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GENETIC ASSOCIATION OF SKIN THICKNESS WITH LAMB SURVIVAL FROM BIRTH TO WEANING, AND GROWTH AND WOOL TRAITS IN NEW ZEALAND ROMNEY SHEEP

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SUMMARY

Lamb survival, as a trait of high economic importance with low heritability, might show more response to selection by considering traits of higher heritability, genetically correlated with survival, as a supplement to direct selection for the trait itself. This study aimed to estimate heritability and genetic association of skin thickness (ST), as a potential trait in indirect selection for lamb survival, with lamb survival from birth to weaning (SAW), and a few growth and wool traits including fat depth (FD), eye-muscle depth (EMD), weaning weight (WWT) and 12-month fleece weight (FWT) in New Zealand Romneys. Data for ST, FD, and EMD were collected using ultrasound scans on hoggets at 8-10 months. Appropriate animal and sire models were applied to estimate the genetic parameters using ASReml software. ST had an estimated heritability of 0.26, and showed genetic correlations of 0.27 (±0.22), 0.22 (±0.10), -0.18 (±0.12), -0.21 (± 0.12) and 0.27 (±0.12) with SAW, FD, EMD, WWT, and FWT, respectively. The preliminary estimates of heritability and genetic correlation of skin thickness with lamb survival, obtained in this study, might suggest the idea of considering this trait in selection for lamb survival, though its unfavourable correlation with other traits should also be considered.

INTRODUCTION

Lamb mortality is a major issue to sheep producers both in New Zealand and worldwide, not only due to economic losses but also as an animal welfare and management problem. Lamb survival rates of 75 to 97% has been reported in New Zealand (Hight and Jury 1970; Dalton *et al*. 1980; Gumbrell and Saville 1986), though mortality rates of up to 40% have been found on some farms (Fisher 2004). In countries like New Zealand, the UK and Australia, where lambing mostly takes place outdoor, thermoregulatory capacity of newborn lambs plays a major role in lamb survival due to its contribution to starvation-exposure mortality rates, as the second most common cause of lamb deaths in the neonatal period after dystocia (Kerslake *et al*. 2005; Everett-Hincks *et al*. 2007).

Due to a low heritability of lamb survival (Lopez-Villalobos and Garrick 1999; Brien *et al*. 2010), indirect selection, based on selection for other easy-to-measure traits of higher heritability that are genetically correlated with survival can be considered as a supplement to direct selection for the trait itself. Skin thickness as a trait of moderate to high heritability (Slee *et al*. 1991; Gregory 1982a) has been shown to be associated with cold tolerance (Samson and Slee 1981), as a component of lamb survival, which is moderately to highly heritable itself (Wolff *et al*. 1987; Slee *et al*. 1991).

Hence, selection for skin thickness might be a potential alternative to selection for cold resistance and consequently lamb survival. Unlike cold resistance, whose assessment needs laboratory-based techniques that are not feasible for breeders, skin thickness could be easily measured in the field using objective techniques like ultrasonography (Brown *et al*. 2000). Prior to implementing this trait in selection for lamb survival, it is inevitable to first estimate its heritability and genetic association with other economic traits. Although a limited number of studies were undertaken for estimating these parameters (Slee *et al*. 1991; Gregory 1982a; Gregory 1982b; Coy 1983; Hynd *et al*. 1996), the size of populations in those experiments were too small. Therefore, the objective of this study was to estimate heritability for ultrasonographically measured traits (skin thickness, subcutaneous fat depth, and eye muscle depth), lamb survival and some growth and wool traits (weaning weight, and fleece weight at 12 months). Also, genetic correlation of skin thickness (as the proposed trait influencing lamb survival) with other traits of interest was estimated.

MATERIALS AND METHODS

Data collection. Data for skin thickness, fat depth and eye muscle depth were collected by ultrasonography on four Terminal Romneys for Increased Genetic Gain (TRIGG) farms in the Manawatu region of New Zealand as part of routine farm operations using ultrasound at approximately 8 months of age, during 2011 to 2015. A commercial operator took measurements using an ultrasound scanning machine (Sonosite M Turbo) with a 38mm probe at 7.5 MHz set at a depth of 40 mm on the left dorsal loin region of the lambs around the 12th rib. Live weight was also recorded at scanning. For three out of four farms the ultrasound data were recorded only during 2011 to 2014. Additional data on date of birth, sex, flock, birth rank, rearing rank, dam age, dam and sire identities, status of lamb at weaning (alive or dead), weaning weight, weaning date, fleece weight at 12 months, and age at shearing were obtained from the Sheep Improvement Limited (SIL) database. Data cleaning was done so that records with dam age of 9 years or more (n=9), birth ranks of 4 and 5 (n=114), and rearing rank of 4 (n=20) were removed from the data because of their small numbers. Also, lambs of unknown parents in the pedigree (n=408) were excluded from the analysis. After data cleaning and editing for incorrect pedigree and outlier values, the data set had 24,097 lambs born to a total of 199 sires and 6,413 dams.

Statistical analysis. Univariate procedure in SAS software (SAS, 2015) was used to check for normality and edit the data (removing outlier observations). Data were analysed by the PROC MIXED procedure in SAS software (SAS, 2015) to identify significant fixed effects to be included in the final models. Sex, birth year, and birth flock were included as fixed effects for all the traits. Furthermore, for all the traits except skin thickness, dam age was included in the final models. Also, weight at ultrasonography was considered as a covariate for the analysis of skin thickness, fat and eye muscle depth. Birth rank was included as fixed effect in the analysis of survival at weaning, and rearing rank for the other traits excluding skin thickness. In addition, age at weaning and age at fleece weight measurement were considered as covariates in the models analysing the traits weaning weight and fleece weight at 12 months, respectively. Also, all the significant two-way interactions between these fixed effects were included in the final models. (Co)variance components were estimated by Restricted Maximum Likelihood (REML) procedure using the ASREML software (Gilmour *et al*. 2015). Appropriate animal models were used for estimation of heritability for all the traits. The random effects included direct additive genetic effect for all the traits, and also maternal genetic and maternal environmental effects for the traits survival at weaning and weaning weight.

Because survival was coded as a binary trait, a generalized linear model analysis was performed, assuming a binomial distribution for this trait and using both logit and probit link functions. For all other traits, a linear animal model was used assuming normal distribution. Genetic correlations were estimated using bivariate analyses applying the best models determined in the univariate analyses. In the bivariate model where survival was included as a trait, a sire model was used and only those sires with at least 50 and 30 records of their progeny for lamb survival and skin thickness, respectively, were included in the analysis. In those models, lamb survival was considered as a threshold trait and skin thickness as normal trait. It should be noted that the statistical analysis was performed using the skin thickness data only from those animals that were alive until ultrasound scanning (at around 8 months age) and this might have led to bias in the resulting genetic correlation of lamb survival with skin thickness.

RESULTS AND DISCUSSION

Number of observations, mean, standard deviation (SD), minimum (Min), maximum (Max), and coefficient of variation (CV) for the analysed traits are presented in Table 1. As shown, ultrasound skin thickness in this study, recorded at around 8 months of age, had a mean of 2.92 mm (Table 1), which is consistent with a report by Jopson *et al*. (2000) in new-born Coopworth lambs in New Zealand, though skin thickness was measured using skinfold callipers in their experiment. In the current study ewe lambs had significantly (P<0.01) thicker skin compared to males (3.24 vs. 2.87), while Jopson *et al*. (2000) did not find any significant difference between ewe and ram lambs. On the other hand, neither birth rank nor age of dam had any significant effect on skin thickness when adjustment was made for live weight at measurement, both of which are in agreement with the study by Jopson *et al*. (2000). Also, skin thickness was significantly affected by both birth flock and year in the present study.

Table 1. Descriptive statistics and number of records for the traits analysed

Trait	No. of records	Mean	SD	Min.	Max.	CV
Survival at weaning (%)	23976	0.81	0.39	0	1.00	47.99
Skin thickness (mm)	6082	2.92	0.50	1.50	5.00	17.20
Fat depth (mm)	6171	2.86	1.43	1.00	12.00	50.02
Eye muscle depth (mm)	4389	25.60	3.14	4.00	38	12.25
Weaning weight (kg)	18657	28.68	6.10	10.00	57.00	21.25
Fleece weight at 12 months (kg)	5426	3.32	0.67	1.60	5.80	20.29

Table 2 presents heritability estimates for the traits of interest and genetic correlation of skin thickness with other traits. As expected, lamb survival at weaning had low direct and maternal heritability estimates, which is in line with several other studies (Lopez-Villalobos and Garrick 1999; Brien *et al*. 2010). As mentioned at the outset, this finding shows that direct genetic selection for this trait is not promising. On the other hand, skin thickness as the main trait of interest considered for indirect selection for lamb survival showed a moderate heritability of 0.26±0.04, which confirms the results from previous studies showing this trait to be heritable (Slee *et al*. 1991; Gregory 1982a). Furthermore, skin thickness showed a positive genetic correlation (0.27±0.22) with lamb survival at weaning, which is favourable and consistent with the results from a study by Jopson *et al*. (2000) that showed 2.7% increase in lamb survival from tagging until weaning for each millimetre of increase in skin thickness in Coopworth sheep. This finding could be attributed to the effect of skin thickness on improved thermoregulation.

Table 2. Estimates (±SE) of the direct (h_a^2) and maternal (h_m^2) heritabilities and maternal environmental (me^2) effects for each trait, and genetic correlations (r_g) with skin thickness

Trait	h_a^2	h_m^2	me^2	r_g
Survival at weaning (using probit link)	0.033 ± 0.01	0.061 ± 0.02	0.008 ± 0.02	0.27 ± 0.22
Survival at weaning (using logit link)	0.035 ± 0.01	0.053 ± 0.02	0.016 ± 0.017	-
Skin thickness	0.26 ± 0.04	-	-	-
Fat depth	0.36 ± 0.04	-	-	0.22 ± 0.10
Eye muscle depth	0.39 ± 0.05	-	-	-0.18 ± 0.12
Weaning weight	0.33 ± 0.04	0.17 ± 0.03	0.14 ± 0.02	-0.21 ± 0.12
Fleece weight at 12 months	0.50 ± 0.04	-	-	0.27 ± 0.12

There was also a favourable positive genetic correlation of 0.27±0.12 between skin thickness and fleece weight at 12 months. Similarly, Gregory (1982b) found a significant genetic correlation of 0.39 between skin thickness and clean fleece weight in South Australian Merino sheep. Contrary to this, Hynd *et al*. (1996) indicated a slight negative correlation between skin weight (as an indicator of thickness) and clean fleece weight. Unfavourably, the genetic correlation of skin thickness and fat depth was positive with a value of 0.22±0.10. In agreement with this, Jopson *et al*. (2000) showed that lambs from lines selected for high backfat depth had thicker skins than those selected for low backfat depth. Also, unfavourable genetic correlations of -0.18±0.12 and -0.21±0.12 were found between skin thickness and the traits eye muscle depth and weaning weight, respectively.

CONCLUSION

The preliminary estimates of heritability of skin thickness, together with its favourable genetic correlation (although with a high standard error) with lamb survival at weaning obtained in this study, suggests the idea of considering this trait as a likely attribute in indirect selection of lamb survival in selection programs. However, its inclusion should be with caution due to its unfavourable genetic correlation with fat depth, eye muscle depth, and weaning weight, as well as high standard errors associated with them. Otherwise, selection of animals with thicker skin might result in lambs with improved survival as well as increased fleece weight, but with a greater fat depth, and less muscle depth and lower weaning weight.

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