GENETIC AND PHENOTYPIC RELATIONSHIPS OF REPRODUCTION WITH LIVE WEIGHT AND WOOL TRAITS IN A MEDITERRANEAN ENVIRONMENT

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SUMMARY
An additive genetic variance ratio (h\textsuperscript{2}) for total weight of lamb weaned per breeding ewe over three reproduction opportunities (TWW3) was estimated in a medium wool resource flock. TWW3 was highly variable, with a coefficient of variation of 50\%. The between bloodline variance ratio for TWW3 was significant (\(P < 0.05\)), but failed to exceed 5\% of the across bloodline phenotypic variation. Within bloodline h\textsuperscript{2} (± s.e.) was estimated at 0.154 ± 0.040 for TWW3. Within bloodline genetic correlations of TWW3 amounted to respectively 0.58 ± 0.11, 0.26 ± 0.11, -0.24 ± 0.11 and 0.17 ± 0.10 with hogget live weight, clean fleece weight, clean fleece weight/kg live weight and fibre diameter. It was concluded that TWW3 would respond to selection in Western Australian Merinos. Genetic correlations with hogget live weight and fleece weight were favourable.

Keywords: Lamb output, fleece weight, fibre diameter.

INTRODUCTION
In sheep production systems, an increase in the efficiency of production per animal can be achieved by a combination of an enhanced net reproduction rate, a shorter production cycle and optimum fibre production (Olivier 1999). Net reproduction is defined as total weight of lamb weaned per breeding ewe (TWW). This trait depends on the number (quantity) of lambs weaned, as well as the weight of the lamb(s), which reflects quality of the product. It has so far not been considered as part of the breeding objective in Australian woolled sheep breeding programs. Most of the available heritability estimates for TWW that were noted in the comprehensive review of Fogarty (1995), were derived from outdated paternal halfsib or parent offspring regression methods. The only Australian study where an animal model was employed for the analysis of data for TWW, involved a terminal dam line (Fogarty \textit{et al}. 1994). Genetic correlations of TWW with other traits are also scarce in the literature. Information on these (co)variances are prerequisites for making informed decisions with regard to selection strategies. This study reports a heritability estimate for TWW over three lambing opportunities (TWW3) in a Merino resource flock. Estimates of genetic correlations with hogget live weight and wool traits are also presented.

MATERIAL AND METHODS
The animals belonged to a resource flock that was based at Katanning in Western Australia. A total of four strains – comprising 16 studs or bloodlines – were represented. Roughly 80 ewes and four rams represented each bloodline within years. New rams were acquired from within bloodlines annually, to keep the base flock representative of the genetic material available in the broader industry. One ram of each bloodline was retained for mating in each following year, to provide links.
between years. Maiden replacements were selected at random from the available candidates (Lewer 1993). The bloodlines were maintained in a single flock, except for mating during November-October and lambing during March-April, when they were maintained in sire groups on small paddocks. These groups were pooled to form larger flocks as soon as possible after birth. All flocks mostly utilised dryland grass-clover paddocks. Cereal stubble and fodder crops were seasonally available. Annual reproduction data included in the study were recorded over a 12-year period from 1982 to 1993 on 2718 ewes born over a 10-year period from 1980 to 1989. Lambs were identified with their dams within 12 hr of birth. Individual weaning weights (in kg) and ages were known for lambs. Individual lamb weaning weights were corrected for weaning age, sex and year of birth prior to the computation of TWW of a ewe over three lambing opportunities (at 2, 3 and 4 years of age – TWW3). Other data included records of hogget live weight, clean fleece weight and fibre diameter for ewes born between 1982 and 1989. Hogget clean fleece weight was also expressed as percentage of hogget live weight where both traits were recorded. This parameter is considered useful for the determination of the potential of animals for fibre production (Herselman et al. (1998). Ewes with reproduction data as well as hogget data ranged from 1856 in the case of clean fleece weight as a percentage of hogget live weight to 1956 for hogget live weight.

The ASREML program (Gilmore et al., 1999) were used to estimate variance components for TWW3 in an uni-variate analysis. TWW3 data only allowed the fitting of models that included direct additive genetic effects. Modeling for hogget live weight and wool traits were derived from earlier analyses by Cloete et al. (2001). These variance ratios are not given, as they generally corresponded with available literature. A variance ratio was computed for bloodline, as expressed relative to the total phenotypic variation. The ratio reported for the direct additive genetic variance, on the other hand, represented a within bloodline heritability estimate. Bi-variate analyses were conducted subsequently, fitting relevant effects for the traits in question, to obtain genetic and phenotypic correlations.

RESULTS

TWW3 was highly variable, as reflected by the mean (± s.d.) of 52.1 ± 26.1 kg (individual ewes ranging from 0 kg to 131.5 kg lamb weaned over three opportunities) resulting in a coefficient of variation of 50%. The between bloodline variance ratio accounted for a small but significant (\(P < 0.05\)) portion (± s.e.) of the overall phenotypic variation in TWW3 (0.05 ± 0.02). The heritability of TWW3 was 0.15 ± 0.04. Genetic correlations of TWW3 with hogget body weight and clean fleece weight were significant (\(P < 0.05\) – more than twice its standard error) and positive (Table 1). When related to the weight of clean wool produced per unit body weight, the genetic correlation was negative (\(P < 0.05\)). The genetic correlation of TWW3 with fibre diameter was positive in sign, but smaller than twice its standard error. Of the phenotypic correlations, only TWW3 with hogget body weight exceeded 0.1. Phenotypic correlations with clean fleece weight and fibre diameter were all lower than 0.1. All phenotypic correlations were positive in sign, barring that for clean fleece weight/kg live weight.
Table 1. Within bloodline genetic and phenotypic correlations of hogget wool and live weight traits with TWW3 in the Katanning base flock

<table>
<thead>
<tr>
<th>Traits included</th>
<th>Genetic correlation (rg)</th>
<th>Phenotypic correlation (rp)</th>
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</thead>
<tbody>
<tr>
<td>TWW3 (kg) with:</td>
<td></td>
<td></td>
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<tr>
<td>Live weight (kg)</td>
<td>0.58 ± 0.11</td>
<td>0.18 ± 0.02</td>
</tr>
<tr>
<td>Clean fleece weight (kg)</td>
<td>0.26 ± 0.11</td>
<td>0.08 ± 0.02</td>
</tr>
<tr>
<td>Clean fleece weight/kg live weight (%)</td>
<td>-0.24 ± 0.11</td>
<td>-0.07 ± 0.03</td>
</tr>
<tr>
<td>Fibre diameter (µm)</td>
<td>0.17 ± 0.10</td>
<td>0.05 ± 0.03</td>
</tr>
</tbody>
</table>

DISCUSSION

In the review of Fogarty (1995), an average coefficient of variation of 43% are given for TWW over > 1 production year. Snyman et al. (1998b) correspondingly found coefficients of variation that ranged from 39 to 58% for TWW3 in three South African Merino flocks. An Afrino flock with a higher reproduction had a lower coefficient of variation; namely 28% (Snyman et al. 1997).

The heritability of TWW3 was estimated at 0.15. This estimate accords with the literature average of 0.13 derived by Fogarty (1995) for TWW in woolled breeds. It is also in agreement with comparable estimates of 0.13 to 0.22 reported by Snyman et al. (1997; 1998b) for three South African Merino flocks. In other breeds, Fogarty et al. (1994) reported an estimate of 0.13 in a Hyfer flock. Snyman et al. (1997) estimated the heritability of TWW3 at 0.17 in a South African Afrino flock. A very similar estimate of 0.16 was published for TWW in Chios dairy sheep in Greece (Ligda et al. 2000), in a totally different production system. Heritability estimates for TWW thus appear to be fairly robust. It is also noteworthy that TWW responded to selection in 4 breeds (Ercanbrack and Knight 1998). The average response in all breeds amounted to 1.9% per year. Two Merino lines that were divergently selected for the ability to rear multiples were also found to differ markedly in TWW (Cloete and Scholtz 1998).

The genetic correlation between hogget live weight and TWW3 was positive and relatively high (Table 1). Corresponding correlations in the literature were higher still, ranging from 0.67 to 0.80 in three South Africa Merino flocks (Snyman et al. 1998b), and 0.89 in an Afrino flock (Snyman et al. 1998a). Our estimate is in close agreement with that of 0.51 reported by Fogarty et al. (1994) in Hyfer sheep. It has also been demonstrated that indirect selection for TWW, using live weight as the criterion, was 67% as effective as direct selection (Ercanbrack and Knight 1998). The phenotypic correlation of TWW3 with hogget live weight was 0.18 (Table 1). Corresponding literature estimates ranged between 0.15 and 0.32 (Fogarty et al. 1994; Snyman et al. 1998a, 1999b). TWW3 was genetically positively related to clean fleece weight. Literature estimates show greater variation in this case. Snyman et al. (1998b) reported genetic correlations ranging from 0.06 to 0.41 in three South African Merino flocks. A high negative correlation of −0.52 were found in an Afrino flock (Snyman et al. 1998a). In the case of clean wool production per kg of live weight, a negative genetic correlation was obtained. Herselman et al. (1998) reported that fitness may be compromised in animals with a high potential for fibre production, although this observation was made at a phenotypic level. The genetic correlation of fibre diameter with TWW3 was positive in this study, albeit not significantly (P < 0.05) different from zero. Our estimate closely corresponded with those
of Snyman et al. (1998b), ranging from 0.18 to 0.26. Phenotypic correlations of TWW3 with fleece traits were below 0.1 in all instances. Low phenotypic correlations of wool traits with reproduction were correspondingly presented in the review of Fogarty (1995).

CONCLUSIONS
Between bloodline differences for TWW3 were small, suggesting that the scope for Western Australian Merino farmers to enhance the average net reproduction of their flocks by switching bloodlines is limited. Coefficients of variation and heritability estimates for TWW3 in this study accorded with those cited from the literature. TWW was demonstrated to respond to selection (Ercanbrack and Knight 1998) in an American study. If required, genetic progress in TWW should also be achievable in Western Australian Merinos. Genetic correlations with hogget live weight and wool traits were generally favourable, except for a positive correlation of fibre diameter with TWW3 (that did not reach significance), and a negative correlation with clean fleece weight/kg live weight.

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REFERENCES