IMPLICATIONS OF SELECTION FOR MEAT AND WOOL TRAITS ON MATERNAL PERFORMANCE IN MERINOS

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SUMMARY
The impact of selection for meat and wool on maternal performance was examined in a large stud Merino flock in southwest Western Australia. Australian Sheep Breeding Values for all important production traits and full lambing records were available for the six years studied. Analyses were completed to determine if any of the production traits were correlated with ewe fecundity, lamb birthweight and lamb survival. The effects of Birth Type, Year, Dam Age and Sire were also included in the analyses. Ewe fecundity was positively correlated with ewe body weight and muscling. Lamb birthweight was negatively correlated with ewe muscling and fleece weight. In single-born lambs, survival decreased as ewe fleece weight increased, independently of lamb birthweight. This correlation was not evident in twin-born lambs. The correlations identified in this paper are important for the Australian sheep industry and breeders should consider the impact of the selection for wool and meat traits on maternal performance when designing their breeding programs.

INTRODUCTION
The Australian Merino has been developed as an efficient wool producer over the last two centuries. While decades of research and selection has been aimed at improving performance for wool traits and more recently meat traits, relatively little attention has been given to the implications of these strategies on maternal performance. In both pure Merino production systems and systems where the Merino is used as the maternal component for first-cross lamb production ewe maternal traits contribute significantly to enterprise profit. Maternal performance encompasses a range of fitness-related traits including: fertility, fecundity, milk production and lamb survival and growth.

Australian sheep producers are fortunate to have at their disposal the world’s best performance recording system for sheep provided by Sheep Genetics Australia. This system can deliver rapid genetic gain in production traits in breeders’ flocks. However, this gain needs to be achieved in a way that ensures fitness is not adversely affected, as selection for high performance has resulted in reduced fitness across a range of species (Rauw et al. 1998). These reductions in fitness can affect enterprise profitability especially in production systems where animal nutritional needs are not always met. It is important to understand any correlations that exist between production traits and maternal performance. This paper tests the hypothesis that selection for fleece weight, muscling and growth will have correlated effects on ewe fecundity, lamb birthweight and lamb survival.

MATERIALS & METHODS
This work utilised information collected by Merinotech (WA) Pty. Ltd. from their stud flock based at “Yarrak” near Kojonup in South-West Western Australia. Full pedigree and Australian Sheep
Breeding Values (ASBVs; generated on the 7th Nov 2006) were available for a range of traits of interest across six production years. Ewes included in the analysis were aged between 2 and 9 years. Lamb birthweight (BWT) was available from the 2002 to 2005 drops with a total of 2415 records analysed. A linear mixed model approach was used to analyse BWT. Fixed effects included in the model were Dam Age, Year, Sire, Birth Type (BT; single or multiple) and Sex. Dam ID was modelled as a random effect. Six dam traits (ASBVs) at hogget age were also modelled as covariates including: Eye Muscle Depth (HEMD), C-site Fat Depth (HFAT), Weight (HWT), Clean Fleece Weight (HCFW), Fibre Diameter (HFD) and Coefficient of Variation of Fibre Diameter (HCVFD). The ranges of ASBVs in the data set used were HWT (-5.2 to 12.6kg), HEMD (-1.9 to 3.6mm), HFAT (-1.9 to 2.2mm), HFD (-1.9 to 2.3μm), HCFW (-9.3 to 32.5%) and HCVFD (-4.2 to 3.6%).

The analyses of ewe fecundity and lamb survival were completed on 2368 and 3408 records from the 2000 to 2005 drops. Ewe fecundity or the probability of a pregnant ewe giving birth to multiple lambs was analysed using a Generalised Linear Regression model, using a binomial variate structure. The variate was determined as pregnant ewes that either did or did not give birth to multiple lambs. Dam Age and Year were included in the model as fixed effects. Covariates included were: HEMD, HFAT, HWT, HCFW, HFD and HCVFD. The same approach was used to analyse lamb survival data with the variate being determined as lambs that were either alive or not at weaning. Sire, BT and Sex included as fixed effects and Dam ID as a random effect in the original model. The analysis was completed with and without birthweight included in the model as a covariate. All analyses were completed using Genstat 8.1 (Genstat 2005), second and third order interactions were included in the original models and the final models were determined by stepwise removal of non-significant terms.

RESULTS AND DISCUSSION

The factors addressed in this analysis of maternal performance were fecundity, lamb birthweight and lamb survival.

Ewe Fecundity. Within the data set, the probability of ewes that lambed having multiple lambs was tested against a range of fixed effects.

**Figure 1. Predicted response (+se) in proportion of multiple births to HEMD ASBV.**

**Figure 2. Predicted response (+se) in proportion of multiple births to HWT ASBV.**
Dam age had a significant effect ($P<0.001$) on the likelihood of ewes bearing multiple lambs, with ewes at their first lambing at 2 years of age having a lower probability of producing twins than older ewes. Year also had a significant effect on ewe fecundity ($P<0.001$). Ewes with higher HEMD had a higher probability (2.1%/mm HEMD; $P<0.05$) of giving birth to multiple lambs (Figure 1), likewise ewe HWT was positively correlated (2.5%/kg HWT; $P<0.01$) with the probability of giving birth to multiple lambs (Figure 2). There was no effect of HFAT or any wool traits on the probability of multiple births.

Increases in either HEMD or HWT result in an increase in lean mass. While fatness has been implicated in affecting fertility it seems likely that lean mass is the greatest contributor to fecundity. Positive genetic and phenotypic correlations between muscle proportion and litter size have been found in Scottish Blackface ewes, with fat proportion found to have little effect (Lambe et al. 2005).

**Lamb Birthweight.** Lamb birthweight (BWT) is important because it is closely linked with lamb survival. There is an optimum range for BWT and lambs outside this range have a reduced chance of survival. Our analysis of the data set revealed a number of production traits that were correlated with BWT. In the model the fixed effects of BT, Sex, Dam age, Year and Sire were all highly significant ($P<0.001$).

There is a known positive genetic correlation between BWT and adult weights (Safari et al. 2005). BWT was positively correlated with HWT in this data set (0.03kg/kg HWT; $P<0.01$). Also significant in the model were the effects of HEMD (-0.09kg/mm HEMD; $P<0.01$) and HCFW (-0.03kg/% HCFW; $P<0.05$). Ewe HEMD was negatively correlated with BWT in this data set, this negative correlation is evident even when the increase in multiple births associated with HEMD is taken into account as birth type was included in the model. Lambe et al. (2005) found a slight negative correlation between carcass muscle weight and BWT in Scottish Blackface sheep, confirming our results. Ewe HCFW was also negatively correlated with lamb birthweight in this data set, which does not agree with published genetic correlations between these two traits (Safari et al. 2005). However, high HCFW genotype sheep have been shown to have impaired energy reserves, although only when these sheep are underfed (Adams et al. 2006). Within the model there was an interaction between Year and HCFW ($P<0.01$), which revealed that the negative correlation between ewe HCFW and BWT was evident in three of the four years however in 2004 there was a positive correlation. Interestingly, of the four years in the data set, 2004 had the highest mean BWT suggesting better nutrition during pregnancy for that year. This would be expected if the negative influence of HCFW on whole body energy metabolism is not seen under good nutritional conditions, as shown by Adams et al. (2007).

**Lamb Survival.** Lamb survival is important to the Australian sheep industry for both economic and animal welfare reasons. It is a trait that encompasses both the maternal ability of the ewe and the innate ability of the lamb to survive, especially through the first 24 hours of life. Lamb survival was analysed with Birth Type ($P<0.001$), Dam Age ($P<0.05$) and Year ($P<0.001$) included in the final model. The probability of a single lamb surviving was negatively correlated with HCFW (-0.47%/% HCFW; $P<0.01$) however this correlation was not evident in twin-born lambs (Figure 3). This finding agrees with the published estimates of a negative correlation between fleece weight and number of lambs weaned (Safari et al. 2005). When birthweight was included in the model it was significant ($P<0.001$), however the correlation between lamb survival and HCFW and the interaction with birth type remained significant. The impact of HCFW on lamb survival is therefore independent
of reductions in birthweight associated with HCFW in this data set. None of the other covariates included in the original model were significant.

Figure 3. Predicted response (±se) of lamb survival to Ewe HCFW for single (—) and multiple born (— -) lambs.

Wool and meat production traits were associated with maternal performance traits. Increased HWT was associated with an increase in fecundity and lamb birth weight with no effects on lamb survival. An increase in HEMD was related to increased fecundity but was also associated with a decrease in lamb birthweight however this reduction in lamb birth weight was not correlated with an increase in lamb mortality. It was surprising that there were no effects of HFAT on any of the maternal performance indicators studied. However, it is likely that HFAT will affect maternal performance in low nutrition environments. In a subset of ewes from this flock that were subjected to low nutrition, ewe HFAT was found to have a positive effect on maternal performance (M. Ferguson unpublished).

These results highlight the need to understand the impacts of selection for performance traits on maternal traits, and for a balanced approach to designing breeding strategies. The most appropriate breeding strategies are likely to differ across nutritional environments. Selection for some traits may have beneficial or detrimental effects on maternal performance depending on the nutritional environment. While rapid genetic gain in performance is very achievable, care must be taken to ensure fitness traits are not adversely affected. Merino production profitability is increasingly reliant on animal sales, and reductions in maternal performance may reduce enterprise profitability.

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