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Lamb survival: a new examination of an old problem

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ABSTRACT

The overall aim of this project is to identify genetic markers for lamb survival. This paper reports the results from the first stage of the investigation aimed to identify the primary causes of lamb death from parturition to three days of age for highly fecund flocks. Flocks in the study consisted of 9 breeds and 12,000 breeding ewes and were located in New Zealand regions; Southland, Otago and Manawatu. All lambs were tagged and identified to their dam and sire. Lambs dead at birth and up to three days of age were collected (n = 1529), weighed, measured and examined by post mortem to determine cause and time of death. Primary causes of lamb death included: dystocia, starvation/exposure, amnion over nose, organ rupture, disease, and unknown.

The mean mortality rate from birth to weaning for the 20 flocks studied was 14 ± 0.6% (SEM) in singles, 16 ± 0.3% in twins and 29 ± 0.6% in triplets. The study showed that the predominant primary cause of lamb deaths from parturition to three days of age was dystocia (difficult births). The dystocia rate was highest for dead single lambs (57 ± 4.2% SEM) ($P < 0.05$), where there was an unexpectedly high incidence for dystocia for dead twin (46 ± 1.7% SEM) and triplet lambs (48 ± 2.3% SEM). This suggests that dystocia as a primary cause of lamb death may be underestimated within highly fecund sheep flocks. The high death rate from dystocia in twin and triplet lambs has not been previously reported and is currently under further investigation.

Key words: lamb survival; dystocia; post-mortem; cause of death; mortality; genetic; phenotypic.

INTRODUCTION

Improved lambing percentage is the biggest contributor to higher profits on New Zealand sheep farms (Geenty, 1997). The national mean lambing percentage from 2000-2003 was 119%, which was significantly greater than the 100% recorded ten years ago (1990-1993) (Anon, 2003). Davis *et al.* (1983) reported that as mean litter size increases above 1.7 the decline in single-bearing ewes is offset by an increase in triplet bearing ewes. The increased proportion of ewes having triplets is of concern to farmers and to industry as lamb mortality in the 24 hours post partum is assumed to be highest in triplets (Amer *et al*., 1999).

Lamb survivability is an increasing problem. Lamb losses of 30% have been recorded between pregnancy scanning and tailing (Aspin, 1997; Anon, 2003). Above a litter size of 2.3 lambs born per ewe lambing; farmers can expect a reduction in flock profitability (Amer *et al.,* 1999). Twin and triplet born lambs have higher mortality rates than singles (Johnson *et al*., 1982; Hinch *et al*., 1983; Scales *et al*., 1986; Hall *et al.,* 1988). The relationship between lambing rate and cause of lamb death in highly fecund ewes is poorly understood.

Lamb survival to weaning has a low heritability (0.02 - 0.13) suggesting that the scope for genetic selection to improve this trait is limited (Everett-Hincks *et al*., 2002 and 2005; Morris *et al*., 2000; Lopez-Villalobos & Garrick, 1999). A recent study has shown that when lamb mortality is analysed as component traits, that is death from difficult births, starvation and cold exposure, the heritability of the individual traits was higher (Southey *et al*., 2002). Identifying genetic differences between sires and developing genetic markers for component traits should enable farmers to improve lamb survival rates in their flocks through enhanced animal selection and breeding programmes. The overall aim of this project is to identify genetic markers for lamb survival. To identify genetic markers, large populations and extensive phenotyping are required. This paper reports the primary cause of lamb death from parturition to three days of age for the highly fecund flocks involved in the genetic investigation.

MATERIALS AND METHODS

Farms and Animals

Twenty performance recorded sheep flocks from thirteen farms were included in the study from the 2003 lambing season. They were located in New Zealand regions; Southland, Otago and Manawatu and had at least 10 years historical information and sire reference linkage to flocks in the study (Table 1).

Farmers recorded parentage, sex, birth rank, rearing rank and fate codes used by Sheep Improvement Limited (SIL) for all lambs. Lamb weight (kg), crown rump length (cm) and girth (cm) were measured on approximately 10% of live lambs at tagging (8-24 hours from birth). All information was recorded in lambing books or computerised data recorders.

TABLE 1: Farm participants, sheep breeds, number of breeding ewes, mean pregnancy scanning percentages and twin and triplet mortality rates for the flocks included in the 2003 study.

Flock	Flock location	Breed	Breeding ewes	Mean PS (live fetuses per ewe)	Mortality rate (twins)		Mortality rate (triplets)	
			(n)	(%)	(n)	(%)	(n)	(%)
A1	Wairarapa	Coopworth	1100	2.11	407	26.7	202	40.7
A2	Wairarapa	Lamb Supreme	235	1.74	68	24.8	19	45.2
B	Otautau	Romney	1172	1.95	224	14.8	69	31.1
C1	Invercargill	Romney	407	1.88	47	9.1	69	31.1
C2	Invercargill	Poll Dorset	160	2.15	19	9.2	8	12.7
D	Balclutha	Romney	409	2.05	78	15.1	38	26.3
E	Otautau	Texel	924	1.74	134	20.0	23	37.1
F1	Gore	Romney	630	2.03	173	21.2	73	41.2
F2	Gore	Growbulk	1217	2.08	355	20.5	155	41.0
G	Gore	Romney	454	1.96	151	25.7	47	53.4
H	Riverton	Romney	879	2.18	153	14.2	112	23.0
I1	Gore	Romney	506	1.83	139	25.3	20	51.3
I2	Gore	Coopworth	693	1.95	181	21.4	40	36.0
J	Te Anau	Lamb Supreme	669	1.75	139	18.2	48	39.0
K1	Riverton	Romney	287	2.16	65	16.8	45	40.5
K2	Riverton	TEFRom	654	2.04	78	8.9	56	20.3
K3	Riverton	Suffolk	105	1.76	24	16.4	-	-
L1	Winton	Romney	349	2.24	26	8.1	45	20.0
L2	Winton	Romney	352	2.26	87	10.5	49	24.0
M	Invercargill	Coopworth	535	2.21	87	13.1	80	27.8

Lamb Supreme: composite consisting predominantly of Romney, Dorset and Texel. Growbulk: 50% Romney, 25% Poll Dorset, 25% Texel. TEFRom: 50% Romney, 25% East Fresian, 25% Texel. PS = pregnancy scanning, determined by real time ultrasound scanner. Mortality rate = proportion of lamb losses from parturition to weaning.

Collection of dead lambs

Lambs dead at birth and up to three days of age were collected, identified and recorded by the farmer during daily shepherding. Dead lambs were collected from the farms every two days, individually bagged and frozen prior to transportation to AgResearch, Invermay Agricultural Centre where they underwent an extensive post-mortem procedure.

Post-mortem data

Each individual lamb was defrosted and its identity and sex recorded. Weight (kg), crown-rump length (cm) and girth diameter (cm) measurements were recorded. Broken or intact foot membranes and physical deformations were noted. The lambs then underwent an internal examination based on the post-mortem procedure developed by McFarlane (1965). The central nervous system was not examined. Spleen tissue and blood were collected for DNA extraction.

Determining cause and time of death

All lambs were assigned one or more causal signs of mortality based on post-mortem and farmer records. These causes included; primary dystocia (localised moderate/severe (> 3 mm) subcutaneous oedema on head, neck, brisket or rib cage), secondary dystocia (localised minor; visible, but not measurable) subcutaneous oedema on head, neck, brisket or rib cage), starvation/exposure (no brown fat on heart or kidneys), rupture (organ rupture), amnion over nose, unnatural (accident), disease (navel infection or watery mouth) and congenital abnormality (based on McFarlane (1965) and veterinary consultation). The terms primary and secondary dystocia were proposed by the authors. A lamb can have a range of causal signs associated with its mortality; therefore each lamb was assigned a primary and a secondary cause of death. The primary causes of death were categorised as follows; dystocia, starvation/exposure, amnion over nose, organ rupture, disease and unknown. The primary cause was assigned depending on the estimated chronological order of the causes resulting from the parturition process and post-parturient events.

Data management and analysis

Data were collected and entered into a custom designed Microsoft Access ® database. Lamb body size measurements were analysed using a univariate mixed linear model (PROC MIXED; SAS, 2003) which contained the fixed effects of lamb status (coded as‘0’ = dead and ‘1’ = alive at three days after birth) or primary dystocia signs (coded as ‘0’ = no dystocia signs and ‘1’ = dystocia signs), litter size, lamb sex, ewe age (two years and three years and older), flock and the interactions between the main effects. Date of birth was fitted as a covariate and retained in the model if statistically significant at $P < 0.05$ to help decide the pathways involved in the differences. The fixed effect interactions between lamb status and litter size, ewe age, sex and flock were only retained in the model if significant at P < 0.05, unless otherwise noted. Least squares means for the main factors affecting the trait of interest were estimated using SAS (SAS, 2003).

PROC CATMOD (SAS, 2003) was used to analyse categorical dependent causes of lamb death and weighted least square estimates for the fixed effects of litter size at birth obtained.

RESULTS

The mortality rate from birth to weaning for the 20 flocks studied was 14% ± 0.6% SEM in single lambs, 16% ± 0.3% SEM in twins and 29% ± 0.6% SEM in triplets. Lamb mortality rates from birth to weaning across flocks ranged from 8 to 27% in twin and 20 to 51% in triplet born lambs (Table 1).

Surviving twin and triplet lambs had significantly (P < 0.001) larger birth weight, crown rump length and girth diameters than twins and triplets that died between parturition and three days of age. Sex, ewe age and date of birth had a significant effect (P < 0.001) on all lamb body size measurements. Ram lambs and lambs born to mixed age ewes had larger lamb body size measurements than ewe lambs and lambs born to two-tooth ewes. There was a significant flock by litter size by lamb status interaction for all lamb body measurements (P < 0.001) (Table 2). Only birth weight data are presented in Table 2. The postmortem procedure identified 70% of dead lambs collected were alive at birth (breathed). Of those that breathed, 23% never walked and 55% of those that had breathed and walked had not fed.

The primary cause of lamb deaths from parturition to three days of age was dystocia (Table 3). Primary dystocia was more important in single than in twin deaths (P < 0.05) (Table 3). There was a significant (P < 0.01) flock by litter size interaction for dystocia rate in dead lambs. Ewe age, sex of lamb and birth date did not have an effect on primary cause of death (P > 0.05).

There was a significant flock by litter size by dystocia signs interaction for birth weight of dead lambs (P < 0.001) (Table 4). Twin born lambs that died with signs of primary dystocia were significantly heavier than twin born lambs that died of other causes (P < 0.05). However, triplet born lambs that died with signs of primary dystocia were not significantly heavier than triplet born lambs that died with no signs of primary dystocia.

TABLE 2: Weight of twin and triplet lambs that died and survived from parturition to 3 days of age within flock (least squares mean ± SE). Weights within litter size that have differing superscripts are different (P < 0.05).

	Twin lambs				Triplet lambs			
Flock	Survived		Died		Survived		Died	
	(n)	(kg)	(n)	(kg)	(n)	(kg)	(n)	(kg)
A1	31	4.6 ± 0.17^a	5	3.5 ± 0.21^b	7	3.8 ± 0.34^a	2	3.0 ± 0.45^b
A2	18	4.3 ± 0.22^a	9	4.2 ± 0.28^a	57	4.0 ± 0.13^a	29	3.4 ± 0.17^b
B	61	5.0 ± 0.12^a	84	4.4 ± 0.11^b	10	3.9 ± 0.29^a	21	3.2 ± 0.20^b
C1	40	5.7 ± 0.15^a	26	4.8 ± 0.18^b	5	5.1 ± 0.41^a	7	4.3 ± 0.34^b
C2	17	4.9 ± 0.22^a	14	4.1 ± 0.24^b	7	4.4 ± 0.34^a	6	3.4 ± 0.37^a
D	54	5.3 ± 0.13^a	26	4.3 ± 0.18^b	17	4.4 ± 0.22^a	19	3.9 ± 0.21^a
E	62	4.3 ± 0.12^a	52	3.8 ± 0.13^b	0		8	3.2 ± 0.32^a
F1	40	5.0 ± 0.15^a	53	4.2 ± 0.12^b	3	3.8 ± 0.52^a	29	3.7 ± 0.17^a
F2	65	4.9 ± 0.12^a	147	4.5 ± 0.08^b	15	4.7 ± 0.24^a	57	3.6 ± 0.12^b
G	32	5.2 ± 0.16^a	42	4.8 ± 0.13^b	0		28	4.0 ± 0.17^a
H	62	5.6 ± 0.12^a	59	4.9 ± 0.12^b	40	4.3 ± 0.15^a	52	3.9 ± 0.13^b
I1	44	4.3 ± 0.14^a	50	3.4 ± 0.12^b	12	3.4 ± 0.26^a	5	3.2 ± 0.40^a
I2	52	4.4 ± 0.13^a	68	3.4 ± 0.11^b	7	3.7 ± 0.34^a	19	3.1 ± 0.21^a
J	45	4.3 ± 0.14^a	29	3.5 ± 0.13^b	8	3.7 ± 0.32^a	28	2.8 ± 0.18^b
K1	35	5.0 ± 0.15^a	26	4.0 ± 0.18^b	6	4.1 ± 0.37^a	21	3.3 ± 0.20^a
K2	36	5.2 ± 0.15^a	34	4.4 ± 0.16^b	15	4.1 ± 0.23^a	24	3.7 ± 0.18^a
K3	13	4.5 ± 0.25^a	16	3.9 ± 0.22^a	0		3	3.4 ± 0.52^a
L1	20	5.8 ± 0.21^a	14	4.4 ± 0.24^b	2	5.8 ± 0.64^a	33	4.0 ± 0.17^b
L2	9	6.5 ± 0.31^a	19	4.3 ± 0.21^b	12	5.2 ± 0.27^a	24	3.9 ± 0.19^b
M	30	5.4 ± 0.17^a	38	4.6 ± 0.15^b	14	5.2 ± 0.24^a	34	3.8 ± 0.15^b
All	766	5.0 ± 0.04^a	811	4.2 ± 0.04^b	237	4.2 ± 0.07^a	450	3.5 ± 0.05^b

TABLE 3: Primary cause of lamb death for all dead lambs (percentage ± standard error). Percentages across litter size have differing superscripts are different (P < 0.05).

Primary Cause of Death	All (n =1529)	Singles (n = 140)	Twins (n = 907)	Triplets (n = 482)
Primary dystocia	47.6 ± 1.28	57.1^{a} ± 4.18	46.2^{b} ± 1.66	47.7^{ab} ± 2.28
Starvation/exposure	27.6 ± 1.11	20.0^{a} ± 3.38	29.2^{b} ± 1.51	26.9^{ab} ± 2.02
Unknown	9.09± 0.74	8.5^{a} ± 2.37	9.4^{a} ± 0.97	8.5^{a} ± 1.27
Secondary dystocia	8.7 ± 0.72	7.1^{a} ± 2.18	8.8^{a} ± 0.94	9.1^{a} ± 1.31
Disease	2.9 ± 0.43	1.4^{a} ± 1.00	2.4^{a} ± 0.51	4.3^{a} ± 0.93
Rupture	2.7 ± 1.14	4.2^{a} ± 1.71	2.6^{a} ± 0.53	2.4^{a} ± 0.71
Amnion over nose	1.1 ± 0.27	1.4^{a} ± 1.00	1.2^{a} ± 0.36	0.8^{a} ± 0.41
P (primary dystocia and other causes specified in table)	****	****	****	****

ns = not significant; P > 0.05; * P < 0.05; ** P < 0.01; *** P < 0.001; **** P < 0.0001

TABLE 4: Lamb birth weight comparison between lambs that died with primary dystocia signs and lambs that died with no signs of primary dystocia (other causes) (least squares mean ± SE). Weights within litter size that have differing superscripts are different (P < 0.05).

	Dead twin lambs					Dead triplet lambs				
Flock	Lambs (n)	Primary dystocia (%)	Primary dystocia (kg)	Other causes (%)	Other causes (kg)	Lambs (n)	Primary dystocia (%)	Primary dystocia (kg)	Other causes (%)	Other causes (kg)
A1	5			100.0	3.4 ± 0.44	2			100.0	3.1 ± 0.69
A2	9			100.0	3.7 ± 0.30	29	3.4	4.6 ± 0.98^{a}	96.6	3.4 ± 0.19^{a}
B	84	56.0	4.7 ± 0.15^{a}	44.0	4.0 ± 0.17^{b}	21	47.6	3.2 ± 0.31^{a}	52.4	3.3 ± 0.30^{a}
C1	26	38.5	5.4 ± 0.32^{a}	61.5	4.4 ± 0.25^{b}	7	71.4	4.7 ± 0.44^{a}	28.6	3.3 ± 0.69^{a}
C2	14	50.0	4.1 ± 0.38^{a}	50.0	4.1 ± 0.37^{a}	6	83.3	3.5 ± 0.44^{a}	16.7	3.5 ± 0.98^{a}
D	26	57.7	4.7 ± 0.26^{a}	42.3	3.7 ± 0.30^{b}	19	42.1	4.0 ± 0.35^{a}	57.9	4.0 ± 0.30^{a}
E	52	15.4	3.9 ± 0.35^{a}	84.6	3.7 ± 0.16^{a}	8	62.5	3.2 ± 0.44^{a}	37.5	2.8 ± 0.57^{a}
F1	53	67.9	4.4 ± 0.16^{a}	32.1	3.8 ± 0.24^{b}	29	55.2	3.8 ± 0.25^{a}	44.8	3.6 ± 0.27^{a}
F2	147	53.7	4.8 ± 0.12^{a}	46.3	4.4 ± 0.12^{b}	57	45.6	3.8 ± 0.19^{a}	54.4	3.5 ± 0.18^{a}
G	42	52.4	4.9 ± 0.21^{a}	47.6	4.6 ± 0.22^{a}	28	57.1	4.1 ± 0.25^{a}	42.9	4.0 ± 0.29^{a}
H	59	59.3	5.2 ± 0.17^{a}	40.7	4.6 ± 0.20^{b}	52	46.2	4.1 ± 0.20^{a}	53.8	3.9 ± 0.19^{a}
I1	50	32.0	3.4 ± 0.25^{a}	68.0	3.5 ± 0.17^{a}	5	80.0	3.5 ± 0.49^{a}	20.0	2.1 ± 0.98^{a}
I2	68	48.5	3.5 ± 0.18^{a}	51.5	3.4 ± 0.17^{a}	19	47.4	3.5 ± 0.33^{a}	52.6	2.7 ± 0.31^{a}
J	29	59.7	3.6 ± 0.20^{a}	10.3	3.5 ± 0.18^{a}	28	35.7	3.2 ± 0.32^{a}	64.3	2.6 ± 0.24^{a}
K1	26	50.0	4.2 ± 0.28^{a}	50.0	3.9 ± 0.27^{a}	22	45.5	3.7 ± 0.31^{a}	54.5	3.0 ± 0.28^{a}
K2	34	44.1	4.6 ± 0.26^{a}	55.9	4.3 ± 0.23^{a}	24	45.8	3.9 ± 0.30^{a}	54.2	3.5 ± 0.27^{a}
K3	16	18.8	4.4 ± 0.57^{a}	81.3	3.9 ± 0.27^{a}	3	33.3	2.6 ± 0.98^{a}	66.7	3.9 ± 0.69^{a}
L1	14	42.9	4.6 ± 0.41^{a}	57.1	4.3 ± 0.35^{a}	33	57.6	3.9 ± 0.35^{a}	42.4	4.3 ± 0.57^{a}
L2	19	47.4	4.5 ± 0.33^{a}	52.6	4.2 ± 0.31^{a}	24	66.7	3.8 ± 0.25^{a}	33.3	4.1 ± 0.29^{a}
M	38	65.8	4.6 ± 0.20^{a}	34.2	4.6 ± 0.27^{a}	34	79.4	3.8 ± 0.19^{a}	20.6	4.3 ± 0.37^{a}
Average	811	46.2	4.4 ± 0.06^{a}	53.8	4.1 ± 0.06^{b}	450	47.7	3.6 ± 0.07^{a}	52.3	3.4 ± 0.07^{a}

DISCUSSION

The primary cause of lamb death from parturition to 3 days of age was dystocia. Over half of the dead single lambs (57%) and nearly half of the dead twin (46%) and triplet lambs (48%) died with signs of dystocia. Localised subcutaneous oedema is a sign of birth pressure and in this study was used as an indicator of difficult births. Haughey (1991) suggested that between 20-60% of neonatal lamb deaths pathologically categorised as starvation/exposure are actually consequences of birth stress. In this study 24% of lambs with starvation exposure signs had experienced birth stress and were therefore diagnosed as primarily dying from dystocia.

The second predominant cause of death was starvation/exposure. Starvation/exposure with no physical signs of birth stress was diagnosed in 20% of dead single, 29% of dead twin and 27% of dead triplet lambs. Previous research has shown that under New Zealand conditions starvation/exposure accounts for approximately 30% of newborn lamb losses (McCutcheon *et al.,* 1981) which is similar to what is reported in this study. Other primary causes identified in this study accounted for 1-9% of total lamb mortality.

The high rate of dystocia has not been previously reported in twin and triplet lambs. In this study dystocia was the primary cause of death in 57% of the dead single lambs and 47% of the dead multiple lambs. A previous New Zealand study has shown dystocia rates of 27% in dead single lambs and 17% in dead multiple lambs (Dalton, 1980). Dalton's paper fails to reference the post-mortem procedure used and therefore it is impossible to identify whether the differing results reported between studies were due to differences in clinicopathological diagnoses. We must also consider that Dalton's research was performed approximately 6 generations ago, during which time selective breeding for increased fecundity, growth and meat yield traits may have resulted in a change in the major cause of lamb death in New Zealand flocks.

Dystocia occurrence is due to a number of complex factors. Dystocia can be a consequence of lamb birth weight, sire breed, dam pelvic conformation (Fogarty & Thompson, 1974), malpresentation, maternal overfeeding or prolonged parturition (Sargison, 1997). In addition, lambs that endure difficult births have trouble maintaining body temperature and have inhibited behaviours in teat searching and suckling (Eales *et al.,* 1982). This can increase the chances of death when subjected to cold stress or under-nutrition.

Lamb birth weight has been reported as the predominant factor leading to dystocia in single lambs (Fogarty *et al.*, 1992). However, in this study, birth weight is unlikely to be the main reason for high dystocia rates in larger litters. Across all flocks in this study, there were no significant weight differences between triplet lambs that died with signs of primary dystocia compared to triplet lambs that died with no signs of primary dystocia (other causes). In addition, only half of the flocks had a significant birth weight difference between twin lambs that died with primary dystocia signs and twin lambs that died with no signs of dystocia. The high rate of deaths from dystocia in twin and triplet lambs was unexpected. It may indicate that dystocia as a primary cause of lamb death is underestimated within highly fecund sheep flocks. The dystocia differences observed in this study in singles and multiples were not consistent across all flocks (Table 4). The variability between farms in dystocia rate offers hope that a genetic or management solution may be able to alleviate this problem. A better understanding of lamb mortality, the mechanisms which cause dystocia and the relationship between birth difficulty and levels of oedema are currently under further investigation.

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