Genetics Of Reproductive Efficiency: A Study Of Merino Resource Flocks In South Australia

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Introduction

There has been little improvement in the reproductive efficiency of the Australian sheep flock over the past 30 years despite management options being available to lift performance (Kleeman *et al.* 2006). Increasing the number of lambs born without improving lamb survival is ethically unacceptable given that lamb survival rates above 90% for singles and 80% for twins are relatively uncommon in Australia (Hinch 2008, *pers.com*). Heritability estimates for lamb survival suggest that making genetic gains would be slow (Safari *et al.* 2005, Afolayan *et al. 2008*). The aim of this paper was to estimate genetic parameters for reproductive efficiency in a South Australian Merino resource flock.

Material and methods

Source of Data. Data was obtained from two projects, the SA Merino Resource Flock (SAMRF) and the SA Selection Demonstration Flocks (SDF), both conducted at Turretfield Research Centre. Established in 1988, the foundation flock for the SAMRF project consisted of 2000 South Australian Merino strain ewes representative of the Bungaree and Collinsville family groups. Annually, 48 rams were selected from four studs representing the family groups and single sire mated to approximately 40 randomly allocated ewes each. Lambs were born in April-May of each year. For more details, see Gifford *et al.* (1992). To establish the SDF project, in 1996 ewes were sourced from the SAMRF to establish four flocks of 200 ewes each, representing three major selection approaches and a randomly selected control. In 1999, a Meat Merino line was added. All SDF lambs were born in June-July of each year. For more details, see Kemper *et al.* (2006).

Data Collection. Pregnant ewes were allocated to lambing paddocks of two-hectares each. Twice-daily lambing rounds were conducted, with lambs identified with their dams and tagged within a maximum of 18 hours of birth. Maternal behaviour score, a subjective measure from 1 to 5 of the ewes mothering ability (Everett-Hincks *et al.* 2005) was also recorded at lamb tagging, where 1 = ewe flees (worst) and 5 = ewe stays close to lamb during tagging (best). Any dead lambs were recorded. Lambs were marked and mulesed at an average age of 40 days and then weaned from their dams at an average age of 91 days, with the identity of all surviving lambs recorded at those times. Before marking, daily checks were conducted, with less frequent checks made after marking. All deaths were recorded.

Statistical Analysis. The data was analysed with ASREML software (Gilmour et al., 2006), using an animal model. Two approaches were taken, firstly, treating lamb survival as a trait

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of the dam and secondly treating lamb survival as a trait of the lamb (reported by Brien *et al.* 2009a and not discussed here). Litter size consisted of 3 classes, none, single and multiple. There were too few higher order births to warrant treating these separately to twins.

The reproduction and lamb survival data, when analysed as a trait of the dam included 20,816 records from 8,172 animals, and 455 known sires. Eight traits were analysed:
Pregnancy Rate (PR) – ultrasound scanned pregnant (yes or no) per ewe joined
Foetal Number (FN) – the number of ultra sound scanned foetuses per ewe joined
Fertility (FERT) – ewes lambing per ewe joined
Litter Size (LS) – number of lambs born for ewes lambing
Litter Survival (SURV) – ratio of lambs weaned to lambs born
Number of Lambs Born (NLB) – number of lambs born per ewe joined
Number of Lambs Weaned (NLW) – number of lambs weaned per ewe joined
Maternal Behaviour Score (MBS) - subjective measure of the ewes mothering ability

The statistical analysis model was as follows. Year (year that the lamb was born) and flock nested within year were fitted to account for the basic design of the experiment. Age of dam, dams type of birth and rearing were fitted as fixed effects and the additive genetic, permanent environmental variances and the sire of the lamb were fitted as random effects.

Results and discussion

Estimates of repeatability, heritability and the phenotypic standard deviation for a range of maternal traits, including litter survival are shown in Table 1.

Table 1. Estimates of heritability (s.e.), repeatability (s.e.) and phenotypic standard deviation (σ_p)

Traits	No. Records	No. Animals	Heritability	Repeatability	σ_p
PR	20,814	8,170	0.08 (0.01)	0.16 (0.01)	0.31
FN	20,814	8,170	0.10 (0.01)	0.17 (0.01)	0.59
FERT	20,816	8,172	0.08 (0.01)	0.16 (0.01)	0.32
LS	17,699	7,575	0.11 (0.01)	0.15 (0.01)	0.45
SURV	17,699	7,575	0.03 (0.02)	0.14 (0.01)	0.33
NLB	20,816	8,172	0.10 (0.01)	0.17 (0.01)	0.60
NLW	20,816	8,172	0.07 (0.01)	0.18 (0.01)	0.58
MBS	4,772	2,084	0.12 (0.02)	0.12 (0.02)	1.48

Heritability and repeatability estimates of all traits were low and are in good agreement with literature estimates (Safari *et al.* 2005, Afolayan *et al.* 2008). Modest genetic progress is thus possible for fertility. The heritability for SURV (to weaning) is particularly low at 0.03 and is similar to the heritability estimate when treating it as a trait of the lamb (Brien *et al.* 2009a). This indicates that genetic gain from direct selection is likely to be slow however, when account is taken of available variation, gain is predicted to still be 14% of that for clean fleece weight, a highly inherited trait (Brien *et al.* 2009a). Although the estimate for heritability of NLW is lower than those NLB and LS (or FN), NLW has been recommended as the trait to select in practice, as emphasis on NLB or LS has been associated with reduced lamb survival (Snowder and Fogarty 2009).

The estimates of heritability and repeatability for MBS are only slightly higher than the values estimated by Everett-Hincks *et al.* (2005), but are much less than those reported by Hatcher, Safari and Atkins (2009) for "Maternal Bond Score". Estimates of genetic and phenotypic correlations among reproduction and litter survival traits are shown in Table 2.

Table 2. Estimates of genetic (below the diagonal) and phenotypic (above the diagonal) correlations among reproduction and litter survival traits

	PR	**FN**	**FERT**	**LS**	**SURV**	**NLB**	**NLW**	**MBS**
PR		0.57	0.90	-0.02	-0.11	0.55	0.41	0.08
FN	0.67		0.53	0.99	-0.23	0.97	0.59	0.08
FERT	0.99	0.67		-0.05	0.03	0.59	0.43	0.05
LS	0.54	0.99	0.09		-0.20	0.99	0.48	0.07
SURV	0.43	-0.28	0.48	-0.45		-0.23	0.75	-0.08
NLB	0.79	0.99	0.68	0.99	-0.17		0.62	0.08
NLW	0.85	0.77	0.75	0.83	0.55	0.91		0.06
MBS	0.11	0.14	0.68	0.07	0.12	0.16	0.25	

s.e's were 0.01 – 0.03 and 0.01 – 0.15 for phenotypic and genetic correlations, respectively

SURV was slightly to moderately negatively correlated (genetically) with FN and LS, but moderately to strongly positively correlated with NLW and positively correlated with PR and FERT, similar to the results of Afolayan *et al.* (2008). MBS was not correlated genetically with SURV but showed a strong positive genetic correlation with FERT and a moderate genetic correlation with NLW. Surprisingly, the genetic correlation between MBS and PR was negligible, given that PR and FERT are almost the same trait (r_g = 0.99, Table 2). These latter two genetic correlations are in the presence of negligible phenotypic correlations (0.05 and 0.06, respectively).

Conclusion

Our results confirm that modest genetic improvement of fertility in Merinos can be obtained, especially with the use of repeat records, as recommended to sheep breeders in Australia.

In contrast, obtaining genetic gain in lamb survival from direct selection is a challenge. This applies whether lamb survival is treated as a trait of the dam or the lamb, and allowing for the presence of considerable phenotypic variation (Brien *et al.* 2009a). Progeny testing and researching indirect selection criteria are both being undertaken by the Sheep CRC in Australia (Brien *et al.* 2009b) to improve the rate of genetic gain possible and others suggest selection for total weight of lambs weaned, rather than component traits like lamb survival in improving overall reproductive efficiency (Snowdon and Fogarty 2009).

In terms of indirect selection criteria, maternal behaviour score does not appear useful, either for the genetic improvement of lamb survival (mainly because of a negligible genetic correlation) or for improvement of fertility. Despite the strong genetic correlation of MBS with fertility, as fertility can be recorded easily and cheaply and so directly selected for, it is unlikely that MBS can add significant extra gain.

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