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Observations on litter size, parturition and maternal behaviour in relation to lamb mortality in fecund Dormer and South African Mutton Merino ewes

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Dormer (n = 166) and SA Mutton Merino (n = 147) ewes were observed continuously during lambing in the autumn lambing seasons of 1989—1991. Although SA Mutton Merino ewes had larger ($P \leq 0.01$) litters at birth than Dormers (2.08 vs. 1.75), higher ($P \leq 0.05$) levels of mortality at birth (0.101 vs. 0.031) and from 3 days to weaning (0.180 vs. 0.110) resulted in this difference being eliminated at weaning (1.35 vs. 1.37). SA Mutton Merino ewes generally took longer to give birth ($P \leq 0.01$; 92 vs. 67 min) and were more likely to be assisted at birth ($P \leq 0.01$; 0.231 vs. 0.102) than Dormers. Post-mortem results suggested that birth stress was more prevalent ($P = 0.053$) amongst 61 perinatal deaths in SA Mutton Merino lambs than in 30 Dormers (0.575 vs. 0.333). Mortalities within *ca.* 1 week of birth amongst assisted lambs (pooled across breeds) were generally higher than in their unassisted contemporaries, significantly ($P \leq 0.05$) so in singles (0.444 vs. 0.044) and triplets (0.604 vs. 0.156). Length of parturition was found to be repeatable ($t = 0.36 \pm 0.07$). Permanent and temporary separation of ewes from ≥ 1 lamb were independent of breed, but were lower ($P \leq 0.05$) amongst ewes caring for singles (0.011) than in ewes caring for twins (0.197) or triplets (0.323). Permanent separation was caused by interference and desertion in respectively 0.500 and 0.239 of affected ewes, while lambs followed a non-interfering ewe in 0.174 of cases. Separation was attributed to udder malfunction in 0.043 of the ewes. The incidence of permanent separation caused by interference by other ewes was higher ($P \leq 0.05$) in Dormer ewes than in SA Mutton Merinos (0.654 vs. 0.300). Ewes moving from their birth sites ≤ 120 min after birth were more likely ($P \leq 0.01$) to be permanently separated from ≥ 1 lamb than ewes which remained longer (0.400 vs. 0.134). This observation was mainly caused by ewes classified as deserting their lamb(s). These ewes left their birth sites sooner ($P \leq 0.01$) than those that were not separated from any lambs (156 vs. 351 min). Separation of ewes from ≥ 1 lamb was related to the density of lambed ewes ($r = 0.56$) increasing by 2.01% ($SE_b = 0.35$) for 1 lambed ewe/ha. Udder malfunction was recorded in 18 ewes, and was accompanied by high levels of lamb mortality (0.643). Selection against rearing failure should be investigated for the improvement of rearing ability and lamb survival in these flocks, before further attempts are made to increase fecundity. Management should facilitate for ewes remaining on their birth sites for a long time after birth, and avoid stocking densities > 11 pregnant ewes/ha at lambing.

Dormer- (n = 166) en SA Vleismerino-ooie (n = 147) het in die 1989—1991-herfslamseisoen onder deurlopende observasie gelam. Alhoewel SA Vleismerino-ooie groter ($P \leq 0.01$) werpsels by geboorte gehad het as Dormers (2.08 vs. 1.75), het hoër ($P \leq 0.05$) vlakke van lamvrektes tydens geboorte (0.101 vs. 0.031) en van 3 dae tot speen (0.180 vs. 0.110) daartoe gelei dat die verskil by speen uitgekanselleer is (1.35 vs. 1.37). SA Vleismerino-ooie het langer geboortes ($P \leq 0.01$; 92 vs. 67 min) gehad as Dormers, en die proporsie ooie wat tydens lam gehelp is, was ook hoër as by Dormers ($P \leq 0.01$; 0.231 vs. 0.102). Volgens post-mortemresultate was geboortestremming 'n meer algemene ($P = 0.053$) oorsaak van 61 perinatale vrektes by SA Vleismerinolammers as by 30 Dormers (0.575 vs. 0.333). Vrektes binne 1 week na geboorte onder lammers van ooie wat tydens geboorte gehelp is, was in die algemeen hoër as by lammers van hulle tydgenote wat self gelam het, met betekenisvolle ($P \leq 0.05$) verskille by enkelinge (0.444 vs. 0.044) en drielinge (0.604 vs. 0.156). Lengte van parturisie was herhaalbaar ($t = 0.36 \pm 0.07$). Permanente en tydelike skeiding van ooie van ≥ 1 lam was onafhanklik van ras, maar was laer ($P \leq 0.05$) by ooie wat enkelinge versorg het (0.011), as by ooie met tweelinge (0.197) of drielinge (0.323). Permanente skeiding is veroorsaak deur onderskeidelik inmenging en verlating ('desertion') by 0.500 en 0.239 van geaffekteerde ooie, terwyl lammers 'n nie-inmengende ooi in 0.174 van die gevalle gevolg het. Skeiding is toegeskryf aan uierprobleme in 0.043 van die ooie. Permanente skeiding as gevolg van inmenging deur ander ooie was hoër ($P \leq 0.05$) by Dormerooie as by SA Vleismerino-ooie (0.654 vs. 0.300). Ooie wat ≤ 120 min ná lam van hulle lamplekke wegbeweeg het, het meer geneig ($P \leq 0.01$) om permanent van ≥ 1 lam geskei te word as ooie wat langer by hul lamplekke gebly het (0.400 vs. 0.134). Die resultaat is grootliks veroorsaak deur ooie wat hul lam(mers) in die steek gelaat het. Hierdie ooie het korter ($P \leq 0.01$) op hulle lamplek vertoef as tydgenote wat nie van enige lam(mers) geskei is nie (156 vs. 351 min). Skeiding van ooie van ≥ 1 lam was verwant aan die digtheid van gelamde ooie ($r = 0.56$), met 'n toename van 2.01% ($SE_b = 0.35$) vir 1 gelamde ooi/ha. Uierprobleme is waargeneem in 18 ooie, en het gepaard gegaan met hoë lamvrektes (0.643). Seleksie teen ooie wat nie lammers grootmaak nie, moet ondersoek word vir die verbetering van grootmaakvermoë en lamoorlewing in dié kuddes, voordat verdere pogings aangewend word om fekunditeit te verbeter. Bestuur moet gemik word daarop om ooie te help om lank op hulle lamplekke te bly, en om digthede > 11 dragtige ooie/ha van lammerooie te vermy.

Keywords: Birth problems, lamb mortality, length of parturition, separation, udder malfunction

Introduction

Lamb mortality, which is an important source of reproductive failure in sheep production (Johnston *et al.*, 1980; Dalton *et al.*, 1980), was recently reviewed (Alexander, 1984; Haughey, 1991). In most flocks, problems at parturition and the starvation-mismothering-exposure (SME) complex are the most important causes of lamb mortality with variable contributions from a host of minor causes, including infections, nutrient deficiencies and predation. Since both major causes involve the ability of ewes to give birth to, and care for their offspring successfully, increasing attention is being focused upon maternal behaviour (Alexander, 1988). Lamb mortality is high in prolific breeds and flocks (Maund *et al.*, 1980; Fogarty & Hall, 1987), with increased levels of prenatal deaths, as well as deaths due to 'prolonged' births (Hinch *et al.*, 1986).

Separation of ewes from ≥ 1 lamb increases with litter size (Alexander *et al.*, 1983b; Alexander *et al.*, 1990), due to interference and lamb stealing by parturient ewes (Winfield, 1970; Alexander *et al.*, 1983a), as well as poor maternal care (Stevens *et al.*, 1982; Alexander *et al.*, 1983a).

In order to suggest ways of improving the efficiency of South African mutton sheep, this study employed intensive observations on ease of birth, post parturient maternal behaviour and separation of ewes from ≥ 1 viable lamb(s) in relation to lamb mortality. Fecund Dormer and SA Mutton Merino ewes were used under conditions regarded as representative of the stud industry in the Western Cape.

Material and Methods

Animals and location

The experimental animals were drawn from the registered Elsenburg Dormer and SA Mutton Merino flocks, described by Van der Merwe (1976) and Vosloo (1967) respectively. These flocks are maintained on the Elsenburg Experimental Farm near Stellenbosch, longitude 18°50 'E and latitude 33°51 'S. The climate is generally mild with maximum average summer temperatures *ca.* 29 °C and minimum winter temperatures *ca.* 7 °C. The average annual precipitation of 605.8 mm falls mainly in winter. During the observation period, maximum temperatures exceeded 30 °C only on very few days and minimum temperatures were generally higher than 10 °C. A total precipitation of 19.5—32.7 mm over 2—4 days was recorded for the respective years. Mean hourly wind speeds averaged 5.9—6.5 km/h, rarely exceeding 10 km/h in any of the years.

Experimental procedure

The experiment was conducted on an area of *ca.* 5 ha, divided into 10 paddocks of *ca.* 0.5 ha each, containing irrigated pasture mainly of kikuyu (*Pennisetum clandestinum*). After being drafted in the observed groups on udder development, ewes were side-branded with stock-marker paint for identification. During the observational period, which lasted for *ca.* 14 days, 1—2 new mobs of ewes were drafted into the experiment every 4—7 days, to replace lambed ewes. Observations were taken in March/April 1989, and in April 1990 and 1991. Periparturient behaviour was recorded for 166 Dormer and 147 SA Mutton Merino ewes, giving birth to 290 and 306 lambs respectively.

Observations were collected by 1—2 observers who walked the paddocks continuously. The ewes adapted to human presence within a short period of time and could be approached very closely (< 5 m) without undue disturbance. Information was relayed by radio to a central recorder overlooking the area, to enable him/her to direct the field observer(s). Five paddocks were used during daylight hours, while five were floodlit for use at night. Every morning at 07:00, unlambed ewes were drifted out of the previous night paddock into the next day paddock. At 18:30, unlambed ewes were drifted into the following night paddock. Care was taken not to disturb recently lambed ewes or their lambs during drifting. Ewes were left on their lambing paddocks for 2.5—3 days. Lambs were weaned at *ca.* 100 days of age, mainly off dryland lucerne pastures.

Data recorded

Recordings included the first definite sign of parturition (straining or the presentation of membranes in > 90% of cases) and length of parturition from the first definite sign to the birth of the last lamb. After being groomed by their mothers for at least 15 min, new-born lambs were tagged, sexed and identified according to the order of birth within a litter. The birth site was marked. Lambs were weighed and side-branded with their mother's number immediately after drifting. Observations were frequent until the lamb(s) had suckled. Subsequently the behaviour of ewes and lambs was recorded every 30 min, for *ca.* 24 h. Intermittent observations continued for 3 days.

Ewes were assisted 3.5—4.5 h after the first definite sign of parturition or as soon as convenient thereafter. Five ewes with abnormal presentations were assisted 30 min after it became clear that a normal birth was unlikely. The incidence of separation of ewes from ≥ 1 lambs was recorded, and an attempt was made to identify causes. Separation was ascribed to interference, desertion (lambs left on birth site for whatever reason), poor milk supply, or a lamb following another non-interfering ewe. Ewes were regarded as being temporarily separated from ≥ 1 lamb after 2 h without contact. Permanent separation was defined as 5.5—6 h without contact and regarded as unlikely to be resolved without human intervention. Lambs not permanently fostered by other ewes, were returned to their mothers at this stage. Lambs not accepted were removed from the trial and regarded as dead. Fourteen lambs, shared equally between two ewes, were regarded as separated from their mothers due to interference. Ewes moving > 15 m from their birth sites for ≥ 2 h were considered to have left the site permanently. Distances were estimated by reference to a grid system in the paddocks.

Ninety-one lambs which died during the perinatal period (before, during or within 7 days of birth) were collected and delivered to the Regional Veterinary Laboratory once daily, or after storage in a cool room (4 °C) over weekends and public holidays. Using procedures described by Haughey (1989), lambs were classified as having died in the antenatal period (characterized by autolysis, subcutaneous oedema or mummification), in the parturient or postparturient period due to birth stress (characterized by oedema of the presenting portion, meconium staining, epicardial petechiae, haemorrhages and congestion of the brain and spinal chord), in the postparturient period with evidence of starvation/mismothering/exposure (SME, characterized by depleted fat reserves, inadequate milk ingesta) or due to other causes (lethal congenital malformations, infections acquired after birth, unknown causes).

Statistical analysis

Reproduction data were analysed by standard least squares procedures (Harvey, 1977; 1982). The fixed model employed for this purpose included the effects of breed (Dormer or SA Mutton Merino), year (1989—1991) and age at lambing (2 years, 3—6 years and ⩾ 7 years – referred to as maiden, mature and old ewes respectively). The same procedure was used to analyse litter mass at birth and rearing as well as length of parturition (transformed to logarithms$_{10}$ to account for a skew distribution), but the fixed effect of litter size (single, twin or triplet) was added to the model. Actual length of parturition was analysed in ewes assisted at birth, since length of parturition almost exclusively determined the need to render assistance. For the analysis on the time that ewes remained on their birth sites (also transformed to logarithms$_{10}$), the number of viable lambs cared for just after birth was used instead of litter size. Two-factor interactions were generally unimportant, and omitted from the discussions. Repeatability (t) of some parameters was estimated with 128 records of 59 ewes that were observed twice or more (k = 2.18). A general

Table 1 Least squares means (± *SE*) for the effects of breed, year and age on the reproductive performance of Dormer and SA Mutton Merino ewes continuously observed during lambing in 1989—1991 as well as the effects of breed, year, sex, dam age and birth type on the mortality of lambs, assessed by Chi^2 procedures

		Number of lambs/ewe available			
Reproduction	Number of ewes	At birth	Born alive	Alive at 3 days	Alive at weaning
Overall mean	313	1.92 ± 0.05	1.79 ± 0.05	1.68 ± 0.05	1.36 ± 0.06
Breed		**	NS	NS	NS
Dormer	166	1.75^{1} ± 0.06	1.72 ± 0.07	1.51 ± 0.07	1.37 ± 0.07
SA Mutton Merino	147	2.08^{2} ± 0.06	1.86 ± 0.07	1.75 ± 0.07	1.35 ± 0.07
Year		**	**	**	**
1989	98	2.24^{2} ± 0.09	2.08^{2} ± 0.10	1.85^{b} ± 0.10	1.41^{b} ± 0.10
1990	105	1.67^{1} ± 0.07	1.55^{1} ± 0.08	1.45^{a} ± 0.08	1.14^{a} ± 0.08
1991	110	1.85^{1} ± 0.09	1.74^{1} ± 0.10	1.73^{b} ± 0.10	1.53^{b} ± 0.10
Age		NS	NS	NS	NS
Maiden	60	1.80 ± 0.09	1.71 ± 0.10	1.63 ± 0.10	1.37 ± 0.10
Mature	216	1.95 ± 0.04	1.75 ± 0.04	1.67 ± 0.05	1.40 ± 0.05
Old	37	2.01 ± 0.10	1.91 ± 0.12	1.74 ± 0.12	1.31 ± 0.12

		Lamb mortality / lamb born			
Lamb mortality	Number of lambs	At birth	Birth—3 days	3 days—weaning	Total
Overall mean	596	0.067	0.064	0.146	0.277
Breed		**	NS	*	**
Dormer	290	0.031^{1}	0.062	0.110^{a}	0.203^{1}
SA Mutton Merino	306	0.101^{2}	0.065	0.180^{b}	0.345^{2}
Year		NS	**	**	**
1989	214	0.065	0.136^{2}	0.192^{b}	0.393^{2}
1990	180	0.078	0.039^{1}	0.172^{b}	0.289^{2}
1991	202	0.059	0.009^{1}	0.074^{a}	0.144^{1}
Sex		*	NS	NS	NS
Ram	312	0.090^{a}	0.051	0.163	0.304
Ewe	284	0.042^{b}	0.077	0.127	0.246
Dam age		NS	NS	*	*
Maiden	103	0.049	0.068	0.097	0.214^{a}
Mature	416	0.077	0.053	0.142	$0.272^{a,b}$
Old	77	0.039	0.117	0.234	0.390^{b}
Birth type		**	**	**	**
Single	77	$0.065^{1,2}$	0.026^{a}	0.052^{1}	0.143^{1}
Twin	375	0.032^{1}	0.043^{a}	0.123^{1}	0.197^{1}
Triplet	144	0.160^{2}	0.139^{b}	0.257^{2}	0.556^{2}

NS Not significant ($P > 0.05$); * significance ($P \leq 0.05$); ** significance ($P \leq 0.01$).

^{a,b} Denote significance ($P \leq 0.05$).

^{1,2} Denote significance ($P \leq 0.01$).

mixed model, containing the random effect of ewes within contemporary groups (breed and birth year) and the fixed effect of age, was fitted to the data (Harvey, 1977). Repeatability was calculated from between and within ewe variance components from these analyses (Turner & Young, 1969). Data were pooled and expressed as proportions where applicable, and compared by non-parametric chi-squared (Chi^2) methods. In the case of lamb mortality data, this was done after least-squares appraisal (Harvey, 1982) to ascertain no significant two-factor interactions between main effects.

Results

Ewe litter size and lamb mortality

Number of lambs born/ewe was 19% higher ($P \leq 0.01$) in SA Mutton Merinos than in Dormers (Table 1). Higher ($P \leq 0.05$) levels of mortality at birth and from 3 days to weaning amongst SA Mutton Merino lambs resulted in no breed difference in lambs weaned/ewe, but Dormers tended to have a higher mass of lamb weaned/ewe (38.2 ± 1.7 vs. 34.4 ± 1.8 kg; $P = 0.055$). The number of lambs born/ewe was highest ($P \leq 0.01$) in 1989. Ewes which lambed in 1991 weaned more lambs/ewe than those which lambed in 1990 ($P \leq 0.01$), due to lower levels of preweaning mortality. Number of lambs weaned/ewe was also higher ($P \leq 0.05$) in 1989 than in 1990. Ewe age did not affect reproduction significantly, but overall lamb mortality levels were higher ($P \leq 0.05$) amongst progeny of old ewes compared to young ewes. Ram lambs sustained higher ($P \leq 0.05$) levels of mortality at birth than ewes, with a similar tendency ($Chi^2 = 2.499$; $P = 0.11$) in total lamb mortalities. Triplets generally had higher ($P \leq 0.05$) age specific and overall mortalities than either singles or twins. Total lamb mortalities were roughly equally divided between the periods: birth to 3 days and 3 days to weaning.

Mass of lamb born and length of parturition

SA Mutton Merinos gave birth to heavier ($P \leq 0.01$) litters than Dormers (Table 2). Mass of lamb born/ewe was also affected ($P \leq 0.01$) by year and age of ewe. Litter size at birth markedly influenced ($P \leq 0.01$) mass of lamb born/ewe available. Dormers experienced shorter ($P \leq 0.01$, $\log_{10}$ transformed) births than SA Mutton Merinos (55.2 vs. 94.4 min; means ± *SE*s – 1.74 ± 0.05 and 1.98 ± 0.05 respectively). A higher ($P \leq 0.05$) proportion of 101 twin-bearing Dormers had births of < 2 h than of 87 SA Mutton Merinos (0.693 vs. 0.517; $Chi^2 = 5.366$; df = 1). No significant breed differences were obtained in single or triplet bearing ewes when classified in this way. A higher ($P \leq 0.05$) proportion of 53 single bearing Dormers did, however, give birth within an hour than of 24 SA Mutton Merinos (0.698 vs. 0.375; $Chi^2 = 5.89$; df = 1).

Least squares adjustment for the larger litters being borne by SA Mutton Merinos reduced the difference in length of parturition between breeds, but it remained significant ($P \leq 0.01$, Table 2). The linear effect of mass of lamb born/ewe as a covariant in the model reduced the observed breed effect substantially ($P = 0.068$), but failed to remove it conclusively. Individual class regressions (± *SE*) for the $\log_{10}$ of length of parturition on litter mass at birth were different ($P = 0.04$) for Dormers and SA Mutton Merinos (1.40 vs. 1.22 min/kg; regressions ± *SE*s: 0.147 ± 0.037 and 0.088 ± 0.034). Triplet litters took longer to be born than twins which, in turn, had longer parturitions than singles ($P \leq 0.05$), but year and ewe age did not significantly affect length of parturition.

Table 2 Least squares means for the effects of breed, year, age and number of lambs born on mass of lamb born and length of parturition ($\log_{10}$ transformed) in Dormer and SA Mutton Merino ewes continuously observed during lambing in 1989—1991

	Mass of lamb born (kg)	Length of parturition (min)	
		Mean ± *SE*	Antilog
Overall mean	7.70 ± 0.10	1.893 ± 0.046	78.2
Breed	**	**	
Dormer	7.52^{1} ± 0.12	1.824^{1} ± 0.052	66.7
SA Mutton Merino	7.88^{2} ± 0.12	1.962^{2} ± 0.054	91.6
Year	**	NS	
1989	$7.68^{a,b}$ ± 0.17	1.913 ± 0.076	81.8
1990	7.37^{a} ± 0.13	1.852 ± 0.059	71.1
1991	8.05^{b} ± 0.17	1.915 ± 0.077	82.2
Age	*	NS	
Maiden	7.30^{a} ± 0.21	1.945 ± 0.097	88.1
Mature	7.88^{b} ± 0.08	1.919 ± 0.034	82.9
Old	7.92^{b} ± 0.20	1.816 ± 0.091	65.5
Number of lambs born	**	**	
1	4.92^{1} ± 0.18	1.658^{a} ± 0.079	45.5
2	7.96^{2} ± 0.10	1.861^{b} ± 0.043	72.6
3	10.23^{3} ± 0.24	2.161^{c} ± 0.106	144.9

NS Not significant ($P > 0.05$).
* Significance ($P \leq 0.05$).
** Significance ($P \leq 0.01$).
^{a,b,c} Denote significance ($P \leq 0.05$).
^{1,2,3} Denote significance ($P \leq 0.01$).

Assistance at birth and survival of assisted lambs

Assistance at birth was independent of year ($Chi^2 = 2.01$; df = 2) and ewe age ($Chi^2 = 2.62$; df = 2). Ewes bearing singles (n = 77) and twins (n = 188) were less likely to be assisted than 48 triplet bearing ewes (0.117 and 0.138 vs. 0.333; $Chi^2 = 12.25$; df = 2; $P \leq 0.01$). The incidence of assistance at birth was higher ($P \leq 0.01$) in SA Mutton Merino ewes than in Dormers (0.231 vs. 0.102; $Chi^2 = 8.57$; df = 1). In singles and twins, levels of assistance were at least two times higher in SA Mutton Merino ewes than in Dormers, but the difference only tended to be significant ($P = 0.06$) in twins (0.195 vs. 0.089; $Chi^2 = 3.58$; df = 1). One in every three triplet bearing ewes was assisted in both breeds (12/36 and 4/12 respectively).

Lamb mortality to *ca.* 1 week was investigated in relation to assistance at birth. Tendencies were similar for Dormer and SA Mutton Merino lambs, and the data were pooled across breeds. Single lambs (n = 9), given birth to by assisted ewes, had a lower ($P \leq 0.01$) probability of survival than 68 contemporaries born without assistance (0.444 vs. 0.044; $Chi^2 = 10.95$; df = 1). A similar tendency was observed in twins, but the difference failed to reach significance (assisted – 7/52 = 0.135 vs. not assisted – 21/324 = 0.065; $Chi^2 = 2.24$; df = 1). Triplet lambs (n = 48) rendered assistance at birth had a markedly lower ($P \leq 0.01$) probability of survival to 1 week

than 96 contemporaries born naturally (0.604 vs. 0.156; Chi^2 = 28.18; df = 1).

Repeatability

The between-ewe variance component for length of parturition was significant ($P \leq 0.01$), and repeatability ($\pm$ *SE*) was estimated at 0.36 $\pm$ 0.07. Including number of lambs born as main effect or litter mass at birth as covariant had little effect on this estimate. Between-ewe variance components for ewes losing $\geq$ 1 lamb during the perinatal period and mass of lamb weaned/ewe were also significant ($P \leq 0.05$; t = 0.29 $\pm$ 0.08 in both cases).

Levels and causes of separation of ewes from ≥1 of their lambs

Of 304 ewes caring for $\geq$ 1 viable lamb shortly after birth, 46 (0.151) were separated permanently from at least one lamb. A further 23 ewes were temporarily separated from at least one lamb. Permanent and temporary separation of ewes from $\geq$ 1 lamb showed no dependence on year or breed. Permanent separation was lower ($P \leq 0.05$) in 95 ewes caring for singles than in respectively 178 and 31 ewes caring for twins or triplets (0.011 vs. 0.197 and 0.323; Chi^2 = 24.59; df = 2). Temporary separation followed the same trend (singles – 0.011; twins – 0.144; triplets – 0.235; Chi^2 = 12.17; df = 2).

Interference by other parturient ewes was the main cause of permanent separation, involving 23 (0.50) of all ewes being permanently separated from $\geq$ 1 lamb(s). Permanent separation as a result of desertion was recorded in 11 ewes (0.239). Lambs followed other non-interfering ewes in eight cases (0.174). Udder problems occurred in two SA Mutton Merino ewes (0.043). Although not significantly different, it was interesting to note that 14 lambs, being shared equally by two ewes during observations, had a low mortality to weaning (0.071) compared to 510 other lambs where no complicating factors (interference, desertion or udder malfunction) were involved (0.251). Interference was a more important cause of permanent separation of 26 Dormer ewes from $\geq$ 1 lambs than of 20 SA Mutton Merino ewes (0.654 vs 0.300; Chi^2 = 4.34; df = 1; $P \leq 0.05$). No significant breed effects were found for other causes of separation.

Movement of ewes from the birth site

Dormers remained longer ($P \leq 0.05$; $\log_{10}$ transformed) on their birth sites than SA Mutton Merinos (257 vs. 338 min; means $\pm$ *SE*s – 2.41 $\pm$ 0.03 and 2.53 $\pm$ 0.04 respectively). The time that ewes remained on their birth sites was unaffected by lambing year, ewe age or number of lambs cared for. Ewes separated permanently from $\geq$ 1 lamb moved sooner ($P \leq$ 0.05) from their birth sites than ewes not separated from any progeny (250 vs. 325 min; $\log_{10}$ transformed means $\pm$ *SE*s – 2.40 $\pm$ 0.04 and 2.51 $\pm$ 0.02 respectively). Similar results were obtained for temporary separation (248 vs. 338 min respectively; means $\pm$ *SE*s – 2.40 $\pm$ 0.04 and 2.53 $\pm$ 0.02).

Ewes which remained on their birth sites for $\leq$ 120 min (n = 20), were more likely ($P \leq 0.01$) to be separated from $\geq$ 1 lamb than 284 ewes remaining for > 120 min (0.400 vs. 0.134; Chi^2 = 8.34; df = 1; Figure 1). The incidence of temporary separation was higher (Chi^2 = 7.316; df = 1, $P \leq$ 0.01) in 67 ewes that remained on their sites for $\leq$ 240 min (0.149), than in 125 ewes that remained for > 360 min (0.032). The relationship of permanent separation with time on the birth

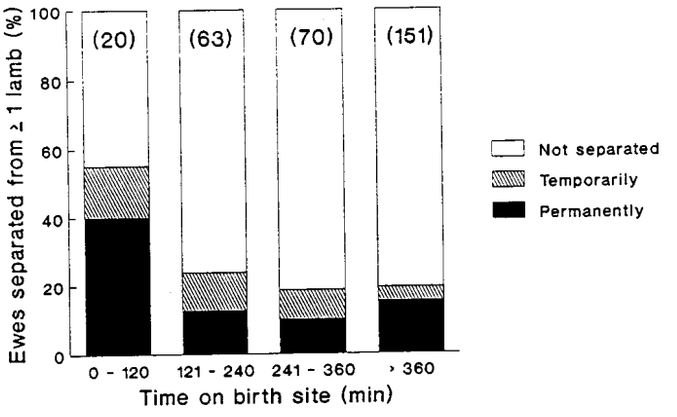

Figure 1 Separation of ewes from at least one lamb in relation to the time that ewes remained within 15 m from their birth sites. The number of ewes in each class is given in parentheses.

site was due solely to ewes leaving lambs. This category (n = 11) was the only group that remained shorter ($P \leq 0.05$) on their birth sites than ewes not separated from any lambs (n = 260; 156 vs. 351 min; $\log_{10}$ transformed means $\pm$ *SE*s – 2.19 $\pm$ 0.08 and 2.55 $\pm$ 0.02 respectively).

The density of lambed ewes

The incidence of permanent separation was related to the number of lambed ewes within paddocks (Figure 2), and increased by 2.01% (SE_b = 0.35) ewes separated from $\geq$ 1 lamb for every additional ewe that lambed. Regressions for the respective lambing years (1989—1991) ranged between 1.7 and 2.3% ewes separated from $\geq$ 1 lamb/lambed ewe, and were not significantly different ($P > 0.35$).

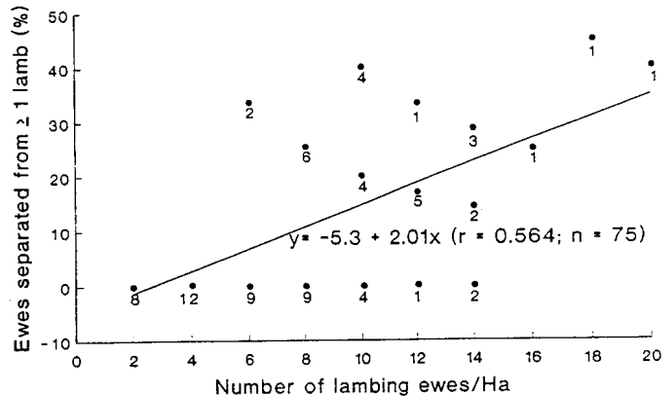

Figure 2 The percentage of ewes permanently separated from at least one lamb in relation to the number of lambed ewes caring for at least one viable lamb per hectare. Each marker represents the number of observations printed underneath.

Causes of perinatal mortality

Antenatal deaths constituted a proportion of *ca.* 0.11 of 30 Dormer and 61 SA Mutton Merino lambs autopsied during the course of the study (Figure 3). Birth stress was more prevalent amongst SA Mutton Merino lambs than in Dormers (Chi^2 = 3.74; P = 0.053; df = 1). Symptoms of SME were diagnosed

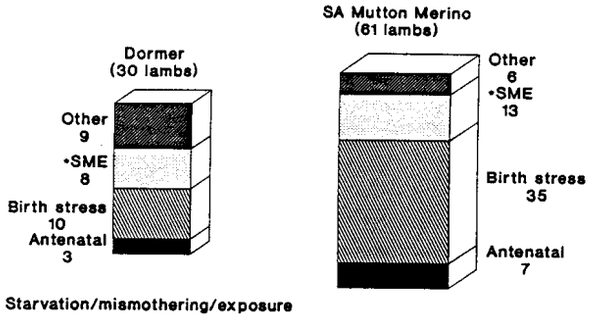

Figure 3 Causes of perinatal lamb mortality in Dormer and SA Mutton Merino lambs, as determined by autopsy of 91 lambs.

in 21 lambs with no breed difference. Dormer lambs were more likely to succumb to other causes than SA Mutton Merinos ($Chi^2 = 4.57$; $P \leq 0.05$; df = 1).

Udder problems

Of the 304 ewes caring for ≥ 1 viable lamb, 18 (0.056) were found to have udder abnormalities. Of these ewes, half had only one functional teat due to shearing injury, while milk production was severely reduced by scar tissue from previous mastitis in the remainder. Mortality amongst lambs from these ewes was high (21/33 = 0.643). No cases of severe, acute mastitis occurred during the investigation.

Discussion and Conclusions

Ewe litter size and lamb mortality

The higher multiple birth rate and levels of lamb mortality of SA Mutton Merino ewes and lambs compared to Dormers is in good agreement with previous results (Brand *et al.*, 1985). Lamb mortality figures for singles and twins were similar, with substantially higher mortality levels for triplets. Corresponding results were reported previously in studies involving fecund breeds or strains (Maund *et al.*, 1980; Brand *et al.*, 1985; Scales *et al.*, 1986). The comparatively high level of lamb mortality from 3 days to weaning is another cause of concern. The causes of these deaths were not determined, but a previous study suggested that mismothering syndromes played a role, while deaths due to acute haemonchosis were also reported (Haughey, 1989).

Length of parturition and birth problems

SA Mutton Merino ewes required more assistance at birth, underwent a longer parturition and displayed a higher proportion of birth stressed lambs than Dormers, thus supporting previous work in these breeds (Brand *et al.*, 1985) and in others (Smith, 1977; Dalton *et al.*, 1980; Woolliams *et al.*, 1983; Alexander *et al.*, 1990). A larger pelvic size was related to selection for increased lamb survival in the Romney breed and lower levels of dystocia in the Marshall Romney strain (Knight *et al.*, 1988) and in other studies (Quinlivan, 1971; Fogarty & Thompson, 1974; McSporran & Fielden, 1979; Haughey *et al.*, 1985; Cloete & Haughey, 1988). The increase in parturition time and deaths with increasing litter size supports previous work (Owens *et al.*, 1985). This study and previous work (Hinch *et al.*, 1986; Haughey, 1991) suggest that the increased total foetal mass of larger litters theoretically imposes greater uterine work load during parturition, increasing its duration. Litter mass at birth was more important as a determinant of length of parturition in Dormer ewes than in SA Mutton Merinos, suggesting that length of parturition in SA Mutton Merino ewes may be partially dependent on other factors. Birth difficulty was clearly related to neonatal deaths in the present study, as was also reported by Arnold & Morgan (1975) and Scales *et al.* (1986).

The finding that length of parturition was repeatable also warrants further attention. Selection may thus alter this parameter, at least in the current flock. Judged by the breed difference in length of parturition, it seems reasonable to assume that this trait has a genetic basis. Breed and strain differences in birth problems and dystocia in the literature may well be related to length of parturition. The occurrence of between-ewe variation for the losing of ≥ 1 lamb in the perinatal period may also be related to repeatability estimates for ewe rearing ability in the literature (Piper *et al.*, 1982; Haughey *et al.*, 1985), although the present estimate of 0.29 is somewhat higher. The estimate of 0.29 for mass of lamb weaned/ewe was also higher than most estimates, ranging from 0.06—0.24 (Clarke & Hohenboken, 1983; Fogarty *et al.*, 1985; Bunge *et al.*, 1990). These parameters were, however, expressed on a per ewe lambed basis, while literature estimates were on a per ewe joined basis.

Selective breeding, as advocated by several authors (Fogarty, 1984; Lindsay *et al.*, 1990; Haughey, 1991), may be important in the control of lamb mortalities. In flocks of low and medium fecundity, lamb survival was demonstrated to respond to selective breeding (Donnelly, 1982; Haughey, 1983; Knight *et al.*, 1988; Cloete, 1990), while selection for the ability to rear multiples also were successful (Atkins, 1980). It is uncertain whether lamb losses will be affected by the same mechanisms in fecund Dormer and SA Mutton Merino ewes. It is also uncertain whether selection will influence lamb survival at ages older than 3 days, when roughly half of the lamb deaths in the present study was recorded. Investigations into multiple rearing ability should nonetheless preclude further attempts to enhance the fecundity of particularly the SA Mutton Merino breed.

Prevalence and causes of separation of ewes from ≥ 1 lamb

The incidence of permanent separation amongst ewes caring for multiples was markedly less than in studies involving fine-wool Merino ewes (Stevens *et al.*, 1982; Alexander *et al.*, 1983a), but was in the same order in studies involving Merinos (Alexander *et al.*, 1983b; Putu *et al.*, 1988a). In other studies, levels of separation amongst ewes belonging to a number of breeds and caring for multiples were less than 10% (Alexander *et al.*, 1983a; 1990). No breed effect was observed in the present study, but the prevalence of separation due to interference was higher amongst Dormer ewes than SA Mutton Merinos. Alexander *et al.* (1990) found a tendency towards higher levels of permanent separation from ≥ 1 lamb in Border Leicester ewes than in Glen Vales. Putu (1990) attributed behavioural characteristics conducive to lamb survival in Trangie Fertility Merinos to selection for increased rearing ability in this strain.

Ewes that were separated from ≥ 1 lamb remained for a shorter time on their birth sites than ewes not separated, as was also reported by Alexander *et al.* (1983b). This observation was mainly due to ewes leaving lambs on the birth site. Separation of ewes from ≥ 1 twin lamb was also related to the time that fine-wool Merino ewes remained on their birth sites in a study involving high levels of permanent separation and rapid movement from birth sites (Alexander *et al.*, 1983a). The

time that ewes remained on their birth sites was influenced by shelter (Alexander *et al.*, 1983a) and the availability of pasture (Putu *et al.*, 1988a). The disturbance of recently lambed ewes from their birth sites by humans or supplementary feeding aggravated the incidence of separation of ewes from their lambs (Putu *et al.*, 1988b). Supplementation by the broadcasting of lupines less frequently (Morcombe *et al.*, 1988) may cause less disturbance to lambing ewes without altering live mass change.

An increase of 1 lambed ewe/ha resulted in an increase of *ca.* 2% in the incidence of ewes permanently separated from ≥ 1 lamb. Winfield (1970) and Alexander *et al.* (1983b) reported increased levels of interference and separation as the number of lambed ewes/ha increased, resulting in inaccuracies in litter size records of ewes, as well as in pedigree information. A stocking density of 2.6 lambed ewes/ha theoretically resulted in no separations. Following reasoning of Alexander *et al.* (1983b), it was calculated that a stocking rate of 11 pregnant ewes/ha would minimize recording errors and separations under the conditions of the present trial. Alexander *et al.* (1983b) correspondingly recommended a stocking rate of 18 pregnant ewes/ha.

Causes of perinatal mortality

Although the proportion of *ca.* 0.11 antenatal deaths in the present study is high compared to the generally accepted value of 2% (Haughey, 1991), it is recognized that antenatal death constitutes a more important cause of lamb mortalities in fecund flocks (Hinch *et al.*, 1986). Birth stress was an important cause of perinatal death, particularly in SA Mutton Merino lambs. Starvation/mismothering/exposure were probably underestimated as causes of perinatal death, as some lambs were returned to their mothers when permanent separation was unlikely to be resolved without human intervention, and since lambs taken from the experiment and regarded as dead were not autopsied. There was furthermore strong evidence that mismothering played a major role in deaths from 3 days to weaning (Haughey, 1989). Dormer lambs were more susceptible to other causes of lamb mortality than SA Mutton Merinos. The practical implication of this finding does, however, need further clarification before it can be turned into a practical advantage.

Udder problems

The incidence of udder problems in the present study was on the lower end of the range reported by Jordan *et al.* (1984). Survival of lambs with affected mothers was correspondingly low. When comparing the performance of ewes with two functional teats with that of ewes with only one functional teat, Jordan *et al.* (1984) found that milk production was reduced by 15—42%, and lambs reared/100 ewes by 6—42. Low levels of nutrition aggravated the effects of udder malfunction (Jordan & Mayer, 1989). Udder health should thus also receive attention in the flocks concerned.

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