GENETICS OF LAMB SURVIVAL: A STUDY OF MERINO RESOURCE FLOCKS IN SOUTH AUSTRALIA

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SUMMARY

Estimates of genetic parameters and variance components were made for lamb survival and correlated traits on data from the SA Merino Resource Flock (1988-1997) and the SA Selection Demonstration Flocks (1996-2006). Very low estimates of direct heritability were obtained for lamb survival, with values of 0.071, 0.044, 0.043, 0.032 and 0.032 for surviving birth, up to 3, 7, 40 (marking) and 91 days (weaning) after birth, respectively, indicating only slow progress would be likely from genetic improvement. Birth weight had low positive phenotypic correlations with lamb survival (values from 0.112 to 0.224), with the genetic correlations being negative to near zero (values from –0.137 to –0.025), indicating little would be gained in lamb survival from genetic manipulation of birth weight. The phenotypic correlations between lamb survival and birth coat score were virtually zero in all cases, however the genetic correlations were low and consistently positive (values from 0.071 to 0.192), being highest for survival to 3 days of age.

INTRODUCTION

Lamb survival rates above 90% for singles and 80% for twins are relatively uncommon in Australia, with such rates remaining a major factor contributing to reproductive inefficiency in the national sheep flock (Hinch 2008, *pers.com*). Heritability estimates for lamb survival suggest that making genetic gains would be slow (Safari *et al.* 2005). In 2007 the Sheep CRC commissioned studies on experimental Merino flocks where the data could provide parameter estimates of much higher precision than those currently available. This paper reports on one of these studies.

MATERIALS AND METHODS

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.* (1990).

In 1996, to establish the SDF project, 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 within a maximum of 18 hours of birth. Lambs were weighed, ear tagged and scored for birth coat (BCS) (Ponzoni *et al.* 1997). 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 were analysed with the ASREML software (Gilmour *et al.* 2006), using an animal model, treating lamb survival as a trait of the lamb. Further analyses, treating lamb survival as a trait of the dam have been performed, but are not reported in this paper. Litter size consisted of 2 classes, single and multiple. There were too few higher order births to warrant treating these separately to twins. Year of lamb birth, flock nested within year, litter size (singles, multiples), age of dam (2,3,4,5,6&7+ years), sex and date of birth were fitted as fixed effects in the statistical model and the additive genetic, maternal, and dam permanent environmental variances were fitted as random effects. The data included information from 23,873 individuals, 605 sires, and 7,526 dams and included all animals that were dead at birth. Five measures of lamb survival were assembled from the data, (i) survived birth (Birth, as recorded at lamb tagging), (ii) survived to 3 days after birth (3 days), (iii) survived to 7 days after birth (7 days), (iv) survived to marking (Mark), and (v) survived to weaning (Wean). All these measures are reported as a proportion of the total number of lambs born (alive and dead).

RESULTS

Environmental Effects. The survival rate for all flocks to weaning was 79%. Of the 21% that died, 40% were dead at birth (by lamb tagging), 74% were dead within 3 days and 80% were dead within 7 days of birth. The survival to weaning of singles was greater than multiples (86% vs. 73%, Table 1). Female lambs had higher survival rates than males, regardless of dam age or birth type (Table 2). The survival of lambs from 2 year old and 6+ year old dams was the poorest.

Table 1. Survival rates of singles vs. multiples between birth and weaning

Birth Type	Number	Birth	3 days	7 days	Marking	Weaning
Singles	11,792	0.94	0.89	0.88	0.87	0.86
Multiples	12,081	0.89	0.82	0.80	0.75	0.73
Combined	23,873	0.91	0.85	0.83	0.80	0.79

Table 2. The effects of sex (female – F, male – M) and age of dam on lamb survival

	Singles					Multiples				
	Birth	3 days	7 days	Mark	Wean	Birth	3 days	7 days	Mark	Wean
					Sex effect					
F	0.94	0.90	0.90	0.89	0.89	0.90	0.82	0.81	0.74	0.73
M	0.92	0.88	0.87	0.85	0.85	0.90	0.80	0.78	0.73	0.72
					Age of dam effect					
2	0.93	0.88	0.87	0.86	0.86	0.87	0.78	0.76	0.67	0.66
3	0.94	0.91	0.91	0.90	0.89	0.91	0.84	0.82	0.76	0.76
4	0.94	0.92	0.91	0.90	0.90	0.91	0.84	0.83	0.78	0.77
5	0.94	0.90	0.90	0.88	0.88	0.91	0.84	0.83	0.78	0.76
6	0.92	0.88	0.88	0.89	0.89	0.89	0.78	0.76	0.72	0.71
7 +	0.91	0.85	0.84	0.81	0.82	0.89	0.75	0.76	0.69	0.68

Genetic Parameters. Estimates of genetic parameters for lamb survival are shown in Table 3. The heritability estimates were very low. Direct heritability declined from the time period of surviving birth to those for the periods including up to 3 and 7 days after birth (0.071 to 0.044 and 0.043, respectively) with the estimates only slightly less for the periods up to marking and weaning. Correlations of lamb survival with birth weight and birth coat score are given in Table 4.

Table 3. Heritability estimates for lamb survival. Standard errors are shown in brackets

Lamb Survival Trait	Direct h^2	Maternal h^2
Birth	0.071 (0.008)	0.016 (0.006)
3 Days	0.044 (0.008)	0.024 (0.006)
7 Days	0.043 (0.008)	0.019 (0.007)
Mark	0.032 (0.007)	0.020 (0.007)
Wean	0.032 (0.007)	0.020 (0.007)

Table 4. Phenotypic (r_p) and genetic (r_g) correlations of lamb survival with birth weight (Birth Wt) and birth coat score (BCS). Standard errors are shown in brackets

Lamb Survival Trait	Birth Wt		BCS	
	r_p	r_g	r_p	r_g
Birth	0.112 (0.008)	-0.137 (0.139)	-0.037 (0.009)	0.071 (0.120)
3 days	0.183 (0.008)	-0.045 (0.147)	0.014 (0.008)	0.192 (0.120)
7 days	0.184 (0.008)	-0.112 (0.112)	0.013 (0.008)	0.130 (0.110)
Mark	0.224 (0.008)	-0.111 (0.161)	0.013 (0.008)	0.127 (0.119)
Wean	0.213 (0.008)	-0.025 (0.165)	0.014 (0.008)	0.109 (0.120)

All correlations between lamb survival and birth weight were low, with phenotypic correlations being positive and genetic correlations being smaller and negative. Similarly, all correlations of lamb survival with birth coat score were low; phenotypically, the correlations were virtually zero in all cases. However, the genetic correlations were consistently positive, with the highest being the correlation with lamb survival to 3 days of age.

DISCUSSION

The data set for lamb survival traits used in our study is among the largest yet to be reported and provides precise estimates of genetic parameters. We confirm earlier reports (e.g. Obst and Day, 1968) that the great majority of lamb loss is in the first 72 hours after birth.

Direct selection for lamb survival. This study confirms earlier reports of very low heritability estimates obtained for lamb survival (Safari *et al.* 2005) and is in close agreement with a recent study on a data set of similar size (Hatcher *et al.* 2009). Response to selection is however not only a function of heritability, but also available variation, selection intensity and generation interval. Similar to Fogarty *et al.* (2006), we have calculated the relative response to selection for lamb survival compared to other traits (Table 5), but have treated it as a threshold character with an underlying scale distributed normally and the deviation of the threshold from the mean being the selection differential (Falconer 1981).

Table 5. Relative response per generation for different traits

Trait	Heritability	CV%	Relative Response
[1]Clean Fleece Weight	0.42	16.3	100
[2]Lamb Survival (to weaning)	0.032	49.4	14

([1]Values from Fogarty *et al.* 2006. [2]Values from this study)

Despite the very low heritability, with high variation, predicted genetic improvement for lamb survival still manages to be 14% of the relative gains possible of that for clean fleece weight, a highly heritable trait. Notwithstanding, the rate of gain predicted is still slow and behoves researchers to find ways to improve it.

Correlated traits and indirect selection. Based on the negligible genetic correlations between birth weight and lamb survival, there appears to be little to be gained in lamb survival from genetic manipulation of birth weight. Our finding that there was only a very slight advantage in survival for progeny of lambs with hairier birth coats (especially to 3 days of age) is similar to the results of a study on the SAMRF project data only (Ponzoni *et al.* 1997). However, data from a range of environments and lambing times is needed before industry recommendations are made about the usefulness of birth coat score as a selection criterion for improving lamb survival.

Finally, with reproductive wastage in sheep flocks attracting increased attention in recent years due to animal welfare and economic considerations, sheep breeders are looking for viable options to improve lamb survival, including genetic ones despite the predictions of slow genetic progress. Increasing potential genetic gain via improving accuracy by identifying a range of useful indirect selection criteria for lamb survival (Brien *et al.* 2009) and by progeny testing of industry sires are approaches currently under investigation by the Sheep CRC. We also note that breeding values for lamb survival are available from Sheep Improvement Limited in New Zealand (Newman 2003) and that useful genetic gains in lamb survival have been made in a South African flock selected for improved maternal ability (Cloete *et al.* 2009).

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