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Sire-line differences in lamb losses from starvation-exposure

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ABSTRACT

Sire-line differences in neonatal lamb mortality due to starvation-exposure (diagnosed using basic 'on farm' observations) were observed in five trials (1390 lambs in 15 sire-groups). After correcting for variations in lamb birth weight and in the cold challenge experienced by each lamb using logistic regression, sire-line differences in lamb mortality due to starvation-exposure were detected in flocks where the cold challenge and the number of progeny in each sire line was sufficient ($P < 0.05$). Although sire-line differences in lamb mortality due to starvation-exposure were detected independent of birth weight, the analyses revealed that birth weight is still the largest influence upon lamb mortality due to cold exposure ($P < 0.05$). These results confirm that due to the large and contradictory role that birth weight has in influencing lamb survival, it is extremely important to record and account for it in any attempt to breed for enhanced lamb survival. The detection of sire-line differences in lamb mortality due to starvation-exposure independent of birth weight could provide a basis to select for improving lamb survival, thus raising the efficiency of lamb production.

Keywords: sheep (*Ovis aries*); cold tolerance; birth weight; climate.

INTRODUCTION

Neonatal lamb mortality due to starvation-exposure is responsible for a loss of approximately NZ$40 million dollars to the New Zealand sheep industry per annum (Gudex, 2001). This figure is likely to be conservative, as it does not account for the loss of selection potential incurred. The losses also pose a welfare problem and therefore a risk to the sheep industry.

Genetic variation in neonatal cold tolerance has been detected not only between, but also within breeds of sheep (Slee, 1985; Wolff *et al*., 1987). This suggests that breeding for improved cold tolerance could be used to improve neonatal survival. However, these results were obtained using laboratory-based techniques to assess cold tolerance, and while they are considered indicative of a lamb's ability to survive cold exposure in the field (Slee *et al*., 1980; Slee, 1985), they are not suitable for use by breeders. By comparison, this study used simple field techniques that are readily available to breeders with minimal or no training, to evaluate the extent to which sire-line variation in losses from starvation-exposure occur, and how this could be used to improve lamb survival in a practical or 'on-farm' situation.

MATERIALS AND METHODS

Flocks used in the trials

Five trials were analysed in total. Two trials involved a single Borderdale flock studied over two lambings. At the first lambing (year 1), the flock comprised of 170 ewes mated in four sire groups and for year 2 it comprised of 135 ewes mated in two sire-groups. The other trials involved a Merino flock of 150 ewes mated in three sire groups and a flock of Coopworth ewes mated to one of three Merino and three Dorset Down sires (total 420 ewes). All ewes in this study were maintained on the Research or Ashley Dene farms at Lincoln University.

Field observation and diagnosis at birth

The age of the ewe, sire, gender, date of birth, birth rank, and the birth weight of the lamb were all recorded, along with the probable cause of death and date of death for all dead lambs. The diagnosis of lamb death due to starvation-exposure was based upon field observations during lambing, using a technique similar to that used by Purser and Young (1964). Dead lambs were classified as having died from starvation-exposure if they died within four days of birth and no other cause of death was obvious, such as a swollen head (dystocia), membranes over the nose (suffocation), unbroken feet membranes (stillborn) or birth defects (poor development or mummification). Lambs that were revived by artificial warming were classified as having died from starvation-exposure.

Climate observations

Daily weather data were collected from the Lincoln University Weather Station at the Research Farm (9.15 km from Ashley Dene). Variables recorded included precipitation (mm/day), average temperature (°C) and the total wind run per day (km/day). Any missing data from the weather station were replaced with long-term mean values for the month. These values were used to calculate the average rate of heat lost (HL) per unit of surface area, by a lamb under given weather conditions on either the day of cold-induced death (if applicable), or the day of birth for each lamb. The predicted rate of heat loss was calculated using the

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following equation derived by Coronato (1999) from the data of Mount and Brown (1982). The equation is:

$HL = 40.38 - (2.12 \times T) + (5.84 \times W) + (0.73 \times P)$

Where: HL = the average predicted rate of heat loss per unit of surface area by a lamb under given weather conditions, measured in watts per square metre (W/m^2)
T = average daily temperature (°C)
W = average daily wind speed (m/second)
P = the daily precipitation (mm)

Statistical analyses

The strength of the univariate relationships between potential predictors and lamb mortality due to cold exposure was assessed using Chi-square tests (categorical variables) and *t*-tests (continuous variables). Given the strong potential for inter-relationships among the predictors of lamb mortality, which could lead to unstable parameter estimates in a multivariate analysis, the inter-relationships between the predictor variables was evaluated using Chi-square, 1-way ANOVA and correlation tests. Predictor variables without strong inter-relationship(s) and showing some association with lamb mortality due to cold exposure were retained for subsequent analysis using logistic regression, along with the most significant variable of any related pairing. A second logistic regression model utilising these variables and the square of birth weight was used to analyse the quadratic effect of birth weight.

RESULTS

Of the 1390 lambs born in this study, 16.5% died and starvation-exposure was the diagnosed cause of 68% of deaths (11.2% of all lambs born). When sire-lines were compared for the incidence of lamb mortality due to cold using Chi-square methodologies, sire effects were significant at the 5% level within the Coopworth – Dorset Down, Merino and Borderdale (year 1) trials (Table 1). Variation between sire-lines was significant at the 10% level within each trial.

Birth weight and the climatic conditions present at birth significantly influenced lamb mortality due to starvation-exposure across all trials. Lighter lambs were more susceptible to death from starvation-exposure ($p < 0.05$), particularly at birth weights below 2.5 kg (Figure 1) and poorer climatic conditions (approximately > 120 W/m^2) were also associated with higher mortality ($P < 0.05$) (Figure 2). The profile of the climatic conditions encountered during each trial is shown in Table 2. The quadratic effect of birth weight was found to be non-significant in all trials ($P > 0.05$). As the litter size increased, the lamb mortality due to starvation-exposure increased significantly in the Coopworth – Merino ($P = 0.001$); Merino ($P = 0.010$), but not in the Borderdale (year 1) ($P = 0.402$); Coopworth – Dorset Down ($P = 0.055$) or Borderdale (year 2) ($P = 0.056$) trials. The age of the dam at lambing and lamb gender had no apparent effect upon lamb mortality due to starvation-exposure ($P > 0\ 05$) in any of the trials.

Birth weight was negatively correlated with litter size in all trials ($P < 0.005$) and variation between sire-lines in birth weight was also detected in the Merino ($P = 0.062$) and both Borderdale ($p < 0.001$) trials, though not in the Coopworth – Dorset Down, ($P = 0.801$) or Coopworth – Merino ($P = 0.640$) trials. No relationships were found between any other predictor variables.

Logistic regression of sire line variation in lamb mortality due to starvation-exposure, correcting for variation in birth weight and the climatic conditions present at birth revealed variation between sire lines in the Coopworth – Dorset Down ($P = 0.018$) and Merino ($P = 0.005$) trials. No sire line variation in lamb mortality due to cold exposure was observed in either Borderdale (year 1, $P = 0.116$ and year 2, $P = 0.859$) or Coopworth – Merino ($P = 0.167$) trials. The predicted rate of heat loss variable in the logistic regression model was found to be associated with lamb mortality due to starvation-exposure in the Borderdale (year 2) ($P < 0.001$), Coopworth – Merino ($P < 0.001$), and Merino ($P = 0.035$) trials (Figure 2). It was not however linked with lamb mortality due to starvation-exposure in the Borderdale (year 1) ($P = 0.230$) or Coopworth – Dorset Down ($P = 0.566$) trial.

DISCUSSION

The presence of variation between sire lines in neonatal lamb mortality due to starvation-exposure suggests that genetic differences in neonatal lamb cold tolerance can be detected in the field using a simple lamb death diagnostic test. These results mirror those found by Slee and Stott (1986), who found variation in the cold resistance of lambs within a breed (Scottish Blackface). They utilized a laboratory-based test (the time required to induce a decline in body temperature in a chilled water bath) to determine the cold resistance of 200 lambs and subsequently used the highest and lowest four rams in each generation in a four generation breeding programme. Lamb cold resistance responded to positive selection with a heritability of 0.27, while negative selection had a heritability of 0.17. The presence of variation between sire-lines in neonatal lamb mortality due to starvation-exposure could provide a basis for genetic improvement in lamb survival by breeding in flocks where lamb mortality due to cold exposure is a concern.

Such genetic improvement of lamb survival is attractive, as the costs involved are relatively small and non-recurrent in contrast to the alternatives of improving nutrition, shelter or increasing the amount of shepherding (Haley *et al.*, 1987). Key conditions required by this test are large sire groups to insure statistical accuracy and the presence of ‘bad’ weather to provide an adequate cold challenge.

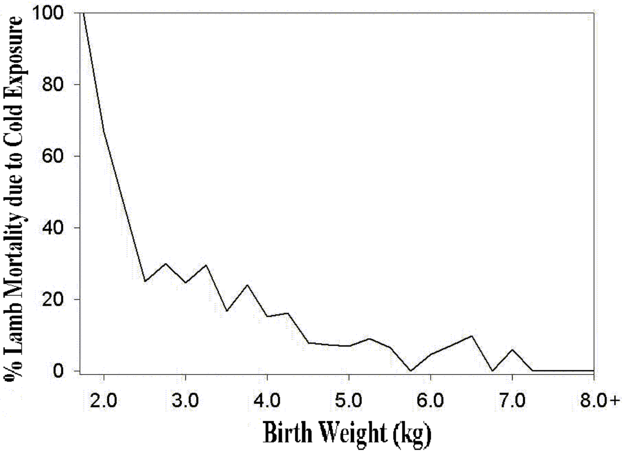
TABLE 1: The lamb mortality caused by starvation-exposure for each sire-line. Significant differences ($P < 0.05$, univariate analysis) between sires within trials in lamb death due to starvation-exposure are represented by different alphabetic subscripts for those trials showing significant sire-line effects. (B = Borderdale, M = Merino, DD = Dorset Down).

Ewe breed	Sire (breed)	Number of lambs born	% Lambs that died from starvation-exposure
Borderdale (Year 1)	4/97 (B)	76	14_a
	25/94 (B)	60	3_b
	16/95 (B)	72	13_a
	82/95 (B)	59	7_{ab}
Borderdale (Year 2)	263/98 (B)	63	8
	266/98 (B)	166	17
Coopworth	8512 (M)	150	11_a
	8255 (M)	121	11_a
	8585 (M)	89	8_b
	129/97 (DD)	128	5_a
	238/97 (DD)	97	3_a
	122/98 (DD)	157	13_b
Merino	26 (M)	54	6_a
	132 (M)	43	33_b
	356 (M)	51	25_b

TABLE 2: Profile of the daily averages in the climatic parameters experienced by each flock during the lambing period.

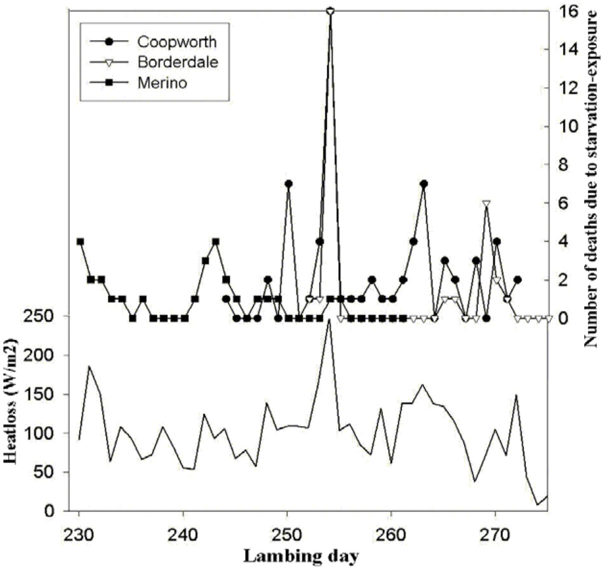
Flock		Range (mean)
Borderdale (Year 1)		
	Temperature (°C)	6 – 15 (10)
	Wind Speed (m/second)	2-22 (12)
	Precipitation (mm)	0 – 16 (1)
	Heat loss per unit of surface area (W/m^2)	36 – 158 (91)
Borderdale (Year 2)		
	Temperature (°C)	0 – 16 (10)
	Wind Speed (m/second)	0 – 34 (16)
	Precipitation (mm)	0 – 29.4 (3)
	Heat loss per unit of surface area (W/m^2)	7 – 249 (116)
Coopworth		
	Temperature (°C)	5 - 18 (9.7)
	Wind Speed (m/second)	6 - 34 (19)
	Precipitation (mm)	0 – 29 (2.5)
	Heat loss per unit of surface area (W/m^2)	105 – 249 (140)
Merino		
	Temperature (°C)	4 – 12 (9)
	Wind Speed (m/second)	5 – 34 (13)
	Precipitation (mm)	0 – 99 (7)
	Heat loss per unit of surface area (W/m^2)	53 – 249 (101)

FIGURE 1: Lamb mortality due to starvation-exposure in each birth weight class for all of the trials.



The diagnosis of lamb death due to starvation-exposure is made difficult because of the interactions with infection, dystocia, mothering ability and birth coat, which can predispose lambs to death from cold exposure (Alexander, 1984). This study used a technique that ruled out other causes of death rather than actually diagnosing death from starvation-exposure. While this technique is thought to have possibly overestimated cold deaths, it is easily carried out by non-science or 'veterinary-trained' people (farmers) and is cheaper and less time consuming than autopsies (Forrest *et al.,* 2003). The autopsy method originally developed by MacFarlane (1965) is commonly used but underestimates deaths from cold exposure (Alexander, 1985) and overestimates deaths from dystocia (Haughey, 1980).

FIGURE 2: The average predicted daily heat loss and lamb mortality due to starvation-exposure on each trial day at the Lincoln site (not including Borderdale Year 1).



Due to the large influence of birth weight upon lamb mortality from starvation-exposure, the sire-line variation in birth weight detected in this study and in those by McGuirk *et al.*, (1982) and Dwyer *et al.*, (2001) raises the question whether selection for birth weight as a method of improving lamb survival would be better than selection for cold tolerance. This approach may be favoured because direct selection for birth weight is simple and removes the requirement for a cold challenge, which is impossible to standardise across all lambs in a commercial flock (Haley *et al.*, 1987). However, increasing lamb survival via selection for higher birth weight is difficult due to correlation between higher birth weights and death from dystocia (Scales *et al.*, 1986).

In two of the trials analysed here, sire-line variation in cold mortality independent of birth weight was detected, suggesting that factor(s) other than birth weight were responsible for the increased neonatal cold tolerance. Recently, variation in the gene coding the β_3 adrenergic receptor has been linked with variation in cold tolerance (Forrest, *et al.,* 2003). The β_3 adrenergic receptor is a key component in the catecholamine stimulation of brown adipose tissue (Strosberg, 1997), that is the principle site of non-shivering thermogenesis (heat production) in the newborn lamb (Alexander & Williams, 1968). Other heritable traits that have been identified as influencing neonatal lamb cold tolerance can be grouped into three main groups: behavioural, physical (mainly insulative – also includes birth weight) and thermogenic traits (Slee, 1985). Early vigour, suckling drive, maternal care and maternal bonding are all traits classified as behavioural, while skin thickness, birth-coat type and length are classified as physical traits.

This study shows that variation between sires in neonatal cold tolerance exists within a range of breeds and that field trials utilising simple diagnosis of the cause of death are sufficient to detect this variation in the presence of an adequate cold challenge. In order to prevent any unwanted genetic alteration of birth weight (and possible consequences with dystocia), birth weight must be recorded and analysed in conjunction with neonatal lamb mortality due to cold exposure. This method of analysing neonatal lamb mortality due to starvation-exposure could provide a basis for selection for improving the number of lambs surviving and thus raise the efficiency of lamb production, particularly in flocks suffering large losses prior to weaning. The variation between sires was large enough to be detected in a single generation, which means that genetic gain could be made over one generation by the selection of 'superior' parents. This is especially relevant to production systems that utilise terminal sires where benefits need to be exhibited by the progeny.

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REFERENCES

Alexander, G. 1984: Constraints to lamb survival. *In:* Lindsay, D.R; Pearce, D.T. (*eds.*) *Reproduction in Sheep*. Canberra, Australian Academy of Science. pp 199-204

Alexander, G. 1985: Physiological and behavioural factors affecting lamb survival under pastoral conditions. *In:* Alexander, G; Barker, J.D; Slee, J. *eds* Factors affecting the survival of new born lambs. Luxembourg, Commission of the European Communities. pp 99–114

Alexander, G.; Williams, D. 1968: Shivering and non-shivering thermogenesis during summit metabolism in young lambs. *Journal of physiology 198:* 251-276

Coronato, F. 1999: Environmental impacts on offspring survival during the lambing period in Central Patagonia. *International journal of biometeorology 43:* 113-118

Dwyer, C. M.; Lawrence, A. B.; Bishop, S. C. 2001: The effects of selection for lean tissue content on maternal and neonatal lamb behaviours in Scottish Blackface sheep. *Animal science 72:* 555-571

Forrest, R.H; Hickford, J.G.H; Hogan, A; Frampton, C. 2003: Polymorphism at the ovine β_3-adrenergic receptor locus: associations with birth weight, growth rate, carcass composition and cold survival. *Animal genetics 34:* 18-25

Gudex, B.W. 2001: Sire-line variation in neonatal lamb cold tolerance. *M.Sc. Thesis.* Lincoln University

Haley, C. S.; Cameron, N. D.; Slee, J.; Bland, R. 1987: Indirect selection. *In:* Fayez, I; Marai, M; Owen, J.B. (*eds.*). New Techniques in Sheep Production. London, Butterworths. pp 116-123

Haughey, K.G. 1980. The role in the pathogenesis of menigeal haemorrhage and congestion in newborn lambs. *Australian veterinary journal 56:* 49–56

MacFarlane, D. 1965. Perinatal lamb losses I. An autopsy method for the investigation of perinatal losses. *New Zealand veterinary journal 13:* 116 – 135

McGuirk, B. J. 1982: Improving lamb survival in merinos. *Animal production in Australia 14:* 23-35

Mount, L. E.; Brown, D. 1982: The use of meteorological records in estimating the effects of weather on sensible heat loss from sheep. *Agricultural meteorology 27:* 241-255

Purser, A. F.; Young, G. B. 1964: Mortality among twin and single lambs. *Animal production 6:* 321-329

Scales, G. H.; Burton, R. N.; Moss, R. A. 1986: Lamb mortality, birthweight, and nutrition in late pregnancy. *New Zealand journal of agricultural research 29:* 75-82

Slee, J. 1985. Genetic factors affecting cold resistance in relation to neonatal lamb survival. *In:* Alexander, G; Barker, J.D; Slee, J. *eds.* Factors affecting the survival of new born lambs. Luxembourg, Commission of the European Communities. pp 21-34

Slee, J.; Griffiths, R. G.; and Samson, D. E. 1980: Hypothermia in newborn lambs induced by experimental immersion in a water bath and by natural exposure outdoors. *Research in veterinary science 28:* 275-280

Slee, J.; Stott, A.W. 1986. Genetic selection for cold resistance in Scottish blackface lambs. *Animal production. 43:* 397-404

Strosberg, A.D. 1997: Structure and function of the β_3 – adrenergic receptor. *Annual Review of Pharmacology and Toxicology 37:* 421-450

Wolff, J. E.; Baker, R. L.; Dobbie, P. M.; Ford, A. J.; Jordan, R. B. 1987: Genetic aspects of cold resistance in newborn lambs. *Proceedings of the New Zealand Society of Animal Production 47:* 93-98