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Half Polypay ewe lambs were bred to Suffolk, North Country Cheviot and Hampshire rams to lamb at about one year of age. Type of birth-rearing significantly affected mortality by 70 days of age and all weights of lambs from birth to weaning. The mortality rate at 70 days of age of twin born-single raised lambs was three times that of either single born and raised lambs or of twin born and raised lambs. Single born and reared lambs were heavier than twin born and reared lambs, with twin born-single reared lambs being intermediate at all ages. Individual Polypay grand-sires had a significant effect on the standing to suckling interval and on weights of lambs up to 10 days of age. Breed of dam's grand-dam was found to be significant until 60 days of age for weights of lambs. Litter weight at weaning per ewe lambing was not significantly influenced by any

effect included in the analysis.

Breed of sire was not significant for any of the variables analyzed. This was perhaps a consequence of differences in performance of the rams due to differences of maturity of rams between breed-groups.

Phenotypic correlations between time intervals around lambing and weights up to weaning were significant in most cases. A lamb heavier at birth has a longer duration of parturition but is faster to stand and to suckle than a lamb of lighter birth weight. Partial correlations between time intervals and weights to weaning, holding birth weight constant, were non-significant, demonstrating that, for a given birth weight, there is little or no association between preweaning weights and either duration of parturition or lamb vigour at birth.

PERINATAL MORTALITY AND PREWEANING GROWTH OF PROGENY OF EWE LAMBS

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PART 1

BIBLIOGRAPHY REVIEW

PERINATAL MORTALITY AND PREWEANING GROWTH IN SHEEP

INTRODUCTION

A common but important means of measuring the productivity of a flock of ewes is the average weight of their litter at weaning: it combines in a single trait several different aspects of ewe reproduction (fertility, prolificacy) and of offspring growth (ewe milking and mothering ability, lamb growth and survival) (Martin and Smith, 1980).

This review will focus primarily on the two last parameters, i.e. lamb growth and survival.

Values found in the literature for perinatal lamb mortality, its occurence in time and its causes will be presented. Average figures for weaning weight and average daily gain up to weaning will be reported along with the factors influencing these traits. They will be classified as those which are attributes of the lamb, such as type of birth, birth weight, genotype, rearing type, etc..., those that are attributes of the dam (breed, parity, behaviour, etc...) and environmental influences either direct (weather, infectious agents) or indirect (factors influencing pregnancy). This classification was adapted from that of Watson (1972).

Finally, conclusions will be drawn on the points whose importance should be emphasized in order to maximise the litter weight at weaning, keeping in mind some economic factors.

Estimates Of Mortality At Birth and Thereafter

From the literature an average mortality rate at birth of 5 to 10 percent could be estimated, these figures becoming 10 to 20 percent when a longer period (like until weaning) is considered. But in both cases the range of lamb mortality reported in the literature is very wide: 2 to 26 percent at birth, 2 to 54.1 percent for longer periods (see table 1 and 2 respectively). The factors most frequently reported as influencing lamb mortality are breed of lamb, breed of dam, breed of sire, sex, type of birth, and ewe age.

TABLE 1. MORTALITY AT BIRTH IN LAMBS AND CALVES

Reference	Range in % mortality	Source of variation
Baharin and Beilhaz (1977)	2.97-8.53	single vs twins
Fredella (1974)	4.6 -7.8	single vs twins
Purser and Young (1964)	11.7-17.3/ 15.8-24.1	single/twins, of different breeds
Bradford et al. (1974)	9 - 18	females vs males
Fredella (1974)	5.26-7.01	females vs males
Donald (1963) (in calves)	6.4-14.7	breeding system
Sidwell et al. (1962)	3 - 6.8	breeding system
More O'Ferral (1974)	5.2-12.2	breed of ram
Obst and Ellis (1977)	18.8-26.5	breed of ram
Wiener (1975)	5.4-12	breed of ram
Wiener et al. (1973)	8.4-22.3	age of dam
Purser and Young (1964)	12.1-40.5	age of dam
Donald (1963) (in calves)	2.4- 3.6	age of dam
Bradford et al. (1974)	11 - 26	litter size
Dun and Hamilton (1965)	11 - 18	in twins fold ⊕ vs fold ⊖
Obst and Ellis (1977)	5 - 30	weather conditions
Watson (1972)	2 - 15	survey
Karam (1959 b)	7.7	average
Laucher (1973)	2.7	average

TABLE 2. POSTNATAL MORTALITY IN LAMBS FOR PERIODS FROM 30 TO 240 DAYS OF AGE

Reference	Period ends at	Range in % mortality	Source of variation
Baker et al. (1978)	weaning	13 - 20	breeds
Dalton et al. (1976)	weaning	5.6-16.1	breeds
Dickerson and Glimp (1975)	10 weeks	28 - 36	breeds
Dickerson et al. (1975)	4 weeks	17 - 37	breeds
Fredella (1974)	1 month	5.8-18.9	breeds
Khalaf et al. (1979 b)	weaning	29	average between breeds
McGuirk et al. (1977)	weaning	12.3-26.6	average between breeds
Ricordeau et al. (1976)	70 days	12.7-20.1	average between breeds
Ricordeau et al. (1977)	90 days	10.3-15.6	average between breeds
Wiener (1975)	240 days	21 - 30.5	average between breeds
Smith (1977)	weaning	32.8-41.9	sire breed
Smith (1977)	weaning	34.4-42.2	dam breed
Fredella (1974)	1 month	10.7-17.6	singles vs twins
Mullaney and Brown (1969)	weaning	14/18-36/52	singles vs twins
Shelton (1964)	120 days	11.7-20.9	singles vs twins
Watson and Elder (1961)	marking	5/16-25/43	singles vs multiples
Fredella (1974)	1 month	10.3-17.6	ewe age
Smith (1977)	weaning	19.6-54.1	ewe age
Hight and Jury (1970)	weaning	17.8	overall F_1-F_4
Sidwell (1962)	weaning	10.6-19.6	breeding type
Ricordeau et al. (1977)	90 days	10 - 23	litter size
Smith (1977)	weaning	27.7-46.6	type of birth
Smith (1977)	weaning	34.4-40.0	sex
Smith (1977)	weaning	36.7-41.5	dystocia
Watson (1972)	weaning	2 - 40	survey
Laucher (1973)	weaning	12.2	average

Occurence Of Death and Age Of Lambs

Most authors agree that the majority of death losses occur within one week of age. Watson and Marigold Edler (1961) state that "at least 90 percent of the deaths in each group occured within three days of birth". Hight and Jury (1970) found that "most of the lamb deaths occured within three days of birth," while Laucher (1973) states that "losses were highest during the first two weeks, 57 percent of all rearing losses."

In most studies, different mortality rates are recorded for different groups of lambs or for several intervals of time. Alexander (1959) reports that 25 of 62 lambs died within 72 hours after birth, eight of 24 singles (33 percent), four sets of twins (21 percent), and nine other twins of the 38 born (23.6 percent). Hight and Jury (1970) found a higher proportion of single than multiple-born lambs dying at birth and a higher percentage of multiple than single-born dying within one to three days of age. This is also recorded by Purser and Young (1964) when stating that 45 percent of singles and 52 percent of twins died between birth and 14 days of age. For 1051 dead lambs examined by Safford and Hoversland (1960) the average age at death was 5.9 days. Watson (1972) observed two to 14 percent mortality around parturition, two to 40 percent within one to three days of age and two to 16 percent from three days of age to marking (about two weeks of age). The following chart (Table 3) describes the occurence in time of death losses, sampled from the literature.

TABLE 3 PERCENTAGE OF TOTAL DEATH LOSS WITHIN DIFFERENT INTERVALS OF TIME (IN DAYS)

Reference	Birth	1 2 3 4 5 6 7 8 9 10	Over 10 days (end of period in parenthesis)
Fredella (1975)	45.8	←——→36.9←——→	17.3 (weaning)
Purvis et al. (1979)	76.1	←——→ 23.9 ←——	——→ (21 days)
Ricordeau et al. (1977)	42	←→ 35——→ ←—— 23 ——	——→ (weaning)
Safford and Hoversland (1960)	←——	56 → ←17→ ←—— 27←——	——→ (weaning)
Watson (1972)	←——	60→ ←——→ 40←——	——→ (weaning)

Causes Of Deaths

Perinatal mortality cases can be classified into five main categories: 1) prenatal deaths (including non-viability of fetus, miscarriage or deaths linked to infection); 2) deaths linked with parturition (dystocia, stillbirths); 3) those due to starvation (ewe or lamb behaviour); 4) infectious or 5) non-infectious agents.

This classification varies from author to author, some of them concentrating on a certain period of time and others on a specific type of mortality, e.g. infectious causes.

Most of the works report a low occurence of death due to infectious agents (Hight and Jury, 1970: 11.6 percent; Watson, 1972: less than one percent; Safford and Hoversland, 1960: 16 percent), but in some cases their incidence might be very important: Laucher (1973) reported 36.5 percent of deaths occuring in the first two weeks of life were due to E. Coli infections.

For Purvis et al. (1979), stillbirths were the major causes of losses (35 percent), as dystocia was for Hight and Jury (1970): 32.3 percent. These authors noticed a marked difference in the importance of dystocia and physiological starvation between single and multiple-born lambs: 44.6 percent and 15.1 percent (dystocia) vs 16.0 percent and 41.7 percent (physiological starvation).

Purser and Young (1964), by contrast, found that among twins, the lambs born dead were relatively less frequent than for singles (4.8 percent vs 1.8 percent), death resulting from parturition difficulties being rare amongst twins (0.3 percent vs 1.6 percent).

Pneumonia was cited by several authors at noticeable levels (Safford and Hoversland, 1960: 16 percent; Vetter et al., 1960: 28 percent) Differences also exist between breeds. Wiener (1975) pointed out that Scottish Blackface were more susceptible than other groups to enteric diseases. Crossbred lambs were less susceptible to enteric diseases, but more susceptible to parasites that the purebreds. The Cheviots were more susceptible to death from environmental stress, i.e. chilling, than the other groups. In Vetter's experiment (1960), Hampshires had a higher frequency of postnatal deaths attributed to pneumonia and Rambouillets for death attributed to starvation.

Preweaning Growth

Preweaning growth is more an indicator of the ewe milking and mothering ability than of lamb growth potential. It is an important trait to consider, however, as litter weight at weaning and preweaning growth are associated moderately and positively with postweaning traits. The correlation between weights at 12 and 16 weeks was 0.83 in an experiment by Martin et al. (1980). The correlations between gain from birth to weaning and gain between 20 and 100 days postweaning, and average daily gain from weaning to 20 weeks of age were .23 and .19, respectively. (Farid and Makarechian, 1978; Mavrogenis et al., 1980.)

Average daily gain, as underlined by Mavrogenis et al. (1980), represents both the genetic potential of lambs for growth and their maternal environment, which is mostly through suckling. Postweaning growth is thus more heritable than preweaning growth as nutrition is not a limiting factor after weaning. The average preweaning daily gain generally varies between 200 and 250 g/day, but there are significant differences between sexes, type of birth, breeds, age of dam and other factors (Table 4). In an experiment with three Iranian fat-tailed breeds and their crosses with Corriedale and Targhee rams (Makarechian et al., 1977), Mehraban ewes produced lambs with the highest preweaning average daily gain among the crossbred lambs. The lambs reared by two year-old ewes had significantly lower rates of growth, whereas sex had a highly significant effect on the preweaning traits in favour of the male lambs.

Peters and Heaney (1974b) found that heterosis was significant in growth rate from birth to 70 days when lambs were reared with their mothers or artificially, whereas Dickerson et al. (1975) approached significance for heterosis in preweaning gain and 10-week weight. In another study, Peters and Heaney (1974a) observed a significant interaction of rearing system with breed of lambs, sex and type of birth in growth rate up to 70 days of age. More O'Ferral and Timon (1974) stated that differences in progeny growth rates were as large within breeds as between breeds.

As for the pattern of growth in time, Jakubec (1958) noticed that the rate of growth decreased considerably at 56 days and then decreased more gradually (in his experiment weaning occured at 126 days of age).

Heritabilities For Lamb Survival and Preweaning Growth

Heritability for lamb survival has been reported by Smith (1977) but at such a level as it "would seemingly discourage direct within population selection for increased viability." (Table 5)

In cattle, Burfening et al. (1978) have found heritabilities estimates of 0.32, 0.21, 0.31, .22 and .16 for calving ease score, percent assisted births, birth weight, 205-day weight and average daily gain. A review of literature is given by Bonaiti et al. (1976) for values of preweaning trait heritabilities in sheep. (Table 6)

TABLE 4. VALUES OF PREWEANING AVERAGE DAILY GAIN FROM THE LITERATURE

Reference	Period of reference and source of variation	Adg (g/kg)
More O'Ferrall and Timon (1974)	birth-weaning	242.8
	birth slaughter	180.4
Robelin et al. (1977)	0-1 week	233
	1-5	278
	5-10	279
	10-16	240
Sidwell and Miller (1971)	birth-weaning: mean	258
	years	230-274
	age of dam	247-266
	type of birth-rearing	244-269
	sex	244-271
	purebred groups	219-297
	2 breed crosses	224-301
Holtmann and Bernard (1969)	28-120 days, sexes	212-228
Burfening (1972)	birth-6 days, sex of co-twin	200-220
Baharin and Beilharz (1977)	birth-weaning, type of birth	142-157

TABLE 5. HERITABILITY ESTIMATES FOR LAMB SURVIVAL TRAITS (from Smith, 1977)

Trait	Heritability
Birth weight	.32 ± 0.05
Dystocia	.13 ± 0.03
Vigour	.10 ± 0.03
Mortality	.06 ± 0.03

TABLE 6. HERITABILITY ESTIMATES FOR PREWEANING TRAITS

Reference	Period	Heritability
Bonaiti et al. (1976)	Adg 10-30 days	.24 ± .05
	Adg 30-90 days	.31 ± .06
Thrift, Whiteman and Kratzer (1973)	Adg 0-70 days	.09 ± .06
Bowman and Hendy (1972)	Adg 0-16 weeks	0
Dars and Acharya (1970)	Adg first month	.12 ± .28
	second month	.33 ± .16
	third month	1.11 ± .35

Traits Of The Lamb

1) Type Of Birth

Differences in perinatal mortality between single-and multiple-born lambs have been reported consistently. However, they are oftentimes associated with other factors such as birth weight (singles being heavier at birth) or breed (twinning percentage varying from breed to breed). On an average, twin mortality is about 50 percent higher than that of single with extremes ranging from 40 percent to 200 percent (Table 7).

Dun and Hamilton (1965) pointed out that almost all deaths in single lambs in their experiment occured before, during or soon after birth, the pattern of mortality being different with twins, most dying after birth and many from starvation. The incidence of stillbirths reported by Fredella (1975) was also different between singles (4.6 percent) and twins (7.81 percent). Even when these differences exist, they are not always significant. Karam (1959b) found that twins had higher mortality rates than singles, but the difference was not significant. Laucher (1973) obtained significance for the male lambs only.

The effect of type of birth on mortality may vary , depending on which secondary factor is introduced. Dickerson et al. (1975) showed that the type of birth effects on viability differed among years but not among sexes or ages of ewes. Peters and Heaney (1974a) did not observe any significant interaction of type of birth with rearing systems (artificially or with their mothers).

Vetter et al. (1960) reported similar differences between breeds, and no interaction of sex and type of birth on lamb losses. Ricordeau et al. (1977) on the contrary noticed differences between the Berrichon du Cher (BC) and the Romanov (RO) breeds, in the increase of mortality with litter size. (Table 8) The differences between singles and twins increase from birth to weaning: For Sidwell et al. (1962) a higher percentage of single lambs were born alive (96.2 percent) and a higher percentage of single lambs born alive were weaned (88.7 percent) than twins (94.2 percent and 80.6 percent, respectively). The difference from birth to weaning was considerably greater than that at birth. Dickerson et al. (1975) found that lambs born as twins were lower than singles in viability at birth (-1.5 percent) at four weeks (-9.8 percent) and when weaned at ten weeks of age (-12.4 percent). Some other factors might enhance these differences such as the relative ability of twins to maintain body temperature under adverse conditions (Alexander et al., 1959).

Some data are also available for greater litter size from experiments with more prolific breeds. Watson (1972) stated that the mortality of twins had been about twice that of singles, losses among triplets being 40 to 50 percent. Vesely and Peters (1965) computed the number of lambs weaned per 100 lambs born as 93.3, 83.6, and 69.1 for singles, twins and triplets respectively. From a histogram by Khalaf et al. (1979b), working with Finn x Dorset Horn, Scottish Halfbred, and Greyface ewes, the following data in Table 9 have been extrapolated.

TABLE 7. MORTALITY IN RELATION WITH MULTIPLICITY OF BIRTH IN LAMBS

Reference	% mortality singles	% mortality twins	Twins/singles mortality ratio
Baharin and Beilharz (1977)	2.93	8.53	2.91
Venkatachalam et al. (1949)	20	35	1.75
Fredella (1974)	10.7	16.7	1.56
Purser and Young (1964)	17.3	24.1	1.39
	11.7	15.8	1.35
Shelton (1964)	11.7	20.9	1.79
Smith (1977) purebred	28.6	47.7	1.67
crossbred	27.7	46.6	1.68
Vetter (1960)	15	23	1.53
Watson and Marigold Elder (1961)	11-16	37-43	2.96
	5-9	25-30	3.93

TABLE 8. BREED, LITTER SIZE, AND PERCENT MORTALITY IN LAMBS (from Ricordeau et al. 1977)

	Litter size	1	2	3	4
% Breed	BC	10	23		
	RO		9	11	10

TABLE 9. MORTALITY IN RELATION WITH LITTER SIZE IN LAMBS (from Khalaf et al. 1979)

Litter size	1	2	3	4	5	6
Lambs born	20	160	97	34	11	8
Lambs dead		25	27	19	9	6
% mortality		15.6	27.8	55.8	81.8	75

The influence of type of birth on preweaning growth is discussed very little in the literature other than stating an advantage of singles over twins. Most of the reports deal with postweaning growth. Baharin and Beilharz (1977) found that twin lambs grew slower to weaning than singles (142 vs 157 g/day). Dickerson et al. (1975) showed that singles lambs were 2.5kg better in gain to ten weeks and 3.2kg heavier at ten weeks than twin lambs.

2) Type of birth-rearing

The weight of a litter at weaning is a good indicator of ewe productivity. However, it cannot measure accurately the genetic potential of growth of individual lambs as it is recorded at the end of a period where maternal effects have been at a maximum, mostly due to the milk production of the mother. The number of lambs raised with a ewe has a direct influence on their gain in weight. Gjedrem (1967) showed that the prenatal influence on weight gain, measured as the difference between single-and twin-born lambs raised as singles decreased from 100 percent (by definition) at birth to 22 percent at weaning. The postnatal influence, measured as the difference between single born lambs raised as singles and as twins therefore increased from zero to 75 percent. In an experiment by Holtmann and Bernard (1969), single lambs were 5.6kg heavier than twin lambs raised as twins at 120 days of age. But they were only 1.27kg heavier than twin lambs raised as singles. The difference in birth weight was .9kg.

Levine and Hohenboken (1978) observed a significant effect on type of birth-rearing on birth weight, April weight (about 7 weeks old), weaning weight and percent survival, as reported in Table 10.

The effects of birth-rearing type on body weight have been shown to change slightly in time as reported by Martin et al. (1980) when calculating multiplicative factors for adjusting weight at different ages to those of twins raised as twins. (Table 11)

3) Sex Of Lamb

The effects of sex on lamb mortality and preweaning growth have been described extensively in the literature. They are, however, oftentimes associated with differences in birth weight. Some values for these differences are reported in Table 12.

In cattle, Burfening et al. (1978) found that calving ease score, percent assisted birth, birth weight, 205 day weight, and adg were significantly affected by sex of calf. Similarly, Makarechian et al. (1977) pointed out that sex had a highly significant effect on preweaning traits in favour of male lambs, and Vetter et al. (1960) showed a significant effect of sex on total lamb losses. On the contrary, in an experiment by Karam (1959b), rams had a higher mortality rate than ewes, but the difference was not significant. Bradford et al. (1974) found a significant difference in mortality between sexes in Oxford Down, Border Leicester, Southdown, Tasmanian Merino, Welsh Mountain and Soay lambs, but not in Finnish lambs. In Jakubec's work (1958) the absolute gain in weight from birth to weaning was

TABLE 10. BIRTH-REARING TYPE, PREWEANING WEIGHTS AND PERCENT SURVIVAL IN SHEEP (from Levine and Hohenboken, 1978)

Type of birth	Type of rearing	Birth weight	April weight	Weaning weight	% survival
S	S	5	21.1	32.9	93
T	S	3.6	17.8	27.3	74
T	T	3.6	16.2	26.7	74

TABLE 11. MULTIPLICATIVE FACTOR FOR WEIGHTS OF LAMBS AS INFLUENCED BY BIRTH-REARING TYPE (from Martin et al., 1980)

Type of birth	Type of rearing		Weight at Birth	4 wks	8 wks	12 wks	16 wks
Single...	Single	1.1	0.51	0.75	0.79	0.81	0.84
Twin....	{Single	2.1	1.00	0.88	0.88	0.90	0.91
	{Twin	2.2	1.00	1.00	1.00	1.00	1.00
Triplet.	{Single	3.1	1.14	0.97	0.97	0.95	0.94
	{Twin	3.2	1.14	1.09	1.06	1.04	1.03
	{Triplet	3.3	1.14	1.25	1.14	1.19	1.16

TABLE 12. BIRTH WEIGHT AND PERCENT SURVIVAL IN MALE AND FEMALE LAMBS

Reference		Birth weight (kg)		% survival	
		M	F	M	F
Levine and Hohenboken (1978)		4.4	4.1	86	81
Smith (1977)	purebred	4.2	4.0	59.7	64.0
	crossbred	4.3	4.0	60.0	65.6
Bradford (1974)	all litters			82	91
	large litters			74	89
Dickerson et al. (1975) (difference with female lambs)	birth	+.12		-1.7	
	4 wks			-3.0	
	10 wks			-2.7	

greater for males than for females but the relative rates of growth were not appreciably different. Dalton et al. (1976) stated that although they were similar at weaning, Merino x Romney ewe lambs had a slower growth rate than wethers from four to 14 months of age.

Adjusting to equal birth weight, the differences between sexes in mortality obtained by Smith (1977) were even larger in both purebred and crossbred lambs (6.9 vs 4.3 percent and 8.1 vs 5.6 percent). Also, sex was the only significant effect on purebred lamb vigour but not on crossbred's when adjusted to a common birth weight.

4) Sex Of Co-Twin

Sex of co-twin can affect significantly both mortality and preweaning growth. Sex of lamb's co-twin affected lamb loss from birth to six days of age. Lamb losses were 5.3 percent higher when a lamb was born co-twin to a male than when it was born co-twin to a female (Burfening, 1972). In the same experiment, lambs born and raised with a female co-twin had a greater adg (220 g/day) than did lambs born and raised with a male co-twin (200 g/day) to 60 days of age. Baharin and Beilharz (1977) reported that male twins with a female in the same litter were superior to all other types of lambs in term of survival at birth, birth weight and preweaning adg.

On the contrary, Vetter et al. (1960) could not find any statistical difference in death losses due to sex of co-twin. (Table 14)

TABLE 13. INFLUENCE OF SEX OF CO-TWIN ON SURVIVAL, BIRTHWEIGHT AND PREWEANING GROWTH IN LAMBS (from Baharin and Beilharz, 1977)

Differences (weighted)	Survival at birth (%)	Birthweight (kg)	Preweaning adg (g/day)
M (F)/ M (M)	+8.1	+.117	+40
F (F)/ F (M)	+0.7	+.413	- 1
M (M)/ F (F)	-5.9	+.103	-91
M (F)/ F (M)	+2.8	+.523	+92

TABLE 14. TYPE OF BIRTH AND MORTALITY IN LAMBS (from Vetter et al., 1960)

Type of birth	% losses	Level of significance
Males	16.7	$P < 0.05$
Females	12.9	
Singles	14.8	$P < 0.05$
Twins: overall	22.7	
M (M)	25.7	NS
M (F)	21.1	
F (M)	21.9	
F (F)	21.8	

5) Birth Weight

Birth weight is a major factor influencing mortality in lambs. Fredella (1975) stated that of all factors studied in his experiment, birth weight had the greatest effect on mortality. However, it does not seem to affect a great deal the future growth of the lambs: Bonaiti et al. (1976) estimated that birth weight only determines 18 percent of the genetic variability in 90-day weight. Mavrogenis et al. (1980) estimated the genetic correlation between birth weight and all weights and gains at five, ten, 15 and 20 weeks of age to be in the range 0.16 to 0.21. Butcher et al. (1964) reported that about 12 percent of the variance in 140-day weight may be attributed to variance in birth weight and Farid and Makarechian (1978) indicated that the contribution of birth weight to the observed variation in gain from birth to weaning were negligible. However, the correlation between birth weight and preweaning average daily gain was 0.28 and highly significant.

The average weight at litter is thus more a function of the influence of birth weight on mortality than on daily gain. A typical pattern of the distribution of mortality in relation to birth weight is that reported by Watson (1972) where losses are high at both extremes of the birth weight range, the single lambs which died tending to be heavier than those surviving, and the twins which died, lighter than those surviving. Alexander et al. (1959) ascertained this statement with surviving vs non-surviving birth weights being 9.6 vs 10.5 lb. for singles and 8.4 vs 8.0 lb. for twins. In Shelton's experiment (1964), death losses were significantly affected by the birth weight of lambs, with losses decreasing from a high of 65.3 percent for lambs weighing less than 4 lb. to a low of 6.4 percent for lambs weighing 10 to 11 lb. Above 11 lb. losses tended to increase slightly.

Shelton stated that death losses may not be the only disadvantage in small lambs, because of the correlation of birth weight with 120-day weight, rate of gain to 120 days and yearling body weight. These two factors of reduced death loss and increased postnatal gain combined yield an estimate of a minimum of 6.8 lb. lamb weight at 120 days associated with each pound increase in birth weight.

Several papers give a threshold weight from which the mortality starts to increase again: Smith (1977), 5.5kg; Karam (1959b), 4.4kg; Laucher (1973), 7kg; Hight and Jury (1970), 8 to 9 lb. in multiple born.

Purvis et al. (1979) emphasized the fact that a low birth weight is related to weakness of the lambs, pointing out that losses due to starvation or septicemia were associated with underweight lambs of 2.5kg or less. With inclement weather conditions (wet spring) this limit was 3kg for twins and triplets.

If a difference of birth weight between surviving and non-surviving lambs can be found (for instance 0.69 to 0.88kg reported by Fredella, 1979), it varies little, however, with the type of birth of the lamb, even though the respective weights decrease with increasing multiplicity of the litter. This is well illustrated in an experiment by Khalaf et al. (1979b)

Bradford et al. (1974) in an egg transfer study also reported the effect of litter size to be mainly through its effect on birth weight. For Oxford lambs in litters of three to five from Finnish recipients, birth weight was 42 percent that of normal single born Oxfords and only 42 percent survived. For Soays the corresponding values were 59 percent for birth weight and 85 percent for survival. However, Finnish lambs were exceptionally small at birth but had the highest viability of all breeds.

There has been an optimum birth weight reported by several authors. Hight and Jury (1970) found that within flocks, lambs of about average birth weight had the highest survival rates. Their data indicated that the optimum birth weight was about 8.5 to 11 lb. for singles and 7 to 10 lb. for twins. For Purser and Young (1964), this optimum was just above the mean. They pointed out though that at lower birth weights, twins seemed to have some advantage over the corresponding singles, while for higher birth weights, singles had the advantage. This is also expressed by Watson and Marigold Elder (1961) when outlining that single lambs which required assistance at birth were heavier than others, and would have probably died if assistance would not have been given. The combined incidence of mortality and need for assistance in their experiment was highest among the heavy single lambs and light twin lambs.

TABLE 15. INFLUENCE OF TYPE OF BIRTH ON BIRTH WEIGHT AND LIVABILITY OF LAMBS (from Khalaf et al., 1979b)

Breed groups	Type of birth	(kg) Surviving	(kg) Non-surviving	(kg) Difference
I	Twins	3.47	2.51	.96
	Triplets	2.98	2.00	.98
	Quadruplets	2.79	1.90	.89
	Quintuplets	2.45	1.35	1.10
II	Twins	4.5	3.64	.86
	Triplets	3.77	2.68	1.09

6) Breed Of Lamb

Mortality of lambs and preweaning growth has been shown to be influenced by breed of lamb. Heterosis has also been reported in many instances for lamb mortality and preweaning growth. Prenatal mortality, i.e. embryo survival, appeared to be independent of breed of embryo in egg transfer experiments by Bradford et al. (1974): the average survival was 69 percent for embryos of Oxford Down, Border Leicester, Finnish Landrace, Southdown, Tasmanian Merino, Welsh Mountain and Soay. The author concluded that the observed breed differences in litter size are normally due to differences in ovulation rate.

As for the differences in progeny growth rates, More O'Ferrall and Timon (1974) assessed that they were as large between breeds as within breeds. The following tables reflect breed differences reported from different sources. (Tables 16, 17 and 18)

TABLES 16-17-18. EFFECT OF BREED OF LAMB ON LAMB MORTALITY

Table 16 Purser and Young (1964)

	Singles		Twins	
	B[a]	WM[a]	B	WM
Mortality rate (%)	17.3	11.	24.1	15.8
Birth weight: all lambs (lb)	7.33	6.62	5.63	5.27
Surviving lambs (lb)	7.51	6.66	5.88	5.38
Non-surviving lambs (lb)	6.53	6.29	4.88	4.73

[a]B: Blackface WM: Welsh Mountain

Table 17 Vetter et al. (1960)

Breed of lamb	death loss %
Hampshire	23
Southdown	21
Shropshire	17
Rambouillet	15

Table 18 Fredella (1975)

Breed of lamb	Stillborn %
Ile de France	9.04
Merino	5.10
Soprovissana	5.61
Württenberg Merino	2.39
Bergamo	9.31
Berrichon	10.93
Campanian Barbary	8.86
Overall	6.12

Comparing three breeds of Iranian fat tailed sheep (Karakul, Mehraban and Naeini) and their crosses with Corriedale and Targhee, Makarechian et al. (1977) found that the crossbreds were significantly superior to the purebreds in all traits, by approximately 7 percent in the preweaning traits and up to 18.4 percent in the post-weaning daily gain. More O'Ferrall and Timon (1974) classified, among eight breeds, the Suffolk, Dorset Horn and Oxford Down as having the heaviest weaning weights (.73 to .86kg above average), the Lincoln, Dorset Down and Ile de France as having the poorest preweaning daily gain and the Targhee and Hampshire breed as being intermediate for most traits. In a Canadian study by Vesely and Peters (1965) using Rambouillet, Romnelet, Canadian Corriedale and Romneldale sheep there were no significant differences found between breed for prolificacy, weaned lamb production and survival ability of lambs, but year effects were significant.

High rates of abnormal presentation associated with a higher mortality rate is mentioned by Bosc and Cornu (1977) with Ile de France, Prealpes du Sud and Romanov breeds. In cattle, Burfening et al. (1978) observed that calving ease score, percent assisted birth, birth weight, 205-day weight and adg were significantly affected by the percent Simmental of the calf genotype. In sheep, Krueger and Wassmuth (1974) indicated significant differences between groups of breeds and crosses, mentioning that crossing with Texel will increase and crossing with Finnsheep will decrease the rate of birth difficulties. A similar advantage of Finnsheep crosses was reported by Dickerson and Glimp (1975) on viability of lambs over those sired by Romney, Hampshire, Dorset or Coarse Wool rams. It was confirmed by Dickerson et al. (1975) when Finn x Domestic (Fx) crosses surpassed Rambouillet x Domestic (Rx) crosses in viability of lambs (81 vs 61 percent) and more in Suffolk and Hampshire than in Corriedale or Coarse Wool sired crosses. Finn lambs were superior in viability and comparable in early growth to crosses of several common U.S. breeds of sheep, in addition to their expected superiority in prolificacy. A study by Levine and Hohenboken (1978) however, failed to substantiate this advantage in surviving percentage of Finnsheep crossbred lambs, over lambs sired by domestic and British breeds. Other comparisons between purebred and crossbred lambs are reported in the following three tables, Tables 19, 20 and 21.

TABLES 19-20-21. EFFECT OF CROSSBREEDING ON MORTALITY OR LIVABILITY OF LAMBS

Table 19. Sidwell et al. (1962)
(Hampshire, Merino, Shropshire, Southdale, Columbia)

Type of cross	% lambs born alive /total born	% lambs weaned/lambs born alive	% lambs weaned/ewe bred
PB	93.2	80.4	89.5
2 breed cross	94.9	84.1	91.4
3 breed cross	95.4	84.0	103.5
4 breed cross	97.0	89.4	117.2

Table 20. Wiener (1975)

	% stillbirth	% mortality (birth-240 days)
Scottish Blackface (SB)	7.0	30.5
Cheviot (CH)	12.0	34.6
Welsh Mountain (WM)	5.4	21.0
SB x CH	10.4	28.2
SB x WM	8.5	23.7
CH x WM	8.9	23.6

Table 21. Hight and Jury (1970)

	Survival rate at weaning (multiple born lamb) in %
Romney (flock 1)	77.9
Romney (flock 2)	76.4
F1 (with BL)	80.4
F2	82.9
F3	78.8
F4	75.3
All flocks	78.6

In another study, Wiener et al. (1973) found statistically significant differences in the number of lambs born and weaned per ewe attributable to the breed of lamb and of its dam and sire. Crossbreeding was associated with a higher weaning percentage. Lamb mortality differed significantly among breeds and crossbreeds of lambs. In the previous study (Wiener and Hayter, 1975), although crosses on average showed an advantage over the mean of the purebred, there were significant differences in the degree of heterosis shown by the three crosses to suggest that specific combining ability may be important. Litter size showed no advantage for one cross (Blackface x Welsh) and almost ten percent for another (Blackface x Cheviot). Closest to showing a uniform general heterotic effect were weaning weight (average 3.2 percent) and lamb survival (5.9 percent). Additive genetic effects of breed were not apparent on birth and 28-day weights in a study by Holtmann and Bernard (1969). However, for the weaning weight adjusted to 120 days of age, the general combining ability of the Suffolk breed was significantly superior to that of Oxford and North Country Cheviot breeds. A crossbreeding experiment was done by Shelton (1964) using Rambouillet and Delaine Merino as dam breeds and Suffolk, Hampshire, Dorset and Columbia as sire breed. As a group, the crossbred lambs had an advantage of .6 lb. in birth weight and 3.7 percent in death losses over Rambouillet.

The occurence and the importance of heterosis varies with the type of cross and with the trait considered.

Sidwell and Miller (1971), for instance, using Hampshire, Targhee, Suffolk, Dorset, Columbia, and Southdale breeds of sheep, found that, for birth weight, 12 out of the 20 crosses showed some degree of heterosis, 14 out of 20 for weaning weight and 15 out of 20 for gain from birth to weaning. The overall crossbred lamb average exceeds the purebreds average by 0.11, 1.3, 1.3 and 0.015kg for birth weight, weaning weight, gain from birth to weaning and average daily gain respectively. Such an advantage for crossbreds over purebreds is also mentioned by McGuirk et al. (1977) for all weight up to slaughter. In this experiment, the hybrid vigour tended to increase with age and was greater at slaughter (10.5 percent) than at either weaning (6.4 percent) or birth (4.2 percent). These authors made the hypothesis of a genotype x environment interaction as there were significant breed by year interaction, showing that the breeds might differ in their ability to perform under the varying set of conditions (weather) encountered in their experiment.

Heterosis in reciprocal crosses among Hampshire, Dorset, Rambouillet, and Coarse Wool was -5 percent for mortality in a report by Dickerson et al. (1975). In Finn crosses with Suffolk, Hampshire and Dorset, it was -12 to -21 percent, but negligible in crosses between Rambouillet and domestic breed. The weighted mean heterosis difference in percent viability for all domestic crosses was 4 and 5 percent at four and ten weeks, amounting to 1/7 of the mean for mortality of parental purebreds. The average heterosis in preweaning gain and ten weeks weight amounted to about 3 percent of the mean for parental purebred lambs. Finally, heterosis was large in Finn crosses with the meat breeds for percent mortality to ten weeks (-12 to -21 percent, or -1/3 to -2/3 of parental mean mortality) and for preweaning gain (8 to 12 percent of parental mean), but negligible for both traits in crosses with Rambouillet or Coarse Wool.

7) Miscellaneous

The resistance of the newborn lamb to adverse environmental factors is dependent upon factors such as birth coat type, ingestion of colostrum and of its antibody content, maintenance of internal temperature and of body weight, vigour of the lamb, etc....

In a survey made by Watson (1972) in Australia there was no association between mortality and birth coat type observed under field conditions. Obst and Ellis (1977), working with Merino and Corriedale sheep, could not explain differences in mortality by differences in proportion of twins, birth weight or birth coat type of the two breeds and concluded that some other genetic factor might be involved. Slee (1978), however, reported that the breed differences in cold resistance were generally consistent with field data on mortality and body temperature regulation of lambs in severe weather. He found that cold resistance was strongly influenced by breed differences in birth coat morphology as well as other physiological factors, partly attributable to the different genetic backgrounds associated with birth coat type: Welsh (L=long coated) and Blackface had the greatest cold resistance measured as the time taken for rectal temperature to fall one degree centigrade and Merino the least. Long coated lambs were on average six times more cold resistant than the average of Welsh (S=short coated) and Merino lambs and Welsh (L) lambs were four times more resistant than the Welsh (S) type. Birth weight and age did not significantly influence cold resistance.

Alexander et al. (1959) observed that in a few lambs (especially twins) death was primarily due to inability to maintain body temperature under adverse conditions. For instance, a rapid fall in temperature occured before death in six lambs which cooled below eighty-five degrees Fahrenheit within 20 minutes of birth and died within 1½ hours. The temperature of other lambs showed only temporary falls, if any, after birth. Those which subsequently died, cooled to below one-hundred degrees Fahrenheit and often below ninety degrees Fahrenheit during the several hours prior to death. In the same experiment, one can also notice that in lambs which died, the weight tended to fall progressively from birth to death: amongst lambs which survived, estimated dry weight fell or remained steady until six to 12 hours after birth, when it commenced to increase. All but four lambs had gained weight by 72 hours after birth.

Maintenance of temperature and body weight is often associated with success to obtain milk. Alexander et al.

(1959) cite weather, adverse maternal factor and poor lamb vigour as factors contributing to failure of lambs to obtain milk. In their mortality observations, they noticed that only four of the 25 lambs which died obtained milk. Of the other 21, three did not stand, six stood, but failed to reach the udder and 12 reached the udder but did not obtain milk. Lambs which died took longer to stand than lambs which survived (37 vs 20 min.) and longer to appear to suck (171 vs 93 min). Obst and Ellis (1977), on the contrary, deny any significant association between lamb mortality and time taken to suck. Watson (1972) stressed the fact that even with good udder function, behaviour of either ewe or lamb which hinders progress towards suckling reduced lamb survival. According to Atroshi and Österberg (1979) birth to suckling time interval is one of the most important measures of vitality, as it is the time during which the lambs exist on their own tissue reserves. In single, twin, and triplet born lambs, this interval was, respectively 38.9, 49.5, and 56.9 min. From standing to suckling, it was reduced to 26.3, 40.0, and 44.5 min., respectively. The data also revealed that it took a shorter time from birth to standing for the second in triplets than for the first and third.

Colostrum intake by lambs is especially important as lambs must acquire the passive immunity given by the antibodies of the colostrum in the first 12 to 20 hours of its life. Colostrum intake had important effect on perinatal mortality as reported by Khalaf (1979 b). Serum globulin and total serum protein values were lower in the lambs which failed to survive, particularly in triplets. Ig G1 was particularly low in non-viable lambs.

At last a factor specific to Merino and Merino crossed breed has been reported by Dun and Hamilton (1965), i.e. skin folds. Using two flocks, the first selected for less skin fold (Fold -) and the other for more (Fold +), a much higher mortality of singles was observed in lambs from Fold + ewes, due to a particular type of dystocia caused by relative oversize of an otherwise healthy lamb with normal presentation of head and forefeet but blockage at the shoulders.

Traits of The Ewe, Ram And Other Ancestors

1) Breed of Ewe

Bradford (1972) found that the genotype of the dam rather than of the offspring is responsible for genetic variation in prenatal survival. Laster et al. (1972) found that ewe breed and breedcross significantly affected the number of lambs born per ewe exposed and number of lambs weaned per ewe lambing. Dickerson et al. (1975) showed that ewe breed affected viability in domestic cross but not in Finn cross lambs. Ewe breed also influenced birth weight and preweaning weight with a range of 3.5 kg in ten week weight. Dickerson and Glimp (1975) showed that differences in number of lambs born could be erased at weaning because of differences in mortality of the lambs between breeds.

Targhee, Rambouillet, and Coarse Wool ewes lost only about 28 percent of lambs, thus weaning at least as many lambs as the more prolific Suffolk or Dorset ewes which lost 34 to 36 percent. Levine and Hohenboken (1978) could not establish significant effects of breed of dam, breed of sire or their interaction on percent survival. However, breed of dam influenced significantly weaning weights. Tchamitchian et al. (1976) observed that total mortality (up to 90 days) of lambs born to three type of crossbred of ewes and sired by Berrichon sires was not significantly different from that obtained with purebred Berrichon lambs. This observation is also made by Dickerson et al. (1975) when stating that viability of crosses of Rambouillet x Domestic breeds was essentially the same as that of purebred lambs from the seven breeds of ewes. Sidwell et al. (1962) outlined that in the crossbred matings there was a tendency for the two breed crosses to rank in the same order as the breed of dam.

Breed of dam had significant effects on the preweaning traits in Makarechian et al.'s experiment (1977): Merino ewes produced more lambs with the highest preweaning daily gain and weaning weight among the crossbreds, but they were the least efficient after weaning. McGuirk et al. (1977) described crossbred lambs from Border Leicester ewes to be heavier at birth and to grow more rapidly to weaning than crossbred lambs from Merino ewes. The preweaning maternal influence on these traits is demonstrated by the results of Peters and Heaney (1974b) when they found that breed of dam had no significant effect on growth rate in artificial rearing but the lambs from Suffolk dams surpassed those from Shropshire dams in growth rate from birth to 70 days and from 70 to 140 days when the lambs were reared with their dams. For Baker et al. (1978) there is evidence of the superior maternal ability (expressed as number of lambs weaned/number of lambs born) of the Steigar ewes over the Dala ewes, even with one-year old ewes. In ewes two years and older, percent lamb losses from birth to weaning were 20 percent for Dala ewes and 13 percent for Steigar ewes. According to Cedillo et al. (1977) the breed effects on total April lamb weight per ewe breed reflected breed differences in maternal ability as well as in fertility, prolificacy and survival.

The effects of purebred vs crossbred ewes are found in many instances, together with the occurrence of heterosis in maternal traits. In an experiment by Wiener and Hayter (1975) more lambs from crossbred ewes survived than from purebred ewes. The crossbred ewes had more and heavier lambs than expected from the average of the purebred contributing to each cross, but the three crossbred types differed in the amount of heterosis shown. In a previous report, Wiener et al. (1973) found that variation attributable to the crossbred type of the dam and to the breed of the dam's sire was significant for lambing and weaning percentage and for the incidence of lamb mortality. Ricordeau et al. (1976) compared lambs born to same type sires or dams. Mortality rates were always lower for lambs having 25 percent of Romanov blood. The following types of both sires and dams were compared: Border Leicester x Berrichon du Cher, Contentin x Berrichon du Cher, Romanov x Berrichon du Cher.

2) Breed Of Ram And Of Other Ancestors

Breed of sire effects on lamb mortality and preweaning growth have been reported widely in the literature, as well as those of the grand sire or grand dam breed. In most instances they are found significant even though some particular study might deny sire's effect on certain traits. Wiener et al. (1973), for example, found that the variation attributable to the breed of sire appeared to be a significant source of variation in number of lambs born and weaned and for lamb mortality. Dalton et al. (1976) showed that sire breed differences were important relative to perinatal lamb mortality. In cattle, Donald (1963) associated the heavier birth weight of calves sired by Friesian and Hereford bulls with greater losses, compared to those sired by Ayrshire and Jersey bulls. In the previous study by Wiener et al. (1973), the breed effect of dam on lamb mortality was highly significant, but the contribution of the breed of the lambs maternal grand dam and grand sire varied in significance. There was an interaction between breed of dam's dam and that of dam's sire in respect to the number of lambs born and weaned, but not for lamb mortality. They concluded that increasing the lambing percentage through the dam's breed may involve increased lamb mortality, but that the paternal contribution could have the opposite effect. Peters and Heaney (1974b) reported that lambs by Suffolk sires surpassed those by Shropshire sires in growth rate from birth to 70 days, and from 70 to 140 days in artificial rearing, but only in the first period when reared with their dam. There was interaction between sire breed and rearing system.

The following tables describe differences between breed of sires in preweaning traits. (Tables 22, 23 and 24)

TABLES 22-23-24. MORTALITY AND BREED OF SIRE IN SHEEP

Table 22. Ricordeau et al. (1976)

Breed of sire	Number of lambs born	0-10 days	Mortality 10-70 days	Total
Border Leicester	390	4.9	4.1	9.0
Contentin	360	9.3	3.9	13.2
Romanov	428	2.4	3.9	6.3

Table 23. Cedillo et al. (1977)

Breed of sire	Prolificacy	% lamb survival to weaning	Lambs weaned/ ewe bred	Weaning weight/ ewe bred (kg)
Cheviot	1.16	50	.38	11.45
Dorset	1.23	74	.42	13.53
Finn	1.62	65	.77	22.80
Romney	1.15	70	.27	8.23

Table 24. More O'Ferral (1974)

Breed of ram	No. of lambs born alive per ewe lambing (1)	No. of lambs dying within 24 hrs. per ewe lambing (2)	Perinatal lamb mortality 100X(2/1)	Litter size
Suffolk	1.45	.12	8.4	1.68
Texel	1.44	.14	9.9	1.68
Dorset Horn	1.50	1.8	12.2	1.68
Hampshire	1.50	.15	10.2	1.66
Oxford Down	1.36	.16	12.0	1.54
Lincoln	1.58	.08	5.2	1.67
Ile de France	1.36	.12	8.9	1.57
Dorset Down	1.50	.15	10.1	1.75
Overall	1.46	.14	9.6	1.65

3) Age And Parity Of Ewe

The effects on age and parity of ewe on lamb viability and preweaning growth traits show, when significant, a typical pattern with a peak for middle aged ewes, with variation between breed of ewe, types of birth of the lambs and systems of rearing. Dickerson et al. (1975) found that age of ewe had large, curvilinear effects on both viability and growth of lambs. Vesely and Peters (1965) observed that two-year old ewes were inferior to middle aged ewes in prolificacy, weaned lamb production and survival ability of lambs. The effects of age of dam reported by McGuirk et al. (1977) were in all cases small and nonsignificant on lamb survival, but significant on all lamb weights. These significant age of dam effects on body weights were also described by Peters and Heaney (1974a). In their experiment, they persisted up to 70 days for lambs reared artifically and up to 140 days for lambs reared with their dams. The influence of age encountered in Dickerson and Glimp's data (1975) differed importantly among breeds for total and live born lambs, but not for live lambs at four or ten weeks of age.

For Karam (1959b) age of dam did not have a significant effect on lamb mortality, though there was a decrease with age up to five years. No significant difference could be measured by Krueger and Wassmuth (1974) in the frequency of birth difficulties between different age groups of ewe in their material.

In cattle, similar differences are reported by Donald

(1963) between purebred and crossbred calves born to cows and heifers. (Table 25)

Wiener et al. (1973) pointed out that females lambing for the first time at approximately one year of age had a lower lambing percentage and a higher mortality among lambs born and a corresponding much lower weaning percentage than did either females which lambed for the first time at two years of age or of later parities. (Table 26)

Survival of lambs to weaning (both singles and twins) increased to a maximum at four to six years of age, thereafter decreasing with age of ewe in the data analysed by Watson (1972). The survival of lambs from six-year old Merino ewes was about two percent greater in singles and ten percent in twins than from a three year old ewe. Similar results have been given by Hight and Jury (1970), where the survival rate of singles increased from two to three-year old lambing in all flocks, reaching a maximum at four or five-year old lambing. A similar pattern was evident for multiples. Multiple born lambs from five-year old ewes had a better chance of survival than singles from two-year old ewes.

Figures about the changes of mortality rates of lambs with age of ewe are shown in Table 27.

TABLE 25 STILLBIRTH AND PARITY OF DAM IN CATTLE (from Donald, 1963)

Parity of dam	Type of calves	% born dead
Heifers	Purebred	14.7
Older cows		2.4
Heifers	Crossbred	6.4
Older cows		3.6

TABLE 26 MORTALITY AND PARITY OF DAM IN SHEEP (from Wiener et al., 1973)

Age/parity of ewe	Number of lambs born	dying (of lambs born alive)	weaned
One-year old	125	22.3	97
Two-years old			
1st parity	160	12.3	140
2nd-3rd parity	157	8.8	143
4th parity	164	8.4	150

TABLE 27 AGE OF DAM AND LAMBS VIABILITY (from Sidwell et al., 1962)

Age of dam	% lambs born alive /total born	% lambs weaned /born alive
2	92.8	79.6
3	96.1	84.0
4	96.9	90.1
5	97.0	83.7
6	96.6	87.6
7	94.4	84.8
8	95.5	77.2
9+	92.1	90.2

Lamb vigour was also reported to be significantly affected by lambing age (Laster et al., 1972). These authors expected such findings as an increase in ewe age, resulted in increased lambing difficulty in their data.

For Mullaney and Brown (1969), the number of lambs born per ewe joined for Merino ewes decreased steadily with age, while the number of lambs weaned per ewe joined and the survival rate of both singles and twins rose to a peak at four to five years, with a subsequent fall. They cited a study by Lax and Turner (1965) where improvement in environment reduced the association between age of ewe and survival of single born lambs. Makarechian et al. (1977) found a significant influence of age of dam on the pre-weaning traits. The lambs born to four-year old ewes were the heaviest and those born to two-year old ewes the lightest at birth. The lambs reared by two-year old ewes had significantly lower rates of growth and were the lightest at weaning.

4) Factors Associated With Parturition

A. Season

Karam (1959a) reported that summer born lambs excelled winter born lambs in birth and weaning weights, but after weaning winter born lambs grew faster than summer born lambs up to 12 months of age. Watson (1972) observed a higher survival rate among spring than autumn born Merino lambs. More spring than autumn lambs died before weaning.

B. Duration of parturition

Atroshi and Österberg (1979) found that in twin and triplet births, the time interval between the first appearance of the lamb and the lamb being expelled was shorter than in single births. The size of single lambs contributed to longer duration of this stage of labour. This tendency is also given in the results of an experiment by Naaktgeboren et al (1971): the duration of labour was strongly associated with the birth weight of lambs. It varied for singles and first born twins between 15 and 70 minutes, while the duration of labour for the second born twin was independent from birth weight and never lasted longer than ten minutes. For Alexander et al. (1959), death appeared to be unassociated with the duration of parturition although more deaths might have resulted from long duration if assistance had not been given in eight deliveries.

In pigs, however, Randall (1972) found that the still-birth rate was higher in prolonged farrowing, which is summarized in Table 28.

TABLE 28. EFFECT OF DURATION OF FARROWING ON INCIDENCE OF STILLBIRTH IN THE SOW (from Randall, 1972)

Duration of farrowing (hrs)	Number of litters	Average litter size	Stillborn piglets	% still-born	% litters with stillborns
1	8	9.8	3	3.8	25
1-2	49	10.4	9	3.7	32.7
2-3	32	10.6	19	5.6	59.4
3-4	10	11.3	11	9.7	50
4-5	9	11.3	6	5.9	55.5
5-6	1	12.0	0	0	0
6	4	11.5	4	30.4	75

C. Birth difficulty

In a set of data presented by Bosc and Cornu (1977), there was, at birth, a high rate of abnormal presentation of lambs. Posterior presentation was found to be dependent upon breed, prolificacy and parity, and was associated with a higher mortality rate.

Atroshi and Österberg (1979) reported than in cases of malpresentation, the lambs born after a long delivery period appeared to be less vigourous and that it took a long time for them to stand up and suckle successfully.

Watson and Marigold Elder (1961) described poor vigour at birth to be associated with death of lambs in the first days of life and correlated with need for assistance at birth of at most 37 percent of the lambs in a first group and 40 percent in a second one.

Of 52 calvings described as difficult in a paper by Donald (1963), 31 resulted in dead calves. Naaktgeboren et al. (1971), citing Grommers (1967), observed that the perinatal mortality of Texel sheep was only 6.7 percent, although assistance had been given in 77.3 percent of all parturitions. In a ewe lamb study by Laster et al. (1972), lambing difficulty was not a large problem and did not appear to have a significant effect on the number of lambs weaned. Purser and Young (1964) found that difficult parturition provided nine percent of the mortality of lambs from young ewes and 13 percent of that of lambs from older ewes. Difficult birth only became a major cause of death for birth weights above a critical value depending on the age of the dam (eight to ten lb.). The birth weight of twins, however, did not exceed the values and the mortality rate due to difficult birth remained low over the whole of their birth weight range.

D. Litter size

Bradford (1972) reports that when lambs were weaned as soon as they had had some colostrum and then reared artificially, it appeared that the number of lambs in the litter did not affect survival other than via birth weight.

5) Maternal Effects

According to Bradford (1972), maternal effects may be expected to be more important in sheep than in cattle or swine because of the greater relative variation in litter size in sheep and the fact that many lambs are partially dependent on their mother's milk supply until the time of marketing or until they have achieved a higher proportion of their slaughter weight than is the case for cattle or swine. He found that the maternal contribution was greater for weights at two to six weeks of age than at birth or 160 days.

Mavrogenis et al. (1980) stated that the maternal environment effects were mostly exerted through suckling. Watson (1972) estimated that loss among lambs from ewes with defective udder function was at least 2½ times greater than among lambs from ewes with normal udder function. Where both sides of the udder were defective, 83 percent of the lambs died. But even with good udder function behaviour of either ewe or lamb which hinders progress towards suckling reduced lamb survival. Alexander et al. (1959) observed that with only one exception, every ewe whose lamb or lambs attempted to suck allowed the attempts to be made when the udder was first reached. They also reported that there was no apparent association neither between type of contents of the udder and lamb deaths nor between rate of secretion and death of lambs. In another paper by Alexander (1962), cited by Atroshi and Österberg (1979), it was noted that lambs may fail to obtain milk for a variety of reasons which include poor maternal behavior. Bradford (1972) underlined that with three or four lambs, maternal behavior and milk supply may come into play and contribute independently of birth weight to the higher mortality usually observed in large litters. However, birth weight high enough to cause difficult parturition may also contribute to aberrant maternal behavior. Such inadapted reactions of the ewes as refusal of lambs or difficulties in fostering lead to difficulties in sheep husbandry, according to Poindron and Signoret (1977).

Dalton et al. (1976) reported that shepherds commented favourably on the satisfactory maternal behavior of Merino x Romney ewes compared with their experiences with straight-bred Merino.

In addition, severe weather conditions can also cause aberrant behavior. Obst and Ellis (1977) noticed that some lambs were deserted by their dams when three hourly mean wind speeds were above ten km/h.

Direct Environmental Effects

Weather, predators and infectious agents are factors affecting losses of lambs cited by Watson (1972). The effect of year is also reported in the literature. Some controlled environmental conditions such as type of housing or management practices also affect lamb performance.

Significant effects of year were found by Levine and Hohenboken (1978) on percent survival and weaning weight, by Cedillo et al. (1977) on kilos of lamb weaned per ewe bred, by Hight and Jury (1970) on survival rate and birth weight and on mortality rate at birth and at four months of age by Karam (1959b).

Watson reported that losses due to predators were variable and also difficult to ascertain. Some lambs were already dead when mutilated and others would have died anyway (weak and starving lambs). This survey showed that infectious agents were in most cases responsible for less than one percent of mortality. This is to contrast with an experiment by Laucher (1973) where the main causes of death were E. Coli infections (36.5 percent). Purvis et al. (1979) observed that the causes of mortality were predominantly non-infectious and less than 25 percent in all cases. Under their experimental conditions, high stress periods accounted for 70 percent of all casualties due to chilling in 1977. This suggested that very young lambs could be at risk even in quite moderate weather conditions.

Watson (1972) observed a steep increase of the incidence of losses in cold wet and windy weather, as well as in very hot weather. In some flocks of his survey, multiple lambs were particularly susceptible to severe weather conditions. The same observation was made by Alexander et al. (1959) where the inability to maintain body temperature under adverse conditions was poor in some lambs, particularly twins. Wet and cold weather associated with malpresentation of the lamb and high birth weight, made the most important contribution to mortality by imposing very high energy demands (Atroshi and Österberg, 1979).

Obst and Ellis (1977) associated the lamb's chance of survival with the weather at time of birth. Wind and rain were more important factors than ambient temperature. In their set of data, the mortality of lambs up to 72 hours of age was related to the weather conditions in the first six hours after birth. They also noticed an increase in mortality with increased temperature. However, this was only seen in Corriedale and not in Merino lambs.

Indirect Environmental Effects

Indirect environmental effects are the environmental factors that affect the lamb during pregnancy through the ewe. Watson (1972) reported that such effects lead to difficulty at birth, poor milk supply or poor mothering in the ewe, retarded physical or physiological development of the lamb at birth or both, or pathological conditions in the lamb at birth. They include inadequate nutrition in late pregnancy, high environmental temperature, ingestion of poisonous plants, pregnancy toxemia, iodine deficiency and others.

Wallace (1948) observed that the lambs from well fed ewes were considerably larger than those from the poorly fed animals and that they also appeared stronger and more alert.

In this experiment, there was only one surviving lamb in the poorest diet. All lambs from the other two groups were born alive although those from the maintenance ewes, and particularly the twins, appeared less strong than those from the supermaintenance group, and a number had to be assisted at birth.

Stern et al. (1978) could not find differences in birth weight between three different maintenance levels. Khalaf (1979a), however, found that lamb birth weight, perinatal mortality and average daily gain from birth to weaning were affected by ewe nutrition and litter size.

According to Scott (1977), temperature does have a marked effect on fertility, embryo survival and fetal development: in ewes exposed to ninety degree Fahrenheit on the day of breeding, none of the embryo survived. Seventy percent of the embryos were lost if the ewes were exposed to this same temperature one day after breeding. Exposure to heat three, five, and eight days after breeding had progressively less effect on embryo survival. Heat stress during gestation also has an adverse effect on fetal development resulting in smaller lambs at birth.

Cheeke (1980) reported some effects of ingestion of poisonous plants during pregnancy: ewes ingesting False Hellebore (Veratrum Californicum) at day 14 of gestation can give birth to cyclops lambs, through the action of steroid alkaloids. Soybean, rapeseed meal and cassava contain goitrogenic glycosides (Thyocyanates) whose absorption in late pregnancy may cause dead lambs.

CONCLUSION

The final production of a weaned lamb is the end-result of a very long process of interrelated events. It deals both with genetic and environmental factors, with eventually some interaction between them (Figure 1).

In order to get the maximum benefit out of each lamb which has been conceived during the mating season, one should focus one's attention at several critical times, which are most important for lamb (or fetus) survival and induction of growth.

As underlined by Bradford et al. (1974), the differences in litter size in sheep are mainly due to differences in ovulation rates between breeds. The embryo survival, however, is very dependent upon the weather conditions during the first days of prenancy. In normal cases, the occurrence of a live lamb at birth will be then expected, in absence of detrimental conditions in feeding (nutrition level, ingestion of poisonous plant...) maternal environment (resulting in difficulty in parturition) or direct environment (presence of infectious agents, stress...). Therefore, a skilled attention at lambing is an essential factor.

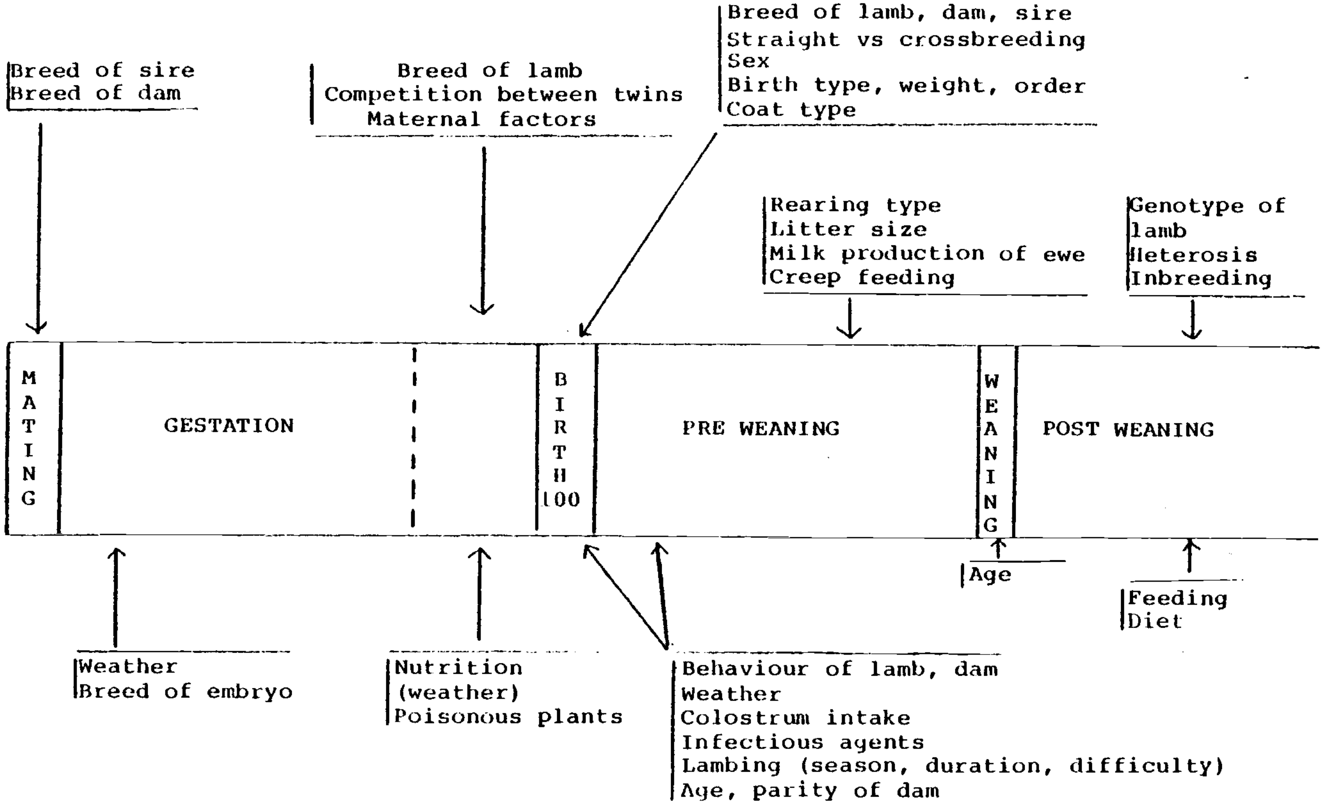
The first few days or even hours of a lamb's life can make the difference between death or life. Lambs must at once receive passive immunity from their dam's colostrum and be protected from adverse weather conditions. Lambs small at birth, especially in large litters, should be given more attention, as well as those being delivered after a difficult birth.

The health status of the udder of the ewe, and its milk production should be checked to enable a ewe to raise an optimal number of lambs. Ewes losing lambs in early stages can be grafted small ones from other litters whose survival or growth could have been compromised. Creep feeding might be provided to erase deficiency in milk production of the ewe and to enable each lamb to express its growth potential. However, before weaning, maternal factors still play a predominant role.

The age at weaning and the method of weaning might also have some consequences on the future development of the lambs. From that time on, genetic factors will be of major importance, primarily differences between straight- or crossbred lambs will become more apparent as time goes on.

It should be kept in mind that the cost of mortality differs widely depending upon the birth type of the lamb. Purvis et al. (1979) reports the following cost of mortality of $19.29, $16.77 and $14.68 for singles, twins, and triplets, respectively. These costs represent the loss in market value of the lamb when it would have been sold less the cost of rearing which was saved because the lamb had died. This ignores the fact that, in case of death of a twin or triplet born lamb, its siblings are likely to grow faster. This cost does not take into account either the consequences on ewe productivity, a ewe not producing a lamb or losing a lamb after birth being an extra burden for the financial health of a sheep operation.

FIGURE 1. FACTORS INFLUENCING MORTALITY OF LAMBS FROM CONCEPTION TO POST WEANING PERIOD



PART II

EXPERIMENTAL RESULTS

INTRODUCTION

Litter weight at weaning is an important trait measuring ewe productivity. It includes in a single figure several attributes of the ewe such as prolificacy, milking and mothering ability as well as attributes of the lamb such as survival and growth rate.

Progeny of ewe lambs have been shown to have a higher mortality and poorer preweaning growth than progeny of older ewes (Dickerson et al., 1975; Fredella, 1974; Peters and Heaney, 1974; Makarechian et al., 1977).

The experiment reported in this paper was designed to determine the causes of variation in mortality and preweaning weights of progeny of ewe lambs, and to relate the sequence of events at birth to these traits.

Special attention has been given to the effects of the breeds included in the genotype of the lambs through their sire and through their dam's grand-sire and grand-dam.

MATERIAL AND METHODS

Population

In the late fall of 1979, 192 ewe lambs of composite ancestry (Figure 1) were mated to three rams each of the Hampshire, North Country Cheviot and Suffolk breeds. For each breed group, at least one ram-lamb and one older ram were used. The Suffolk and Hampshire groups had two ram-lambs and the North Country Cheviot two mature rams. Ewes were exposed in nine single-sire mating groups on similar pastures at the same location. The lambing season lasted from March 4 to April 10. One hundred thirty-three ewes lambed, producing 173 lambs (including stillbirths) of which 80 were twins.

Management Practices

Ewes gave birth to their lambs in pens containing approximately 20 total ewes. After lambing, ewes were moved with their lamb(s) to an individual pen where they were allowed to stay for one day. They were then moved to a so called "social-pen" with other ewes of contemporary lambing. After 10 to 15 days in the barn, lambs and ewes were moved to pasture. Lambs had access to a creep ration and were weaned on May 28, 1980. Further details of the routine sheep management practices at Oregon State University are given by Klinger and Hohenboken (1978).

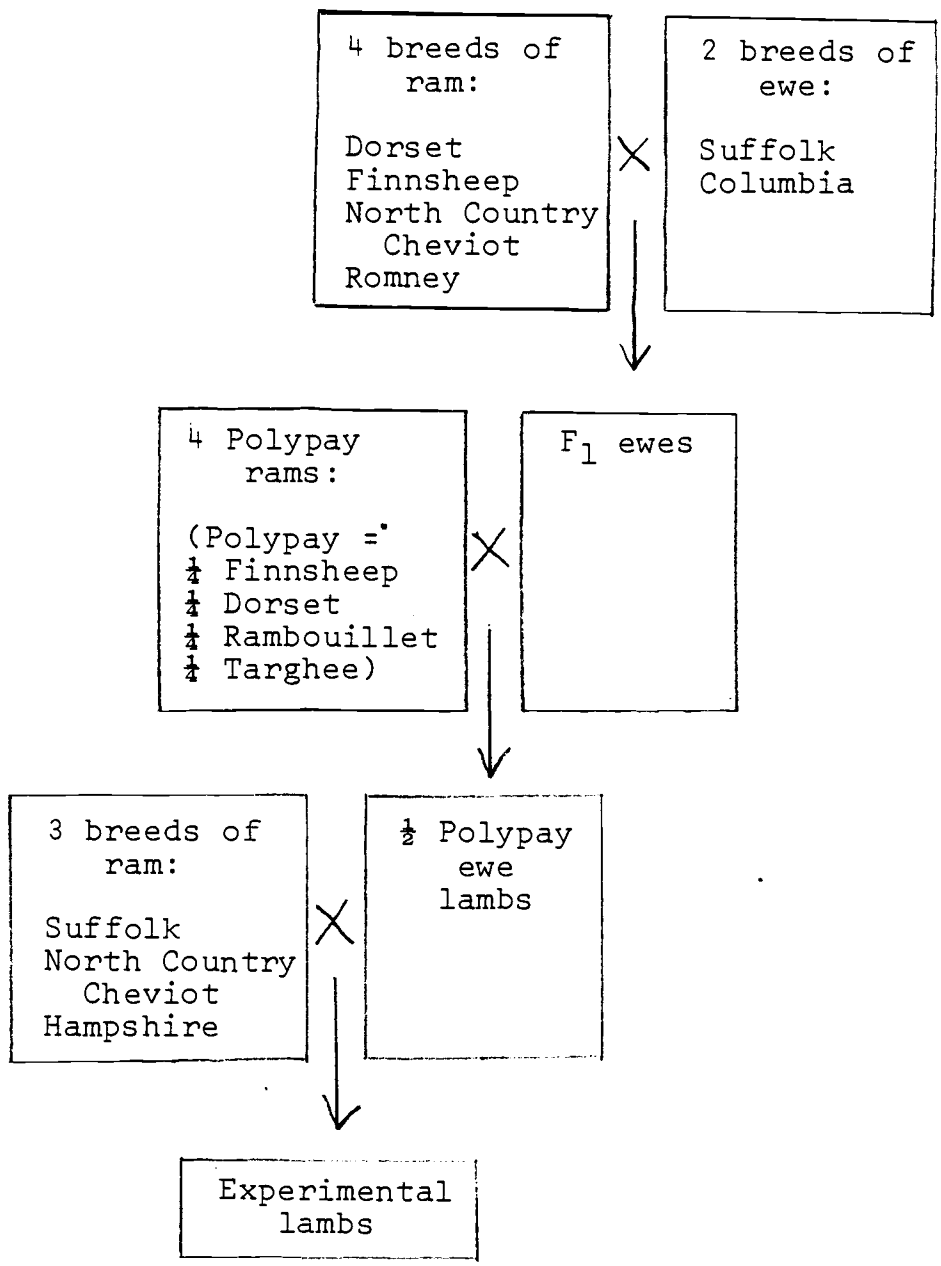
Collection of Data

During parturition, the sequence of events was observed. Times were taken when 1) the waterbag burst, 2) the lamb was visible (feet and head), 3) the lamb was completely on the ground, 4) the lamb was standing and 5) the lamb was suckling its dam. Lamb sex, type of birth and birth weight were recorded. Weights were subsequently taken at approximately 5, 10, 45, 60 and 70 days of age and adjusted to these ages by regression of growth on age during the period of time preceeding each weight. Weaning occurred at about 70 days of age.

Analytical Procedures

Analyses of variance and correlations were performed with S.P.S.S. (Statistical Package for the Social Sciences). The model for the ANOVA of the litter weight at weaning included the effects of breed of sire, sire within breed, individual Polypay grand-sire, breed of dam's grand-sire and breed of dam's grand-dam. When analyzing mortality data, time intervals around lambing and weights up to 70 days of age, the effects of sex and type of birth and the interactions of breed of sire x sex, breed of sire x type of birth and sex x type of birth were added.

FIGURE 2. MATING SYSTEM SHOWING THE GENETIC BACKGROUND OF THE LAMBS IN THE EXPERIMENT



RESULTS AND DISCUSSION

Time Intervals Around Lambing

Three time intervals will be discussed: lamb is visible (feet and head) - lamb is completely on the ground (V-G), lamb is on the ground - lamb is standing (G-ST) and lamb is standing - lamb is suckling (ST-SU). The only effect found to be significant was that of individual Polypay grand-sires for the ST-SU interval. The least-squares means for V-G, G-ST and ST-SU are reported in Table 29, together with the interval G-SU which is the arithmetic sum of G-ST and ST-SU. According to Atroshi and Österberg (1979), the birth to suckling interval (here labeled G-SU) is one of the most important measures of vitality as it is the time during which the lamb exists on its own tissue reserves. A broad range in G-SU is found between individual Polypay grand-sires (from 40.2 to 58.2 min), due to their significant effect on the ST-SU interval. The breed of ram, at the dam's grand-sire level has the largest range in the G-SU interval (18.5 min). The range among breed of dam's grand dam is only half as much (8.3 min). North Country Cheviot sired lambs have a reputation among commercial sheep producers for being very vigorous at birth. The advantage of the North Country Cheviot sired lambs is only shown for the G-ST interval since they actually took longer to suckle once they were standing than lambs sired by the two ram breeds. Those of Dorset ancestry are the fastest of all lambs to suckle.

TABLE 29. LEAST-SQUARES MEANS (LSM) AND SIGNIFICANCE LEVELS FOR TIME INTERVALS AROUND BIRTH (min)

Source	Time intervals[a]			
	V-G	G-ST	ST-SU	G-SU
Population average	19.50 (46)[c]	19.52 (78)	25.85 (103)	45.37
Breed of sire	NS[b]	NS	NS	
Suffolk	23.58 (10)	29.25 (21)	20.81 (30)	50.06
North Country Cheviot	25.85 (16)	13.27 (24)	31.42 (31)	44.69
Hampshire	10.90 (20)	16.03 (33)	25.27 (42)	41.30
Individual grand-sires	NS	NS	*	
644	17.52 (22)	20.60 (29)	37.57 (35)	58.17
6135	16.73 (5)	21.23 (11)	18.98 (21)	40.21
6224	13.17 (10)	15.55 (21)	24.75 (31)	40.30
6424	26.62 (9)	20.68 (11)	22.03 (16)	42.71
Breed of dam's grand-sire	NS	NS	NS	
Dorset	6.80 (12)	19.58 (23)	14.27 (33)	33.85
Finnsheep	19.10 (13)	15.75 (17)	34.78 (22)	50.53
North Country Cheviot	34.05 (10)	17.38 (14)	27.25 (18)	44.63
Romney	17.88 (11)	25.35 (18)	27.03 (30)	52.38
Breed of dam;s grand-dam	NS	NS	NS	
Columbia	14.03 (25)	17.17 (38)	32.35 (56)	49.52
Suffolk	24.97 (21)	21.87 (34)	19.32 (47)	41.19
Sex	NS	NS	NS	
Males	24.18 (24)	22.77 (41)	25.76 (53)	48.53
Females	14.82 (22)	16.27 (37)	25.90 (50)	42.17
Type of birth-rearing	NS	NS	NS	
Single/single	24.25 (24)	25.20 (44)	25.40 (59)	50.60
Twin/single	17.73 (6)	12.75 (10)	24.65 (13)	37.40
Twin/twin	16.52 (16)	20.60 (26)	27.45 (31)	48.05

[a]V: lamb visible
G: lamb on the ground
ST: lamb standing
SU: lamb suckling

[b]NS = non significant
*$P < .05$

[c]number of lambs per subclass

It should also be noticed that the lambs of Finnsheep ancestry are the fastest to stand up but the slowest to suckle, once standing. Twin born lambs are faster to suckle than single born lambs but again the difference is not significant.

When one looks at the V-G interval,the Hampshire-sired lambs are faster to be born than either the Suffolk-sired or the North Country Cheviot-sired lambs (10.9 vs 25.6 and 25.8 min, respectively).

Those lambs having Dorset as dam's breed of grand-sire are fastest of all to be born (6.8 min). Twin lambs have a shorter V-G interval than single lambs. Males have longer V-G and G-SU intervals (24.2 vs 14.8 min for V-G and 48.5 vs 42.2 min for G-SU).

When V-G, G-ST and ST-SU intervals are compared for surviving and non-surviving lambs at different ages up to weaning (Table 30), it appears that the greatest difference between surviving and non-surviving lambs is found for the G-ST interval, ranging from 3.8 to 4.9 min whereas the differences between surviving and non-surviving lambs for V-G and ST-SU are smaller.

In all cases, surviving lambs had longer intervals than non-surviving lambs. This may be due in part to the fact that twin lambs had higher mortality rates than single lambs and twin lambs generally had shorter intervals than single lambs (Tables 29 and 31).

TABLE 30. TIME INTERVALS AROUND BIRTH FOR SURVIVING AND NON-SURVIVING LAMBS (min)

Time interval[a]	Status of lamb	Lambs surviving at				
		5 days	10 days	45 days	60 days	70 days
V-G	Non surviving	16.82 (2)[b]	16.27 (3)	13.65 (4)	13.65 (4)	14.83 (5)
	Surviving	17.07 (44)	17.12 (43)	17.38 (42)	17.38 (42)	17.33 (41)
G-ST	Non surviving	12.13 (6)	11.58 (7)	11.53 (8)	11.53 (8)	12.62 (10)
	Surviving	16.23 (72)	16.35 (71)	16.43 (70)	16.43 (70)	16.42 (68)
ST-SU	Non surviving	25.28 (9)	26.47 (9)	24.42 (12)	23.08 (13)	25.90 (15)
	Surviving	27.03 (95)	26.95 (94)	27.23 (91)	27.45 (90)	27.07 (88)
G-SU	Non surviving	37.41	38.05	35.95	34.61	38.52
	Surviving	43.26	43.30	43.66	43.88	43.49

[a] V: lamb visible
G: lamb on the ground
ST: lamb standing
SU: lamb suckling

[b] number of lambs per subclass

TABLE 31. LEAST-SQUARES MEANS AND SIGNIFICANCE LEVELS FOR MORTALITY RATES FROM BIRTH TO 70 DAYS OF AGE

Source	% mortality by	
	5 days	70 days
Population average	11.38	21.72
Breed of sire	NS[a]	NS
Suffolk	8.98	18.00
North Country Cheviot	14.35	23.52
Hampshire	10.81	23.64
Individual grand-sires	NS	NS
644	10.11	20.21
6135	11.61	27.23
6224	17.36	22.32
6424	6.44	17.12
Breed of dam's grand-sire	NS	NS
Dorset	8.19	13.22
Finnsheep	11.17	23.14
North Country Cheviot	10.66	26.58
Romney	15.50	23.94
Breed of dam's grand-dam	NS	NS
Columbia	9.16	21.67
Suffolk	13.60	21.77
Sex	NS	NS
Males	16.19	28.71
Females	6.57	14.73
Type of birth-rearing	NS	*
Single/single	3.42	12.27
Twin/single	18.92	38.72
Twin/twin	11.80	14.17

[a]NS = non significant.

*$P<.05$

Mortality Rates from Birth to Weaning

Least-squares means for lamb mortality are reported in Table 31. Lambs born and reared as twins had higher ($P<.05$) mortality rates by 70 days of age than lambs born and reared as singles. However the highest rates were for lambs born as twins and reared as singles. Evidently, factors that resulted in the death of the first lamb from a set of twins also had similar detrimental effects on the remaining lamb. Differences between sexes appear to be large for mortality incidence by five days of age (9.6%) and by weaning (14.%), males having higher rates than females.

Suffolk sired lambs have lower mortality rates. Of all breeds, the Dorset, used as a dam's grand-sire breed, is the most beneficial to lamb survival at birth as well as at weaning. The beneficial effect of a Finn ancestry as reported by Krueger and Wassmuth (1974) and Dickerson et al., (1975) is not found here.

Table 32 presents the percent of total preweaning mortality that has occurred by different ages up to weaning. Only 42% of total preweaning mortality occurred within 5 days for the Hampshire-sired lambs whereas 70% of total mortality is reached during the same period by the North Country Cheviot-sired lambs. By 45 days, however, the Hampshire and North Country Cheviot-sired lambs both reached the 90% level whereas the Suffolk-sired lambs only attained 83% of total preweaning mortality. This pattern of higher mortality in younger than in older lambs is

TABLE 32. PERCENT OF TOTAL PREWEANING MORTALITY REACHED AT DIFFERENT AGES UP TO WEANING BY BREED OF SIRE

Breed of sire	% of total mortality reached at				
	5 days	10 days	45 days	60 days	70 days
Average	54	71	89	93	100
Suffolk	50	83	83	100	100
North Country Cheviot	70	70	90	90	100
Hampshire	42	67	92	92	100
χ^2	NS[a]	NS	NS	NS	

[a]NS = non significant.

indicated in numerous articles in the literature (Laucher, 1973; Purser and Young, 1964; Purvis et al., 1979; Ricordeau et al., 1977; Safford and Hoversland, 1960; Watson, 1972).

Lamb Weights from Birth to Weaning

The least-squares means for all weights from birth to weaning are given in Table 33. The analysis of variance for weights at birth, 5, 10, 45, 60 and 70 days of age shows type of birth-rearing, individual grand-sire and breed of dam's grand-dam to have significant effects. Single born and reared lambs were heavier at all weights than twin born and reared lambs. Lambs born as twins and reared as singles were intermediate. Similar effects have been reported by Holtmann and Bernard (1969), Levine and Hohenboken (1978) and Martin et al., (1980).

Up to 10 days of age the twins raised as singles were more similar to twins raised as twins than to singles raised as singles. After 10 days of age and until weaning they were more similar to singles raised as singles.

It is interesting to notice that females were heavier at birth than males which is in contradiction with values found in the literature (Hight and Jury, 1970; Smith, 1977; Sidwell and Miller, 1971; Levine and Hohenboken, 1978; Holtmann and Bernard, 1969; Burfening, 1972). However, the male lambs had a faster growth rate and they became heavier than the female lamb by 45 days of age.

North Country Cheviot-sired lambs are generally lighter than Suffolk and Hampshire-sired lambs at all weights.

The differences between individual grand-sires of the Polypay breed were significant for weights to 10 days of age.

TABLE 33. LEAST-SQUARES MEANS AND SIGNIFICANCE LEVELS FOR WEIGHTS FROM BIRTH TO WEANING AT 70 DAYS OF AGE

Source	Weights (Kg) at					
	Birth	5 days	10 days	45 days	60 days	70 days
Population average	3.40 (169)	4.22 (156)	5.43 (149)	13.87 (144)	17.51 (143)	19.20 (141)
Breed of sire	NS[a]	NS	NS	NS	NS	NS
Suffolk	3.42 (49)	4.21 (46)	5.23 (44)	14.03 (44)	17.80 (43)	19.25 (43)
North Country Cheviot	3.35 (56)	4.24 (49)	5.32 (49)	13.46 (47)	17.10 (47)	18.43 (46)
Hampshire	3.41 (64)	4.21 (59)	5.65 (56)	14.12 (53)	17.64 (53)	19.92 (52)
Individual grand-sires	*	*	*	NS	NS	NS
644	3.17 (52)	3.97 (48)	5.22 (45)	13.58 (45)	17.30 (45)	19.70 (44)
6135	3.19 (39)	4.03 (36)	5.15 (35)	13.31 (31)	16.89 (31)	18.44 (31)
6224	3.53 (49)	4.50 (43)	5.79 (43)	14.49 (42)	17.76 (41)	19.39 (41)
6424	3.70 (29)	4.39 (27)	5.57 (26)	14.09 (26)	18.12 (26)	19.26 (25)
Breed of dam's grand-sire	NS	NS	NS	NS	NS	NS
Dorset	3.34 (49)	4.05 (45)	5.28 (44)	13.88 (44)	17.13 (44)	19.84 (44)
Finnsheep	3.35 (43)	4.14 (40)	5.33 (38)	13.73 (36)	17.81 (36)	18.93 (36)
North Country Cheviot	3.55 (37)	4.36 (34)	5.62 (32)	14.12 (32)	17.79 (31)	19.19 (29)
Romney	3.35 (40)	4.34 (35)	5.51 (35)	13.74 (32)	17.33 (32)	18.85 (32)
Breed of dam's grand-dam	*	**	*	*	**	NS
Columbia	3.26 (89)	3.97 (83)	5.20 (79)	13.39 (71)	16.66 (71)	18.64 (70)
Suffolk	3.53 (80)	4.47 (71)	5.67 (70)	14.34 (73)	18.37 (72)	19.76 (71)
Sex	NS	NS	NS	NS	NS	NS
Males	3.27 (88)	4.07 (78)	5.23 (75)	13.87 (76)	17.74 (76)	19.43 (75)
Females	3.53 (81)	4.37 (76)	5.63 (76)	13.86 (68)	17.29 (67)	18.97 (66)
Type of birth-rearing	***	***	***	***	***	***
Single/single	4.11 (88)	5.14 (88)	6.46 (88)	15.73 (85)	19.51 (80)	21.19 (83)
Twin/single	3.17 (18)	3.90 (18)	5.19 (18)	14.07 (17)	18.04 (17)	19.56 (16)
Twin/twin	2.90 (41)	3.63 (41)	4.65 (41)	11.81 (40)	15.00 (40)	16.76 (40)

[a]NS = non significant.

*P<.05.

**P<.01.

***P<.001.

Between breed of the dam's grand-dam, lambs of Suffolk ancestry are heavier at all weights from birth to weaning than lambs of Columbia ancestry. Differences are significant up to 60 days of age.

The differences in birth weight of surviving (S) vs non-surviving (NS) lambs are given in Table 34. As found in the literature (Burfening, 1972; Fredella, 1975; Hight and Jury, 1970; Khalaf et al., 1979b), the surviving lambs at each period are heavier than those dead by the same period. The difference between S and NS lambs decreases from 5 to 70 days of age (from .70 to .39 Kg). It is found that the birth weight of NS lambs increases with a later occurrence of death whereas the birth weight for the S lambs remains constant.

Litter Weight at Weaning

Of all effects included in the analysis, the only significant one was that of individual sires on litter weight per ewe exposed to breeding. This is primarily due to one of the rams of the North Country Cheviot breed having only 1/3 of the ewes in his breeding group giving birth to lambs. Ewe fertility averaged 75% for all other individual sire groups. The least-squares means for litter weight at weaning are given in table 35, both per ewe exposed to breeding and per ewe lambing. Cedillo et al (1977) reported significant differences between breeds of sire and between breeds of dam for litter weight of lamb weaned per ewe exposed with ewe lambs. The ewes used by Cedillo et al (1977) were the grand-dams of the experimental lambs used in this study. The litter weight per ewe exposed

TABLE 34. BIRTH WEIGHT OF LAMBS DEAD OR ALIVE AT DIFFERENT AGES BETWEEN BIRTH AND WEANING

Status of lamb	Days after birth				
	5	10	45	60	70
Surviving	3.62	3.63	3.64	3.63	3.62
Non-surviving	2.92	3.00	3.10	3.17	3.23
Difference	.70	.63	.54	.46	.39

to breeding is about 70% of the litter weight per ewe lambing. This reflects the average fertility of the ewe lambs in the experiment.

Even though differences are non significant among breed of sire, ewes mated to North Country Cheviot rams had lower litter weights at weaning than ewes mated to either Hampshire or Suffolk rams. Ewes mated to Hampshire rams had higher litter weights per ewe exposed due primarily to differences in fertility favoring those ewes mated to Hampshire rams (77% vs. 64% and 66% for Suffolk and North County Cheviot rams respectively).

TABLE 35. LEAST-SQUARES MEANS AND SIGNIFICANCE LEVELS FOR LITTER WEIGHT AT WEANING

Source	Litter weight (kg)	
	per ewe exposed to breeding	per ewe lambing
Population average	14.37	20.98
Breed of sire	NS[a]	NS
Suffolk	13.66	21.66
North Country Cheviot	13.23	20.01
Hampshire	16.24	21.28
Polypay grand-sires	NS	NS
644	16.36	22.67
6135	13.12	19.31
6224	15.24	21.47
6424	12.78	20.48
Breed of dam's grand-sire	NS	NS
Dorset	16.67	22.75
Finn	15.05	22.37
North Country Cheviot	11.80	19.20
Romney	13.97	19.61
Breed of dam's grand-dam	NS	NS
Columbia	14.22	20.24
Suffolk	14.53	21.73

[a] NS= non significant.

Phenotypic Correlations

All possible phenotypic correlations between time intervals around lambing and weights from birth to weaning are reported in Table 36, most of them being significant. The lamb visible-lamb on the ground interval (V-G) is positively correlated to birth weight and all subsequent weights up to weaning. However, significance only remains until ten days of age. Naaktgeboren et al., (1971) have also shown that the duration of labour was positively associated with birth weight of the lamb.

Both of the intervals of G-ST and ST-SU are negatively correlated with birth weight and weights from birth to weaning. The correlations between G-ST and preweaning weights of lamb are significant until weaning whereas those between ST-SU and preweaning weights are only significant at birth, 5 days of age and 70 days of age.

The sign of the correlation suggests that lambs of poor vigour, as indicated by longer G-ST and ST-SU intervals, have a shorter duration of parturition (V-G), are lighter at birth and have poorer growth rates. In twins, this might suggest that the effect of a lighter birth weight on preweaning growth could be enhanced through a poorer vigour at birth. However, partial correlations between intervals of time around lambing and preweaning weights, computed holding birth weight constant, are no longer significant. This indicates that the association between the different time intervals and preweaning weights is mostly obtained through differences in birth weight. Thus, heavier lambs will have a longer V-G interval and are likely to grow faster than lighter lambs that have a

TABLE 36. PHENOTYPIC CORRELATIONS BETWEEN TIME INTERVALS AROUND BIRTH AND WEIGHT OF LAMBS FROM BIRTH TO WEANING AND SIGNIFICANCE LEVELS

	Time intervals[a]			Weights at					
Trait	V-G	G-ST	ST-SU	Birth	5 days	10 days	45 days	60 days	70 days
B-V	.57 * (10)[c]	-.21 NS[b] (10)	.27 NS (10)	.44 NS (10)	.33 NS (10)	.49 NS (9)	.52 NS (9)	.44 NS (9)	.37 NS (9)
V-G		-.10 NS (45)	.09 NS (43)	.57 *** (46)	.43 ** (44)	.39 ** (43)	.17 NS (42)	.19 NS (42)	.14 NS (41)
G-ST			.11 NS (74)	-.26 * (78)	-.30 ** (72)	-.32 ** (71)	-.44 *** (70)	-.43 ** (70)	-.48 *** (68)
ST-SU				-.16 * (103)	-.22 * (95)	-.17 NS (94)	-.16 NS (91)	-.16 NS (90)	-.22 ** (88)
Birth wt					.94 *** (54)	.92 *** (149)	.76 *** (144)	.71 *** (143)	.58 *** (141)
5 day wt						.95 *** (149)	.82 *** (144)	.76 *** (143)	.61 *** (141)
10 day wt							.87 *** (144)	.80 *** (143)	.65 *** (141)
45 day wt								.92 *** (143)	.74 *** (141)
60 day wt									.79 *** (141)

[a] V: lamb visible
G: lamb on the ground
ST: lamb standing
SU: lamb suckling

[b] NS = non significant

*P< .05.
**P< .01.
***P< .001.

[c] number of lambs per subclass

shorter V-G interval. Heavier lambs appear in most cases more vigourous (shorter G-ST and ST-SU intervals) than lighter lambs (longer G-ST and ST-SU intervals). Consequently, a selection towards heavier birth weight could lead to more vigourous and faster growing lambs. However, the increase in birth weight should not go to the point where the incidence of birth difficulty increases. All weights from birth to weaning are significantly correlated to each other, the correlations being maximum between weights taken at adjacent period. This pattern has also been reported by Mavrogenis et al., (1980), Martin et al., (1980) and Bonaiti et al., (1976).

CONCLUSION

Despite the general lack of significance of the effects included in the analyses, it is the belief of the author that the general trends reported here remain valid and applicable in other instances.

The importance of the type of birth-rearing, breed of sire, of the dam's grand-sire and grand-dam should be underlined. Also the variation present between progeny of individual grand-sires should be emphasized as effective selection of genetic material is only possible if this variation exist. The significance of the Polypay grand-sires indicates that the heritability of maternal effects for intervals around lambing and weights of lambs up to 10 days of age are relatively high. However the Polypay is a new composite breed which has not been completely stabilised and the effects of the individual Polypay grand-sires might be confounded with breed effects.

Using ewe lambs as dams in the experiment limits the expression of the genetic potential of their progeny. Bradford (1972) reminds us that maternal effects may be expected to be more important in sheep than in cattle or swine because of the fact that the lambs are dependent on their mother's milk supply until they have achieved a higher proportion of their slaughter weight than is the case for cattle and swine. And this is believed to play a decisive role in the case of ewe lambs since they are producing less milk than mature ewes and probably less than the lamb needs for optimum growth.

However, the lifetime productivity of a ewe is increased by breeding her to lamb at about one year of age, as reported by Baker et al., (1978). Under the present economic conditions it is of major importance to increase the efficiency of production at all levels and the practice of breeding ewe lambs for lambing at the end of their first year, together with a better knowledge of the factors influencing survival and preweaning growth of their progeny is a step towards this achievement.

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