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Patterns of lamb survival in high fecundity Booroola flocks

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ABSTRACT

Lamb survival and birth weight data from a Booroola × Romney flock and a Booroola × Merino flock were collected between 1975 and 1981. The mean litter sizes for these flocks were 1.96 and 1.76 respectively, with litter sizes ranging from 1 to 4 within each flock.

Effects of year, ewe age, birth rank and birth weight on lamb survival were assessed by fitting a sequence of logit models to the data. Birth weight was identified as the key parameter, with year and birth rank effects being markedly reduced once the variability due to birth weight was accounted for. An apparent ewe age effect was completely explained in terms of lamb birth weight. At any given birth weight lambs born of large litters ($\geq$ 3) had a lower probability of survival than contemporary lambs born as singles or twins.

Keywords Lamb; survival; birth weight; fecundity; multiple-births

INTRODUCTION

It is well known that survival in twin born lambs is 3 to 10% lower than for single born animals and that overall lamb mortality can vary widely from 5 to 25% depending on the proportion of multiples, the environment and year (Dalton *et al.*, 1980; Kelly, 1982). These data relate mainly to New Zealand flocks of 110 to 150% lambs born/ewe lambing and there is little published information available on lamb survival in flocks with lambing percentages above 150% and particularly for lambs from litters of 3 or more.

This paper presents data on the survival of lambs born in 2 flocks of Booroola cross ewes with litter sizes ranging from 1 to 4 and examines factors contributing to variation in survival within these flocks.

MATERIALS AND METHODS

The data presented were collected from 2 flocks of 200 to 300 ewes. Flock 1 was run at Invermay Agricultural Research Centre and flock 2 at Tara Hills High Country Research Station. Flock 1 consisted of first cross Booroola Merino × Romney ewes born in 1975 and 1976 and lambing in 1977/81. The flock was rotationally grazed together throughout the year (15 stock units/ha) except at lambing when they were set stocked in smaller groups (50 to 60). Mean lambing date was 25 September and lamb birth weights, birth ranks, survival to weaning (12 weeks) and age at death were recorded from all of the 1492 lambs born.

Flock 2 consisted of 2 to 6-year-old Booroola Merino × Merino ewes lambing in the period 1975/80. This flock was set stocked throughout the year (8 stock units/ha) being subdivided into smaller flocks of 20 to 40 ewes at lambing. The mean lambing date was 22 October. Similar data to that recorded for flock 1 were recorded for the 3849 lambs born in this flock. The mean mating weights of ewes in the 2 flocks were 46.2 and 48.4 kg for flocks 1 and 2 respectively.

Statistical Analyses

Mean lamb survival data was determined for each sub-group classified according to year, ewe age (twotooths *v* older), birth rank (1 to 4) and birth weight (0.5 kg categories between 1.5 and 6.0 kg). Statistical models were formulated which predicted sub-group survival probabilities so that the likelihood of obtaining the observed patterns of survival was maximised. This maximum likelihood approach was facilitated through using a logit transformation where, denoting a survival probability as p; its logit is simply the logarithim of the 'odds of survival' $\log_e (p/1\text{-}p)$. The logits were in turn predicted using a linear model of qualitative factors such as birth rank and the quantitative factor birth weight as a hyperbolic function fitted first or last in the model.

Mean birth weights for each sub-group were determined from least squares estimates.

RESULTS

The mean litter sizes were respectively 1.96 and 1.76 for flocks 1 and 2 while the mean numbers of lambs surviving per 100 lambs born were 68.8 and 79.4. Table 1 summarises lamb birth weight and survival data for the 2 flocks within litter sizes.

There was a progressive reduction in birth weight from single to quadruplet born lambs, birth weights of quadruplets being about half that of singles. This

TABLE 1 Birth rank differences in mean lamb birth weight, survival and the proportion of lambs dying within 48 hours post partum in 2 Booroola cross flocks.

Birth rank		Single	Twin	Triplet	Quadruplet
Flock 1:	n	253	584	495	160
	Birth weight (kg)	4.9	3.6	2.9	2.5
	Survival (%)	88.5	75.6	50.3	42.9
	Deaths to 48 h*	0.73	0.69	0.82	0.93
Flock 2:	n	890	1788	939	
	Birth weight (kg)	4.3	3.4	2.6	2.2
	Survival (%)	92.9	82.4	65.1	56.7
	Deaths to 48 h*	0.66	0.75	0.82	0.86

* The proportion of lamb deaths to weaning occurring in the first 48 hours of life.

is further illustrated by the ratio of total litter weights for singles, twins, triplets and quadruplets being 100:147:178:204 and 100:158:181:204 for flocks 1 and 2 respectively, showing a progressively smaller increase in total litter weight for each increase in birth rank. This decline in birth weight with increased litter size was paralleled by a decline in survival rate and an increase in the proportion of lamb deaths occurring within 48 hours post partum ($P < 0.01$).

The results of an analysis of the survival data using the models described are presented in Table 2. Birth weight contributed a large amount to the variation in survival for both flocks ($P < 0.001$) as indicated by the χ^2 values. Year effects were also highly significant ($P < 0.001$) while birth rank, although having its effect largely reduced by fitting birth weight first in the model still had a significant influence on survival. However ewe age did not contribute significantly to survival differences after variation due to birth weight had been accounted for.

DISCUSSION

The factors influencing lamb survival in the 2 high fecundity Booroola cross flocks reported here would appear to be similar to those reported by other workers. Birth weight is of greater importance in explaining variation in survival than for studies of lower fecundity flocks such as that of Dalton *et al.* (1980), but this is not unexpected because a much higher proportion of multiple born lambs are of low birth weight.

Yearly variations in survival and the absence of ewe age effects after accounting for the effect of birth weight are also consistent with other studies. However the effect of litter size independent of birth weight has not to our knowledge been reported. The lower probability of survival of triplets and quadruplets at equal birth weights compared to singles or twins (Fig. 1) raises the possibility of starvation resulting from mis-mothering of lambs born in litters

TABLE 2 Chi-square values for 2 flocks showing the reductions in deviance due to fitting birth weight first (F) or last (L).

Source of deviance	Flock 1					Flock 2				
	χ^2F	Sig	χ^2L	Sig	df	χ^2F	Sig	χ^2L	Sig	df
Birth weight	235.8	***	—		1	606.2	***	—		1
Year	65.3	***	55.2	***	4	36.1	***	32.5	***	5
Ewe age	2.2	NS	2.4	NS	1	2.5	NS	9.3	**	1
Birth rank	26.7	***	193.1	***	3	13.8	***	307.3	***	3
Birth weight	—		79.3	***	1	—		309.5	***	1
Residual	203.8		203.8		134	450.9		450.9	***	238

Fig. 1 presents, for flock 1, the relationships between birth weight and survival for an average year and ewe age within various birth ranks. The predicted survival for each birth rank at actual birth weights and at a flock mean birth weight (i.e., equal birth weight for all birth ranks) are indicated.

of 3 or more. Nevertheless the age of death information shows that a large proportion of lamb deaths in high birth ranks occurs within 48 hours post partum. Deaths associated with starvation/mis-mothering would be expected to begin at about 48 hours unless complicated by exposure. More detailed studies of

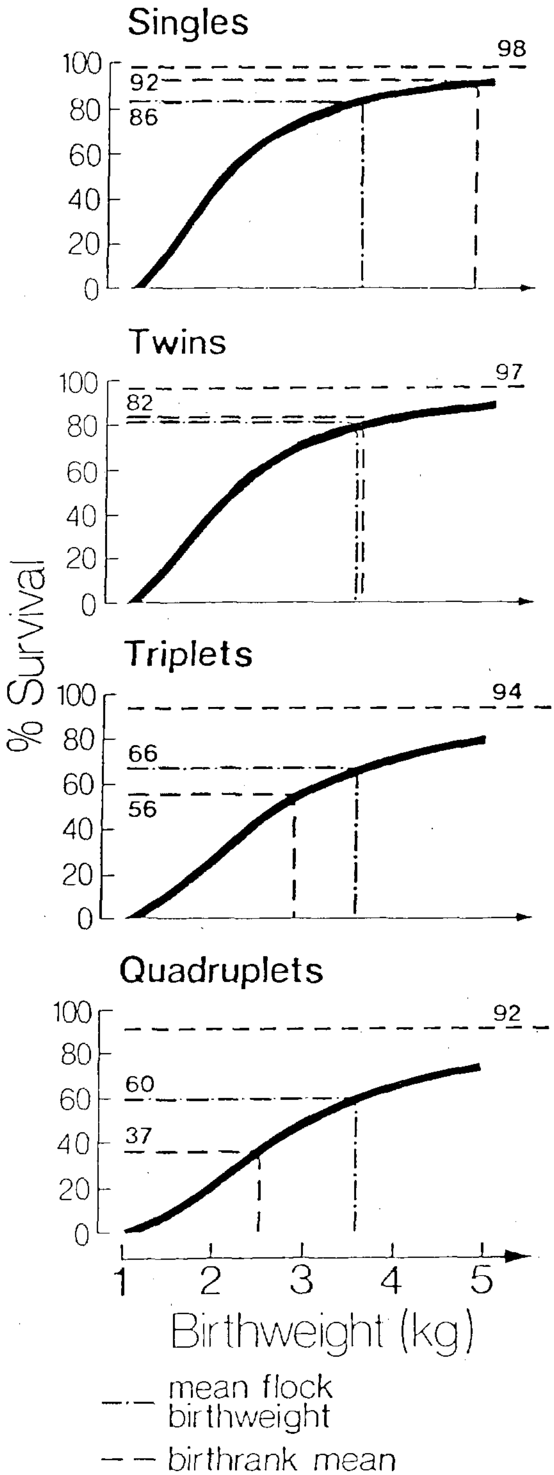

FIG. 1 Predicted lamb birth weight—survival relationships in an average year for lambs of various birth ranks (flock 1).

deaths in these flocks indicate that over 50% of triplet and quadruplet deaths occur prior to or within a few hours of birth. Another small proportion die of starvation. However a large proportion of these as well as the lambs dying soon after birth have evidence of damage to the central nervous system associated with the birth process (G. N. Hinch, unpublished).

The importance of birth weight as a factor influencing the survival of lambs born in large litters clearly indicate that increases in birth weight must have priority as a method of improving lamb survival in high fecundity flocks. Assuming that we can obtain by nutritional manipulation, in late pregnancy a maximum increase in triplet birth weight of 30% (Khalaf *et al.*, 1979) it is possible that the birth weights of triplet born lambs in flocks 1 and 2 could be increased to the flock mean birth weight of 3.6 and 3.4 respectively. This would give predicted survivals of 66 and 79%, still well below that normally expected for singles or twins. It would seem that maximum survival in triplets and quadruplets may be dependent largely on preferential husbandry practices unless other means of increasing birth weight can be found.

Reports that lamb birth weight and ewe mating weight are highly correlated in between-breed comparisons (e.g., Donald and Russell, 1970) suggest the possibility that cross breeding of the small (~ 50 kg) Booroola with breeds of larger mature size may have beneficial effects on lamb birth weights. However survival responses diminish rapidly at birth weights above 4.0 kg and it would seem likely that other factors would then become limiting to survival of multiple born lambs. The maximum survival value of 94% for flock 1 triplets illustrates this point with at least 6% mortality occurring even at birth weights well in excess of 5 kg. This survival limit is set by the qualitative factors of birth rank and year and differs somewhat between flocks.

On a flock basis, associated with the possibility of increasing triplet birth weights, is the possibility of decreased survival of single and twin lambs due to dystocia. The litter weight ratio reported for the flocks in this study is consistent with reports for other high fecundity breeds (Donald and Russell, 1970) indicating that the effects on birth weight of intra-uterine competition and/or uterine capacity are similar in most breeds. If this is the case increases in triplet birth weights to > 3.5 kg would result in single lamb birth weights of > 5.5 kg. Such weights are well above the optimum 4.7 kg reported by Dalton *et al.* (1980) for survival of predominantly single born lambs.

Consequently it would seem that the identification, using ultrasonic devices in early pregnancy (Wilkins *et al.*, 1982), of ewes carrying 3 or more lambs may be a useful management tool allowing preferential feeding of such ewes to obtain maximum birth weights. At the same time ewes carrying single lambs could be restrictively fed to avoid excessive birth weights and dystocia.

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