THE IMPACT OF PHENOTYPIC SELECTION FOR CLEAN FLEECE WEIGHT ON REPRODUCTION

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SUMMARY
A retrospective analysis of the reproductive performance of the medium wool strain from the Trangie QPLUS project has found that within flock phenotypic selection of hoggets for bodyweight will lead to large improvements in reproductive performance. Selection for fibre diameter is independent of reproduction while selection for CFW will lead to fewer progeny surviving to weaning. Precision management strategies for high CFW breeding ewes particularly those carrying twins in times of poor feed supply may overcome the detrimental impact of phenotypic selection for high CFW.

INTRODUCTION
The Merino breed is arguably the key to the future prosperity of the Australian sheep industry – the majority of the Australian wool clip is grown by Merinos and the breed is an important source of maternal genetics for the meat production. Genetic and phenotypic selection for increased fleece weight and improved wool quality has been a feature of Merino improvement since the breed was first introduced into Australia. In the last decade drought and low wool prices have resulted in a decline in Merino sheep numbers, which has increased pressure on the Merino to fulfil the role of a dual purpose meat and wool animal (Richards and Atkins 2004). However, recent research has suggested that ‘fitness’ or the capacity to successfully reproduce may be compromised in animals with a high potential for fibre production (Adams et al. 2006; Cloete et al. 2002a; 2002b; Greeff 2005; Herselman et al. 1998). A recent review of genetic parameter estimates found that the weighted mean genetic correlations between fleece weight and the various reproduction traits were small and negative, except for weight of lamb weaned per ewe joined (0.16) (Safari et al. 2005). All of the phenotypic correlations reported were close to 0. Establishing which component trait of Merino reproduction is most sensitive to selection for increased clean fleece weight (CFW) is the first step in developing potential genetic or management solutions to ensure continued improvement of the Merino breed into the future. This paper reports results from a retrospective analysis of the QPLUS database that investigated the impact of phenotypic selection based on hogget clean fleece weight, fibre diameter (FD) and bodyweight (BW) on the components of reproduction.

MATERIALS AND METHODS
The reproductive performance of 3,500 ewes from the medium wool strain of the Trangie QPLUS flock (Taylor and Atkins 1997) first mated as hoggets at approximately 15 months of age between 1994 and 2003 formed the basis of this analysis. Ewes were born between 1993 and 2002 and were selected to remain in the breeding flock on the basis of their index rank for each of the five selection lines (industry, 3%, 8% and 15% micron premiums and a randomly selected control) within the Haddon Rig medium wool strain. Individual ewes remained in the breeding flock for at least two but up to seven consecutive joinings. No deliberate selection was based on reproduction, dry ewes (even
repeats) were retained in the flock as dictated by their CFW and FD. Joining occurred in mid-January of each year for a period of five weeks. Pregnancy scanning for foetal number using real-time ultrasound occurred in early April. At lambing in mid June individual ewes were identified as well as the identity of any lamb(s). Each lamb was ear tagged, weighed and identified for sex within 24 hours of birth. Survival of progeny was recorded at weaning in mid September, prior to the ewe shearing.

For this analysis the hogget clean fleece weight (CFW), fibre diameter (FD) and subsequent unfasted off-shears bodyweight (BW) of each ewe within a drop was used to allocate her to one of eight phenotypic groups representing those sheep classified as high for each of the three traits (HHH) to those classified as low (LLL) and the six combinations in between (HHL, HLH, HHH, LHH, LHL and LLH). Each ewe was allocated to one of the eight groups using an equal weights index of their standardised deviation with a revolving pattern of allocation; this ensured that the best available ewe was allocated to each group. The impact of CFW, FD or BW on each of the reproduction traits (Table 1) was determined by coding each animal as either H (High) or L (Low) for CFW, FD and BW and then fitting these codes in a model that included other fixed effects of year mated and age as well as the random effect of dam using ASREML (Gilmour et al. 2002). Although reproduction and survival are categorical traits, their distribution within this dataset was approximately symmetrical; hence they were analyses as normal continuous traits. The phenotypic ($\sigma^2_p$), within ($\sigma^2_e$) and between ($\sigma^2_b$) animal variances were used to calculate the repeatability $r = (\sigma^2_b / \sigma^2_p)$ of each reproduction trait. The significance and relative magnitude of the CFW, FD and BW deviations provide a clear indication as to which had the greatest impact on each of the components of reproduction.

RESULTS AND DISCUSSION

The repeatabilities for each component of reproduction in this study ranged between 0.10 for litter size to 0.15 for lambs weaned and survival to weaning (Table 1) which are within the range of those reported previously for reproduction traits (Fogarty 1995).

Table 1. Summary of variance partitioning, repeatability ($r$) average performance ($\bar{x}$) and CFW, FD and BW deviations from the average for each component of reproduction.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Variance partitioning</th>
<th>Deviations/100 ewes$\wedge$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sigma^2_p$</td>
<td>$\sigma^2_e$</td>
</tr>
<tr>
<td>Lambs scanned</td>
<td>0.40</td>
<td>0.36</td>
</tr>
<tr>
<td>Prop ewes lambing</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>Litter size</td>
<td>0.26</td>
<td>0.24</td>
</tr>
<tr>
<td>Lambs born</td>
<td>0.49</td>
<td>0.43</td>
</tr>
<tr>
<td>Lambs weaned</td>
<td>0.49</td>
<td>0.41</td>
</tr>
<tr>
<td>Survival to weaning</td>
<td>0.48</td>
<td>0.41</td>
</tr>
</tbody>
</table>

$\wedge$ Lambs scanned, lambs born and lambs weaned are per ewe joined; litter size is per ewe lambing and survival to weaning is per lambs born. $\wedge$ These numbers represent the deviation between the high and low animal within each of the CFW, FD and BWT phenotypes - a negative deviation indicates that the high phenotype is greater than the low for the trait in question. ns = not significant, * P<0.05, ** P<0.01 and *** P<0.001.

Not surprisingly, BW had a significant impact on all of the component reproduction traits. Ewes that were phenotypically heavier as hoggets consistently scanned nearly 11 more lambs in utero per 100 ewes, had 2.3% more ewes lambing, greater litter sizes, 12 % more lambs born, 11% more weaners and 2.8 % higher survival to weaning than those ewes with lighter hogget BW (Table 1).
Lambs born to high BW ewes were heavier at both birth (+0.12 kg) and weaning (+0.91 kg) than those born to lighter ewes (P<0.001). Clearly within flock phenotypic selection for BW at hogget age will lead to significant improvement in the reproductive performance of the flock. FD had no significant impact on any of the reproduction traits indicating that within a flock phenotypic selection for finer animals will have no impact on the reproduction of the flock.

CFW had no impact on the ability of a ewe to conceive, the proportion of ewes lambing, litter size or the number of lambs born. CFW did have a significant impact on the number of lambs weaned (P<0.05) and survival of the progeny to weaning (P<0.001) with the influence of CFW on survival to weaning being greater than that of BW. Despite no significant difference in either birth of weaning weight deviations (0.02 and 0.09 kg respectively) of progeny born to high or low CFW ewes, progeny of high CFW ewes are 4% less likely to survive to weaning than progeny of low CFW ewes. A similar impact of high CFW on progeny survival was identified by Refshauge et al. (2006a) who found that despite no significant difference in birth weight of lambs born to these ewes, there was evidence that the high CFW phenotype weaned fewer lambs per ewe joined.

The relative impact of CFW on progeny survival to weaning was reasonably persistent over the 10 years in which mating occurred (Figure 1) despite a significant interaction between FW and year mated (P=0.039). With the exception of three years, 1994, 1995 and 2002, during which there was no difference in survival to weaning between high and low CFW ewes, the progeny of high CFW ewes had consistently lower survival rates than the progeny of low CFW ewes with the difference ranging from effectively 0 in 2002 to nearly 11 % during 1997.

The consistency of the poor survival of high CFW progeny to weaning across years indicates that these phenotypic effects may be overcome by precision management of the breeding ewe flock. Recent intensive animal house studies have indicated that energy metabolism is adversely affected by selection for wool growth in that high CFW sheep tend to have a lower metabolic energy status and body fatness than low CFW sheep and an apparent greater feed intake not fully accounted for by their relatively lean mass (Adams et al. 2006). This implies that high CFW sheep may require more supplementation when feed supply is limiting. Preliminary analysis of data from a field study found
that ewe fat score was affected negatively among sheep selected for high CFW when feed intake was restricted by higher stocking rates (Refshauge et al. 2006b) has confirmed this implication. The critical period of the breeding cycle for high CFW ewes appears to be lactation. The management protocol for the QPLUS project required the sheep within the experiment to be maintained in forward store condition (fat score 3-4) (Taylor and Atkins 1997), even at this level of nutrition, the high CFW ewes were less able than low CFW ewes to successfully rear their progeny to weaning. Dove et al. (1994) found that milk production was influenced by the level of body reserves in the ewe at parturition with corresponding negative impacts on liveweight and body composition of their lambs. While ewes are able to mobilise their body reserves, primarily carcase and internal fat deposits, during pregnancy and early lactation (Lambe et al. 2004) it is likely that high CFW ewes who tend to have lower fat reserves simply can not supply enough energy to support lactation – this is likely to be further exacerbated when feed supply is limiting and high CFW ewes are carrying twins.

CONCLUSIONS
Selecting hogget ewes on the basis of BW alone will improve the reproduction of these ewes in their own lifetime. Selection for FD will have no impact on reproduction. This study has shown that phenotypic selection for increased CFW in these ewes may reduce the survival of their progeny to weaning. Precision management strategies are required for high CFW ewes to improve the survival of their progeny to weaning, particularly for high CFW carrying twins in times of reduced feed supply. Further work is required to identify the critical level of CFW over which precision management interventions are required and assess their applicability in a range of production systems.

ACKNOWLEDGEMENTS
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REFERENCES