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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 (F1), second-cross (F2), third-cross (F3), and fourth-cross (F4), 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 F1 lambs and then declined with interbreeding to the F2 and F4 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 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 in-
creased.

The literature indicates a wide variety of factors asso-
ciated 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 in-
formation on these causes has arisen from experimental
studies or from observations made on sheep confined in
small areas or kept under lowland conditions. Neverthe-
less, 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 Whata-
whata Hill Country Research Station.

EXPERIMENTAL

The records of 7,727 lambs born to 7,091 purebred Rom-
ney and Border Leicester × Romney two-tooth to four-
year-old ewes during the 9-year period 1959-67 were avail-
able 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 con-
ditions. 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 back-
ground to the RCR flock ewes, referred to as the Re-
mainder (RER) flock, was also maintained and from this
a random sample of ewes was used for mating with
Border Leicester rams for production of F1
progeny. Further crossbred ewes were generated by mating
progeny with F1 rams bred at the Hill Station. All cross-
bred ewes were mated as one flock. The lambs from the
first-, second- and third-cross ewes are referred to as F2,
F3 and F4, 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 overshoot 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 ear-tags 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 F₁ ewe flock than in the other five flocks; the percentage of ewes lambing with multiple births was higher in the crossbred ewes (flocks F₂, F₃, F₄) than in the Romney ewes (flocks RCR, RER); the number of lambs born per 100 ewes present at lambing was greatest for F₁ ewes and then tended to decline with the interbreeding without selection of the F₂ and F₃ 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 F₂ lambs from F₁ ewes, but declined to the F₃ and F₄ 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

<table>
<thead>
<tr>
<th>Sire</th>
<th>RER</th>
<th>RCR</th>
<th>F₁</th>
<th>F₂</th>
<th>F₃</th>
<th>F₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ewe</td>
<td>Romney</td>
<td>Romney</td>
<td>Border Leicester</td>
<td>F₁</td>
<td>F₂</td>
<td>F₃</td>
</tr>
<tr>
<td>No. years' records</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>No. ewes at lambing</td>
<td>1,158</td>
<td>1,596</td>
<td>1,344</td>
<td>1,401</td>
<td>1,234</td>
<td>558</td>
</tr>
<tr>
<td>Ewes lambing (%)</td>
<td>87</td>
<td>88</td>
<td>84</td>
<td>93</td>
<td>88</td>
<td>87</td>
</tr>
<tr>
<td>Multiple births (%)</td>
<td>17</td>
<td>17</td>
<td>14</td>
<td>35</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Lambs born per 100 ewes at lambing</td>
<td>100</td>
<td>103</td>
<td>96</td>
<td>126</td>
<td>115</td>
<td>181</td>
</tr>
<tr>
<td>Lambs weaned per 100 ewes at lambing</td>
<td>80</td>
<td>84</td>
<td>80</td>
<td>107</td>
<td>93</td>
<td>93</td>
</tr>
<tr>
<td>Lamb survival rate (%)</td>
<td>80</td>
<td>82</td>
<td>83</td>
<td>86</td>
<td>81</td>
<td>78</td>
</tr>
</tbody>
</table>
In the statistical analysis of the data, the effects of environmental factors — namely, year, dam age, sex and birth rank, and flock (RER, RCR, F₁, F₂ F₃ and F₄) — 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.

![Survival Rate for Different Dam Ages](image)

**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 F1 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 F4 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).](image-url)
LAMB MORTALITY

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, F1, F2, F3 and F4 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 F2 lambs and then declined to the F3 and F4 lambs with the exception of the F1 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 F1 lambs, survival rates also increased from the Romney to the F2 lambs, and then declined with interbreeding in the F3 and further in the F4 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 F₂ lambs from first-cross (F₁) ewes could reflect a more favourable maternal environment of their dams, together with possible heterosis effects. It could be expected that, in the F₂ 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 F₁ lambs (Falconer, 1960). With interbreeding of the F₂ lambs as ewes, the effect of maternal and heterosis effects on the survival rate of unselected F₁ and F₂ 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 F₁ 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>
<thead>
<tr>
<th>Birth Rank</th>
<th>Single No.</th>
<th>%</th>
<th>Twin No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lambs diagnosed</td>
<td>389</td>
<td>50.2</td>
<td>309</td>
<td>53.1</td>
</tr>
<tr>
<td>Lambs not diagnosed</td>
<td>75</td>
<td>9.7</td>
<td>41</td>
<td>7.0</td>
</tr>
<tr>
<td>Total autopsies</td>
<td>464</td>
<td>59.9</td>
<td>350</td>
<td>60.1</td>
</tr>
<tr>
<td>Dead: No autopsy</td>
<td>120</td>
<td>15.5</td>
<td>73</td>
<td>12.5</td>
</tr>
<tr>
<td>Fostered</td>
<td>24</td>
<td>3.1</td>
<td>24</td>
<td>4.1</td>
</tr>
<tr>
<td>Dead: Missing carcass</td>
<td>167</td>
<td>21.5</td>
<td>135</td>
<td>23.2</td>
</tr>
<tr>
<td>Total</td>
<td>775</td>
<td>582</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Mortality Characteristics, all Flocks, 1959-67
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, prenatal, 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
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, F3 and F4 lambs and lowest with F1 and F2 lambs. In multiple-born lambs, losses from starvation were highest for Romney (46 and 43%), F3 (42%), and F4 (45%), and lowest for F1 (35%), and F2 (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.
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, F1, F2, F3 and F4 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 subgroups, 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 subgroups, 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

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