GENETICS OF LAMB SURVIVAL: PRELIMINARY STUDIES OF THE INFORMATION NUCLEUS FLOCK

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SUMMARY

Poor lamb survival is recognised in Australia as a major contributor to reproductive inefficiency in the national flock. This paper provides preliminary estimates of phenotypic and genetic parameters on lamb survival and related traits for the 2007 and 2008 data from the CRC for Sheep Industry Innovation's Information Nucleus. The paper focuses on the potential utility of measurements on related traits for achieving genetic improvement in lamb survival. Although timed lamb behaviour traits show consistently high genetic correlations with lamb survival to 3 days of age, no obvious candidates have yet been identified for commercial use as indicator traits to genetically improve lamb survival.

INTRODUCTION

Poor lamb survival is a major contributor to reproductive inefficiency in sheep flocks in Australia (Alexander 1984), with survival rarely exceeding 90% and 80% in singles and twins, respectively (Hinch *pers.com.*). This paper provides preliminary estimates of phenotypic and genetic parameters on lamb survival and related traits from the CRC for Sheep Industry Innovation's Information Nucleus (IN) (Fogarty *et al.* 2007). The paper focuses on the potential utility of measurements on related traits for achieving genetic improvement in lamb survival.

MATERIALS AND METHODS

Information Nucleus. The data is from records of the 2007 and 2008 lambings of the IN, which operates as a series of linked flocks at research sites in widely differing environments around Australia, genetically testing key young industry sires for an extensive range of traits. The IN is directly linked to breeders and industry through the Sheep Genetics database (Fogarty *et al.* 2007). The 8 sites of the IN and the approximate number of ewes mated at sites each year are Armidale (1000 ewes), Trangie and Cowra (500 ewes each) in NSW, Rutherglen and Hamilton (500 ewes each) in Victoria, Struan and Turretfield (500 ewes each) in SA and Katanning (1000 ewes) in WA. Of the total ewe numbers, 80% are Merinos and 20% are Border Leicester-Merinos. All sites except Trangie had their first mating in 2007. Except for 2007 (when 65 sires were mated), approximately 100 sires are mated each year by AI, with most sires represented across all sites. Matings in the IN included Merino sires by Merino ewes, terminal sires by Merino ewes, maternal sires by Merino ewes and terminal sires by Border Leicester-Merino ewes. Further details of the sire and dam genotypes mated in the IN are provided by Fogarty *et al.* (2007).

Data collection. Prior to lambing, pregnant ewes were randomly allocated to lambing paddocks of 1-20 ha each. Commencing in 2008, to assist in pedigree accuracy, no lambing paddock contained ewes representing more than one individual sire for each sire breed used in the IN. Twice-daily lambing rounds were conducted, with lambs identified with their dams within 18 hours of birth. The lamb measurements and scores recorded are outlined in Tables 1 and 2. Dead lambs, where possible, were measured in the field as appropriate and collected for later autopsy. 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 both times. Before marking, daily checks were conducted, with less frequent checking after marking. All deaths were recorded. For more details of the data collected within the IN, see Geenty *et al.* (2009).

Table 1. Lamb measurements/scores recorded from lambing till weaning at all sites in 2008

Time of collection	Measurement/Score
Lambing (lambing rounds lasted 10 days)	Lamb identification, date of birth, birth weight (BWT), type of birth, birth coat score (BCS), estimated lamb age, rectal temperature, lamb vigour scores (overall score and 5 component scores), sex, dam identification, 3 skeletal measurements, cause of death from autopsy on dead lambs and lamb survival to 3 days of age
Marking	Survival to marking
Weaning	Date, lamb weight, type of rearing, survival to weaning

At the 2007 lambing of the IN, no site collected skeletal measurements and only four sites collected data on rectal temperatures, detailed lamb vigour scores and performed autopsies on dead lambs. All other remaining measurements and scores were collected in 2007 as well as 2008.

Table 2. Measurement and scoring systems on lambs for assessed traits

Trait	**Measurements/Scores**
Birth Coat (BCS)	Score range 1 to 7, 1 is no halo hair, 7 is extreme halo hair
Estimated Lamb Age	0= Wet – limited membrane breakage on feet (new born) 1= 1-4 hours old – has walked – still wet and at birth-site 2= > 4 hours old – dry – difficult to catch – follows mother
Rectal Temperature (RT)	At lamb tagging
Lamb Vigour:-	
Overall Score (OBV)	0= lamb still wet – new born - invalid record, 1= Constant struggle, 5= Little movement when held – lies on release
Time-based values (sec)	Based on time taken from release to bleat, stand, contact ewe, contact udder and follow ewe. Recordings stopped after 3 minutes
Skeletal measures (cm):-	
• Crown Rump (CRL)	Distance from back of the skull/nape of the neck to base of the tail
• Metacarpal (ML)	Length of the lower leg bone (front leg – knee to fetlock)
• Thorax	Maximum abdominal circumference around the rib cage
Cause of death	Autopsy procedure outlined by Holst (2004)

*Data Analysis***.** An animal model was fitted to the data using ASREML (Gilmour *et al.* 2006). The specific analytical model fitted IN site, lamb genotype, sex, year of birth, age of dam and any significant interactions as fixed effects, with individual sire fitted as a random effect. Correlations were calculated using bivariate analyses with fitted effects as described above. Estimated lamb age was used as a covariate for rectal temperature and the lamb behaviour traits (OBV and time-based values). Analyses were performed with and without birth weight in the model as a covariate.

RESULTS AND DISCUSSION

Estimates of heritabilities for traits measured at birth and their phenotypic and genetic correlations with lamb survival (based on 2007 and 2008 IN data) are given in Table 3, where birth weight has not been fitted as a covariate. Although the standard errors for estimates of heritabilities and phenotype correlations are low, indicating good precision, those for genetic correlations are much higher, so the estimates should be regarded as preliminary.

Table 3. Trait heritabilities (h^2) and phenotypic (r_P) and genetic correlations (r_G) between lamb survival to 3 days and to weaning and traits recorded at birth in 2007 and 2008. Results shown are without birth weight fitted as a covariate. Standard errors are shown in brackets

Trait	h^2	Lamb Survival to 3 days		Lamb Survival to Weaning	
		r_P	r_G	r_P	r_G
BWT	0.20 (0.03)	0.21 (0.01)	-0.51 (0.27)	0.24 (0.01)	-0.45 (0.16)
BCS	0.52 (0.06)	0.11 (0.02)	0.37 (0.21)	0.12 (0.01)	0.25 (0.14)
OBV	0.09 (0.02)	0.04 (0.01)	0.24 (0.27)	0.06 (0.01)	0.14 (0.18)
Bleat	0.12 (0.03)	-0.01 (0.02)	-0.57 (0.27)	0.03 (0.02)	-0.38 (0.20)
Stand	0.09 (0.02)	-0.04 (0.02)	-0.39 (0.30)	0.03 (0.02)	-0.45 (0.21)
Contact	0.06 (0.02)	-0.01 (0.02)	-0.48 (0.35)	0.02 (0.02)	0.04 (0.24)
Udder	0.12 (0.04)	0.04 (0.02)	-0.39 (0.32)	0.03 (0.02)	-0.20 (0.23)
Follow	0.06 (0.02)	-0.04 (0.02)	-0.59 (0.40)	0.02 (0.02)	-0.39 (0.27)
RT	0.14 (0.03)	0.36 (0.01)	0.28 (0.23)	0.32 (0.01)	0.31 (0.17)
CRL	0.30 (0.05)	-0.02 (0.02)	-0.55 (0.29)	0.05 (0.02)	-0.29 (0.20)
ML	0.34 (0.06)	0.11 (0.02)	-0.37 (0.25)	0.13 (0.02)	-0.32 (0.20)
Thorax	0.15 (0.03)	0.22 (0.02)	-0.39 (0.31)	0.24 (0.02)	-0.31 (0.23)

Heritabilities were moderate for birth weight and high for birth coat score, similar to earlier reports (Ponzoni *et al.* 1997; Safari *et al.* 2005). However, although the phenotypic correlations between birth weight and both lamb survival traits are low, similar to earlier reports, the genetic correlations are moderate to high and negative, in contrast to the zero or near zero estimates obtained from 2 recent large-scale studies in Merinos (Hatcher *et al.* 2009; Brien *et al.* 2009). Similarly, whilst the phenotypic correlations of birth coat score with both lamb survival traits are low and positive, the genetic correlations are moderate, especially for lamb survival up to 3 days of age and are higher than earlier reports (Hatcher *et al.* 2009; Brien *et al.* 2009). These differences in results may be partly due to the inclusion of several lamb genotypes and multiple sites in our data. Our results require further investigation and analysis, especially once a more complete set of dam pedigrees can be assembled on IN foundation ewes.

Heritabilities for lamb behaviour traits, including OBV and the time-based values, are all in the low range. This likely reflects a high degree of environmental variation, some of which is unavoidable as part of the intervention by humans when collecting the data. The phenotypic correlations of these behaviour traits with both lamb survival traits are zero or near zero, but the genetic correlations between the timed lamb behaviours and lamb survival are in general moderate to high and negative (the shorter the time elapsed from release of the lamb to the expression of the behaviour, the higher the lamb survival), with the estimates being higher for lamb survival to 3 days of age than for the longer period up to weaning. The fitting of birth weight as a covariate in the analysis of the data made no difference to the size of the genetic correlations between timed lamb behaviour traits and lamb survival. The genetic correlations between OBV and both lamb survival traits are lower and positive (favourable) and could reflect the subjective scoring system and its discrete categories in contrast to the quantitative basis of the timed traits.

Rectal temperature had low heritability but was both phenotypically and genetically moderately correlated with both lamb survival traits in a positive (favourable) direction. Little difference was made to these correlation estimates by the fitting of birth weight as a covariate. Finally, the skeletal measures of lambs had moderate heritability, although thorax circumference was the lowest at 0.15, and despite zero to lowly positive phenotypic correlations with lamb survival traits, all had moderately negative genetic correlations. Fitting birth weight as a covariate more than halved the genetic correlations with lamb survival to 3 days of age (to -0.18, -0.15 and -0.15 for CRL, ML and Thorax, respectively) indicating some remaining correlation with lamb survival that is independent of birth weight. These skeletal measures are a proxy for lamb shape and suggest that lamb shape itself is genetically linked to lamb survival.

The consistent high negative genotypic correlations between timed lamb behaviour traits and survival to 3 days are interesting and suggest further evaluation in future years is justified to improve precision of the correlation estimates. Although these traits are useful in further research, they do not immediately appeal as easy, cheap and quick to measure indicator traits in commercial breeding programs. Although rectal temperature and skeletal measures of lambs at birth are less time consuming to measure and well genetically correlated with lamb survival, especially to 3 days of age, they also require further investigation to determine their commercial usefulness.

In conclusion, whilst these preliminary results from the IN show promise, to date there are no obvious candidates for commercial use as indicator traits for genetically improving lamb survival.

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