
VOLUME 62 2002

ISSN 0370-2731/2000 Proceedings of the New Zealand Society of Animal Production **60:** 61-64

Lamb survival traits in Coopworth sheep selected for high or low backfat depth

N.B. JOPSON, G.J. GREER, W.E. BAIN, J.A. FINDLAY AND J.C. MCEWAN

AgResearch, Invermay Agricultural Centre, Private Bag 50034, Mosgiel.

ABSTRACT

Consumer preferences for lean healthy meat have driven genetic selection for leanness in the terminal sire and dual purpose sheep industries over the last 20 years. The Invermay Coopworth lean and fat selection lines were established in 1980 to study the effects of selection for live weight adjusted leanness on carcass traits, and the correlated responses in other traits. This paper reports the findings of two year's data on lamb survival and performance in the lean and fat selection lines. Records were collected from 817 lambs comprising 325, 337 and 155 from the fat, lean, and a random-bred control line, respectively. Neo-natal mortality was not significantly different between the three lines, with approximately 93% of lambs born surviving until tagging. Lamb survival from tagging until weaning differed significantly between the selection lines ($P<0.05$), with fat line animals having 10.9% better lamb survival than lean line animals (95.5 verses 84.6%), after adjusting for differences in year, birth weight, birth rank, skin thickness, wool length, age of dam, mothering ability and ewe udder volume. Fat line lambs were 0.9 ± 0.1kg (mean ± SEM) lighter than lean line animals, with control line animals intermediate. Udder volume (as measured by water displacement) did not differ between the three lines. Mothering ability (as measured by distance from ewe to the new born lamb during handling in the field) did not differ significantly between the lean and fat lines. Fat line lambs had thicker skins than lean line lambs at the same birth weight ($P<0.01$), but had no difference in wool length. The differences in lamb mortality between the lean and fat lines cannot be fully explained by differences in birth weight, indicating some physiological difference between the lines affecting survival.

Keywords: Sheep; selection; leanness; survival

INTRODUCTION

Selection to increase carcass weight without the correlated increase in carcass fatness has been a feature of the New Zealand sheep industry over the last two decades (Clarke and Rae, 1991). There is anecdotal evidence that selection for large lean carcasses has resulted in higher lamb mortality, but to date there has been little experimental data suitable to test this hypothesis. There have been a number of selection experiments examining the direct and correlated effects of selection for high and/or low fatness in sheep (e.g., Bennett *et al.*, 1988; Cameron and Bracken, 1992; Morris *et al.*, 1997). Selection for leanness in Coopworth sheep has been shown to increase birth weight in lean and decrease birth weight in fat lambs relative to a randomly selected control line (Morris *et al.*, 1997). This would be expected to result in differences in survival between lines given the relationship between birth weight and survival (Hight and Jury, 1970; Alexander, 1984). Preliminary work in this area demonstrated differences between selection lines over and above that which could be explained by differences in birth weight, but the results required independent confirmation, because the lines were grazed and managed separately during lambing. The objective of the present experiment was to critically examine effect of selection for and against carcass fatness on neo-natal survival in the Invermay Coopworth Selection lines, with the lines grazed together under identical management conditions.

MATERIALS AND METHODS

Lamb survival data was collected from the 1997 and 1998 lambings of the Invermay Coopworth selection lines. These animals have been selected for and against live weight adjusted backfat thickness since the lines were established in 1980. A random-bred control line has also been maintained over this period. After 14 years and ten generations, the lean and fat lines were 3.6 phenotypic standard deviations apart in the selection trait (Morris *et al.*, 1997). Four rams from each selection line were selected to be used for mating within their selection line each year based on their animal-model BLUP breeding values. Control line rams were randomly selected. Each ram was mated to between 30 and 40 ewes from the same selection line for 20 days. Ewes were aged three to six years. Following mating, ewes from the three lines were grouped together and run as a single mob. During pregnancy, ewes were fed at a level to approximately maintain their conceptus-free body weight. Lambs were tagged within 12 hours of birth. Traits recorded at tagging included birth weight, sex, birth rank, wool depth and mid-side skin thickness using skinfold callipers ("Adipometer Skinfold Caliper", Fat Control Inc., Stewartstown, Pennsylvania, USA). A maternal behaviour score (mothering ability; MA) was also recorded at tagging for each ewe using a 5-point scale as described by O'Connor *et al.* (1985), where a score of 1 related to the ewe fleeing at the shepherds approach and showing no interest in the lamb, and a score of 5 related to the ewe staying close to the shepherd during lamb handling. A total of 299 ewes were used to produce 817 lambs over the two years of the experiment, comprising 325, 337 and 155 from the fat, lean and control lines, respectively.

Udder volume was measured at two, five and eight weeks post-parturition using a water displacement technique (Davis *et al.*, 1980). Volume was used as an indication of milk secretory tissue. Mastitis was measured in ewes for the 1997 lambing two weeks post-parturition. Two milk samples were collected per ewe, one from each gland. Mastitis was quantified using the RTM (rapid test for mastitis) test. Equal volumes of milk and test reagent (120ml of Nonidet 620P (Shell Chemicals) made up to one litre in deionized water with the addition of a small amount of bromo-cresol-purple) were mixed in a small beaker. Amount of gel formation was scored to grade the degree of mastitis with scores ranging from 0 (no gel formation) to 3 (a junket-like mixture). The incidence of mastitis was low with no consistent trend, so ewes were not tested in the second year.

During lambing beats, particular attention was paid to looking for dead lambs, and where possible, determining the cause of death (e.g., dystocia, uncleaned, mismothered, dead at birth, starvation/exposure) and age at death.

STATISTICAL ANALYSIS

Data were analysed using the PROC GLM procedure in SAS (SAS Institute Inc., 1992). Survival until tagging and survival from tagging until weaning were tested in models that included terms for selection line, year, birth date, birth rank, sex, age of dam, and the linear and quadratic effects of birth weight. Where appropriate, MA, ewe udder volume, lamb skin thickness and wool length were added to the model. Sire within selection line and year was fitted as a random effect and the selection line differences were tested using the sire-within-line degrees of freedom. First order interactions with genotype were tested and non-significant interactions ($P>0.05$) removed from the model. Selection line differences in birth and weaning weight, wool length, skin thickness and the ewe traits MA, udder volume and mating and pre-lamb live weight were analysed separately.

RESULTS

Ewe traits: The effects of selection line, number of lambs born (NLB) and age of dam on NLB, MA, udder volume 2 weeks post-partum, mean udder volume, and mating live weight are presented in Table 1. MA was the only trait in which there were significant differences between selection lines, but the differences were not significant between the fat and lean lines. Control line ewes had significantly higher MA scores than both the lean and fat line ewes. The differences in NLB were not significant between selection lines after adjustment for year, age of dam and mating weight. Ewes heavier at mating tended to have a higher NLB, and ewes bearing multiples had significantly larger udder volumes ($P<0.05$). Ewes became more protective (i.e., higher MA) of their lambs with increasing age and increasing NLB.

Lamb traits: Lamb traits potentially affecting neo-natal survival are presented in Table 2. Lean line lambs were 0.94kg heavier than their fat line contemporaries at birth ($P<0.001$), with control lambs intermediate after adjustment for year, birth weight, sex and age of dam. Selection line differences were no longer significant by weaning at 12 weeks of age. Difference in wool length between selection lines were not significant after adjusting for differences in birth weight (slope = 0.41mm/kg; SEM=0.07), birth rank, year, sex and age of dam. However, there were significant selection line differences in skin thickness, with lean line animals being almost 0.5mm less than fat line animals after adjustment for birth weight (slope =0.37mm/kg; SEM=0.06), birth rank, year, sex and age of dam. Single lambs were significantly heavier than multiple born lambs and males heavier than females. These differences were maintained through to weaning. Wool was significantly longer in females than their male contemporaries ($P<0.001$) at the same birth weight, but there were no differences between sexes in skin thickness. Age of dam had little effect on any of the lamb traits, with the exception of birth weight; albeit no primiparous 2 year old ewes were present. Birth weight increased as dams increased from 3 to 5 years of age. The difference in birth weight between lambs born to five or six year old dams was not significant.

Survival analysis: Average survival figures for the three lines are presented in Table 3 for models with and without adjustment for birth rank and birth weight effects. Selection line differences were not significant for any of the three models tested for survival until tagging. Selection line differences in survival from tagging until weaning were significant ($P<0.05$) for all three models. Differences in birth rank did not account for a significant amount of the variation in survival from tagging until weaning, when fitted with or without birth weight, in a model also adjusting for sex, age of dam, MA, wool length (0.02mm/% increase in survival; SEM = 0.01; $P<0.05$), skin thickness (0.03mm/% increase in survival, SEM = 0.01; $P<0.05$) and udder volume two weeks post-partum ($P>0.05$). Birth weight and birth weight squared terms (model 3) were both highly significant ($P<0.001$).

Lamb survival until tagging (i.e., within the first 12 hours of life) and from tagging until weaning, relative to birth weight are presented in Figure 1a and b, respectively. For the trait survival until tagging, the first order interactions between selection line and birth weight, and between selection line and birth weight squared were significant ($P<0.05$). These factors combined to produce differences in the optimum birth weight for survival between lines. They were 4.24, 4.43 and 4.78kg for the control, fat and lean lines, respectively. Age of dam was the only fixed effect to achieve significance ($P<0.05$) after adjustment for birth weight and selection line, with lamb mortality rates dropping with increasing ewe age. Birth weight differences appear to account for all the variation caused by NLB.

Survival data for the period from tagging to weaning differed in that the first order interactions of birth weight and birth weight squared with selection line were not significant. The survival curves for the selection lines were parallel, but with significantly different intercepts ($P<0.01$). The optimum birth weight for survival from tagging until weaning for all three lines was 5.01kg . Of the three lines, the fat line had the highest survival (95.5 ± 3.4%; least squares mean ± SEM), with the control and lean lines at 88.3 ± 4.1 and 84.6 ± 3.3% survival, respectively.

TABLE 1: Selection line, NLB and age of dam differences in ewe reproductive and weight traits.

Effect	NLB	Mothering ability	Udder volume 1 (l)	Mean udder volume (l)	Mating live weight (kg)
Line					
Fat	1.90	4.28	0.97	0.83	62.8
Control	1.98	4.59	0.86	0.75	65.2
Lean	2.08	4.26	0.97	0.82	65.1
Mean SEM	0.07	0.06	0.03	0.03	1.1
Significance	NS	**	NS	NS	NS
NLB					
1		4.15	0.84	0.71	61.9
2		4.37	0.99	0.82	62.8
3		4.62	0.96	0.86	68.5
Mean SEM	0.07	0.02	0.02	0.7	
Significance	***	***	***	***	
Age of dam					
3	1.97	4.10	0.88	0.75	61.8
4	2.05	4.35	0.88	0.76	63.8
5	1.95	4.36	0.91	0.80	64.9
6	1.96	4.69	1.04	0.89	67.1
Mean SEM	0.05	0.07	0.02	0.03	1.0
Significance	**	***	***	***	***

The model for NLB included fixed effects of year, selection line, age of dam, mating live weight and the first order interactions between selection line and mating weight and age of dam and mating weight, sire nested within selection line and year was included as a random effect. The model for all other traits included fixed effects for year, selection line, NLB and age of dam with sire nested within selection line and year as a random effect.

TABLE 2: Selection line, birth rank, sex and age of dam effects on traits potentially influencing lamb survival.

Effect	Birth weight (kg)	Weaning weight (kg)	Skin thickness (mm)	Wool length (mm)
Line				
Fat	3.89	24.2	3.56	6.54
Control	4.42	26.0	3.05	6.21
Lean	4.83	25.8	3.04	6.36
Mean SEM	0.10	0.7	0.11	0.15
Significance	***	NS	**	NS
Birth rank				
1	5.04	28.7	3.28	6.46
2	4.34	24.3	3.19	6.20
3	3.75	23.1	3.19	6.47
Mean SEM	0.06	0.7	0.09	0.12
Significance	***	***	NS	*
Sex				
Male	4.54	26.2	3.16	6.15
Female	4.21	24.5	3.28	6.60
Mean SEM	0.05	0.3	0.07	0.09
Significance	***	***	NS	***
Age of dam				
3	4.28	25.3	3.15	6.48
4	4.33	24.9	3.21	6.41
5	4.50	25.7	3.22	6.33
6	4.41	25.4	3.29	6.28
Mean SEM	0.07	0.4	0.09	0.12
Significance	*	NS	NS	NS

Models for birth and weaning weight included fixed effects of year, selection line, birth rank, sex and age of dam with sire nested within selection line and year as a random effect. Skin thickness and wool length models included the same effects, with the addition of birth weight and the first order interaction between selection line and age of dam.

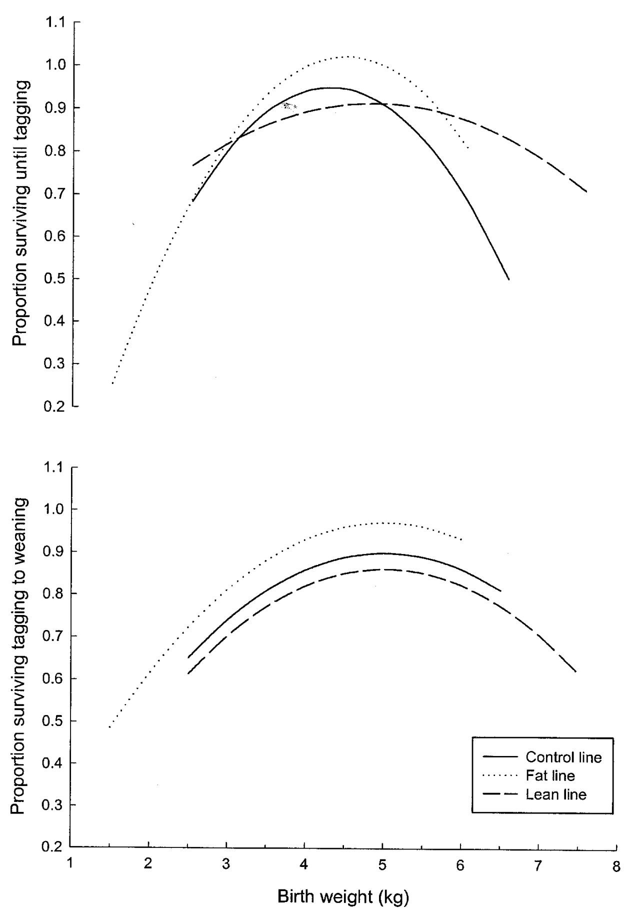
TABLE 3. Lamb survival differences (least squares means) between selection lines.

	Selection line			
	Fat	Control	Lean	mean SEM
Survival until tagging[†]				
model 1	0.97	0.93	0.90	0.03
model 2	0.96	0.92	0.89	0.03
model 3	0.98	0.92	0.89	0.03
Survival from tagging until weaning[§]				
model 1	0.96^{a}	0.90^{ab}	0.86^{b}	0.02
model 2	0.95^{c}	0.91^{cd}	0.87^{d}	0.02
model 3	0.97^{e}	0.90^{f}	0.86^{f}	0.03

[†] The base model (model 1) fitted selection line, sex, age of dam and year as fixed effects and sire nested within breed as random. Model 2 added birth rank as a fixed effect, and model 3 added terms for birth rank, birth weight and birth weight squared.

[§] The base model (model 1) fitted selection line, sex, MA, age of dam and year as fixed effects, wool length, skin thickness, and udder volume two weeks after parturition as covariates and sire nested within breed as random. Model 2 added the fixed effect birth rank, and model 3 added terms for birth rank, birth weight and birth weight squared.

FIGURE 1: Lamb survival curves relative to birth weight for the period from birth until tagging (top) and from tagging until weaning (bottom) for lean and fat selection lines, and a random-bred control line.



DISCUSSION

The results clearly demonstrate that selection for and against leanness has resulted in differences in lamb survival that cannot be accounted for by differences in birth weight, mothering ability, milk production, and some measures of insulation (skin thickness and wool length) or by differences between years. Selection has moved apart the curves for survival relative to birth weight, rather than the selection lines being in different regions of the same curve. When compared at the same birth weight, survival from tagging until weaning in the fat line is approximately 10% better than the control and lean lines.

Differences in MA have been reported to be correlated with improved lamb survival (O'Connor *et al.*, 1985), but the lean and fat lines did not differ in this trait. Likewise, udder volume, an indicator trait for milk production, did not differ between the lean and fat selection lines. Both lamb wool length and skin thickness at birth (adjusted for birth weight) were positively correlated with survival from tagging until weaning, but the selection lines only differed in skin thickness. Each millimetre increase in wool and skin thickness produced a 2.3 and 2.7% increase in lamb survival, respectively.

The optimal birth weights determined for survival in this experiment were similar to the 3.5 to 5.5kg range reported in the literature (Hight and Jury, 1970; Dalton *et al.*, 1980; Hinch *et al.*, 1983). While a greater proportion of the lean line lambs were in the optimum birth weight range compared to the fat line, the lower intercept meant that average survival was significantly lower. Analysis of the age at death data revealed that approximately two thirds of the lambs died during the first week of life and the remaining third were evenly distributed across the remaining 11 weeks until weaning. Post mortems were not conducted on dead lambs in this experiment (obvious causes of death were recorded), and the low total number of lamb deaths (n = 19 and 41 for the fat and lean lines, respectively) meant that the main causes of death between the lines could not be determined.

Most lamb mortality studies have identified a combination of starvation and exposure as the main cause of lamb death (Hight and Jury, 1970; Dalton *et al.*, 1980; Slee and Stott, 1986). While factors such as low birth weights tended to make lambs more susceptible to exposure, the results presented here have shown that variation in survival is greater than can be accounted for by variation in birth weight. Slee and his collaborators established that cold resistance in new born lambs was a trait with moderate to high heritability and sufficient genetic variation to select upon (Slee and Stott, 1986; Slee *et al.*, 1991). Slee and Simpson (1991) found that much of the differences in cold tolerance in lines of Scottish Black sheep selected for and against cold tolerance could be accounted for by the presence of a single gene which inhibits the normal metabolic response of newborn lambs to exogenous noradrenaline, with associated effects on non-shivering thermogenesis. In future experiments we will test cold resistance of new born lambs in the lean and fat selection lines to determine if the remaining variation in lamb survival is due to their ability to survive a cold challenge in the first week of life. At this stage it is uncertain if this observation of lamb survival differences after selection for reduced backfat depth is general or specific to this experiment. However, the importance of lamb survival suggests further that work is warranted.

REFERENCES

Alexander, G. 1984. Constraints to lamb survival. Pp. 199-209 In: Reproduction in Sheep, D.R. Lindsay; D.T. Pearce (eds.). Australian Wool Corporation Technical Publication, Australian Academy of Science, Canberra, ACT.

Bennett, G.L.; Meyer, H.H.; Kirton, A.H. 1988. Effects of selection for divergent ultrasonic fat depth in rams on progeny fatness. *Animal Production* **47:** 379-386.

Cameron, N.D.; Bracken, J. 1992. Selection for carcass lean content in a terminal sire breed of sheep. *Animal Production* **54:** 367-377.

Clarke, J.N.; Rae, A.L. 1991. Selection for lean and against fat in sheep. *Proceedings of the New Zealand Society of Animal Production* **51:** 401-404.

Dalton, D.C.; Knight, T.W.; Johnson, D.L. 1980. Lamb survival in sheep breeds on New Zealand hill country. *New Zealand Journal of Agricultural Research* **23:** 167-173.

Davis, S.R.; Hughson, G.; Farquhar, P.A.; Rattray, P.V. 1980. The relationship between the degree of udder development and milk production in Coopworth ewes. *Proceedings of the New Zealand Society of Animal Production* **40:** 163-165.

Hight, G.K.; Jury, K.E. 1970. Hill country sheep production II. Lamb mortality and birth weights in Romney and Border Leicester x Romney flocks. *New Zealand Journal of Agricultural Research* **13:** 735-752.

Hinch, G.N.; Kelly, R.W.; Owens, J.L.; Crosbie, S.F. 1983. Patterns of lambs survival in high fecundity Booroola flocks. *Proceedings of the New Zealand Society of Animal Production* **43:** 29-32.

Morris, C.A.; McEwan, J.C.; Fennessy, P.F.; Bain, W.E.; Greer, G.J.; Hickey, S.M. 1997. Selection for high or low backfat depth in Coopworth sheep: juvenile traits. *Animal Science* **65:** 93-103.

O'Connor, C.E.; Jay, N.P.; Nicol, A.M.; Beatson, P.R. 1985. Ewe maternal behaviour score and lamb survival. *Proceedings of the New Zealand Society of Animal Production* **45:** 159-162.

SAS Institute Inc. 1992. SAS Technical Report P-229, SAS/STAT Software: Changes and Enhancements, Release 6.07. SAS Institute Inc, Cary, N.C., 620 pp.

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

Slee, J.; Simpson, S.P. 1991. Description of the effects of a single gene which inhibits the normal metabolic response of newborn lambs to exogenous noradrenaline. *Research in Veterinary Science* **51:** 34-39.

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