fineness meter.

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 in the model describing the latter two traits. All other effects were highly significant ($P < 0.001$) for all three 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 was as follows:

$$y = \mathrm{X}\boldsymbol{b} + \mathrm{Z}_1\boldsymbol{a} + \mathrm{Z}_2\boldsymbol{m} + \boldsymbol{e}$$

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

It was assumed that:

$$\mathrm{Var}(\boldsymbol{a}) = \mathrm{Z}_1\mathrm{AZ}_1'\sigma_a^2, \quad \mathrm{Var}(\boldsymbol{m}) = \mathrm{Z}_2\mathrm{AZ}_2'\sigma_m^2,$$
$$\mathrm{Cov}(\boldsymbol{a},\boldsymbol{m}) = \mathrm{Z}_1\mathrm{AZ}_2'\sigma_{am} \text{ and } \mathrm{Var}(\boldsymbol{e}) = \mathrm{I}\sigma_e^2 \text{ with}$$
$$\mathrm{Var}(y) = \mathrm{Z}_1\mathrm{AZ}_1'\sigma_a^2 + \mathrm{Z}_2\mathrm{AZ}_2'\sigma_m^2 + \mathrm{Z}_1\mathrm{AZ}_2'\sigma_{am} + \mathrm{I}\sigma_e^2,$$

where σ_{am} is the covariance between direct additive and maternal additive effects, σ_a^2, σ_m^2 and σ_e^2 are the direct additive, maternal additive and error variance, respectively, A is the numerator relationship matrix with inbreeding included and I is an identity matrix.

Estimates were obtained by a derivative-free restricted maximum likelihood algorithm using the programme of Meyer (1989: 1991). The variance of the function values was used as the convergence criterion. Analyses were carried out using the simplex method suggested by Meyer (1989).

Results and Discussion

The means ($\overline{X}$), standard deviations (*SD*) and coefficients of variation (*CV*) are supplied in Table 1.

The mean values for Merino studs tested at the SA Fleece Testing Centre from 1979 to 1988 are roughly as follows (Delport *et al.*, 1990):

Table 1 Means ($\overline{X}$), standard deviations (*SD*) and coefficients of variation (*CV*%) for BW, CFW and MFD

Trait	$\overline{X}$	*SD*	*CV*%
BW (kg)	50.39	15.73	31.22
CFW (kg)	5.41	1.84	34.01
MFD (μm)	23.19	2.27	9.79

Table 2 Estimates of variance components and heritabilities for direct additive (***a***) and maternal additive (***m***) components for BW, CFW and MFD

	Traits		
Parameter	BW	CFW	MFD
σ_a^2	11.970	0.190	1.879
σ_m^2	0.405	0.018	0.037
σ_{am}	1.255	−0.021	−0.071
σ_e^2	17.748	0.469	1.155
σ_p^2	31.378	0.657	3.000
h_a^2	0.381	0.289	0.626
SE	0.043	0.002	0.021
h_m^2	0.013	0.027	0.012
SE	0.009	0.000	0.015
σ_{am}/σ_p^2	0.040	−0.031	−0.024
SE	0.016	0.001	0.000
r_{Gam}	0.570	−0.352	−0.267

Body weight = 48 kg, CFW = 4.25 kg and MFD = 21 μm.

The Grootfontein stud is therefore slightly above average for all three traits.

The large *CV*'s for BW and CFW are most probably largely due to fluctuating levels of nutrition under different managers.

The estimates of variance components and heritabilities for direct additive and maternal additive components for the three traits are given in Table 2.

The estimates of maternal additive variances and resulting heritabilities (h_m^2) 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 — pers. comm.) and Johnson (1993 — pers. comm.) 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 the age of 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 estimates of the genetic correlations between direct and maternal effects were positive for BW and negative for CFW and MFD. No straightforward explanation exists for this apparent descrepancy which is by no means unique to sheep, these traits or this study. The estimates of the direct additive variances and heritabilities are well within the range of published estimates (Erasmus *et al.*, 1990) and indicate that selection should be effective. The proportion of σ_{am} to the phenotypic variance was only 4.0%, −3.1% and −2.4% for BW, CFW and MFD, respectively.

Conclusions

The results obtained suggest that maternal components can be ignored in selection and genetic studies involving these traits.

The high direct heritability estimates obtained to date for traits considered of importance in Merino sheep have led to the almost general recommendation in the past that selection, in practice, be based on own phenotype alone. Most, but not all of the estimates of genetic correlation supported these recommendations in the sense that no serious detrimental correlated responses to selection would be expected. Also, none of the traits considered are sex limited. Therefore, progeny testing and the keeping of pedigree records were *inter alia* largely viewed as superfluous.

The results of this study seem to support these recommendations, since the maternal additive component of variance was also found to be almost negligible for the traits studied, stressing the importance of the direct additive variance which can be directly utilized for selection improvement.

The recording of parentage has, however, become essential, not only for Best Linear Unbiased Prediction (BLUP) of breeding values, but also to help clarify certain important and yet unresolved questions in the industry. The differences and size of estimates of genetic correlations between direct and maternal effects obtained in this study testify to this.

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