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 4.07%, -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.

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
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:

\[
y = Xb + Z_a a + Z_m m + e
\]

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, \(X\), \(Z_a\) and \(Z_m\) are design matrices and \(e\) is a random vector of residuals.

It was assumed that:

\[
\begin{align*}
\operatorname{Var}(a) & = Z_a Z_a' \sigma_a^2, \\
\operatorname{Var}(m) & = Z_m Z_m' \sigma_m^2, \\
\operatorname{Cov}(a,m) & = Z_a Z_m' \sigma_{am}, \\
\operatorname{Var}(e) & = I \sigma_e^2, \\
\operatorname{Var}(y) & = Z_a Z_a' \sigma_a^2 + Z_m Z_m' \sigma_m^2 + Z_i Z_i' \sigma_{am} + I \sigma_e^2,
\end{align*}
\]

where \(\sigma_{am}\) is the covariance between direct additive and maternal additive effects, \(\sigma_a^2\), \(\sigma_m^2\) and \(\sigma_{am}\) 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 \((\bar{X})\), standard deviations \((SD)\) and coefficients of variation \((CV\%)\) for BW, CFW and MFD 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 (Delpot et al., 1990):

<table>
<thead>
<tr>
<th>Trait</th>
<th>(\bar{X})</th>
<th>SD</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td>50.39</td>
<td>15.73</td>
<td>31.22</td>
</tr>
<tr>
<td>CFW (kg)</td>
<td>5.41</td>
<td>1.84</td>
<td>34.01</td>
</tr>
<tr>
<td>MFD ((\mu m))</td>
<td>23.19</td>
<td>2.27</td>
<td>9.79</td>
</tr>
</tbody>
</table>

Body weight = 48 kg, CFW = 4.25 kg and MFD = 21 \(\mu m\).

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 the genetic correlations between direct additive and maternal additive genetic effects for the three traits are given in Table 2.

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

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 selec-
tion would be expected. Also, none of the traits considered are
sex limited. Therefore, progeny testing and the keeping of pedi-
gree records were *inter alia* largely viewed as superfluous.

The results of this study seem to support these recommenda-
tions, 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 unre-
solved 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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