Relationships among skin thickness, fat depth and eye muscle depth in sires and their progeny, and the breeding value for survival of their progeny

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Abstract

Lamb survival to weaning is an important determinant of farmer income and an animal welfare issue. The aim of this study was to determine whether skin thickness, fat depth and eye muscle depth (EMD) of the sires were related to skin thickness, fat depth, EMD and survival estimated breeding value (eBV) of their progeny. Data from a total of 19,436 lambs born between 2010 and 2013 inclusive were obtained from four farmers who comprise the Terminal Romneys for Increased Genetic Gain (TRIGG) group. Records included weaning weight, flock, sex, birth rank, date of birth, dam identity, sire identity and live weight at ultrasound measurement; skin thickness, fat depth and EMD measured using ultrasound at eight-months of age; and the survival eBV. Heritabilities for weaning weight, skin thickness, fat depth and EMD were 0.60±0.08, 0.21±0.07, 0.25±0.08 and 0.61±0.23 respectively. Skin thickness and EMD of the sire were positively correlated with progeny survival eBV while sire fat depth was negatively correlated with lamb survival eBV. Skin thickness, EMD and fat depth showed promise as indirect selection criteria for improved lamb survival. Additional data are required to confirm this.

Keywords: lamb survival; skin thickness; fat depth; eye muscle depth; heritability

Introduction

The main source of income on New Zealand sheep farms is the number of lambs available for slaughter. Hence the main driver of profit on New Zealand sheep farms is the number of lambs which survive to weaning (Beef+Lamb New Zealand 2014). Lamb mortality rates on some farms can reach 32% (Morris & Kenyon 2004). These deaths create both production losses and welfare issues for the farmers (Mellor & Stafford 2004) and are greatly influenced by the weather at lambing time. The two major causes of lamb deaths in the neonatal period are dystocia and starvation/exposure (McCutcheon et al. 1981; Kerslake et al. 2005). Hypothermia and cold exposure are major contributors to starvation/exposure mortality rates (Mellor & Stafford 2004). Lambs which have better resistance to cold exposure may have better insulative properties which result in increased survivability. Insulative properties include fleece, skin thickness, fat depth and eye muscle depth (EMD). Fleece characteristics have been looked into previously, therefore this study will focus on the subcutaneous traits of skin thickness, fat depth and EMD.

Heritability estimates of lamb survival have been reported as very low (0.02 – 0.13) (Kerslake et al. 2005; Brien et al. 2010; Boujenane et al. 2013). In a study where the variable components of survival were considered separately at different time periods, including the first 24 hours after birth, the derived heritability estimate was 0.63 (Boujenane et al. 2013). Although the heritability estimate of skin thickness measured with skin-fold callipers in 30-hour-old Merino lambs was estimated at 0.35±0.19 (Slee et al. 1991), skin thickness has not been directly related to lamb survival. Heritability estimates of fat depth over the *M. Longissimus dorsi* at the 12th rib in 14-month-old Romney sheep has been reported as 0.29 (McEwan et al. 1993). Using a flock of Coopworth sheep selected for increased backfat thickness Jopson et al. (2000) reported that sheep with a higher backfat thickness had thicker skin and a higher survival rate than low backfat sheep. While EMD has been reported as having a positive genetic correlation with lamb survival to weaning of 0.17±0.07, the same authors reported a negative phenotypic correlation for the same relationship of -0.04±0.02 (Brien et al. 2013).

The lamb survival estimated breeding value (eBV) calculated by Sheep Improvement Limited (SIL) includes a very high economic value for survival reflecting the relatively high value of saleable lambs compared with other products derived from sheep on the same farm (Young & McIntyre 2006; Beef+Lamb New Zealand 2014).

The aim of this paper is to determine the relationships between the insulative properties of skin thickness, fat depth, EMD and lamb survival eBV; and to estimate the heritability of these traits.

Materials and methods

Data

Data were collected on four Terminal Romneys for Increased Genetic Gain (TRIGG) farms as part of normal farm operations. Ewe and ram lambs on each farm were grazed in separate mobs from weaning onwards. Not all lambs that were weaned had ultrasound measurements taken. Skin thickness, fat depth and EMD were recorded in eight-month-old Romney lambs, on the left side of the animal at the 'C' site over the *M. Longissimus dorsi*, approximately 50 mm from the centre of the backline without clipping the wool (Brown et al. 2000). An ultrasound scanning machine (Sonosite M Turbo) using a

38 mm probe at 7.5 Mhz set at a depth of 40 mm was used by a commercial operator to take the measurements. Live weight (LW8) was measured at scanning. Scans were all completed within 2 days each year. Additional data were obtained from SIL which included survival eBV, weaning weight, flock, sex, birth rank, date of birth, dam identity and sire identity. The survival eBV for each of the recorded lambs are calculated by SIL based on lambs born that died before weaning (Young & McIntyre 2006). Data cleaning occurred to remove individual records which had a birth rank of 4 (n=84) or 5 (n=5), fat depth of zero (n=1) and no sire recorded (n=356). The remaining data set included individual records for 19,436 lambs born to a total of 160 sires and 5,599 dams.

Statistical analysis

SAS (Version 9.4, SAS Institute Inc., Carey, North Carolina, USA, 2014) was used for data analysis. Raw means and standard deviations were calculated for weaning weight, LW8, skin thickness, fat depth, EMD and survival eBV.

Regression coefficients among skin thickness, fat depth, EMD and survival eBV were calculated. A general linear model that included the fixed effects of flock, year, sex, birth rank; and skin thickness, fat depth or EMD of the sire as covariates to determine the effect of the sire traits on skin, fat, EMD and survival eBV of the progeny were used.

Heritabilities were determined using a mixed model that included the fixed effects of year, flock, birth rank and sex. Sire was included as a random effect. Only sires with at least 50 progeny were included in the heritability calculation.

Results

Descriptive statistics of the traits after data cleaning are given in Table 1. There were a greater number of records of weaning weight than skin thickness. The records which had the greatest number of sires represented were the weaning weight and survival eBV (n=160).

Table 1 Number of individual eight-month-old lambs with records, number of the sires of the individuals, and mean ± standard deviation (SD) for weaning weight, live weight at ultrasound measurement, skin thickness, fat depth, eye muscle depth and survival estimated breeding value (eBV).

Trait	n[1] lambs	n sires	Mean ± SD
Weaning weight (kg)	14,888	160	29.0 ± 6.1
Live weight at ultrasound measurement (kg)	2,563	97	45.4 ± 5.7
Skin thickness (mm)	3,968	116	3.0 ± 0.4
Fat depth (mm)	4,340	124	3.0 ± 1.4
Eye muscle depth (mm)	2,982	110	25.6 ± 3.3
Survival eBV (%)	19,436	160	0.04 ± 0.02

[1]number of lambs or sires included in the analysis.

The number of progeny and number of sires included in each analysis and the regression coefficient ± standard error of the relationship between the progeny and sire data for skin thickness, fat depth and EMD and the progeny survival eBV are shown in Table 2.

Skin thickness, fat depth and EMD of the sires were all correlated ($P < 0.05$) with survival eBV of the progeny. Fat depth and EMD of the progeny increased with increasing skin thickness and fat depth of the sires ($P < 0.05$). EMD of the progeny also increased with increasing EMD of the sire.

Skin thickness and EMD of the sires had a significant positive relationship with survival eBV of progeny. For every 1mm increase in skin thickness and EMD there was an increase in survival eBV of 0.006±0.001% and 0.0004±0.0001% respectively. Fat depth of the sires had a significant negative relationship with survival eBV. Skin thickness of the sire had a positive regression coefficient ($P < 0.05$) with fat depth of the progeny.

Table 2 Number of eight-month-old progeny records and the number of sire records used in the analysis with the regression coefficient ± standard error between progeny skin thickness, fat depth, eye muscle depth (EMD) and survival eBV and the skin thickness, fat depth and EMD of their sire. Values marked with an asterisk are significant at P <0.05.

	Sire trait								
	Skin thickness (mm)			Fat depth (mm)			Eye muscle depth (mm)		
Progeny trait	n[1] progeny	n sires	Regression coefficient	n progeny	n sires	Regression coefficient	n progeny	n sires	Regression coefficient
Skin thickness (mm)	854	35	0.06 ± 0.03	901	35	0.01 ± 0.01	328	21	-0.001 ± 0.008
Fat depth (mm)	860	35	0.22 ± 0.10*	907	35	0.32 ± 0.04*	333	21	0.00 ± 0.03
Eye muscle depth (mm)	793	21	0.66 ± 0.24*	840	21	0.56 ± 0.09*	328	21	0.13 ± 0.05*
Survival eBV (%)	3,734	38	0.006 ± 0.001*	4,037	38	-0.0008 ± 0.0002*	1,572	26	0.0004 ± 0.0001*

[1]number of lambs or sires included in the analysis

Weaning weight and EMD were highly heritable and skin thickness and fat depth were moderately heritable (Table 3).

Table 3 Number of eight-month-old progeny records and the number of sire records used to derive heritability estimate ± standard error of weaning live weight, skin thickness, fat depth and eye muscle depth.

Trait	n[1] lambs	n sires	Heritability estimates
Weaning live weight	16,770	90	0.60 ± 0.08
Skin thickness	6,892	27	0.21 ± 0.07
Fat depth	7,562	30	0.25 ± 0.08
Eye muscle depth	4,303	16	0.61 ± 0.23

[1]number of lambs or sires included in the analysis.

Discussion

The mean skin thickness, fat depth and EMD in this study were all consistent with previous reports for grazing sheep in New Zealand (Clarke et al. 1998; Jopson et al. 2000; Hall et al. 2002).

Weaning weight heritability estimate was 0.64±0.09 which was greater than the heritability estimate reported by Pickering et al. (2012) of 0.14±0.00. Their estimate was derived from 2 million recorded pedigree dual-purpose Romney sheep in New Zealand. The high heritability estimate found in the present study was most likely caused by using only a small data set with no maternal effect being fitted. Not allowing for maternal effects may result in an overestimation of the true heritability particularly given that there are a high proportion of related ewes in the TRIGG group.

While the heritability estimate for skin thickness of 0.20±0.07 would suggest that a moderate rate of genetic gain could be achieved with direct selection for this trait; the estimate may be overestimated, as was the case with the weaning weight heritability estimate, due to a limited number of sires in the analysis (Table 3). Nevertheless, the heritability estimate of skin thickness measured by skin fold callipers at tagging was reported as 0.35 (Slee et al. 1991). Variation between these estimates indicates that further investigation into the heritability of skin thickness would be warranted with an adjustment for the dam as well as for the sire.

The heritability estimate of fat depth at eight months of age was moderate (0.25±0.08), but similar to previous reports of 0.29 in New Zealand Romneys reported by McEwan et al. (1993), 0.29±0.05 in female and 0.24±0.06 in male six-month-old 'Lamb Supreme' lambs (Clarke et al. 1998) and, 0.28 and 0.31 reported by Atkins et al. (1991) for Australian Poll Dorset lambs which were four- to six-month-old and 12- to 16-month-old respectively.

The estimated heritability of EMD at eight months was 0.61±0.13 which is greater than 0.26 reported by McEwan et al. (1993), measured at 12 months of age in New Zealand Romney lambs. The heritability estimate in the current study is also greater than 0.15±0.06 reported by Gilmour et al. (1994) in five- to nine-months-old Australian Poll Dorset lambs at the C site using 161 sires. EMD in the current study was also measured at the C site. As heritabilities are population specific, McEwan et al. (1993) likely presents the more comparable study. The discrepancy between the current and previous estimates of EMD heritability could be a result of over-estimating heritability in the current study in a similar manner as for weaning weight.

Sire skin thickness at eight months of age had a positive association with survival eBV of progeny, which showed an increase in survival eBV by 0.006±0.001% for every 1 mm increase in skin thickness. Skin thickness had a moderate heritability estimate, therefore skin thickness could be selected for as an indirect measure of lamb survival eBV.

Sire fat depth was negatively related to progeny survival eBV, where for every 1 mm decrease in sire fat depth the survival eBV increased by 0.0008±0.0002%. Fat depth had a moderate heritability estimate, this suggests that fat depth could be selected against as an indirect measure of lamb survival eBV. However, skin thickness of the sire had a positive association with fat depth of the progeny. As fat depth of the sire had an insignificant regression coefficient with skin thickness of the progeny, it indicates that the sire fat depth does not influence the progeny skin thickness. Further information is required before a clear conclusion can be drawn on the relationships between skin thickness, fat depth and survival.

The EMD was related to survival eBV where for every 1 mm increase in EMD of the sire, survival BV of progeny increased by 0.0004±0.0001%. Brien et al. (2013) reported a positive genetic correlation between lamb survival to weaning and EMD (0.17) in agreement with the current study. As EMD showed a relatively high heritability estimate, EMD could be used as an indirect measure to increase lamb survival eBV. However, the small increase in survival eBV achieved from 1 mm increase in sire EMD suggests this approach would be too slow to be of practical use on-farm.

While thicker skin and greater EMD were associated with increased survival eBV, fat depth shows a negative influence on survival eBV. This may indicate that fat depth at the C site does not play a role in increasing the survival to weaning but skin thickness and EMD do.

In conclusion the data analysed in this study indicated that an increase in either sire skin thickness or sire EMD, or a decrease in sire fat depth were positively related to lamb survival eBV. This suggests these traits could be used as a means of increasing lamb survival although potential genetic gains per generation would be small. However, there are some limitations to this study in that it was based on a relatively small data set and maternal effects were not taken into account. Further investigation into these traits is warranted.

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References

Atkins KD, Murray JI, Gilmour AR, Luff AL 1991. Genetic variation in liveweight and ultrasonic fat depth in Australian Poll Dorset Sheep. Australian Journal of Agricultural Research 42: 629-640.

Beef+Lamb New Zealand 2014. New Season Outlook. p 28, Wellington.

Boujenane I, Chikhi A, Lakcher O, Ibnelbachyr M 2013. Genetic and environmental factors affecting perinatal and preweaning survival of D'man lambs. Tropical Animal Health and Production 45: 1391-1397.

Brien FD, Hebart ML, Smith DH, Edwards JEH, Greeff JC, Hart KW, Refshauge G, Bird-Gardiner TL, Gaunt G, Behrendt R, Robertson MW, Hinch GN, Geenty KG, van der Werf JHJ 2010. Opportunities for genetic improvement of lamb survival. Animal Production Science 50: 1017-1025.

Brien FD, Rutley D, Mortimer S, Hocking Edwards JE 2013. Genetic relationships between lamb survival and meat traits. Proceedings of the Association of Advancement of Animal Breeding 20: 237-240.

Brown DJ, Wolcott ML, Crook BJ 2000. The measurement of skin thickness in Merino sheep using real time ultrasound. Wool Technology and Sheep Breeding 48: 269-276.

Clarke JN, Nicoll GB, Mowat CM 1998. Genetic parameters for liveweight and live animal ultra-sound fat and eye muscle dimensions in a synthetic terminal sire breed. proceedings of the New Zealand Society of Animal Production 58: 140-142.

Gilmour AR, Luff AF, Fogarty NM, Banks R 1994. Genetic parameters for ultrasound fat depth and eye muscle measurements in live Poll Dorset sheep. Australian Journal of Agricultural Research 45: 1281-1291.

Hall DG, Gilmour AR, Fogarty NM, Holst PJ 2002. Growth and carcass composition of second-cross lambs. 2. Relationship between estimated breeding values of sires and their progeny performance under fast and slow growth regimes. Australian Journal of Agricultural Research 53: 1341-1348.

Jopson NB, Greer GJ, Bain WE, Findlay JA, McEwan JC 2000. Lamb survival traits in Coopworth sheep selected for high or low backfat depth. Proceedings of the New Zealand Society of Animal Production 60: 61-64.

Kerslake JI, Everett-Hincks JM, Campbell AW 2005. Lamb survival: a new examination of an old problem. Proceedings of the New Zealand Society of Animal Production 65: 13-18.

McCutcheon SN, Holmes CW, McDonald MF 1981. The starvation-exposure syndrome and neonatal lamb mortality: A review. Proceedings of the New Zealand Society of Animal Production 41: 209-217.

McEwan JC, Clarke JN, Hickey SM, Knowler KJ 1993. Heritability of ultrasounic fat and muscle depths in Romney sheep. Proceedings of the New Zealand Society of Animal Production 53: 347-350.

Mellor DJ, Stafford KJ 2004. Animal welfare implications of neonatal mortality and morbidity in farm animals. The Veterinary Journal 168: 118-133.

Morris ST, Kenyon PR 2004. The effect of litter size and sward height on ewe and lamb performance. New Zealand Journal of Agricultural Research 47: 275-286.

Pickering NK, Dodds KG, Blair HT, Hickson RE, Johnson PL, McEwan JC 2012. Genetic parameters for production traits in New Zealand dual-purpose sheep, with an emphasis on dagginess. Journal of Animal Science 90: 1411-1420.

Slee J, Alexander G, Bradley LR, Jackson N, Stevens D 1991. Genetic aspects of cold resistance and related characterisitcs in newborn Merino lambs. Australian Journal of Experimental Agriculture 31: 175-182.

Young MJ, McIntyre S 2006. Lamb Survival; SIL Technical note. p 4.