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Effects of birth weight on survival in twin born lambs

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ABSTRACT

Lamb survival to weaning decreases as litter size increases (single > twin > triplet > quads), with birth weight being a major factor affecting survival. The purpose of the present study was to investigate the effects of birth weight (BWT) and related traits on survival in twin born lambs. Data from a total of 3,834 twin lambs born to mixed aged ewes were analysed. For statistical analysis the lambs were allocated according to birth weight (BWT) within litter to three groups (Light = Lightest lambs within pairs, Equal = Lambs of similar weight within pairs and Heavy = Heaviest lambs within pairs). The survival rates differed ($P < 0.05$) between Light, Equal and Heavy (80%, 89% and 83%, respectively). BWT was positively related ($P < 0.001$) to survival in the Light group, but not in the other two groups. The smaller the difference in BWT between siblings, the higher the likelihood of the Light lambs surviving. Therefore, reducing the difference in BWT within a set of twins will have the potential to increase overall lamb survival.

Keywords: sheep, twin, survival, birth weight**.**

INTRODUCTION

Lambing percentage is a major contributor to higher profits on New Zealand sheep farms and has increased from 100 % in 1990 to 124 % in 2006 (Meat and Wool New Zealand, 2006). As lambing percentage increases, so does the proportion of twin- and triplet-born lambs (Amer *et al*., 1999). Given that multiple born lambs have lower survival rates to weaning than singletons (single 82.6 %, twin 80.3%, triplets 59.3%; Kenyon *et al.* 2002), improving their survival rate has become a major challenge for the sheep industry. Many pre- and post-natal factors affect lamb survival; this paper investigates the effect of twin-born lamb birth weight.

In triplet-born lambs both birth weight (BWT) and the percentage of the total litter weight represented by BWT (PBWT) (Morel *et al*., 2008) are associated with survival. Interestingly, a positive relationship between BWT and survival was observed only for the lightest lamb within a triplet set. However, the negative relationship between lamb mortality and PBWT was identical in all three BWT Groups of Light, Medium and Heavy. This suggests that the survival of a lamb within a triplet set is dependant on its BWT relative to the BWTs of its littermates. The PBWT therefore represents the competitive ability for survival of a lamb within its litter.

The purpose of the present study was to investigate the effects of birth weight itself and variation within a set on survival of twin born lambs.

MATERIALS AND METHODS

Data from a total of 3,834 twin lambs born to mixed age (3-5 years) ewes were analysed. The data set included; 762 East Friesian cross lambs and 696 Romney cross lambs from a study on year-round lambing in the Manawatu (de Nicolo *et al.,* 2008), and Romney cross lambs from a study on mid-pregnancy shearing conducted at Massey University, Riverside farm in the Wairarapa (n = 1,312) and at Massey University, Tuapaka farm in the Manawatu (n = 1,064) (Kenyon *et al.,* 2006).

Live weight and condition score (CS) of each ewe was recorded at mating (MatWT, MatCS) and at set stocking, which was usually one week before the planned start of lambing (PWT, PCS). Lamb live weights were recorded for all twin lambs born within 24 hours of birth (BWT) and at weaning (WWT) for the surviving lambs. Weaning rank was recorded (WR). Sets of lambs in which either one or both were found dead at 24 hours were included in the present study.

For statistical analysis the lambs were allocated according to their birth weight within litter, to three BWT groups. When the birth weight of the littermates was different the lighter one was allocated to the ‘Light’ group and the heavier one to the ‘Heavy’ group. Littermates of the same birth weight were allocated to the ‘Equal’ group. The following parameters were calculated: total litter birth weight (TBWT), the percentage of the TBWT for each lamb (PBWT = BWT/TBWT) and lamb average daily liveweight gain from birth to weaning (ADG).

A linear model (Proc GLM, SAS, 2008) with sex, BWT Group and fate at weaning (dead or alive)

TABLE 1: Means and standard deviation (in brackets) for lamb and ewe performance at three locations.

Measurement	Trial locations		
	Riverside	Manawatu	Tuapaka
Lambs			
Number born	1,312	1,458	1,064
Birth weight (kg)	4.90 (0.82)	4.56 (0.93)	4.72 (0.80)
Ratio light / heavy	0.94 (0.09)	0.93 (0.11)	0.93 (0.10)
Total litter weight (kg)	9.80 (1.42)	9.13 (1.56)	9.45 (1.33)
Number weaned	1,055	1,241	8,59
Weaning age (d)	86.1 (6.0)	81.0 (17.9)	89.3 (5.1)
Weaning weight (kg)	27.7 (4.6)	22.1 (5.6)	22.6 (4.0)
Average daily gain (kg/d)	0.264 (0.049)	0.217 (0.053)	0.200 (0.042)
Ewes			
Mating live weight (kg)	58.5 (6.6)	61.0 (8.4)	59.6 (6.7)
Mating condition score	2.4 (0.6)	2.4 (0.7)	2.7 (0.5)
Set stocking live weight (kg)	71.0 (7.4)	68.4 (8.7)	69.0 (6.2)
Set stocking condition score	2.8 (0.6)	2.6 (0.7)	2.6 (0.4)
Coefficient of variation (%)	9.3 (8.0)	12.0 (11.7)	10.6 (11.4)

TABLE 2: Birth weight (BWT) and percentage total lamb birth weight (PBWT) for littermates that were different with the lighter one allocated to the 'Light' group and the heavier one to the 'Heavy' group or littermates of the same birth weight allocated to the 'Equal' group, that were alive or dead at weaning. RSD = Residual standard deviation.

Measurement	Dead at weaning			Alive at weaning			RSD
	Light	Equal	Heavy	Light	Equal	Heavy	
Number of lambs	352	29	298	1,436	229	1,490	
BWT (kg)	4.12^{a}	4.59^{bc}	4.99^{d}	4.45^{b}	4.84^{cd}	5.11^{e}	0.57
PBWT (%)	44.6^{a}	-	53.9^{c}	46.3^{b}	-	54.0^{c}	0.1

Means followed by different letter are different from each other (P <0.05).

TABLE 3: Survival (mean ± standard error of mean) where the birth weights of littermates were different with the lighter one allocated to the 'Light' group and the heavier one to the 'Heavy' group or littermates of the same birth weight allocated to the 'Equal' group and Odds ratio.

Birth weight group	Survival[1]	Comparison	Odds ratio
Light	$1.39^{a} \pm 0.06$ (80.1)	Light vs Heavy	1.24
Equal	$2.11^{c} \pm 0.21$ (89.2)	Light vs Equal	2.05
Heavy	$1.61^{b} \pm 0.06$ (83.4)	Equal vs Heavy	0.5

Means followed by different letter are different from each other (P <0.05).
[1]Survival values are logit transformed with back-transformed values (%) in parentheses.

as fixed effects and their interaction was fitted to the PBWT data. Ewe as a random effect was added to the model for the BWT data.

The effect of BWT Group (Light, Equal, and Heavy) and Study and their interaction on lamb survival up to weaning was assessed with a logistic model (Proc Genmod; SAS.2008) and odd ratios for survival were calculated. The effect of individual lamb birth weight (BWT) and percentage of total litter birth weight (PBWT) on survival to weaning was assessed with a logistic model (Proc Genmod; SAS, 2008) with BWT or PBWT as covariates and BWT Group as a fixed effect and their interaction. Given that in the Equal Group, PBWT is constant (50%), animals in this group were not included in the covariate analysis.

A linear model (Proc GLM; SAS, 2008) with the fixed effects of sex, BWT Group and weaning rank and their interaction was fitted to the average daily liveweight gain data.

Multiple linear (Proc REG; SAS, 2008) and logit regressions (Proc Genmod; SAS, 2008) were fitted to investigate the relationship between lamb survival and ewes live weight and/or condition scores.

FIGURE 1: Relationship between birth weight and mortality overall for all lambs (solid bold line) and for lambs where the birth weights of littermates were different with the lighter one allocated to the 'Light' group (solid line), and the heavier one to the 'Heavy' group (dashed line) or littermates of the same birth weight allocated to the 'Equal' group (dotted line).

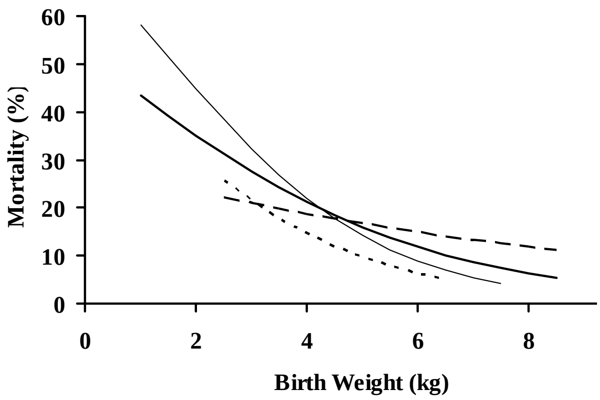
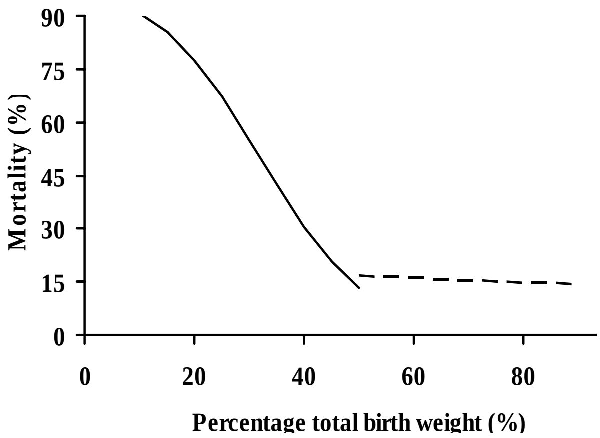


FIGURE 2: Relationship between percentage total birth weight and mortality for lambs where the birth weights of littermates were different with the lighter one allocated to the 'Light' group (solid line), and the heavier one to the 'Heavy' group (dashed line).



RESULTS

The means and standard deviation of the lamb and ewe data recorded in the three previous experiments are presented in Table 1. The main difference between the three experiments was that lambs in the Manawatu experiment were weaned around a week earlier, but had similar liveweight gains (ADG) to weaning as the lambs in the Tuapaka study.

The birth weight of the lambs in the Heavy, Equal and Light group were 5.09 kg ± 0.79 (SD), 4.75 kg ± 0.71 and 4.35 kg ± 0.81, respectively. Lambs from the Light group which survived to weaning were 0.33 kg heavier at birth and had a PBWT 2 percentage points greater than those that died (P <0.05, Table 2). In the Heavy group, there was a 0.12 kg difference (5.11 kg vs 4.99 kg) in birth weight between lambs that died or survived, but no difference in PWBT were observed.

The percentage survival to weaning was different between studies (Manawatu 88.0 %, Riverside 83.5 % and Tuapaka 81.8 %, CHI^2 P <0.01) and between BWT group (Light: 80.1% < Heavy: 83.4% < Equal: 89.2%; P <0.001). The lighter lamb within a pair of twins was 1.2 times more likely to die than the heavier one (Table 3).

The relationship between lamb BWT and mortality for the different BWT groups is presented in Figure 1. In all groups, as BWT increased mortality decreased, however this relationship is significant only for the Light group (Light: logistic regression: Mortality = 0.8581 - 0.5328 x BWT, P = 0.0001; Equal: Mortality = 0.094 - 0.463 x BWT, P = 0.098; Heavy Group Mortality = -0.919 – 0.1364 x BWT, P = 0.089). Over all groups Mortality = 0.0805 – 0.384 x BWT, P <0.001*)*.

In the Light group an increase in PWBT was associated with a decrease in mortality (logistic regression: Mortality = 3.307 – 10.335 x (PBWT/100), P <0.0001), but no such relationship existed in the Heavy group (Mortality = -1.591 – 0.112 x (PBWT/100), P >0.05) (Figure 2).

Male lambs were heavier at birth (BWT = 4.75 kg) (P.C.H. Morel, Unpublished data) and had a 0.015 kg/d higher ADG to weaning than females (BWT = 4.55 kg) lambs (P <0.0001, Table 4).

ADG to weaning was 0.028 kg/d greater (P <0.0001) for lambs reared as a single than twin. ADG was lower for Light born lambs than Heavy and Equal born lambs (P <0.05).

Overall, both BWT and PBWT were related (P <0.001) to ADG, with an extra 1 kg live weight at birth corresponding to an extra 0.014 kg/d in liveweight gain to weaning, however, the coefficient of variations were low (R^2 = 4% and 1%, respectively).

Live weights and condition scores of ewes at mating and when set stocking did not differ between ewes rearing 0, 1, or 2 lambs to weaning (P.C.H. Morel, Unpublished data).

Multiple linear and logit regressions were fitted to investigate the relationship between lamb survival, lamb birth weight, lamb liveweight gain to weaning and ewe live weight and condition scores. A multiple linear regression with set stocking live weight, live weight and condition score change between mating and set stocking explained 7 % of the variation in birth weight (P <0.001). Such that an extra 0.1 kg in lamb birth weight occurred for every 4.4 kg increase in ewe live weight at set

TABLE 4: Least square mean daily gain from birth to weaning for male and female lambs, lambs reared as single or twins, and where the birth weights of littermates were different with the lighter one allocated to the 'Light' group and the heavier one to the 'Heavy' group or littermates of the same birth weight allocated to the 'Equal' group. SEM = Standard error of mean.

Parameter	Effect						
	Sex		Weaning rank		Birth weight group		
	Male	Female	1	2	Light	Equal	Heavy
ADG (g/d)	246[b]	232[a]	253[b]	225[a]	233[a]	243[b]	244[b]
SEM	1.7	1.7	2.4	1.2	1.6	3.3	1.5

Within effect, means followed by different letters are different (P <0.05)

stocking, a +9 kg ewe liveweight gain and a +0.93 change in condition score from mating to set stocking. Only change in ewe live weight between mating and set stocking influenced lamb survival (P <0.01) such that lamb survival increases by 0.38 % per kg extra ewe liveweight gain during pregnancy.

Ewe live weight at set stocking and changes in ewe condition score during pregnancy accounted for 8.5 % (P <0.001) of the variation in lamb liveweight gain up to weaning. An extra 1 kg ewe live weight at set stocking, and +1 point change in ewe condition score correspond to an extra 0.001 kg/d and 0.017 kg/d in lamb liveweight gain to weaning, respectively.

The coefficient of variation for BWT for ewe weaning two lambs was lower (9.7 %, P <0.001)) than those weaning one (12.7 %) or no lamb (13.4 %).

DISCUSSION

It has been established that the main causes of death before weaning in lambs are starvation, pneumonia and trauma, with birth weight and genotype, irrespective of litter size, being the main contributing factors (Huffman *et al.,* 1985, Yapi *et al.,* 1990). The relationship between birth weight and survival (mortality) is best described by a quadratic function, whereas in a first phase, survival increases as birth weight increases, and then is constant before decreasing for large birth weight values. Such a relationship has been found across litter sizes in different countries: Kuwait (Malik et al., 1998), New Zealand (Kenyon *et al.,* 2002), Spain (Casellas et al., 2007) and Scotland (Sawalha et al., 2007), and within litter sizes for single, twin and triplet born lambs in New Zealand (Everett-Hincks & Dodds, 2008). Recently, we have shown an effect of birth weight on survival rate, which varies between light, medium and heavy lambs within a triplet set (Morel *et al.,* 2008). For light lamb, mortality decreased as BWT increased. In the case of the medium lamb, BWT did not influence mortality while in the Heavy group there was a trend showing that an increased BWT was associated with increased mortality. However, when BWT was expressed as a % of total litter weight a similar negative relationship between lamb mortality and PBWT was found in the three BWT Groups. In the present study with twin born lambs, the relationship between PBWT and mortality was negative in the Light lamb group only, and not different from zero in the Heavy group. This indicates, as observed with triplets, that mechanisms which increase birth weight of the smallest lamb within a set, or that reduce the variation within a set should increase lamb survival to weaning. It is not known if the positive effect of increasing the birth weight of the lightest lamb is due to it having a greater ability to cope with adverse weather conditions or increasing its ability to compete with its litter mate, or some other mechanism. Interestingly, mortality rates were not observed to increase with BW over 6 kg. Established research would suggest that birth weights above 6 kg are likely to increase mortality rates (Dalton *et al.,* 1980). However, Thomson *et al.,* (2004) have also reported no negative effect of a high birth weight on lamb survival to weaning.

Increased twin lamb liveweight gain to weaning can be achieved through greater ewe live weight at set stocking and/or greater changes in ewe condition score during pregnancy. Furthermore, greater ewe liveweight gains during pregnancy are associated with improved lamb survival. Although the effects are relatively small they are not surprising given that ewe nutrition affects lamb birth weight (Morris & Kenyon, 2004) and milk production (Bizelis *et al.,* 2000). Interestingly, in triplet lambs Morel *et al.,* (2008) reported that ewe condition score at mating and at set stocking had no effect on the number of lambs weaned or their lamb growth.

CONCLUSION

Within a twin lamb pair the lighter lamb was less likely to survive than its heavier sibling. In addition, survival rates were higher in those litter pairs where birth weights were equal. Therefore, there is potential for increasing twin lamb survival by increasing the birth weight of the lighter lamb and/or reducing the variation in birth weight. The challenge for the industry is to develop methods to achieve this. Increasing ewe live weight at set stocking and changes in ewe live weight and condition score during pregnancy had positive effects on lamb growth, while increasing ewe liveweight gain increased lamb survival. Even though the expected effects may be small, this represents a potential means for farmers to increase productivity.

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