LAMB MORTALITY IN HILL COUNTRY FLOCKS

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SUMMARY

The factors associated with lamb mortality in 7,727 lambs born to 7,091 two-tooth to four-year-old ewes over the 9-year period 1959-67 were studied. The lambs (from six flocks) were Romney (two flocks) or first-cross (F_1), second-cross (F_2), third-cross (F_3), and fourth-cross (F_4), Border Leicester × Romney sheep. Data are presented of the effects of flock, age of dam, lamb sex, birth rank, mortality characteristic, age at death and birth weight on survival rate (lambs weaned as percentage of all lambs born). The overall survival rate was 82.2%.

Survival rate for single-born lambs was highest from six-tooth ewes, and in multiple-born lambs from four-year-old ewes. Mortality of twin lambs was higher than for singles. Year of birth had a marked effect on survival rate, with the variability in survival rate between years being greater for multiple- than single-born lambs.

Female lambs had a higher survival rate than castrated male lambs, the overall difference in lambs weaned as a percentage of lambs born being 5.8. Within sexes and birth rank, survival rate increased from the Romney to F_2 lambs and then declined with interbreeding to the F_3 and F_4 lambs. This indicates that maternal and/or heterosis effects influenced lamb mortality.

On a 60% sample of the dead lambs only, 44.6% of single lambs died of dystokia, and 15.1% from physiological starvation. In the sample of multiple-born lambs autopsied, 16% died from dystokia and 41.7% from starvation. Infections accounted for 11.6%, and pre-natal deaths for 10.3% of the remaining deaths. Most of these deaths occurred within 3 days of birth, with relatively more single- than multiple-born lambs dying at birth.

The survival rate of single- or multiple-born lambs was related to birth weight. In single-born lambs, survival rate was highest in lambs of about average birth weight and decreased with lambs of lower or higher birth weights. In multiple-born lambs, survival rate was lowest with lambs of low birth weight and increased with in-increasing birth weight.

IT IS widely recognized that between 5 and 25% (Wallace, 1949; McFarlane, 1955; Scott, 1962) of all lambs born die between birth and weaning. This loss entails not only the lambs themselves for the purposes for which they were

intended — meat and/or wool production — but also the ewes cutting less wool and requiring more feed than if they had not been pregnant, resulting in a lower stocking rate with in-lamb ewes, and to a lower selection pressure through fewer animals being available. In addition, ram and management costs per unit of lambs produced are increased.

The literature indicates a wide variety of factors associated with lamb mortality. These include ewe nutrition in late pregnancy, the failure of ewes to lamb without difficulty, to malpresentations, large lambs causing dystokia, physiological starvation from mismothering and lack of milk, an unfavourable environment, misadventure, congenital abnormalities and infections. Much of the information on these causes has arisen from experimental studies or from observations made on sheep confined in small areas or kept under lowland conditions. Nevertheless, there is often poor definition of the primary causes of lamb deaths, even in intensively shepherded flocks. For sheep on hill country in New Zealand, few data on lamb deaths are available. The purpose of this paper is to report on factors associated with lamb mortality in Romney and Border Leicester × Romney crossbred flocks at the Whatawhata Hill Country Research Station.

EXPERIMENTAL

The records of 7,727 lambs born to 7,091 purebred Romney and Border Leicester × Romney two-tooth to four-year-old ewes during the 9-year period 1959-67 were available for this study. The lamb mortality data were part of those collected during the investigation of the productivity of Romney compared with first-, second-, and third-cross Border Leicester × Romney ewes under hill country conditions. In this experiment, a flock of Romney Control (RCR) ewes has been mated to Romney rams from other flocks. A second Romney flock of similar genetic background to the RCR flock ewes, referred to as the Remainder (RER) flock, was also maintained and from this a random sample of ewes was used for mating with Border Leicester rams for production of F_1 progeny. Further crossbred ewes were generated by mating progeny with F_1 rams bred at the Hill Station. All crossbred ewes were mated as one flock. The lambs from the first-, second- and third-cross ewes are referred to as F_2, F_3 and F_4, respectively. A study of the factors associated with lamb mortality was therefore possible in six flocks,

the lambs being described as Remainder Romney, Romney Control, F_1, F_2 F_3 and F_4 lambs.

Lambing usually commenced in the third week of August. Early lambing ewes were preferentially fed for a short period before lambing, and "unlambed" ewes shedded as the lambing paddocks reached the required stocking rate. Lambed ewes were generally set-stocked until weaning. Multiple-born lambs were reared with those single-born from birth, and without any preferential treatment. Dry or lost lamb ewes were rejoined with lambed ewes after the end of the flock lambing. All ewe offspring except those with black wool, under or overshot jaws, and those with obvious structural defects were retained and first mated to lamb at two years of age. All flocks were grazed together from birth, except over the mating period. The sheep were grazed on hill country, and the mature ewe flock used to assist with land development. Artificial shelter was not provided and generally no supplementary feed has been available. No culling of ewes on reproductive performance was practised, and all females were culled after lambing as four-year-olds.

Lambs were weighed and identified with numbered eartags within 24 hr of birth, and their sex, birth rank, dam number, and age recorded. Lambs were docked and castrated with elastrator rubber rings at birth and the navel cords generally treated with iodine. At about 3 weeks of age the lambs were vaccinated for enterotoxaemia and scabby mouth (contagious ecthyma). Weaning was in late November or early December at an average age of 80 to 85 days. Intensive paddock shepherding during daylight hours, particularly during the first 7 days of life, was aimed at, and thereafter the sheep were periodically inspected until weaning. Assistance was given wherever possible to lambing ewes. In the early years only, a total of 49 lambs were fostered on to other ewes. These fostered lambs were included as non-surviving lambs but the subsequent records of all their progeny were excluded.

A high proportion of the lambs dying before weaning were examined *post mortem* at the Ruakura Diagnostic Station. This information, together with shepherding notes, was used to classify the causes of death. Any lamb not present at weaning or lamb shearing was classified as dying prior to weaning, and the survival rate calculated as the proportion of live lambs present at weaning of all lambs tagged at birth, whether dead or alive.

RESULTS AND DISCUSSION

The full data are extensive; to give some indication of the numbers of animals involved and overall differences in fertility between the six flocks a summary of the fertility data for the years 1959-67 is given in Table 1. While age of ewe and year effects are partly confounded with flocks in Table 1, the following points were substantiated by a more detailed analysis: the number of ewes lambing as a percentage of the number of ewes present at lambing was higher in the F_1 ewe flock than in the other five flocks; the percentage of ewes lambing with multiple births was higher in the crossbred ewes (flocks F_2, F_3, F_4) than in the Romney ewes (flocks RCR, RER); the number of lambs born per 100 ewes present at lambing was greatest for F_1 ewes and then tended to decline with the interbreeding without selection of the F_2 and F_3 ewes, but not to the level of the parent Romney flock. Similar trends were evident for the number of lambs weaned per 100 ewes at lambing. The overall lamb survival rate was highest for the F_2 lambs from F_1 ewes, but declined to the F_3 and F_4 lambs. No selection was practised to attempt to offset this decline. These data therefore indicate that large differences in fertility and lamb survival rate to weaning occurred between these genetically different flocks, and that interbreeding without selection depressed reproductive fitness in a hill-country environment. The overall survival rate was 82.2%, or a total of 1,377 (17.8%) lambs died from prior to parturition to weaning of the total of 7,727 lambs born.

TABLE 1: OVERALL FERTILITY ANALYSIS, 1959-67

	Flock Name					
	RER	*RCR*	*F_1*	*F_2*	*F_3*	*F_4*
Sire	Romney	Romney	Border Leicester	F_1	F_1	F_1
Ewe	Romney	Romney	Romney	F_1	F_2	F_3
No. years' records	6	9	8	9	8	6
No. ewes at lambing	1,158	1,396	1,344	1,401	1,234	558
Ewes lambing (%)	87	88	84	93	88	87
Multiple births (%)	17	17	14	35	30	35
Lambs born per 100 ewes at lambing	100	103	96	126	115	181
Lambs weaned per 100 ewes at lambing	80	84	80	107	93	93
Lamb survival rate (%)	80	82	83	86	81	78

In the statistical analysis of the data, the effects of environmental factors — namely, year, dam age, sex and birth rank, and flock (RER, RCR, F_1, F_2 F_3 and F_4) — on lamb survival rate were studied in analysis of variance. The proportions in each flock, year, dam, age, sex and birth rank sub-groups were weighted according to the number of lambs in these analyses. In this paper a summary of these analyses only will be presented.

Age of Dam

The overall effect of age of dam on survival rate of single- and multiple-born lambs is shown in Fig. 1. Over all flocks, the survival rate of single-born lambs increased from the two-tooth to the six-tooth lambing, and then declined slightly to the four-year-old stage, but this decline was not evident for the multiple-born lambs. Multiple-born lambs from older ewes had an equal or better chance of survival than single-born lambs from younger ewes.

Least squares estimates of the survival rate of single- and multiple-born lambs were 75.8, 81.5, 83.4 and 83.6% for lambs born from 2-tooth, 4-tooth, 6-tooth and 4-year old dams, respectively.

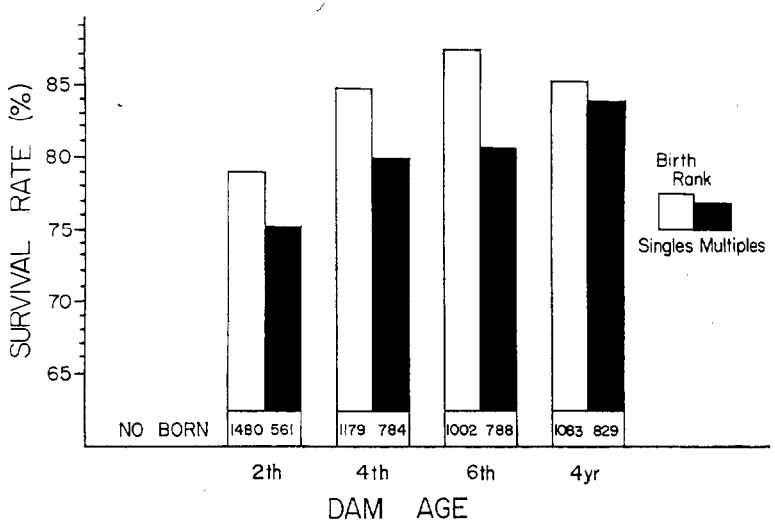

Fig. 1: *Overall effect of dam age and birth rank on percentage survival of lambs (1959-67).*

Birth Rank

Histograms of the survival rate of single- and multiple-born lambs within flocks are presented in Fig. 2. With the exception of F_1 animals, single-born lambs had a higher survival rate than multiple-born lambs. Most of the multiple-born lambs were twins. The within-flock birth rank differences in survival rate were 3.1, 3.0, −0.1, 5.4, 5.1, and 5.1% for the Remainder to F_4 lambs, respectively; or an overall higher survival rate of single-born lambs of 3.3%. This overall difference is not great enough to cancel more than a small proportion of the influence of multiple-born lambs on lambing percentage. There was a wider range in survival rate of multiple-born lambs (11.6%) than in single-born lambs (1.4%) between years, indicating that with unfavourable conditions twins were more susceptible to death than singles.

A practical system of identifying those ewes with twin lambs *in utero* could materially assist in the development of methods to reduce these losses of multiple-born lambs, particularly in unfavourable conditions and where the maternal environment and the lambs' ability to survive is poor.

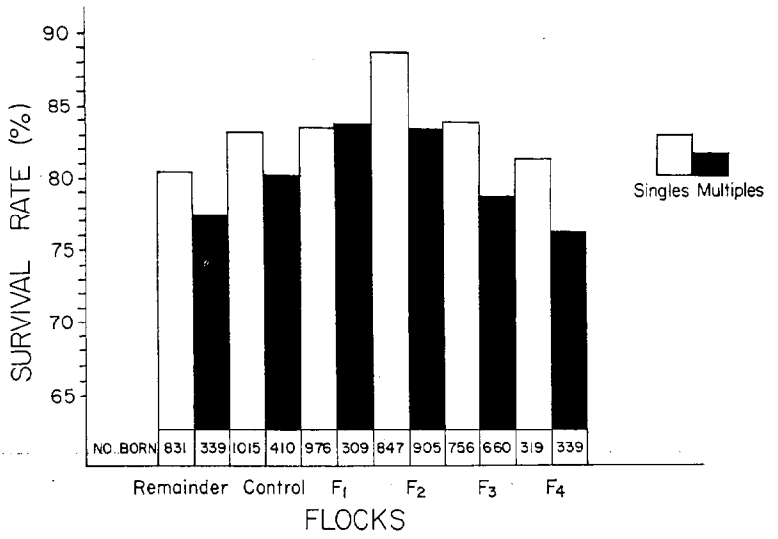

FIG. 2: *Effect of birth rank within flocks on percentage survival of lambs (1959-67).*

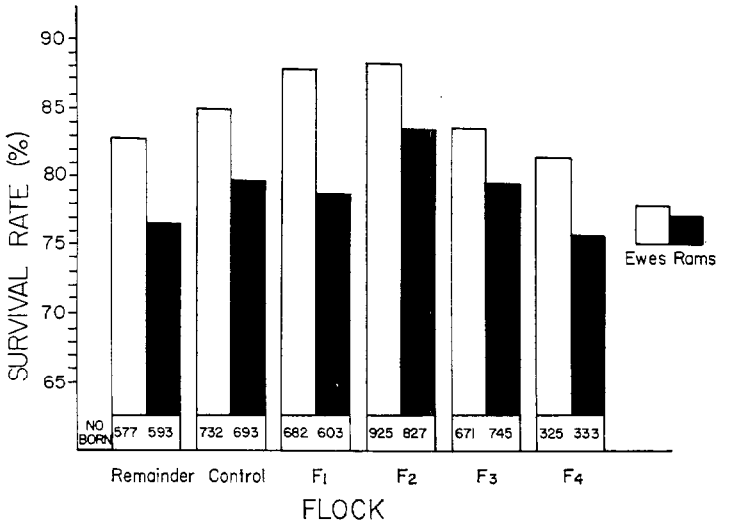

FIG. 3: *Effect of lamb sex within flocks on percentage survival of lambs (1959-67).*

LAMB SEX

The effect of lamb sex within flocks is illustrated in Fig. 3. Within all flocks, female lambs had a higher survival rate than male lambs. This difference in survival rate was 6.3, 5.1, 9.1, 4.7, 4.0 and 5.8% for the Remainder, Control, F_1 F_2, F_3 and F_4 lambs, respectively. The least squares difference in percentage survival rate was consistent within birth rank classes, the difference for singles being 5.2 (86.5 *v.* 81.3%) and for multiples 6.8 or an overall difference of 5.8 (84.0 *v.* 78.2%).

FLOCK EFFECTS

In the study of lamb sex within flocks the survival rate increased from Romney to F_2 lambs and then declined to the F_3 and F_4 lambs with the exception of the F_1 male lambs. A similar pattern of flock effects was evident when survival rate was related to birth rank within flocks. Here, with the exception of the single F_1 lambs, survival rates also increased from the Romney to the F_2 lambs, and then declined with interbreeding in the F_3 and further in the F_4 lambs. This was substantiated by least squares estimates.

This indicates that important differences were present between flocks in survival rate, owing either to a more

favourable maternal environment and/or to the ability of the lambs themselves to survive. The higher survival rate of F_2 lambs from first-cross (F_1) ewes could reflect a more favourable maternal environment of their dams, together with possible heterosis effects. It could be expected that, in the F_2 lambs, survival rate could have been increased by any maternal effect being at a maximum when their dams are at the first-cross stage, plus about half the non-maternal heterosis effect, if any, observed in the F_1 lambs (Falconer, 1960). With interbreeding of the F_2 lambs as ewes, the effect of maternal and heterosis effects on the survival rate of unselected F_3 and F_4 lambs could be expected to decline, resulting in a higher mortality rate. Although these effects were not isolated in the present experiment, their combined influences appear to be substantiated by these results. A similar advantage in survival rate of Border Leicester crossbred lambs, and particularly those from F_1 ewes, has been previously observed (Coop and Clark, 1965; Pattie and Smith, 1964), and could be anticipated from reviews on crossbreeding in sheep (Rae, 1952; Bowman, 1959; 1966).

Mortality Characteristics

Of the 7,727 lambs born over the 9 years of this study, 6,350 or 82.2% were reared by their dams to weaning, and 1,377 or 17.8% were dead, missing or fostered before weaning. Of the dead lambs (see Table 2), 464 (59.9%) single and 350 (60.1%) twins or triplets were subjected to a post-mortem examination at the Ruakura Diagnostic Station. Of the remaining dead lambs, 193 were unsuitable for diagnostic examination, 48 were fostered, 302 were missing but no carcasses were found, and 20 with unknown birth rank or dates were omitted from the analy-

Table 2: Mortality Characteristics, all Flocks, 1959-67

	Birth Rank			
	Single		*Twin*	
	No.	*%*	*No.*	*%*
Lambs diagnosed	389	50.2	309	53.1
Lambs not diagnosed	75	9.7	41	7.0
Total autopsies	464	59.9	350	60.1
Dead: No autopsy	120	15.5	73	12.5
Fostered	24	3.1	24	4.1
Dead: Missing carcass	167	21.5	135	23.2
Total	775		582	

sis. Thus, post-mortem results were available on 60% of all lambs dying. The proportion of those lambs not sent for diagnosis, that were missing or fostered, was similar in single- and multiple-birth rank classes.

On the basis of the post-mortem results, together with shepherding notes on this sample, the causes of death were classified into seven broad classes, namely, pre-natal, dystokia, starvation, infections, abnormalities, misadventure and undiagnosed deaths. Up to 9 subgroups were also classified, but only the main classes will be considered in this paper.

Prenatal deaths included those dying *in utero*, mummified foetuses, and where mortality was attributable to *Brucella abortus*, vibriosis, toxoplasmosis and leptospirosis. Dystokia or difficult births included those dying of asphyxiation or inhalation of foetal fluids. Lambs dying of physiological starvation included those not fed, deaths from exposure, neonatal diarrhoea, and those that were too immature to survive naturally or that exhibited some condition preventing feeding. Deaths from postnatal infections included those due to acute navel infections, from enterotoxaemia, parasitism, and abscesses. Lambs were classified as dying from misadventure if they drowned or choked, died of uncomplicated exposure without physiological starvation, from physical injury, post-docking haemorrhage, blowfly strike, intestinal obstruction and constipation. Undiagnosed deaths included those for which no satisfactory cause of death was established by the veterinarians carrying out the autopsies.

The relative importance of these mortality characteristics in this sample of dead lambs, within birth rank classes, is given in Fig. 4. The data show clearly a relative difference in the importance of dystokia and physiological starvation between single- and multiple-born lambs. For single-born lambs, 44.6% died of dystokia and 15.1% from starvation. In contrast, in multiple-born lambs some 16.0% of all classified deaths were from dystokia and 41.7% from starvation. The relative importance of postnatal infections, abnormalities, misadventure and undiagnosed characteristics were essentially similar to single- and multiple-born lambs. Overall, the four main causes of lamb mortality were dystokia (32.3%), starvation (26.5%), infections (11.6%) and uterine deaths (10.3%). Dystokia and starvation were associated with 59% of all diagnosed deaths, while relatively few lambs died before parturition. Only a small proportion of lambs died from abnormalities (1.4%), or misadventure (3.7%). In this

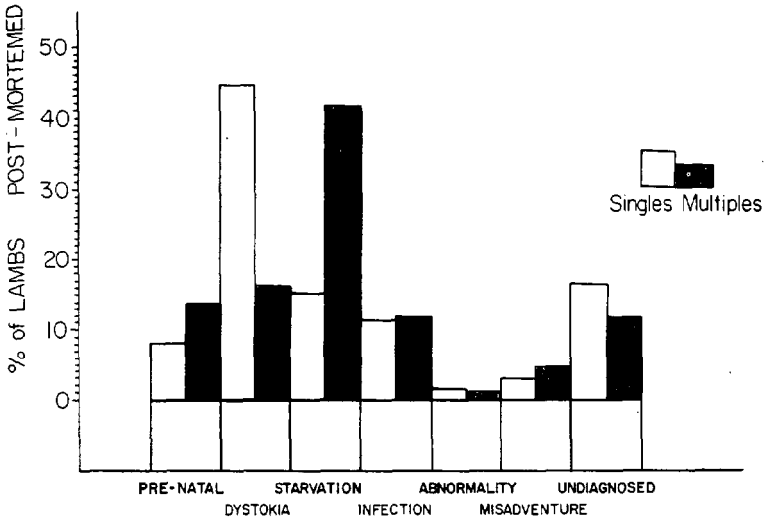

FIG. 4: *Lamb mortality characteristics (all flocks, 1959-67).*

sample there was an indication that the overall differences in survival rate between flocks could be associated with differences in the proportions of deaths from dystokia and starvation. In single-born lambs, losses from dystokia tended to be relatively higher in Romney, F_3 and F_4 lambs and lowest with F_1 and F_2 lambs. In multiple-born lambs, losses from starvation were highest for Romney (46 and 43%), F_3 (42%), and F_4 (45%), and lowest for F_1 (35%), and F_2 (36%) lambs.

AGE AT DEATH

The ages at which the deaths occurred were divided into those dying at birth, between 1 and 3 days, between 4 and 7 days, from 8 days to weaning, and unknown. The proportion dying within each of these periods for single- and multiple-born lambs is given in Fig. 5.

Most of the lamb deaths occurred within 3 days of birth. As would be expected from the analysis of the mortality characteristics, a higher proportion of single- than multiple-born lambs died at birth, while a higher proportion of multiple-born than single-born lambs died within 1 to 3 days of age. About 23% of the lambs which died were of unknown age. The main proportion of these were missing prior to weaning.

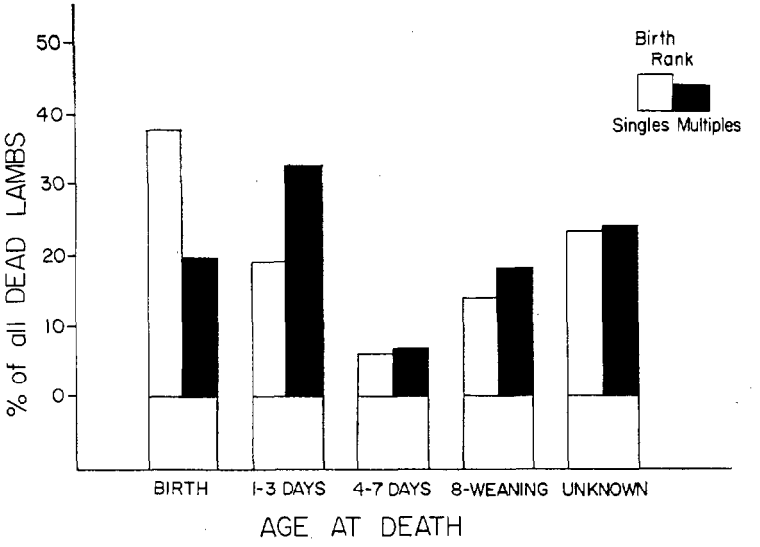

FIG. 5: *Overall mortality age distribution within birth rank (1959-67).*

This indicates that efforts to reduce the rate of lamb mortality should be directed to the period up to 3 days after birth, since this short period accounted for some 57% of single- and 52% of multiple-born lambs that died prior to weaning.

BIRTH WEIGHT AND SURVIVAL RATE

An analysis was made of the relationship between birth weight and survival rate within 1 lb weight ranges on the pooled years' data. The relationship for single-born lambs within flocks is presented in Fig. 6. It is apparent that lambs of below or above average birth weight have a decreasing survival rate, and that, within flocks, lambs of about average birth weight have the highest survival rate.

The overall relationship between survival rate and birth weight in multiple-born lambs is shown in Fig. 7. In all flocks, multiple-born lambs with the lowest birth weights had the lowest survival rate and this increased with increasing birth weight up to about 8 to 9 lb. Multiple-born lambs weighing less than 5.0 to 5.9 lb at birth had a very low survival rate.

The frequency distribution of the proportion of single- or multiple-born lambs within the birth weight groups were essentially similar in all flocks. This indicates that

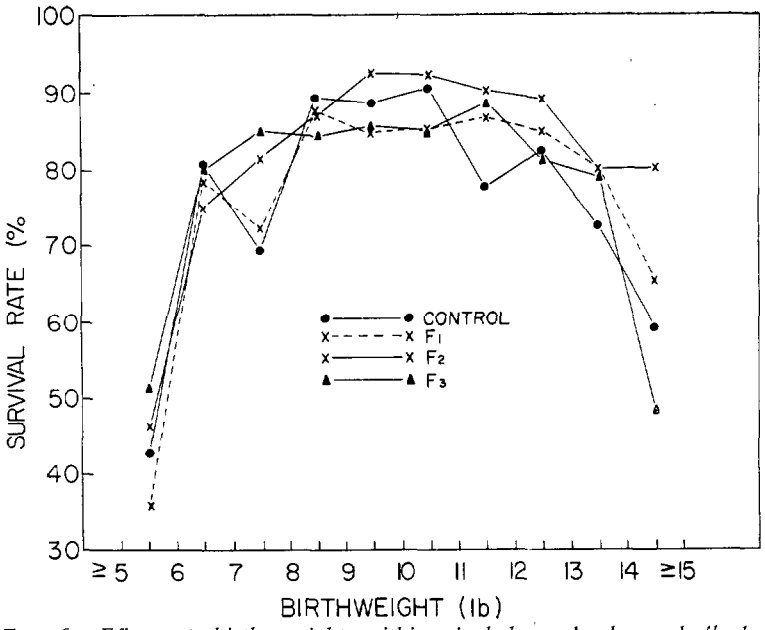

FIG. 6: *Effect of birth weight within single-born lambs and flocks. (1959-67).*

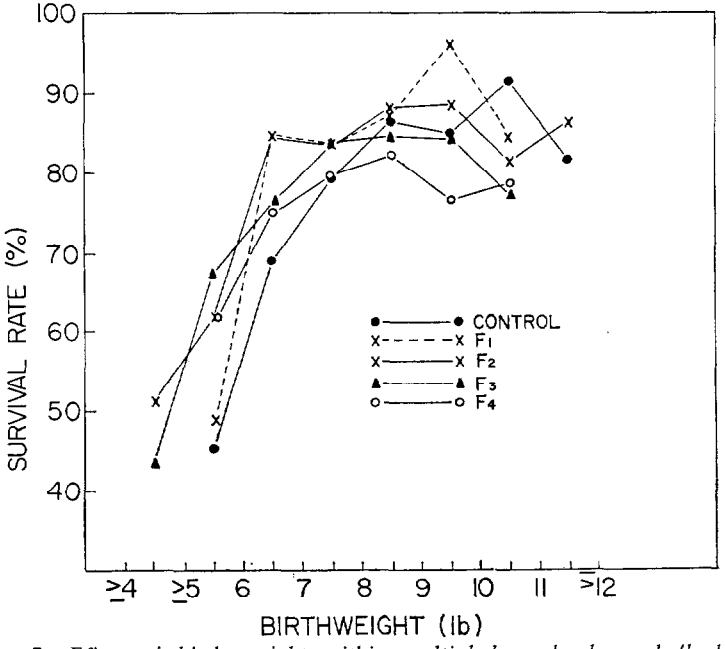

FIG. 7: *Effect of birth weight within multiple-born lambs and flocks. (1959-67).*

factors other than the distribution of birth weight of single- or multiple-born lambs are likely to be associated with the between-flock differences in survival rate.

The mean birth weights for the RER, RCR, F_1, F_2, F_3 and F_4 flocks were 9.0, 9.3, 9.6, 8.7, 8.4 and 8.3 lb, respectively. Within birth rank, sex, flock and dam age sub-groups, the lambs that survived had a higher birth weight than those which died. The overall birth weight of all surviving lambs was 9.7 lb compared with 8.1 lb for those dying before weaning. Overall, twin lambs generally had a lower average birth weight and a higher mortality rate than single-born lambs within flocks. Within flocks and age of dam, single-born lambs weighed 1.7 to 2.7 lb heavier at birth than multiple-born lambs, with the difference being greater with male than female lambs. Within birth rank, flock and sex sub-groups, birth weights, generally increased from the two-tooth to six-tooth lambing. Male lambs had a consistently higher birth weight than female lambs.

The chances of single- or multiple-born lambs within flocks surviving, therefore, seem to be closely related to birth weight. The cause of the differences in survival rate between birth weight groups would be expected to differ over the range of birth weights studied and between single- and multiple-born lambs. The higher mortality of lambs with low birth weights might be expected to be largely due to deaths at birth or from starvation, while in lambs of high birth weight a higher mortality rate may be expected to be from difficult births. The susceptibility of lambs with heavier than average birth weight to death from difficult births is almost certainly greater than indicated by the overall analyses, since no account is taken of the lambs saved when assisted during parturition. The 48 fostered lambs excluded from the analysis might also be assumed to have died of starvation. It seems clear, however, that improvement in the overall mortality rate of both singles and twins would require that a higher proportion of lambs born in a particular flock were near the optimum birth weight. These data indicate this weight to be about 8½ to 11 lb for singles and about 7 to 10 lb for twins. This is likely to require differential feeding and management together with pre-lambing identification of ewes bearing twins from those with singles. Clearly, the genetic and environmental factors associated with lamb deaths within 3 days of birth, and particularly from dystokia and starvation, are important and merit further study.

ACKNOWLEDGEMENTS

It is a pleasure to thank J. B. Clayton, G. Reed, J. P. Muller and numerous other staff at Whatawhata for valuable technical assistance in the management and recording of these data under difficult conditions; Miss J. Webster and Miss K. Curtis-Taylor and officers of the Biometrics Section, Department of Agriculture, for assistance in coding and computing the results; and to several colleagues for their valuable help during this project. E. A. Clarke's contribution in designing the experiment and collecting the field records up to 1961 is gratefully acknowledged. Several pathologists at the Ruakura Diagnostic Station have made a major contribution in carrying out the post-mortem examinations. The illustrations in this paper are the work of the Ruakura Art Section.

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