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A Comparison Between Crossbred and Straightbred Production of Targhee Range Ewes

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A COMPARISON BETWEEN CROSSBRED AND STRAIGHTBRED PRODUCTION OF TARGHEE RANGE EWES

BY

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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JMP

"For we preach not ourselves, but Christ Jesus the Lord; and ourselves your servants for Jesus' sake."

2 Cor. 4:5

To those whom I dearly cherish, my father, mother, brother and sisters, I dedicate this dissertation.

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INTRODUCTION

Due to economic pressure, more sheep producers are applying the principles of genetics and improved flock management to increase production. The two products having a direct bearing on ranch income are kilograms of lamb produced and wool yield.

The number of lambs born to each ewe is chiefly determined by (1) the number of ova shed during estrus, (2) the number of fertilized ova which ultimately establish themselves as viable fetuses and (3) the number of live lambs born. The ability of a lamb to survive from birth to weaning is determined by the lamb's genotype and postnatal environment.

The variation of body weight in sheep is the result of many factors acting independently, in cooperation or antagonistically with each other. Genetic variability in weight will show itself best under optimum nutritional conditions. It has been demonstrated that the growth rate of lambs raised under pastoral conditions is directly related to the quality and quantity of available forage.

Research has brought out that the quantity of wool produced is influenced by the annual number of shearings, age, size, nutrition, pregnancy, lactation and inheritance of the sheep.

This investigation was initiated to determine the effect of crossbred *vs*. straightbred production under the environmental conditions found at the Antelope Range Research Station, Buffalo, South Dakota.

REVIEW OF LITERATURE

Some factors of value in lamb and wool research are nutrition, litter size, sex, body size, birth weight, weaning weight, mortality and breed, sire and dam effects.

Prolificacy in Sheep

"Ewes, yearly by twinning, rich masters do make; the lambs of such twinners for breeders go take." Youatt (1891) quoted this old English adage to emphasize the common belief among sheepmen that twinning is heritable and also to illustrate the vast economic importance of prolificacy in sheep.

Sire Effect

Several studies have found that the number of lambs born per ewe is influenced by the breed of sire to which the ewe is bred (Mathews, 1920; Elliott, 1935; Zivkovic, 1964, 1966; Ceranic, 1966; Iwan *et al.*, 1971; Maund and Duffell, 1977).

Some investigations have suggested that individual sires do influence litter size (Biegert, 1938; Reeve and Robertson, 1953). A 22% variation in ewe fertility as reported by Hohenboken *et al.* (1976a) was due to differences in individual sires. Other studies have found that more lambs are born to ewes bred to twin-born than single-born sires (Rietz and Roberts, 1915; Harris, 1916; Wentworth and Sweet, 1917). Turner (1969) reported that twin-born rams on an average sire 10% more lambs than single-born rams. Bradford (1972) stated that differences in litter size due to the sires were the result of survival potential type genes transmitted to the embryo. Differences between the lambing rate of rams selected for high and low prolificacy occur after fertilization and prior to day 35 after breeding (Burfening et al., 1977).

Vakil et al. (1968) also found that age of sire had a significant influence on twinning potential. The twinning potential decreased with age after peaking in yearlings.

Age of Dam

Older ewes tend to produce more twins than younger ewes (Heape, 1899; Kelley, 1939). Hammond (1941) and Leitch et al. (1959) pointed out the reason as being due to the younger ewes having to complete their growth at the same time as they are caring for their pregnancy. Also, Bennett et al. (1964) stated that the number of lambs born to a 2-year-old ewe is dependent upon both her body weight at mating time and the degree of feed restriction through the mid-term of pregnancy. Researchers have found that a ewe's lambing performance increases up to 5, 6 or 7 years of age (depending on the breed of ewe) and then declines with additional age (Pearl, 1913; Jones and Rouse, 1920; Wriedt, 1925; Biegert, 1938; Desai and Winters, 1951a; Donald, 1962; Dhaliwal et al., 1963; Turner and Dolling, 1965; Slyter, 1968; Hallgrimsson, 1966, as cited by Eikje, 1971b; Dickerson and Glimp, 1975). The longest production record reported on a ewe was by Mattoon (1825) in which he reported that a ewe produced 36 lambs in her 19 years of life. Turner (1969) pointed out the possibility that ewes of flocks of higher levels of average fertility could reach their optimum production and start declining at an earlier age than ewes from flocks of lower levels of average fertility.

Ewe's Type of Birth

Published results from investigations show that twin-born ewes are more prolific in their lifetime than single-born ewes (Marshall and Potts, 1921; Desai and Winters, 1951a; Wright and Stevens, 1953). Turner (1969) indicated that twin-born ewes are most generally 5 to 16% more productive than single-born ewes. Mechling and Carter (1969) cited that a twin ewe born as a first lamb averaged 1.83 lambs per parturition in a lifetime as compared to 1.54, 1.70, 1.73, 1.76 and 1.80 from twins born in the second through sixth parturitions. They also expressed that twin-born ewes whose dams were twins produced more lambs in a lifetime than if their dam was single born. There was not much variation found with single-born ewes.

Smirnov (1935) concluded from his study that ewes born co-twin with a male produced .2 lambs less than ewes born co-twin to a female. An interesting article by Ainsworth-Davis and Turner (1910) with Oxford Down sheep reported that ewes from mixed twins produced twice as many female as male offspring and that ewes from ewe twins nearly always delivered male lambs.

Ewe Size

Many studies have shown that flushing a ewe before breeding increases the number of ova ovulated (provided the ewes are not already in a high nutritional condition), and this tends to result in more multiple births (Heape, 1899, 1900; Marshall, 1908b; Clark, 1934a; Underwood and Shier, 1941; Thomson and Aitken, 1959). The heaviest ewes during breeding tend to produce most of the multiple births (Bell, 1912). For each 2.2 lb (1 kg) gain in live weight of the ewe before mating, 1.3% more twin ovulations occur (Fletcher, 1971) or .0118 more lambs per litter are gained (Johansson and Hansson, 1943). It has been observed that a 6 to 7% increase in twinning rate occurs with every 10-lb (4.5-kg) increase in live weight of a 100-lb (45-kg) ewe (Coop and Hayman, 1962; Coop, 1962, 1966). In addition, Coop and Clark (1966) found that the percent of ewes which are open decreased almost linearly with increasing live weight of the ewe from 20% at live weights below 70 lb (32 kg) to 8 to 12% at 90 to 100 lb (41 to 45 kg).

Number of Lambings

Investigators have reported that ewes which produce twins in their first lambing (yearling or 2-year-old) will usually have a higher lambing rate for the next few years than ewes of the same age which were lambless or produced singles in their first lambing (Smirnov, 1935; Biegert, 1938; Roeper, 1960, as cited by Politiek, 1965; Inskeep *et al.*, 1967; More O'Farrall, 1976; Ransom, 1978).

Marshall (1903, 1904) stated that openness in ewes is normally due to the absence or scarcity of graafian follicles available for ovulation during the breeding season. Researchers have found the percent of open ewes decreases with age up to 5 years and then increases with further aging (Dry, 1936; Wallace, 1958; Leech and Sellers, 1959; Turner, 1966). Wallace (1958) suggested that ewes which are open as 2-year-olds are more prone to be open again later in life. Reports on the frequency of open ewes in flocks usually range between 2 and 5.5% (Nichols, 1924; White and Roberts, 1927; Johansson and Hansson, 1943; Leech and Sellers, 1959; Taneja, 1966; Maijala, 1974).

Heritability and Repeatability

The literature generally place the value of heritability for multiple births in the range of 15% or less. Some of the heritability estimates in sheep are .09 (Rietz and Roberts, 1915), .07 (Desai and Winters, 1951b), .04 (Ragab and Asker, 1954), .11 (Rendel, 1956), .03 to .31 (Rae, 1956), .03 (Gjedrem, 1966), .10 to .20 (Maijala, 1967), .21 (Vakil *et al.*, 1968), .10 to .15 (Mechling and Carter, 1969) and .08 (Eikje, 1975).

Intra-ewe repeatability for multiple births ranges mainly between 10 to 23%. Some of the values from the literature are .09 (Rietz and Roberts, 1915), .22 (Johansson and Hansson, 1943), .05 (Desai and Winters, 1951b), .08 (Mason and Dassat, 1954), .12 to .25 (Rae and Ch'ang, 1955), .09 (Rendel, 1956), .11 (Inskeep *et al.*, 1967), .23 (Maijala, 1967) and .17 to .20 (Mechling and Carter, 1969).

Twinning and Sex Ratios

According to Salerno (1959), twinning may result from two distinct biological mechanisms: (1) the production of two distinct ova and their fertilization within a brief period of time (dizygotic twins) and (2) the fission or splitting of a single fertilized ovum at either the blastomere or the blastocyst stage (monozygotic twins). Ratios of twinning from the literature and their frequences of occurrence are given in table 1. These twinning ratios tend to follow a 1 male/male: 2 male/female:1 female/female distribution.

A review of the literature strongly suggests that monozygotic twinning is rare in sheep. Researchers reporting cases of monozygotic twinning are Assheton (1898a), Adametz (1931, cited by Kronacher, 1932), Cohrs (1934), Henning (1937), Arthur (1956), Rowson and Moor (1964) and Scanlon (1972). The morphology and development of monozygotic twins has been investigated by Corner (1922).

Assheton's (1898a) discovery that a 7-day-old blastocyst had two germinal areas, Scanlon's (1972) case of monozygotic twin transuterine migration and Abenes and Woody's (1971) observation that transuterine migration occurs in the ewe between days 10 and 14 after conception have made it possible to narrow the time in which monozygotic divisioning is completed. Rowson and Moor (1964) have also found that it is possible by days 12 through 14 after conception to establish if embryos are developing in a single set of membranes.

Johansson and Hansson (1943) stated that the frequency of triplet and quadruplet births to twins in sheep is 5 and .25%,

TABLE 1. TWINNING RATIOS AND THEIR FREQUENCIES

Ratio MM:MF:FF[a]	Percentage MM:MF:FF	Source
87:187:83	24.4:52.4:23.2	Bernardin (1890)
38:67:34	27.3:48.2:24.5	Lillie (1917)
129:273:121	24.7:52.2:23.1	Clark (1931)
1,164:2,685:1,239	22.9:52.8:24.3	Johansson (1932a)
87:184:90	24.1:51.0:24.9	Chapman and Lush (1932)
161:323:163	24.9:49.9:25.2	Henning (1939)
5,885:12,359:6,191	24.1:50.6:25.3	Johansson and Hansson (1943)
164:340:173	24.2:50.2:25.6	Barton (1949)
46:99:48	23.8:51.3:24.9	Mason and Dassat (1954)
197:418:207	24.0:50.8:25.2	Donald and Purser (1956)
160:284:162	26.4:46.9:26.7	Teodoreanu (1961)
480:850:440	27.1:48.0:24.9	Burfening (1972)

[a] Male/male:male/female:female/female.

respectively. Many researchers have found a 3:1 distribution of mixed sex triplets to like sex triplets at birth (Wentworth, 1914; Johansson, 1932a; Dry, 1936; Barton, 1949).

A review of the literature reveals that generally a little more than 49% of the lambs are male and a little less than 51% are female at birth (Darwin, 1874; Wilckens, 1886; Nichols, 1926, 1927a; Richter, 1926; Teodoreanu, 1926, 1961; Chapman and Lush, 1932; Johansson, 1932a; Dry, 1936; Johansson and Hansson, 1943; Mason and Dassat, 1954; Donald and Purser, 1956; Kostic, 1967). Henning (1939) reported finding a prenatal sex ratio of 50.9 males to 49.1 females in slaughter house material. The topic of sex ratios has been excellently covered in the reviews by Parkes (1926), Johansson (1932b), Crew (1937) and Lawrence (1941). General comparisons of sex ratios within type of birth are presented in table 2.

TABLE 2. NUMBER OF MALE VERSUS FEMALE LAMBS PER TYPE OF BIRTH

Single[a] M:F[b]	Twin M:F	Triplet M:F	Quadruplet M:F	Source
47.7:52.3	49.3:50.7	40.7:59.3	--	Chapman (1931)
--	49.3:50.7	47.7:52.3	--	Johansson (1932a)
47.7:52.3	49.6:50.4	40.7:59.3	--	Chapman and Lush (1932)
51.7:48.3	45.0:55.0	50.0:50.0	--	Rasmussen (1941)
50.0:50.0	49.4:50.6	49.1:50.9	43.5:56.5	Johansson and Hansson (1943)
49.7:50.3	49.3:50.7	54.5:45.5	--	Barton (1949)
49.0:51.0	51.1:48.9	--	--	Burfening (1972)

[a] Type of birth.
[b] Sex ratio of newly born lambs, male:female.

Date of Lambing

It has been noted by many researchers that most multiple births occur at the onset of the lambing season and increase to a peak level before the middle of the season (Heape, 1899, 1900; Marshall, 1905, 1908a,b; Bell, 1912; Nichols, 1924; Hammond, 1944; Ragab and Asker, 1954; Hohenboken *et al.*, 1976a). Investigations have generally revealed that as the litter size increases the gestation period will shorten (Chapman, 1931; Terrill, 1944; Terrill and Hazel, 1947; Reynolds, 1959; McCance, 1962; Eikje, 1971b). Furthermore, studies have shown that undernourishing a ewe during her pregnancy will tend to shorten her gestation period (Alexander, 1956b; Alexander *et al.*, 1956). Gestation length was found to be slightly longer for larger and later maturing breeds (Bonsma, 1939). It also tends to get longer as a ewe advances in age (Terrill, 1944).

Several investigators have found that birth weights tend to increase with advancement of the lambing season (Carlyle and McConnell, 1902; Chapman, 1931; Donald and McLean, 1935; Shelton, 1964b; Burfening, 1972; Stegeman, 1974). Burfening (1972) reported finding .031 and .044 lb (.014 and .02 kg) per day gains during gestation for single and twin sets, respectively. Humphrey and Kleinheinz (1907) stated that male lambs are generally carried longer *in utero* than female lambs. However, Hammond (1932) stated that this larger size of the male at birth is not due to the longer gestation length because males are also larger in animals that produce litters.

Birth Weight

At term, according to Colin (1888), Malan and Curson (1937), Schinckel (1963) and Rattray *et al.* (1974), a fetus represents approximately 60 to 70% of the uterine discharge.

Campbell and Nel (1967) defined birth weight as the weight of the newborn lamb as soon as it has been freed of the placental mucous membranes and naval cord immediately prior to nursing. They also pointed out that weight of the lamb may be influenced by excretions, early growth, milk intake, the amount of moisture on its fleece from fetal fluids as well as the age postpartum when the birth weight is recorded. McDonald (1962) indicated that a lamb's coat can contain as much as 400 ml of fluid at birth. Weight loss due to coat drying is about 260 g and the metabolic loss averages 20 g per hour according to Alexander (1956a). He then stated that a lamb gains an average of 89 g in the first 12 hours if it has nursed.

Sire Effect

Many investigators have reported that the sire breed does influence the birth weight of lambs (Sidky, 1948; Asker et al., 1954; Hunter, 1956; Starke et al., 1958; Bellows et al., 1963; Donald et al., 1968; Iwan et al., 1971; Sidwell and Miller, 1971b; Smith, 1977a). Sidwell and Miller (1971b) found a .75-lb (.34-kg) advantage for Suffolk x Targhee lambs over Targhee straightbreds.

Chapman and Lush (1932) suggested that 7.5% of the gross variance of birth weight is due to individual sires.

Age of Dam

According to numerous studies, the birth weight for lambs increases as a ewe advances in age with maximum values occurring between 4 and 6 years of age and then they decrease with further advances in age (Bonsma, 1939; Chapman, 1931; Ali, 1952; MacNaughton, 1956; Lambe et al., 1965; Hight and Jury, 1970; Eikje, 1971a; Peters and Heaney, 1974). Many reports showed that 2-year-olds had 10% lighter weight lambs at birth than older, mature ewes (Donald and McLean, 1935; Nelson and Venkatachalam, 1949; Bichard and McG. Cooper, 1966). Cloete (1939) pointed out that virgin Merinos of mature age produced lambs equal in birth weight to ewes of the same age which had previously lambed. The age of dam effect accounted for 4.37% of the variation in birth weight (Lambe et al., 1965).

Ewe Size

Hunter et al. (1954) reported finding that birth weight is influenced by the breed of dam. According to some studies, the male lamb gains about .74 to 1 lb (.34 to .45 kg) and the female lamb .71 to 1 lb (.32 to .45 kg) for every 10-lb (4.5-kg) increase in a ewe's live weight (Donald and McLean, 1935; Bonsma, 1939). Hamada (1954) gave a figure of .59 lb (.27 kg) gain in twin females for every 10-lb (4.5-kg) gain in the ewe's weight. Others noting that the heaviest ewes bore the heaviest lambs were Hammond (1932), Mason and Dassat (1954) and Slyter (1968).

Walton and Hammond (1938) found that a fetus is proportional to the mother's size. According to a few investigations, the single's average birth weight was 6.5 to 8.97% and the twin sets' average birth weight was 9.14 to 10.6% of the dam's live weight in sheep (Villegas, 1939; Donald and Russell, 1970). Starke et al. (1958) summarized by stating that the weight of a lamb, irrespective of breeding, is approximately 7.5% of the average weight of both parents.

Litter Size

Research has found that usually singles are heavier at birth than twins (Ali, 1952; MacNaughton, 1956; Hight and Jury, 1970; Lind, 1970). It has been suggested that singles on an average weigh approximately 20 to 22% more than twins at birth (Nelson and Venkatachalam, 1949; Bichard and McG. Cooper, 1966). Studies have shown that triplets on an average are approximately 10% lighter than twins at birth (Hammond, 1932; Bichard and McG. Cooper, 1966).

Villegas (1939) and Cloete (1939) pointed out that as litter size increases the total birth weight of a litter increases. Several investigators have found the total single's weight to be only 60 to 70% of the total twins' weight at birth (Villegas, 1939; Starke et al., 1958; Boshier et al., 1969).

Sex

Investigators have found that generally males are 5 to 7% heavier than females at birth (Underwood and Shier, 1942; Nelson and Venkatachalam, 1949; Bichard and McG. Cooper, 1966; Jabbar and Ahmad, 1972). It has also been noted that generally the single males are heaviest, then the single females, the twin males and the lightest at birth are the twin females (Mason and Dassat, 1954; Large and Taylor, 1954; Juma and Faraj, 1966; Bush and Lewis, 1977).

Chapman (1931) found that like sex twins and mixed sex twins averaged 2.5 and 2.2 lb (1.1 and 1.0 kg) lighter, respectively, than single male lambs. Studies have reported that lambs born co-twin to a female are significantly heavier at birth than lambs born co-twin to a male (Teodoreanu, 1926, 1961; Beatty, 1956; Donald and Purser, 1956; Burfening, 1972).

Prenatal Nutrition

Inadequate nutrition during pregnancy usually results in smaller lambs at birth as reported by several researchers (Thomson and Fraser, 1939; Thomson and Thomson, 1948-9; Palsson and Verges, 1952; Thomson and Aitken, 1959; Meaker and Van Niekerk, 1977). Reports have also revealed that heavy feeding of undernourished ewes in the last month prior to parturition will result in normal sized lambs (Thomson and Fraser, 1939; Pomeroy, 1955; McClymont and Lambourne, 1958). Pomeroy (1955) then went on to say that undernourishment in late pregnancy will yield undersized lambs, even if a high level of nutrition existed in early gestation.

The fetal weight can be retarded by day 90 of gestation if the ewe is undernourished (Taplin and Everitt, 1964; Everitt, 1964). Everitt (1964) also noticed that inadequate nutrition of the ewe reduced the weight of the functional cotyledonal material. Studies have shown that a positive correlation exists between the weight of functional cotyledons and birth weight (Alexander, 1964a; Stegeman, 1974). Reports have found that two-thirds of the final fetal weight is put on during the last 40 days of gestation (Curson and Malan, 1935; Winters and Feuffel, 1935; Wallace, 1948b). Research has shown that as the litter size is increased the weight per fetus decreases in proportion after day 70 of gestation (Hammond, 1921a; Winters and Feuffel, 1935; Cloete, 1939; Rattray _et al_., 1974; Robinson _et al_., 1977). Generally, the male fetuses are heavier than the female fetuses, provided the placenta can meet their demands (Stegeman, 1974).

Naaktgeboren and Stegeman (1969) stated that the influence of placental weight on birth weight is greater than that due to the sex of the fetus. According to Cloete (1939), Barcroft and Kennedy (1939), Robinson (1951a), Amoroso (1961) and Stegeman (1974), the sheep placenta attains its maximum weight around the halfway point in the gestational period. Stegeman (1974) indicated that the significance of the placenta in determining fetal weight is connected with the total surface area at which exchange between maternal and fetal circulation takes place.

Effect of High Temperatures

It has been found by several researchers that high temperatures (100 to 105 F) during the last half of gestation will slow down fetal growth (Yeates, 1953, 1956, 1958; Shelton, 1964b; Alexander and Williams, 1966a). Alexander and Williams (1966a) have reported that high temperatures will also retard placental growth.

Heritability and Repeatability

Heritability for birth weight was generally reported in the 30 to 36% range. Some values from the literature are .25 to .30 (Chapman and Lush, 1932), .33 (Blackwell, 1953), .34 (Ragab *et al*., 1953), .27 and .36 (MacNaughton, 1956) and .32 (Smith, 1977a).

Reports on repeatability of birth weight were usually found to be half the values reported for heritabilities. Samples from the literature are .18 (Blackwell, 1953), .12 (Blackwell and Henderson, 1955), .27 and .36 (MacNaughton, 1956) and .13 (Juma and Faraj, 1966).

Weaning Weight

Weaning weight is both a measure of the inherent rate of gain and a partial measure of the dam's milking ability (Scott, 1975).

Suckling Period

Alexander and Williams (1966b) noticed that the most frequent teat seeking of a lamb occurs during the first 2 hours after birth and then decreases rapidly with time. Sojetado (1952) pointed out that lambs nurse an average duration of 58.7 seconds during the day and 60 seconds at night during the first days of life. Ewbank (1964, 1967) found that lambs will suckle the ewe any time during the first 2 weeks of life, but thereafter the ewe limits the number of nursing periods. He went on to say that twins will suckle more frequently than single lambs during the first month of life. Furthermore, twins and singles of the same age have similar average nursing durations (Ewbank, 1967). Observers have noted that as a lamb grows older its duration and frequency of sucking decreases (Sojetado, 1952; Munro, 1955, 1956; Ricordeau et al., 1960; Ewbank, 1967).

According to many researchers, the more lambs a ewe suckles the more milk she produces during her lactational period (Guyer and Dyer, 1954; Davies, 1958; Doney and Munro, 1962; Ceramic, 1967; Goot, 1974; Peart et al., 1975). Peart et al. (1975) also stated that the more lambs a ewe suckles the sooner she will reach her peak production. N.R.C. (1975) lists twin-nursing ewes as yielding 20 to 40% more milk than single-nursing ewes. Moore (1966) found that a lamb's ability to obtain milk is more important in relation to milk yield than a ewe's ability to produce it during the first 6 or 7 weeks of lactation.

Orr et al. (1977) stated that lamb growth through the first 4 weeks of life and time spent nursing are significantly and positively correlated. Also, early lamb growth and quantity of ewe's milk produced are highly correlated according to other sources (Neidig and Iddings, 1919; Whiting et al., 1952; Burris and Baugus, 1955). A .90 coefficient of correlation for weight gain of lamb to milk consumed at 1 month of age has been reported (Wallace, 1948a; Burris and Baugus, 1955). However, the correlation coefficient gradually decreased with advancing age of lambs. Scales (1968) claimed that 55% of the total lamb growth due to milk production occurred during the first half of lactation. During this period, an extra .032-lb (.014-kg) gain in lamb weight was recorded per week for every extra milliliter per hour increase in milk yield. Barnicoat et al. (1949) and Hunter (1956) have implied that a twin actually receives only about two-thirds as much milk as a single lamb.

Wallace (1948a) suggested that 38% of the total milk yield of a ewe occurs during the first month and 30, 21 and 11% are produced in the second, third and fourth months, respectively. Studies have indicated that the first lactation yields the lowest output and then milk yield increases to a maximum during the fourth or fifth lactation (Bonsma, 1939; Starke, 1953; Mason and Dassat, 1954; Hunter, 1956). Bonsma (1939) and Starke (1953) indicated that higher milk production comes from the heaviest ewes at parturition and crossbreds.

Sire Effect

Numerous studies have stated that they found a breed of sire effect on growth rates in lambs (Bonsma, 1936, 1939; Sidky, 1948;

DeBaca et al., 1956; U.S.D.A., 1956; Allden and Anderson, 1957; Seebeck, 1965; Sidwell and Miller, 1971b; Dickerson, 1977). Sidwell and Miller (1971b) reported that Suffolk x Targhee lambs weighed 5.3 lb (2.4 kg) more than Targhee straightbreds. It has been suggested that individual sires account for 1 to 2% of the total variation in lamb growth traits (Hohenboken et al., 1976b).

Age of Dam

The weaning weight of a lamb increases as a ewe gets closer to 4 through 6 years of age and then it decreases with advancing age of ewe (Hazel and Terrill, 1945a; Nelson and Venkatachalam, 1949; Blackwell, 1953; MacNaughton, 1956; Lambe et al., 1965; Peters and Heaney, 1974; Hohenboken et al., 1976b).

Ewe's Weight

Hammond (1932) and Sidky (1948) stated that a dam's live weight is positively correlated to the weaning weight of her progeny. A 10% increase in the live weight of a 100-lb (45-kg) ewe results in a 1.2-lb (.54-kg) or 1.8% increase in total weaning weight of lambs (Coop and Hayman, 1962).

Litter Size

According to numerous reports, single lambs outweigh twin lambs by weaning time, approximately 115 days (Phillips, 1928; Sidwell and Grandstaff, 1949; Hazel and Terrill, 1946a; Ali, 1952; Thomson and Thomson, 1953; Ransom and Mullaney, 1976). Other sources have pointed out that lambs reared as singles even if born as twins will outweigh lambs reared as twins by weaning time (Brown, 1964; Ranson and Mullaney, 1976). Bush and Lewis (1977) have listed male singles, female singles, male twins and female twins in that order as being the heaviest at weaning time. It has been observed that lambs born and raised co-twin with a female had a greater average daily gain than lambs born and raised co-twin with a male through 60 days of age (Burfening, 1972).

Some studies have found that growth rate differences due to type of birth and type of rearing decreased with advancing age of lambs (Harrington _et al._, 1958; Starovoitenko and Elin, 1965).

Sex of Lambs

According to several workers, there is a 5 to 8% weight advantage for males over females by weaning time (Phillips and Dawson, 1940; Bichard and McG. Cooper, 1966; Ransom and Mullaney, 1976). Burfening (1972) found that sex of co-twin ($P < .05$) affected 60-day but not 120-day weights in lambs.

Numerous studies have reported that rams were more efficient in feed conversion than wethers; and, thus, they gained weight more rapidly (Hinman, 1931; Bradford and Spurlock, 1964; Kiley, 1976). Campbell and Bosman (1964) concluded that ram lambs gain weight the fastest, then late castrated and then early castrates up to weaning. Most research indicates that single wether lambs gain more readily than single ewe lambs through weaning time (Shier and Davenport, 1936; Large and Taylor, 1954; Slen and Banky, 1961; Lind, 1970). In addition, Underwood and Shier (1942) found that wethers gain weight faster than ewe lambs when both were of the same birth weight. Wallace (1948a) pointed out that wethers from a twin set outweighed ewe lambs from a twin set at weaning time. In other investigations, it was found that the greatest rate of gain was made by the ram, then the wether, then the intact ewe and least by the spayed female lamb (McClaugherty et al., 1959; Everitt and Jury, 1966).

Nutrition in Lambs

Murray (1921) stated that in sheep the apparent maximum rate of growth is attained at 1 or 2 weeks postpartum and continues somewhat uniformly until age 12 to 15 weeks and then it starts to decrease. This effect was evident in an experiment with 6- and 11-week-old lambs on pasture (Hamilton et al., 1976). However, many investigators have indicated that the acceleration phase of lamb growth ends between days 60 and 80 postpartum (Donald and McLean, 1935; Brody, 1945; Bush and Lewis, 1977). Ritzman (1917) stated that a lamb gains 60% of its total yearling weight in the first 3 months of life, almost 20% in the next 3 months, approximately 20% in the third 3-month period and less than 5% in the last 3 months.

The stage of growth of an animal at the time of nutritional restriction is of prime importance in determining the extent of recovery from malnutrition (Wilson and Osbourn, 1960). Stunting is somewhat apparent in the mature sheep if its growth has been restricted during its initial 6 months of life (Allden, 1961). According to Allden (1961) and Schinckel (1963), sheep older than 6 months of age have a great capacity to compensate for any nutritional disadvantage which was incurred early in life. Jacobsz et al. (1971) found in sheep older than 6 months that rate of gain differed only by the amount of digestible energy and nitrogen needs per unit of gain.

Studies conducted by Hammond (1921b, 1932) have shown that live weight gains were increased in years of above average rainfall. However, range data reported by Bush and Lewis (1977) showed the best rate of gain occurred in relatively dry years. According to Johnson (1924), the growth of the lamb during the first few months postpartum can be retarded by either high humidity and temperature or by excessive rainfall and cold weather.

Heritability and Repeatability

Weaning weight heritabilities seemed to vary widely (.03 to .45) among the sheep breeds studied. Values from the literature are .30 (Hazel and Terrill, 1945b) and .33 (MacNaughton, 1956) for Rambouillet; .32 (Hazel and Terrill, 1946b) and .45 (MacNaughton, 1956) for Corriedale; .14 (Gregory, 1977) for Dorset; .08 (Hazel and Terrill, 1946b) for Targhee; .03 (Hanrahan, 1976) and .30 (More O'Farrall, 1976) for Galway; .16 (Hazel and Terrill, 1946b) for Columbia; .19, .22 (Gjedrem, 1967) and .09 (Eikje, 1975) for Dala; .07 (Gjedrem, 1967) and .13 (Eikje, 1975) for Steigar; .11 (Eikje, 1975) for Cheviot and .07 (Eikje, 1975) for Rygja breeds. Others which reported heritability estimates but had combined the data on their breeds were Nelson and Venkatachalam (1949), Blackwell (1953), Blackwell and Henderson (1955) and Gjedrem (1966). They reported .33, .07, .07 and .37, respectively.

The heritability estimate for total weaning weight was .19 (Blackwell and Henderson, 1955) and for total number of lambs weaned was .01 to .03 (Eikje, 1975).

Some of the repeatabilities listed for individual weaning weight were .22 (Sidwell and Grandstaff, 1949), .07 (Blackwell, 1953), .08 (Blackwell and Henderson, 1955), .25 and .30 (MacNaughton, 1956) and .16 (Eikje, 1975). These also varied due to breed differences.

There is a big difference in weaning weight in favor of lambs coming from flocks selected for higher weaning weight than from flocks selected for low weaning weight (Pattie and Williams, 1966). Studies have generally shown that the earliest born (Bonsma, 1939; Phillips and Dawson, 1940; Hammond, 1944) and the heaviest lambs at birth (Underwood and Shier, 1942; Bush and Lewis, 1977) gain the most rapid through weaning. Bush and Lewis (1977) have found that birth weight accounted for 20% of the variability in rate of gain.

Parturition and Early Postnatal Life

It is during the first 2 weeks of postpartum accommodation that approximately 70% of all postnatal lamb deaths occur. It is therefore deemed necessary at this point to present the normal aspects of this period and then follow it up with a discussion of lamb mortality.

Parturition

According to several studies, over 50% of all single and twin sheep fetuses by day 85 of gestation were found in the anterior presentation (Curson and Mare, 1934; Curson and Quinlan, 1934; Reimers *et al.*, 1973; Scanlon, 1976). In addition, Reimers *et al.* (1973) noted that over 90% of the fetuses have attained the anterior presentation by day 120. They also suggested that twin fetuses probably attain the anterior orientation earlier than single fetuses.

Bassett and Phillips (1955) found by using dissection and radiography that the pubic symphysis does not relax at all, but the sacroiliac joints commence to relax and the sacrosciatic ligament begins to elongate during the second month of gestation. Roberts (1971) and Arthur (1975) stated that near the time of parturition (24 to 48 hours before) the caudal borders of the sacrosciatic ligament between the coccygeal vertebrae and ischial tuberosity becomes very relaxed and flaccid. This tends to elevate the apex of the sacrum. According to Hindson and Ward (1973), the uterine contractions change from the pregnancy form (contractions lasting 5 to 10 minutes and occurring at 30-minute intervals) to the parturient form (contractions of 1/2 minute duration and occurring in 1-minute intervals) about 12 to 30 hours before fetal expulsion. The cervix dilates slowly at first but during the last hour before delivery its tempo of dilation is very rapid (Hindson *et al.*, 1965). Hindson *et al.* (1968) have reported that the uterine activity is quite similar in both horns of a ewe carrying twins. They also found that around 7 hours prepartum one horn will develop contractions of greater amplitude and frequency than the other and the resulting difference progressively becomes greater. Hindson and Ward (1973) pointed out that a fetus weighing 20% more than its co-twin will be delivered first. However, if the weight difference is less than 20%, the first lamb delivered may not be the heaviest one.

Around 70% of all pregnant ewes display parturient uneasiness within 2 hours of delivery (Wallace, 1949). Furthermore, it has been recorded in several studies that older ewes give little warning before they lamb (Wallace, 1949; Ellis, 1958; Lindahl, 1964). Alexander (1960) pointed out that first lambing ewes have generally the longest labor period. Also, Baier (1966) stated that the chance of a fetus getting infections from the birth canal increases as the time interval between fetal escape from the amnion and birth becomes lengthened. Lindahl (1964) reported that parturition of ewes delivering multiple births occurs at greatest frequency between 9 and 12 am and 3 to 6 pm. He then went on to say that older ewes bearing singles and younger ewes showed no specific parturition time patterns. According to George (1969), parturition patterns vary between sheep breeds but are fairly constant within a breed.

Early Postnatal Life

A ewe normally stands within seconds of giving birth and smells the newborn lamb. She then commences vigorous licking (grooming) and ingestion of the allantoic and amniotic membranes in which the lamb may be enveloped (Alexander *et al.*, 1974). Several researchers have observed that generally lambs are first successful in standing by 10 minutes after birth (Collias, 1956; Shillito and Hoyland, 1971). Wallace (1949) indicated that 70% of the lambs are standing within

30 minutes of birth. According to Alexander (1968), the lambs from ewes on a high plane of nutrition are the quickest to stand. He also stated that singles tend to stand up sooner than twins.

Several investigators have noted that single-born lambs are quicker to reach the udder than are twin-born lambs (Wallace, 1949; Alexander, 1958). Alexander (1958) also pointed out that lambs from ewes on a high plane of nutrition are quicker to suckle than lambs from ewes on a lower plane of nutrition. Observations on the lamb's trial and error first attempts at nursing have been reported by Scott (1945). Alexander (1966) stated that a ewe guides the lamb to her udder by using her own body configuration and grooming. However, neither orientation nor grooming alone can facilitate the sucking drive of lambs to any great extent (Alexander and Williams, 1964). McCance and Alexander (1959) found that a copious lactation usually commenced at parturition if a ewe had gained weight during her pregnancy. It has also been reported that the onset of lactation is somewhat slower in ewes which have given birth to twins (Alexander and Davies, 1959).

According to several studies, a ewe or goat needs at least 5 to 10 or even 30 minutes of licking her newborn before she can identify it by smell (Fraser, 1926; Collias, 1956; Alexander, 1960, 1966; Klopfer, 1964; Klopfer _et al._, 1964; Smith _et al._, 1966; Klopfer and Gamble, 1966; Bouissou, 1968; Morgan _et al._, 1975). It has been recorded in many investigations that in a short time the mother also uses sight and sound to identify her offspring (Alexander, 1960;

Smith, 1965; Lindsay and Fletcher, 1968; Shillito and Alexander, 1975; Poindron and Carrick, 1976). In addition, Hersher et al. (1963) pointed out that mothers, if they have foster young, can discriminate them from alien young. Tschanz (1962) and Kilgour (1972) stated the fact that lambs are unable until the third day postpartum to discriminate between who or what is their real mother. Tschanz (1962) then went on to say that a lamb knows its mother by sight after the third day. It has been observed in many studies that, if young are separated from the mother before she has had a chance to lick them off, she is most likely to reject them on their return, either temporarily or permanently, or fail to show them specific individual care (Collias, 1953; Hersher et al., 1957, 1958; Klopfer, 1964; Klopfer et al., 1964).

Normal lambs from adequately fed ewes achieve summit metabolism (the metabolic rate measured in an environment of temperature and air movement just sufficient to cause a fall in rectal temperature of approximately 1 C per 20 minutes) about five times the basal level within minutes of birth (Alexander, 1964b). Alexander (1958) stated that under severe weather conditions the newborn lamb can use up 70 kcal per hour of energy from its initial energy reserves (600 to 700 kcal). However, under severe cold (Alexander and Williams, 1966c) or high (Shelton, 1964b) environmental temperature conditions, a lamb's chance of survival is greatly depressed. Alexander (1966) pointed out that body heat loss increases for the lamb when air temperature drops, air movement increases or when water is evaporating from the animal. Alexander (1964b) suggested that ingestion of milk does not increase the summit metabolic rate, but its maintenance depends upon adequate nutrition. Researchers have found that less heat is lost from lambs with hairy coats than lambs with fine-wooled coats, larger than smaller lambs (McDonald, 1962; Alexander, 1964b, 1966) and single-born than twin-born (McDonald, 1962).

Lamb Mortality

The material reviewed in this section will cover the embryonic, fetal and postpartum phases of lamb life.

Embryonic Mortality

It seems that in sheep most ovum and embryonic work is based on the original information provided by the studies of Kuhlmann (1754), Baer (1828, 1937), Bischoff (1844), Bonnet (1884, 1889), Assheton (1898b) and Kolster (1903).

Some investigators have reported that the sheep ovum reaches the uterus in the 16 or 32 cell stage (Clark, 1934b; Green and Winters, 1945). Studies have indicated that these cell stages of the ovum reach the uterus around day 3 after ovulation (Assheton, 1898b; Sobotta, 1916; Andersen, 1927; Clark, 1934b; Kelley, 1939; Davies and Wimsatt, 1966; Holst, 1974). It has been found that the ovum is transported to the uterus by cilia (Grosser, 1915) and smooth muscle contractions of the oviduct (Sobotta, 1916). It has been suggested by Robinson (1951b) that the greatest concentration of embryonic death occurs at the attachment stage. Psychoyos (1973) and Enders (1976) pointed out that the age of the blastocyst at the time of implantation is fixed to within a few hours, so strict synchrony must be kept between embryonic and uterine events for implantation to occur. Several investigators have indicated that attachment of the embryo to the uterus (the sticky wall of the chorionic sac adheres to the concave surface of the maternal caruncles) occurs between day 15 and 18 after conception (Assheton, 1906; Uren, 1935; Chang and Rowson, 1965; Davies and Wimsatt, 1966; Boshier, 1969; Wimsatt, 1975). The basal embryonic mortality seemed to lie between 20 and 30% in sheep according to Dutt (1954), Hart (1956) and Edey (1969, 1976). Other studies have noted that the peak in embryonic losses occurred around days 17 through 23 after conception (Robinson, 1951b; Hart, 1956; Hulet et al., 1956; Quinlivan et al., 1966; Edey, 1976). In research conducted by Robinson (1951b, 1957), Foote et al. (1959), Quinlivan et al. (1966) and Edey (1969), essentially all of the embryonic losses occurred within the first month following conception. In addition, Robinson (1951b) pointed out that once placentation has proceeded to the extent of allantochorion formation the chances of subsequent loss are diminished.

It has been shown in some studies that embryonic mortality increases as the number of ovulations per female increases during the breeding season (Brambell, 1948; Casida et al., 1966; Edey, 1966, 1976). Doney et al. (1973) found that a higher embryonic loss occurred in ewes in which two corpora lutea were on one ovary than in ewes in which a single corpora luteum occurred on each ovary. Probably the first record of transuterine migration in sheep was that by Bonnet (1884), when he reported three cases in a flock of research ewes. Bischoff

(1845) suggested that uterine contractions are the most likely cause of ovum migration. However, it was found by Cloud and Casida (1969) that the embryo itself can stimulate uterine motility of the ipsilateral horn before day 14 after ovulation. There have been many investigations which have noted a 4 to 8% transuterine embryo migration in single ovulating ewes (Naaktgeboren and Stegeman, 1969; Scanlon, 1972; Reimers et al., 1973). Still other studies reported that it is of common occurrence for one embryo to migrate to the contralateral horn when two or more ova are shed from a single ovary (Kupfer, 1923; Curson, 1934; Boyd et al., 1944; Scanlon, 1972; Doney et al., 1973; Reimers et al., 1973). Abenes and Woody (1971) stated that all embryo migrations are completed by day 14 after conception.

Several researchers have implied that the causes of embryonic mortality are defects inherent within the embryo or adverse factors operative within the maternal environment (Corner, 1923; Roberts and Crew, 1925; Nichols, 1927b; Mohr, 1929; Hammond, 1941; Casida, 1956; Bishop, 1964; Boyd, 1965; Baier, 1965). Bishop (1964) pointed out that the principle genetic causes of embryonic death are lethal factors carried by the spermatozoon, ovum or both. He went on to say that lethal genes may be in the form of point mutations, deletions, replications, inversions or translocations. Young (1967) stated that crossbreeding will reduce embryonic mortality. However, Boyd (1965) pointed out that certain breeds of ewe differ in their capacity to carry embryos *in utero* regardless of the breed of the embryo.

Some investigators have reported that mortality of embryos in young ewes is quite a bit higher than in mature ewes (Hasnain, 1964; Boyd, 1965; Edgar, 1962). Averill (1955) found that ovum and embryonic deaths are highest at the onset and end of the breeding season. In addition, Laffey and Hart (1959) reported that losses are twice as great in the latter part of the season than in the beginning. It was recorded by Dutt et al. (1959) and Alliston et al. (1961) that high ambient temperatures (90 F) will cause ova to become morphologically abnormal. Heat stress shortly after fertilization causes many embryos to die (Ulberg and Burfening, 1967). Also, inadequate nutrition of ewes will tend to increase embryonic death (Giroud, 1968).

Fetal Mortality

Most of the basic work on the morphological aspects of placentation and fetal growth of sheep was done by Assheton (1906), Jenkinson (1906), Paton et al. (1907), Cloete (1939), Winters and Feuffel (1935), Green and Winters (1945) and Green (1946).

Most researchers have been reporting a 20 to 48% embryonic and fetal loss from conception through birth (Morley, 1954; Hanly, 1961; Hasnain, 1964; Baier, 1965; Maund and Duffell, 1977). Kupfer (1923) and Henning (1939) found that fetal mortality increases directly with the number of ova shed by a female. Hammond (1921a) found that the percent of atrophic fetuses was greater when two ova were shed by one ovary than if one came from each ovary. Furthermore, Hammond (1914, 1921a) and Edey (1969) stated that, in those species which produce only one young at birth, absorption or abortion of the embryo results from its death; but, in those species in which many young are produced, the dead and mummified fetuses are carried to term.

Some investigators reported that 10 to 20% of all lambs die before birth (McFarlane, 1954; Stamp, 1967). Schinckel (1963) pointed out that increased neonatal mortality may be due to inadequate nutrition of ewes in late gestation. It has been suggested by several investigators that abortion probably occurs at a rate of .8 to 3% in sheep (Nichols, 1926; Watson, 1962a; Taneja, 1966; Ercanbrack, 1968; Quinlivan and Martin, 1971b). Abortion is three times more common in ewes bearing twins than singles (Quinlivan and Martin, 1971b). According to Thibault (1971) the prolonged survival of the gamates in the female genital tract before fertilization will usually result in a higher incidence of abortion. It was also suggested by McFarlane (1952) that abortion prior to the normal lambing date is often an indication of an infection in the ewe's reproductive tract. Watson (1962a) stated that the following bacterial organisms can cause abortion in the ewe: Vibrio fetus, Listeria monocytogenes, Brucella abortus, Brucella melitensis, Brucella suis, Salmonella abortus-ovis, Salmonella typhimurium and Salmonella dublin. Watson (1962b) then went on to say that the major viral infection of the ovine is enzootic abortion.

Several studies have indicated that stillbirths occur at the rate of 2.3 to 7.1% during a normal lambing season (White and Roberts, 1927; Chapman, 1931; Chapman and Lush, 1932; Bell, 1947a; Venkatachalam et al., 1949; Watson, 1962a; Grommers, 1967; Ercanbrack, 1968; Whitelaw, 1976). According to Crew (1937), Lawrence (1941) and Alexander et al. (1955), more male than female lambs are stillborn. Others have found that stillbirths are more common in the lighter than average weight lambs (Chapman, 1931; Purser and Young, 1964). Some investigations suggested that the number of stillbirths increase directly with increases in litter size (Chapman and Lush, 1932; Johansson and Hansson, 1943). Stillbirths have also been associated with prolonged labor (Alexander, 1960) and inadequate nutrition of ewes (Thomson and Thomson, 1948-9).

Dawes and Parry (1965) and Hammond (1944) stated that the viability of the newborn is greatly affected by its stage of development at birth. Dawes and Parry (1965) noticed that lambs less than 95% of the normal gestational age were 15% less viable. Huggett (1941) related the fact that the placental weight varies from one-twelfth to one-fourth that of the fetal term weight. He went on to state that fetal survival ability increases as the placental size increases.

Postnatal Mortality

Mortality rate is higher in lambs which are slower than average to stand and suckle (Alexander, 1958). Research has shown that, if a lamb has not nursed by the sixth hour postpartum, its teat seeking activity and chance of ever sucking successfully are greatly reduced (Alexander, 1966; Alexander and Williams, 1966c). Depending upon their prenatal nutrition and the air temperature, lambs not receiving milk can survive from 16 hours to 4 days (Alexander, 1966). According to

Duren and Dahmen (1976), if a lamb does not get its colostrum within 2 to 3 hours postpartum, it will probably become hypoglycemic and eventually die. Several investigators have suggested that normal lamb starvation in a flock ranges from 2 to 25% but depends a great deal on the management system involved (Bell, 1947a; Safford and Hoversland, 1960; Hartley and Boyes, 1964; Hight and Jury, 1970; Maund and Duffell, 1977). Lamb starvation is at its lowest in offspring of ewes 4 to 6 years of age (McDonald, 1966).

More lambs are lost from ewes with unsound udders than from ewes with sound udders (Moule, 1954). Beck et al. (1968) found that udder infections increase with advancing age in ewes. In addition, McCance and Alexander (1959) found that inadequately fed ewes during the last 6 weeks of gestation had a delayed copious lactation through 12 hours postpartum. A few studies have reported that after lactational onset the rate was only half that of the well nourished ewes (Alexander et al., 1956; McCance and Alexander, 1959).

Several studies suggest that ewes experiencing prolonged labor periods (Wallace, 1949; Alexander, 1968; Shelley, 1970) and maiden ewes (Wallace, 1949; Alexander, 1964a, 1966, 1968) are the poorest mothers. Alexander (1960) suggested that maternal behavior in older ewes is facilitated by the reflexes conditioned during previous lactations and in young ewes it is inhibited by the pain and shock of parturition. With high stocking rates, more lambs become separated from their mothers following interference by alien ewes (Winfield, 1970). According to Alexander (1964b, 1966), lambs from inadequately nourished ewes quite often wander off and are lost before the ewe has a chance to recuperate from the exhausting ordeal of parturition.

Sire Effect. Many investigators have found that lamb mortality is influenced directly by the breed of sire (Thompson, 1951; Smith, 1977a). Also, studies have reported that crossbreeding may enhance the livability of lambs (U.S.D.A., 1956; Galal et al., 1974; Smith, 1977a). Still others have indicated that lamb livability for both singles and twins is curvilinear with age of dam and is maximal with ewes 4 to 6 years old (Karam, 1959; Purser and Young, 1959; Gjedrem, 1966; McDonald, 1966; Galal et al., 1974; Dickerson et al., 1975).

Bell (1947a,b) has reported finding in sheep higher incidents of lamb mortality being associated with individual sires and/or dams.

Litter Size. Early postnatal deaths increase directly with increasing litter size in either purebreds or crossbreds according to numerous researchers (Thomson, 1932; Johansson and Hansson, 1943; McHugh and Edwards, 1958; Shelton, 1964a; Bichard and McG. Cooper, 1966; Gunnarsson et al., 1972; Whitelaw, 1976). Burfening (1972) noticed that sex of a lamb's co-twin greatly ($P<.01$) influenced the lamb's survival from birth through 60 days postpartum. Losses were 5.3% higher through 60 days of age when a lamb was born co-twin to a male than a female.

Sex. Several studies have found at least through weaning that females have a better survival ability than males (Ragab et al., 1954;

Karam, 1959; Gunn and Robinson, 1963; Boyd et al., 1964; Lax and Turner, 1965; Hight and Jury, 1970; Burfening, 1972; Dickerson et al., 1975).

Time Postpartum. Leech (1976) pointed out that mortality per unit of time decreases sharply from birth to sexual maturity and concurrent with this is a shift in the causes of mortality. Several studies have indicated that normally by day 3 postpartum 50 to 56% of all lamb mortality has occurred (Moule, 1954; Papadopoulos and Robinson, 1957; Safford and Hoversland, 1960).

Research findings tend to suggest that normally 70 to 73% of all lamb mortality has occurred by day 14 postpartum (Venkatachalam et al., 1949; McHugh and Edwards, 1958; Safford and Hoversland, 1960; Purser and Young, 1964; Beck et al., 1968).

Dystocia. Four- through 6-year-old ewes have the least number of cases of dystocia of all ages of ewes (McDonald, 1966). Several investigators have reported that dystocia occurs more frequently in ewes giving birth to single male than female lambs (Gunn, 1968; Gunn and Robinson, 1963; Smith, 1977a). Others have reported that the occurrence of dystocia increases with increasing birth weights (Purser and Young, 1964; Smith, 1977b). It has been stated by some that lambs at either extreme of the birth weight scale have a low level of survival (Purser and Young, 1959; Bowman, 1966; Hight and Jury, 1970). Lambs born single or twin of similar birth weight have similar survival rates (Bowman, 1966).

Predators. Many investigators have reported either 90% of all predation, or 1.0 through 3.5% of the total lambs in a range flock, are killed by coyotes every year (Bowns et al., 1973; Henne, 1975; Klebenow and McAdoo, 1976; Tigner and Larson, 1977; Nass, 1977; McAdoo and Klebenow, 1978). Gee et al. (1977) stated that approximately 33% of all lamb losses on range and mountain pastures can be attributed to coyotes each year in the western 15 states of the United States.

Heritability. Heritability estimates for livability as found in the literature were .19 (Shelton and Menzies, 1970) and .06 (Smith, 1977a). Smith (1977a) also calculated a .13 paternal half-sib heritability estimate for dystocia and .10 for lamb vigor.

Figure 1 was assembled based on information presented in the preceding review on lamb mortality. Percentage estimates of losses of viable offspring are given for the different stages of development through weaning of the original number of ova shed during estrus in an average flock. Estimates are given for the percentage of viable offspring born and weaned from the total percentage of ova shed.

Ewe Losses and Removals

Some researchers have suggested that 2 to 13% of the ewes in an average flock die each year (Heape, 1899; Thomson and Aitken, 1959; Campbell, 1962). The greatest death loss occurs in ewes 6 years and older according to several studies (Mason and Dassat, 1954; Leech and Sellers, 1959; Campbell, 1962; Matthews et al., 1977). Quinlivan and Martin (1971a) noticed that 1.8% of all ewes studied died between

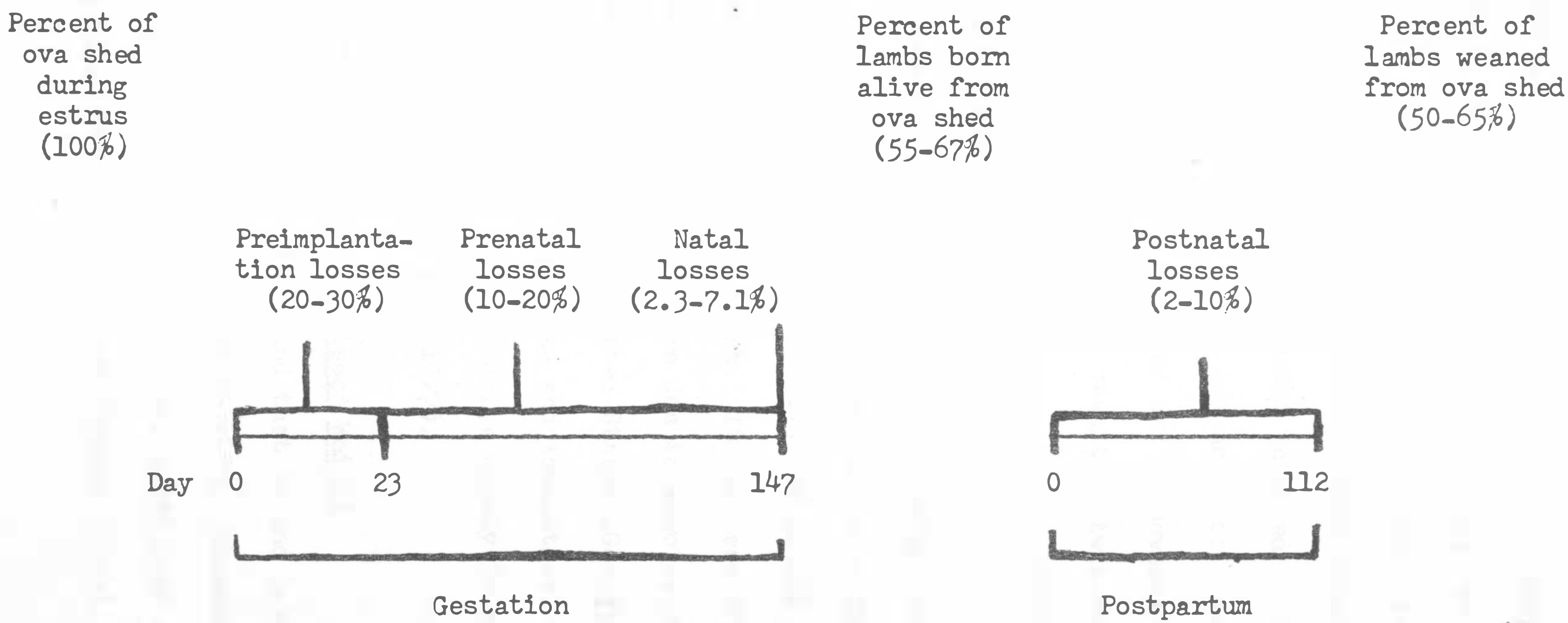

Figure 1. Percentages of losses and survivals of lambs at different stages of development from ovulation through weaning.

mating and lambing. They went on to report (1971b) that a 1% ewe death loss occurred during lambing. Leech and Sellers (1959) found that ewes giving birth to twins and triplets were three times more prone to death within 7 days of lambing than ewes carrying singles. According to others, 70 to 78% of all ewe deaths occurred in the last one-third of gestation and the early part of lactation (Leech and Sellers, 1959; Gunn, 1967). It has been pointed out in several studies that inadequate nutrition in late pregnancy may result in twin-bearing ewes coming down with pregnancy toxemia (Thomson and Aitken, 1959; Schinckel, 1963; Forbes and Singleton, 1964).

Matthews *et al.* (1977) reported having experienced considerable predator losses in the Utah experimental range flock. According to Henne (1975), coyotes accounted for 92.8% of all predator kills of adult sheep on one Montana ranch. It has been stated that 25% of all adult sheep losses each year are due to coyotes on the western ranges or mountain pastures of the United States (Gee *et al.*, 1977).

Due to management systems and localities, reports on death losses and culling reasons vary quite widely in ewes (Terrill, 1939; Slyter, 1968; Matthews *et al.*, 1977).

Fleece Weight

Several studies have found that 2- and 3-year-olds produce the heaviest wool clip (Lush and Jones, 1923; Johansson and Berge, 1939; Blackwell, 1953; Rendel, 1954; Gruev, 1959; Coop and Hayman, 1962; Wright *et al.*, 1975). Wright and Stevens (1953), Brown *et al.* (1966)

and Turner (1962) have reported that single-born ewes produce more wool per year in their lifetime than twin-born ewes. Brown et al. (1966) have also recorded that progeny of mature ewes shear more wool than progeny of 2-year-olds. Hill (1921) found that a high positive correlation existed for production of similar weight fleeces from year to year in ewes.

It has been suggested that a ewe's fleece weight is closely correlated with her body weight (Galpin, 1947). More O'Farrall and Vail (1962) reported finding an increase of 20 lb (9 kg) in body weight resulted in .7 lb (.3 kg) more fleece weight. Some reported correlations between body weight and wool weight were found to lie between .3 and .5 (Johansson and Berge, 1939; Mason and Dassat, 1954; Turner, 1956; Gruev, 1959).

Several investigations have shown that a nonpregnant ewe produces 6 to 15% more wool than one which has been pregnant and has lactated that year (Johansson and Berge, 1939; Ross, 1965; Kennedy and Kennedy, 1968; Hight et al., 1976). Some studies have stated that pregnancy alone accounts for the reduction in wool weight (Lush and Jones, 1923; Berge, 1942; Brown et al., 1966; Kennedy and Kennedy, 1968; Armstrong and O'Rourke, 1976). Also, it has been found in several investigations that wool weight decreases directly as the number of lambs carried during pregnancy increases (Lush and Jones, 1923; Blackwell, 1953; Palian, 1960; Turner, 1962, 1972; Ross, 1965; Vesely et al., 1965; Hight et al., 1976). Other investigators have reported a 3 to 15% reduction in wool weight due to only lactation (Corbett, 1964; Brown *et al*., 1966; Kennedy and Kennedy, 1968; Goot, 1972; Hight *et al*., 1976). According to Lush and Jones (1923), Bosman (1935), Blackwell (1953), Turner (1962) and Hight *et al*. (1976), the more lambs a ewe rears during her lactational period the lower her total wool weight. Hight *et al*. (1976) also pointed out that fleeces of ewes rearing more than one lamb were more clotted, unsound and of a lower quality grade than those from ewes rearing one lamb, which, in turn, tended to be poorer than those of dry ewes.

Davenport and Ritzman (1926) reported that inadequate nutrition in sheep for a long period of time will tend to lower the total wool production. Marston (1955) stated that the nutritional quality of the fodder available during the first 18 months of life imposes permanent limitations on a sheep's subsequent wool producing capacity. Allden (1961) noted similar effects with inadequately nutritioned lambs for the first 6 months postpartum.

Miller (1933) suggested that a 20% variation in gross fleece weights in most sheep breeds is due to individual differences in age, size, sex, environment and genetic constitution, the amount of grease and moisture and the degree of mixture of debris, soil, sand, dung, etc.

The following are heritability estimates of wool weight as found in the literature: .33 (Johansson and Berge, 1939), .40 (Morley, 1955), .42 (Blackwell and Henderson, 1955), .30's and lower .40's (Rae, 1956) and .31 (Gjedrem, 1966).

Repeatabilities for wool weight were generally found in the literature in the range of .43 to .61 (Rasmussen, 1942; Mason and Dassat, 1954; Blackwell and Henderson, 1955; Palian, 1960; Eikje, 1975).

MATERIALS AND METHODS

Flock Management

Production data on a flock of straightbred Targhee ewes were collected during the years 1971 through 1975 at the Antelope Range Research Station, 15 miles (24 km) east of Buffalo, South Dakota. Two hundred sixty-one yearling ewes were purchased in 1970. The ewes were randomly allotted into two groups with one group bred to Suffolk and the other to Targhee rams. The groups were rotated every year. Ewes were first bred to lamb as 2-year-olds and no replacements were added. A 34-day breeding season was utilized, starting approximately September 22 each year. Each ram bred a maximum of 43 ewes per year. The number per sire decreased each successive year. All ewes were weighed at the beginning of the breeding season.

During the winter months while on range, the ewes were fed 1 lb (.4 kg) of alfalfa hay per head per day. On days of snow cover, 3 to 4 lb (1.4 to 1.8 kg) of prairie hay per head were also fed. Two to 3 weeks before lambing through 60 days postlambing, ewes were fed .50 lb (.23 kg) barley or .67 lb (.30 kg) of oats per head per day. The type of grain fed depended on its availability.

Ewes were shed lambed starting in mid-February. Lambs were individually identified and birth date, type of birth, sex of lamb, breed of sire, birth weight and weaning weight were recorded. Also, weights were kept on male lambs which were raised with dam under range conditions from birth through 150 days postpartum. Lambs received no grain supplement. All castration was done within a few days of birth. Lambs were vaccinated for contagious ecthyma and enterotoxemia at 3 to 8 weeks of age. The weaning date was approximately June 1 each year.

Ewes were shorn prior to lambing and fleece weights were recorded. Records were also kept on death and disposal reasons of ewes and lambs. One hundred thirty-one ewes still remained in the flock at the termination of this study in 1975.

The vegetation that the sheep grazed was of the northern mixed prairie type. The dominant cool-season grasses were western wheatgrass (Agropyron smithii) and needleandthread (Stipa comata). The dominant warm-season grass was blue grama (Bouteloua gracilis). Other common grasses were green needlegrass (Stipa viridula), prairie sandreed (Calamovilfa longifolia), prairie junegrass (Koeleria cristata), little bluestem (Andropogon scoparius) and the blue grasses (Poa species). Threadleaf sedge (Carex filifolia), needleleaf sedge (Carex elocharis) and silver sagebrush (Artemisia cana) were also fairly abundant.

Statistical Analysis

The data were analyzed by least squares analysis for unequal subclass numbers as outlined by Harvey (1975). Duncan's (1955) new multiple range test was employed for mean comparisons if the F-test showed significant differences among treatments. Data employing multiple and linear regression were analyzed according to the procedures of Steel and Torrie (1960). Significance was checked at both the 1 and 5% levels in this manuscript. All weaning weights adjusted to 90 days were adjusted for age of dam, type of birth, type of rearing and sex by utilizing Scott's (1975) method.

Since all ewes were of the same age in each respective year, age of dam was confounded with year. Type of birth was represented as either single or multiple, since only 10 sets of triplets were born. When analyzing for date of lambing, only those lambs born between February 14 and April 19 were considered for birth and weaning weights.

Growth data were collected under range conditions for wether lambs from 1971 through 1973 and again in 1975. Data were also collected for ram lambs in 1974 and 1975.

Performance traits analyzed by least squares were birth weight, total birth weight, date of lambing, co-twinning, sex within type of birth, actual weaning and adjusted weaning weights, actual total weaning and adjusted total weaning weights, July weight, August weight, fleece weight, number of lambs born per ewe exposed and lambing, number of lambs weaned per ewe exposed and lambing and actual and adjusted kilograms of lamb weaned per ewe exposed.

A multiple regression of birth weight and total birth weight was computed with type of birth and ewe breeding weight as independent variables. Correlation coefficients for fleece weight and number of lambs born per ewe lambing were obtained by linear regression on ewe breeding weight.

A chi-square test was employed to analyze the frequency of twinning types and also the percent of exposed ewes which lambed.

RESULTS AND DISCUSSION

Ewe Productivity

The mean percent of ewes lambing of those exposed to rams was 93.35. The percentages varied from 91.27 in 1972 to 95.72 in 1974 (table 3). The overall mean percentage of exposed ewes which lambed was higher than the 78 to 88% given in the literature for Targhee ewes (Terrill and Stoehr, 1939; Sidwell and Miller, 1971a; Dickerson and Glimp, 1975). This variable was analyzed by chi-square and no significant differences between years were found.

Table 4 shows the analyses of variance for the number of lambs born per ewe exposed and per ewe lambed. The means and standard errors for these traits are presented in table 5. Ewes exposed to rams averaged 1.42 lambs and ewes which lambed averaged 1.52 lambs per ewe. These averages are higher than those reported by Terrill and Stoehr (1939) but similar to Sidwell and Miller's (1971a). Lambs born per ewe exposed increased from 1.24 to 1.54 for 2-year-old through 6-year-old ewes, respectively. Likewise, the number of lambs born per ewe lambed also increased from 1.34 to 1.68 in 2-year-olds through 6-year-olds, respectively. The results indicate that lambing performance does increase directly with advancing age through at least the first 6 years. However, the possibility of a curvilinear effect of age of dam on lamb production as reported by Dickerson and Glimp (1975) could not be tested in this study, since production past 6 years was not available.

TABLE 3. PERCENTAGE OF EXPOSED EWES LAMBING

Parameter	Percent
Year	
1971	92.70
1972	91.27
1973	95.28
1974	95.72
1975	91.78
Breed of sire	
Targhee	93.85
Suffolk	92.85

TABLE 4. LEAST SQUARES ANALYSIS OF VARIANCE FOR NUMBER OF LAMBS BORN AND WEANED PER EWE EXPOSED AND LAMBED

Source of variation	No. lambs born per ewe				No. lambs weaned per ewe			
	Exposed		Lambed		Exposed		Lambed	
	df	MS	df	MS	df	MS	df	MS
Age of dam	4	3.79*	4	3.28**	4	9.71**	4	8.79**
Breed of sire	1	.00	1	.03	1	1.68*	1	2.31**
Age x sire	4	.15	4	.07	4	.17	4	.26
Residual	1028		959		1028		959	

* $P < .05$.
** $P < .01$.

TABLE 5. LEAST SQUARES MEANS AND STANDARD ERRORS FOR NUMBER OF LAMBS BORN AND WEANED PER EWE EXPOSED AND LAMBED

Parameter	No. lambs born per ewe		No. lambs weaned per ewe	
	Exposed	Lambed	Exposed	Lambed
Age of dam				
2	$1.24 \pm .04^{a}$	$1.34 \pm .03^{a}$	$.93 \pm .04^{a}$	$1.00 \pm .04^{a}$
3	$1.36 \pm .04^{a}$	$1.48 \pm .03^{b}$	$1.13 \pm .04^{b}$	$1.24 \pm .04^{b}$
4	$1.52 \pm .04^{b}$	$1.59 \pm .03^{bc}$	$1.42 \pm .04^{c}$	$1.49 \pm .04^{c}$
5	$1.52 \pm .04^{b}$	$1.59 \pm .04^{bc}$	$1.25 \pm .05^{b}$	$1.31 \pm .04^{b}$
6	$1.54 \pm .05^{b}$	$1.68 \pm .04^{c}$	$.89 \pm .05^{a}$	$.97 \pm .05^{a}$
Breed of sire				
Targhee	$1.44 \pm .03$	$1.53 \pm .02$	$1.08 \pm .03^{a}$	$1.15 \pm .03^{a}$
Suffolk	$1.44 \pm .03$	$1.54 \pm .02$	$1.17 \pm .03^{b}$	$1.25 \pm .03^{b}$

a,b,c Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

Table 6 shows the linear regression of ewe breeding weight on number of lambs born per ewe lambed. The number of lambs born to a ewe increased by .0027 for every kilogram increase in ewe breeding weight. Five percent of the variation in the number of lambs born per ewe lambed was due to the ewe's breeding weight.

TABLE 6. LINEAR REGRESSION OF EWE BREEDING WEIGHT ON NUMBER OF LAMBS BORN PER EWE LAMBED

Step	Intercept	Ewe breeding weight (lambs/kg)	R^2
1	.3126	.0027	.05**

** $P < .01$.

The analysis of variance for date of lambing is presented in table 7. The means for lambing date are given in table 8. The average date of lambing from the beginning of each year varied from 59.42 in 1971 to 68.37 in 1973. The significance for age of dam was due to the variation in the actual starting date of a breeding season. When all years were readjusted to the same starting date, only a slight difference was found between the lambing dates. These differences were smaller than those reported by Terrill and Hazel (1947). They found a .27 day per year increase with advancement of age in ewes.

The number and frequency of the different types of twin births are recorded in table 9. Year differences were found for the types of twin births (chi-square, $P<.05$). However, there seems to be no apparent explanation for this. The frequency levels were similar in 1973 and 1974 but varied greatly in the other years studied. The overall frequency ratio of 24.5:51.5:24.0 is similar to that reported by Clark (1931). This study found the sex distribution of twin pairs to approximate a 1 male/male:2 male/female:1 female/female ratio.

Table 10 gives the analysis of variance for secondary sex ratios within type of birth. Table 11 shows the secondary sex ratios within type of birth. Out of every one hundred lambs born 50.5 were male. The single's ratio was 52.1 and the twin's ratio was 49.8 males per every one hundred newly born lambs within that respective birth type. It was previously stated in the review that generally a little less than 49% of the lambs at birth are expected to be male. Therefore, the secondary sex ratio for males in this investigation was slightly greater

TABLE 7. LEAST SQUARES ANALYSIS OF VARIANCE FOR LAMBING DATE

Source of variation	df	MS
Age of dam	4	2252.08**
Breed of sire	1	160.78
Type of birth	1	137.84
Age x sire	4	73.98
Age x type of birth	4	95.92
Sire x type of birth	1	81.90
Residual	937	

** $P<.01$.

TABLE 8. LEAST SQUARES MEANS AND STANDARD ERRORS FOR LAMBING DATE

Parameter	Average date
Age of dam	
2	$59.42 \pm .47^{a}$
3	$64.43 \pm .46^{c}$
4	$68.37 \pm .49^{d}$
5	$61.58 \pm .52^{b}$
6	$64.39 \pm .66^{c}$
Breed of sire	
Targhee	$64.06 \pm .32$
Suffolk	$63.21 \pm .33$
Type of birth	
Single	$64.04 \pm .35$
Multiple	$63.23 \pm .31$

[a,b,c,d] Means within subclasses bearing a different superscript are significantly ($P<.05$) different.

TABLE 9. NUMBER AND FREQUENCY OF TWIN TYPES

Year	Total number MM: MF: FF[a]			Frequencies MM: MF: FF		
	MM:	MF:	FF[a]	MM:	MF:	FF
1971	47:	76:	34	29.9:	48.5:	21.6
1972	66:	104:	36	32.0:	50.6:	17.4
1973	56:	117:	68	23.2:	48.6:	28.2
1974	44:	104:	58	21.4:	50.4:	28.2
1975	24:	98:	36	15.2:	62.0:	22.8
1971-75	237:	499:	232	24.5:	51.5:	24.0

[a] Represents male/male:male/female:female/female twins.

TABLE 10. LEAST SQUARES ANALYSIS OF VARIANCE FOR SECONDARY SEX RATIOS WITHIN TYPE OF BIRTH

Source of variation	Single		Twin	
	df	MS	df	MS
Year	4	.24	4	.40
Breed of sire	1	.78	1	.27
Year x sire	4	.06	4	.75*
Residual	452		994	

* $P < .05$.

TABLE 11. SECONDARY SEX RATIOS WITHIN TYPE OF BIRTH

Parameter	Single Male:female	Twin Male:female
Year		
1971	51.6:48.4	53.5:46.5
1972	45.5:54.5	55.4:44.6
1973	55.4:44.6	47.3:52.7
1974	59.1:40.9	46.1:53.9
1975	53.9:46.1	45.9:54.1
Breed of sire		
Targhee	48.5:51.5	51.3:48.7
Suffolk	57.7:42.3	48.0:52.0

than that normally reported. The year x sire interaction was significant ($P<.05$) for secondary sex ratios in twins. No explanation for this is apparent.

Birth Weight

The analysis of variance for birth weight is presented in table 12. Table 13 gives the least squares means for this factor. The birth weight ranged from 4.70 kg (10.34 lb) in lambs born to 2-year-old ewes through 5.12 kg (11.26 lb) in lambs born to 5-year-olds. The lambs born to 2-year-old ewes were lighter ($P<.05$) than those born to the other age groups of ewes. Any variation in birth weights found in the older four age groups of ewes was probably due to the confounding effect of year with age of dam. Many researchers have suggested that birth weight of lambs should increase directly with age of dam through 6 years and then decrease with further aging (Bonsma, 1939; MacNaughton, 1956; Peters and Heaney, 1974). The crossbred lambs weighed .44 kg (.97 lb) more ($P<.01$) than the straightbred lambs. Singles were 1.04 kg (2.29 lb) heavier ($P<.01$) than multiple birth lambs. Male lambs outweighed ($P<.01$) female lambs by .41 kg (.90 lb) at birth. It was noted that with an increase in litter size the birth weight differences between Suffolk and Targhee sired lambs decreased accordingly (from .57 kg to .32 kg or 1.25 to .70 lb). There was also a greater difference in birth weight between single and twin male lambs (1.14 kg) than between females of similar birth types (.94 kg). Male singles were the heaviest (5.76 kg) at birth, then female singles (5.26 kg), twin males (4.62 kg) and

TABLE 12. LEAST SQUARES ANALYSIS OF VARIANCE FOR LAMB BIRTH WEIGHT

Source of variation	df	MS
Age of dam	4	7.92**
Breed of sire	1	58.70**
Type of birth	1	288.27**
Sex	1	49.45**
Age x sire	4	.60
Age x type of birth	4	.15
Age x sex	4	.56
Sire x type of birth	1	4.53**
Sire x sex	1	.44
Type of birth x sex	1	2.82**
Residual	1438	

** $P < .01$.

TABLE 13. LEAST SQUARES MEANS AND STANDARD ERRORS FOR LAMB BIRTH WEIGHT

Parameter	Mean weight (kg)
Age of dam	
2	$4.70 \pm .04^{a}$
3	$5.06 \pm .04^{b}$
4	$5.03 \pm .04^{b}$
5	$5.12 \pm .05^{b}$
6	$5.04 \pm .06^{b}$
Breed of sire	
Targhee	$4.77 \pm .03^{a}$
Suffolk	$5.21 \pm .03^{b}$
Type of birth	
Single	$5.51 \pm .04^{a}$
Multiple	$4.47 \pm .02^{b}$
Sex of lamb	
Male	$5.20 \pm .03^{a}$
Female	$4.79 \pm .04^{b}$

[a,b] Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

the lightest were the twin females (4.31 kg). This finding is in agreement with results reported by Mason and Dassat (1954) and Bush and Lewis (1977).

Table 14 represents the analysis of variance for birth weight of twins. The least squares means are given in table 15. The birth weights for twin-born lambs increased directly as the age of dam increased from 2 through 6 years. Crossbred twin-born lambs were .31 kg (.68 lb) heavier ($P < .01$) than straightbreds. Males which had male co-twins were slightly heavier than males with female co-twins, which, in turn, were heavier than females with female co-twins. The lightest birth weight twins were females with male co-twins. Burfening (1972) reported that lambs born co-twin to a male were generally of lower birth weight than lambs born co-twin to a female. Donald and Purser (1956) suggested that the male lamb *in utero* derives its nutrients at the expense of the female, thus causing her to be smaller and him larger in mixed sex twins. Stegeman (1974) also pointed out that the male will be larger than the female lamb at birth provided the placenta meets his needs. The results in this study showed that like sex twin types differed by .22 kg (.48 lb) and unlike sex twin types by .37 kg (.81 lb). Donald and Purser (1956) reported similar differences.

Table 16 shows that a negative correlation existed between litter size and individual birth weight. Others have also reported a reduction in individual lamb birth weights due to increased litter size (Starovoitenko and Elin, 1965; Hight and Jury, 1970; Lind, 1970). Type of birth accounted for 26.2% of the variation ($P < .01$) in the lamb's

TABLE 14. LEAST SQUARES ANALYSIS OF VARIANCE FOR BIRTH WEIGHT OF TWINS

Source of variation	df	MS
Age of dam	4	6.65**
Breed of sire	1	21.22**
Co-twin	3	7.61**
Age x sire	4	.27
Age x co-twin	12	.65
Sire x co-twin	3	.42
Residual	940	

** $P < .01$.

TABLE 15. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BIRTH WEIGHT OF TWINS

Parameter	Mean weight (kg)
Age of dam	
2	$4.14 \pm .05^a$
3	$4.58 \pm .04^b$
4	$4.55 \pm .04^b$
5	$4.61 \pm .04^b$
6	$4.66 \pm .05^b$
Breed of sire	
Targhee	$4.35 \pm .03^a$
Suffolk	$4.66 \pm .03^b$
Type of co-twin[d]	
Female (male)	$4.28 \pm .04^a$
Female (female)	$4.44 \pm .04^b$
Male (female)	$4.65 \pm .04^c$
Male (male)	$4.66 \pm .04^c$

[a,b,c] Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

[d] Co-twin of a lamb is in parenthesis.

TABLE 16. MULTIPLE REGRESSION OF TYPE OF BIRTH AND EWE BREEDING WEIGHT ON INDIVIDUAL BIRTH WEIGHT OF LAMB

Step	Intercept	Type of birth (kg/lamb)	Ewe breeding weight (kg lamb/kg ewe)	R^2
1	6.4741	-.0997	--	.262**
2	5.4740	-.1063	.0078	.025**

** $P<.01$.

birth weight. One kilogram increase in ewe breeding weight resulted in a .0078 kg (.0172 lb) increase in lamb birth weight. Therefore, 2.5% of the variation ($P<.01$) in individual lamb birth weight was due to the ewe's breeding weight.

The analysis of variance for total birth weight is presented in table 17. Table 18 shows the least squares means for this factor. Total birth weight averages ranged from 6.79 kg (14.94 lb) for lambs born to 2-year-olds through 7.44 kg (16.37 lb) for lambs from 5-year-old ewes. Total average birth weights were similar for ewes bearing lambs in all age groups except for the 2-year-old ewes, in which they were lighter ($P<.05$). The average total birth weight of ewes bearing crossbred lambs was .55 kg (1.21 lb) heavier ($P<.01$) than ewes bearing straightbreds. The mean total birth weight of ewes bearing multiple lambs was 3.5 kg (7.7 lb) more ($P<.01$) than for ewes bearing singles. It was also noted that the total birth weight difference between single and multiple births tended to increase (3.08 to 3.77 kg) with advancement of age in ewes.

TABLE 17. LEAST SQUARES ANALYSIS OF VARIANCE FOR TOTAL BIRTH WEIGHT OF LAMBS

Source of variation	df	MS
Age of dam	4	15.05**
Breed of sire	1	68.88**
Type of birth	1	2573.44**
Age x sire	4	.11
Age x type of birth	4	2.79*
Sire x type of birth	1	.29
Residual	940	

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

TABLE 18. LEAST SQUARES MEANS AND STANDARD ERRORS FOR TOTAL BIRTH WEIGHT OF LAMBS

Parameter	Mean weight (kg)
Age of dam	
2	6.79 ± .07[a]
3	7.39 ± .07[b]
4	7.34 ± .07[b]
5	7.44 ± .08[b]
6	7.43 ± .10[b]
Breed of sire	
Targhee	7.00 ± .04[a]
Suffolk	7.55 ± .05[b]
Type of birth	
Single	5.53 ± .05[a]
Multiple	9.03 ± .04[b]

[a,b] Means within subclasses bearing a different superscript are significantly (P<.05) different.

Table 19 shows the effect of the multiple regression of birth type and ewe breeding weight on total birth weight of lambs. Type of birth accounted for 70.2% of the variation ($P < .01$) in total birth weight. The results show that a positive correlation existed between total birth weight and birth type. Others stating similar findings were Villegas (1939) and Cloete (1939). For every kilogram increase in ewe breeding weight, total birth weight increased by .0124 kg (.0273 lb). Differences in ewe breeding weight accounted for 1.2% of the variation ($P < .01$) in total birth weight.

TABLE 19. MULTIPLE REGRESSION OF TYPE OF BIRTH AND EWE BREEDING WEIGHT ON TOTAL BIRTH WEIGHT OF LAMBS

Step	Intercept	Type of birth (kg/lamb)	Ewe breeding weight (kg lamb/kg ewe)	R^2
1	1.9108	3.5529	--	.702**
2	.3170	3.4479	.0124	.012**

** $P < .01$.

Weaning Weight

Table 5 shows the results of the analyses for the number of lambs weaned per ewe exposed and per ewe lambed. The analysis of variance for these traits is found in table 4. Ewes exposed to rams averaged 1.13 lambs and ewes which lambed averaged 1.21 lambs per ewe. Lambs weaned per ewe exposed increased from .93 for 2-year-old ewes to 1.42 for 4-year-olds and then decreased to .89 for 6-year-old ewes. A similar trend was noted for number of lambs weaned per ewe lambed. Terrill (1939) also reported that the greatest number of lambs weaned per ewe bred occurred for 4-year-old ewes. In addition, .09 and .10 more crossbred lambs were weaned than straightbreds per ewe exposed and per ewe lambed, respectively (table 5).

The analysis of variance for weaning weight is presented in table 20. The least squares means for this factor are given in table 21. The mean weaning weight ranged from 22.40 kg (49.28 lb) for lambs from 2-year-old ewes to 32.94 kg (72.47 lb) for lambs from 5-year-old ewes. The lambs from 2-year-old ewes were lighter ($P<.05$) at weaning time than lambs from other age groups of ewes. The variations found among the other four age groups were probably due to length of time from birth through weaning and/or age of dam being confounded with year. Blackwell (1953), MacNaughton (1956) and Hohenboken et al. (1976b) reported that weaning weight of offspring increased directly as ewes advanced in age through about 6 years and then decreased with further aging. The crossbred lambs weighed 2.14 kg (4.71 lb) more ($P<.01$) than straightbred lambs at weaning. Male lambs were 1.22 kg (2.68 lb)

TABLE 20. LEAST SQUARES ANALYSIS OF VARIANCE FOR LAMB WEANING WEIGHT

Source of variation	df	MS
Age of dam	4	4269.17**
Breed of sire	1	1172.05**
Type of rearing	1	6441.68**
Sex	1	387.91**
Age x sire	4	14.18
Age x type of rearing	4	117.64**
Age x sex	4	22.09
Sire x type of rearing	1	.02
Sire x sex	1	26.06
Type of rearing x sex	1	11.77
Residual	1132	

** $P < .01$.

TABLE 21. LEAST SQUARES MEANS AND STANDARD ERRORS FOR LAMB WEANING WEIGHT

Parameter	Mean weight (kg)
Age of dam	
2	$22.40 \pm .27^a$
3	$31.49 \pm .24^c$
4	$25.61 \pm .24^b$
5	$32.94 \pm .26^d$
6	$26.21 \pm .42^b$
Breed of sire	
Targhee	$26.66 \pm .19^a$
Suffolk	$28.80 \pm .18^b$
Type of rearing	
Single	$30.45 \pm .17^a$
Multiple	$25.01 \pm .20^b$
Sex	
Male	$28.34 \pm .18^a$
Female	$27.12 \pm .18^b$

^{a,b,c,d} Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

heavier ($P < .01$) than the females. Single reared lambs outweighed ($P < .01$) multiple reared lambs by 5.44 kg (11.97 lb). The age of dam x type of rearing interaction was significant ($P < .01$), but there was no apparent explanation for this.

The weaning weights of twins were analyzed (tables 22 and 23) and the significant ($P < .01$) main effects were age of dam, breed of sire and co-twinning. Twin lambs reared by 2-year-old ewes were lighter ($P < .05$) at weaning than lambs reared by older ewes. The variation in the weights of twin lambs reared by older ewes was probably due to the better growing conditions and/or the age of the lambs at weaning time. Crossbred twin lambs were 1.74 kg (3.83 lb) heavier ($P < .01$) at weaning than straightbred twins. The records also show that female lambs born co-twin with either sex were lighter ($P < .05$) at weaning than males born co-twin with either sex. At weaning the males born co-twin with a male were the heaviest (26.46 kg), then males born co-twin with a female (26.18 kg), females born co-twin with a female (25.08 kg) and the lightest were females born co-twin with a male (24.69 kg). However, Burfening (1972) observed that lambs born and raised co-twin with a male were much lighter in weight at 60 days postpartum than lambs with female co-twins. Results tend to indicate that males, regardless of the co-twin sex, were more capable of gaining weight than were females born co-twin with either sex (table 23).

The analyses of variance for actual and adjusted weaning weight of lamb per ewe exposed are given in table 24. The least squares means and standard errors for these weights are presented in table 25. In

TABLE 22. LEAST SQUARES ANALYSIS OF VARIANCE FOR WEANING WEIGHT OF TWINS

Source of variation	df	MS
Age of dam	4	2045.66**
Breed of sire	1	469.05**
Co-twin	3	111.81**
Age x sire	4	16.92
Age x co-twin	12	20.13
Sire x co-twin	3	9.90
Residual	702	

** $P < .01$.

TABLE 23. LEAST SQUARES MEANS AND STANDARD ERRORS FOR WEANING WEIGHT OF TWINS

Parameter	Mean weight (kg)
Age of dam	
2	20.56 ± .39[a]
3	28.54 ± .31[d]
4	23.47 ± .28[b]
5	30.12 ± .31[e]
6	25.32 ± .46[c]
Breed of sire	
Targhee	24.73 ± .23[a]
Suffolk	26.47 ± .22[b]
Type of co-twin[f]	
Female (male)	24.69 ± .31[a]
Female (female)	25.08 ± .32[a]
Male (female)	26.18 ± .30[b]
Male (male)	26.46 ± .35[b]

[a,b,c,d,e] Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

[f] Co-twin of lamb is in parenthesis.

TABLE 24. LEAST SQUARES ANALYSES OF VARIANCE FOR WEIGHT AND ADJUSTED WEIGHT OF LAMB WEANED PER EWE EXPOSED

Source of variation	Weight of lamb weaned per ewe exposed: Actual df	Actual MS	Adjusted df	Adjusted MS
Year	4	2757.49**	4	448.47**
Breed of sire	1	681.52**	1	467.30**
Type of rearing	2	98329.65**	2	107528.62**
Year x sire	4	17.63	4	14.55
Year x type of rearing	8	665.26**	8	234.08**
Sire x type of rearing	2	141.09**	2	169.09*
Residual	1016		1016	

* $P < .05$.
** $P < .01$.

TABLE 25. LEAST SQUARES MEANS AND STANDARD ERRORS FOR WEIGHT AND ADJUSTED WEIGHT OF LAMB WEANED PER EWE EXPOSED

Parameter	Weight of lamb weaned per ewe exposed: Actual (kg)	Adjusted (kg)
Year		
1971	21.50 ± .19[a]	25.94 ± .50[a]
1972	30.35 ± .35[c]	28.89 ± .48[cd]
1973	25.52 ± .48[b]	26.35 ± .69[ab]
1974	31.73 ± .41[d]	30.11 ± .59[d]
1975	26.47 ± .54[b]	27.71 ± .78[bc]
Breed of sire		
Targhee	26.17 ± .26[a]	27.02 ± .37[a]
Suffolk	28.06 ± .26[b]	28.58 ± .37[b]
Type of rearing		
Single	30.65 ± .21[a]	30.11 ± .30[a]
Multiple	50.71 ± .35[b]	53.18 ± .51[b]

[a,b,c,d] Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

actual weaning weight, 2-year-old ewes weaned less ($P<.05$) kilograms of lamb per ewe exposed than did the older ewes. Confounding of year with age of dam was probably the variable which caused the variation seen between the other four age groups of ewes. Year effects could be the probable cause for variation between the different age groups of ewes for adjusted weaning weight per ewe exposed. Ewes rearing crossbred lambs weaned more ($P<.01$) kilograms of lamb, both actual and adjusted, than ewes rearing straightbreds. In addition, ewes rearing singles weaned approximately three-fifths as many kilograms of lamb, both actual and adjusted, than ewes rearing twins per ewe exposed. As the litter size reared increased, both the total actual and adjusted weaning weight difference widened accordingly. Both year x type of rearing and sire x type of rearing interactions were significant ($P<.01$) for actual and adjusted weaning weight per ewe exposed. In all four cases no explanation is apparent for this significance.

Weaning weight was adjusted and analyzed (tables 26 and 27) to find out if the breed of sire did influence the weening weights of these range lambs. The results did show a significant ($P<.01$) advantage for crossbred lambs at weaning time.

Table 28 shows the analyses of variance for actual and adjusted total weaning weight of lambs per ewe having lambs to wean. The least squares means for these factors are given in table 29. This study found that 2-year-old ewes produced ($P<.05$) less actual total kilograms of lamb at weaning than did the older ewes. The probable cause of variation between the other age groups of ewes for actual total weaning

TABLE 26. LEAST SQUARES ANALYSIS OF VARIANCE FOR BREED OF SIRE EFFECT ON ADJUSTED WEANING WEIGHT OF LAMB

Source of variation	df	MS
Breed of sire	1	764.78**
Residual	1151	

** $P < .01$.

TABLE 27. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BREED OF SIRE EFFECT ON ADJUSTED WEANING WEIGHT OF LAMB

Parameter	Mean weight (kg)
Breed of sire	
Targhee	$27.92 \pm .20^{a}$
Suffolk	$29.55 \pm .19^{b}$

a,b Means within subclasses bearing a different superscript are significantly ($P < .01$) different.

TABLE 28. LEAST SQUARES ANALYSIS OF VARIANCE FOR ACTUAL AND ADJUSTED TOTAL WEANING WEIGHT OF LAMB PER EWE WEANING LAMBS

Source of variation	Total weaning weight			
	Actual		Adjusted	
	df	MS	df	MS
Year	4	5457.26**	4	1042.78**
Breed of sire	1	1393.98**	1	1162.04**
Type of rearing	1	54674.52**	1	72341.65**
Year x sire	4	21.78	4	20.46
Year x type of rearing	4	340.50**	4	319.12**
Sire x type of rearing	1	57.82	1	57.58
Residual	854		854	

** $P < .01$.

TABLE 29. LEAST SQUARES MEANS AND STANDARD ERRORS FOR ACTUAL AND ADJUSTED TOTAL WEANING WEIGHT OF LAMB PER EWE WEANING LAMBS

Parameter	Total weaning weight	
	Actual (kg)	Adjusted (kg)
Year		
1971	$32.29 \pm .46^{a}$	$38.90 \pm .66^{a}$
1972	$45.46 \pm .38^{d}$	$43.01 \pm .54^{b}$
1973	$38.28 \pm .37^{b}$	$39.53 \pm .52^{a}$
1974	$47.60 \pm .41^{e}$	$45.18 \pm .58^{c}$
1975	$39.73 \pm .72^{c}$	41.64 ± 1.07^{b}
Breed of sire		
Targhee	$39.28 \pm .31^{a}$	$40.37 \pm .44^{a}$
Suffolk	$42.09 \pm .29^{b}$	$42.93 \pm .40^{b}$
Type of rearing		
Single	$30.65 \pm .22^{a}$	$30.11 \pm .32^{a}$
Multiple	$50.53 \pm .39^{b}$	$53.19 \pm .54^{b}$

[a,b,c,d,e] Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

was that of the confounding effect of year with age of dam. Year effects could be the probable cause for the variation among the different age groups of ewes for adjusted total weaning weight. Ewes weaning crossbred lambs produced ($P<.01$) a higher average total weaning weight, both actual and adjusted, than ewes weaning straightbreds. Ewes weaning multiples weaned more ($P<.01$) actual and adjusted total kilograms of lamb than ewes weaning singles. In addition, it was noted that, as a ewe advanced in age, the average actual and adjusted total weaning weight differences between singles and multiples became increasingly greater (14.6 to 24.7 kg and 20.9 to 28.2 kg, respectively).

The analyses of variance for July and August pasture weights of male lambs are shown in table 30. The means for these months are given in table 31. The July male lambs showed a yearly increase in weights for successive years from 1971 through 1974 and then a decrease occurred in 1975. July crossbred lambs were 4.52 kg (9.94 lb) heavier ($P<.01$) than the straightbred lambs. Lambs reared as singles outweighed ($P<.01$) the lambs reared as multiples in July by 6.27 kg (13.79 lb). Similar trends were noted for August weights. August lamb weights averaged 5.86 kg (12.90 lb) more than July lamb weights.

The average growth curve for male lambs raised on pasture is presented in figure 2. This study found that a steady rate of gain occurred in the male lambs through at least 150 days postpartum. However, many reports on the growth of lambs have indicated that a lamb's rate of gain slows down somewhere between 60 and 80 days postpartum (Donald and McLean, 1935; Brody, 1945; Bush and Lewis,

TABLE 30. LEAST SQUARES ANALYSES OF VARIANCE FOR JULY AND AUGUST WEIGHTS OF MALE PASTURE LAMBS

Source of variation	July weight		August weight	
	df	MS	df	MS
Year	4	719.12**	4	220.34**
Breed of sire	1	743.03**	1	603.97**
Type of rearing	1	1170.18**	1	1145.88**
Year x sire	4	27.11	4	24.69
Year x type of rearing	4	33.44	4	40.20
Sire x type of rearing	1	1.86	1	13.66
Residual	147		146	

** $P < .01$.

TABLE 31. LEAST SQUARES MEANS AND STANDARD ERRORS FOR JULY AND AUGUST WEIGHTS OF MALE PASTURE LAMBS

Parameter	July weight (kg)	August weight (kg)
Year		
1971	$33.85 \pm .77^{a}$	$42.65 \pm .81^{ab}$
1972	$38.57 \pm .77^{b}$	$44.04 \pm .80^{b}$
1973	$39.77 \pm .85^{b}$	$47.22 \pm .88^{c}$
1974	$46.86 \pm .87^{c}$	$48.23 \pm .90^{c}$
1975	35.40 ± 1.30^{a}	40.68 ± 1.35^{a}
Breed of sire		
Targhee	$36.63 \pm .60^{a}$	$42.52 \pm .62^{a}$
Suffolk	$41.15 \pm .53^{b}$	$46.61 \pm .55^{b}$
Type of rearing		
Single	$42.03 \pm .51^{a}$	$47.67 \pm .53^{a}$
Multiple	$35.76 \pm .67^{b}$	$41.46 \pm .69^{b}$

^{a,b,c} Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

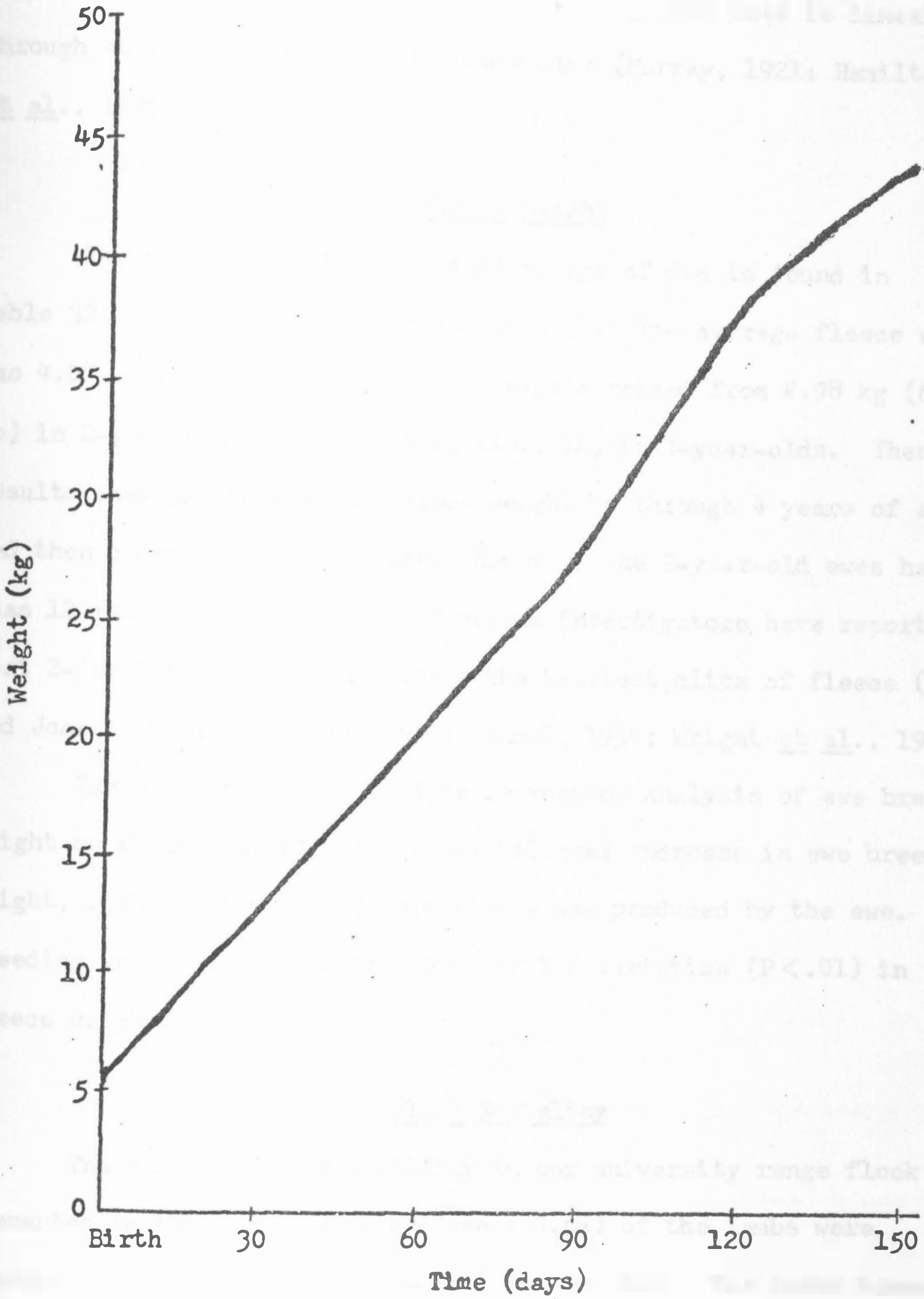

Figure 2. The average growth curve through 150 days postpartum of male lambs raised under range conditions.

1977). Yet, others have indicated that the growth rate is linear through at least 11 to 15 weeks postpartum (Murray, 1921; Hamilton et al., 1976).

Fleece Weight

The analysis of fleece weight by age of dam is found in table 32. The means are given in table 33. The average fleece weight was 4.08 kg (8.97 lb). The fleece weights ranged from 2.98 kg (6.54 lb) in 2-year-old ewes to 4.59 kg (10.1 lb) in 4-year-olds. These results show an increase in fleece weight up through 4 years of age and then a decrease takes place. However, the 2-year-old ewes had less than 12 months fleece growth. Numerous investigators have reported that 2- or 3-year-old ewes produce the heaviest clips of fleece (Lush and Jones, 1923; Blackwell, 1953; Rendel, 1954; Wright et al., 1975).

Table 34 shows the multiple regression analysis of ewe breeding weight on fleece weight. For every kilogram increase in ewe breeding weight, .0232 kg (.0510 lb) more fleece was produced by the ewe. Ewe breeding weight accounted for 23.4% of the variation ($P < .01$) in fleece weight.

Flock Mortality

The causes of lamb mortality in our university range flock are presented in table 35. A percentage (39.6%) of the lambs were unaccounted for or they were removed and bum fed. The lambs bummed were those whose mothers left them or could not provide milk for them or lambs which wandered off and lost their mothers. They were removed

TABLE 32. LEAST SQUARES ANALYSIS OF VARIANCE FOR EWE FLEECE WEIGHT

Source of variation	df	MS
Age of dam	4	106.43**
Residual	1024	

** $P < .01$.

TABLE 33. LEAST SQUARES MEANS AND STANDARD ERRORS FOR EWE FLEECE WEIGHT

Parameter	Mean weight (kg)
Age of dam	
2	$2.98 \pm .04^{a}$
3	$4.39 \pm .04^{bc}$
4	$4.59 \pm .04^{d}$
5	$4.32 \pm .05^{b}$
6	$4.48 \pm .06^{cd}$

[a,b,c,d] Means within subclasses bearing a different superscript are significantly ($P < .05$) different.

TABLE 34. LINEAR REGRESSION OF EWE BREEDING WEIGHT ON FLEECE WEIGHT

Step	Intercept	Ewe breeding weight (kg/kg ewe)	R^2
1	.8187	.0232	.234**

** $P < .01$.

TABLE 35. CAUSES OF DEATH IN RANGE LAMBS THROUGH WEANING

Cause of death	No.	Percent
Stillborn	3	1.0
Mummified	1	.3
Immature	1	.3
Physical abnormality	16	5.2
Water on brain	1	.3
Dystocia	4	1.3
Miscellaneous birth losses	35	11.5
Laid on by ewe	12	3.9
Starvation	28	9.2
Froze or chilled	2	.6
Drowned	4	1.3
Enterotoxemia	3	1.0
White muscle disease	2	.6
Winter storms	32	10.5
Undetermined	40	13.1
Missing	83	27.2
Bummed	38	12.4
Total	305	99.7

from the flock to prevent them from dying of starvation. There were in addition large losses of lambs due to troubled births, winter storms and starvation. A very high percentage of the 1975 losses was due to snow storms. It was noted that 25.57% of all lamb mortality occurred at birth, 55.08% by day 10 and 66.23% by day 30 postpartum. The records also show that the lightest average birth weight (3.9 kg) of lambs lost occurred at birth, then from day 1 through 10 (4.2 kg) and then from day 11 through 30 (4.4 kg). The heaviest average weight of lambs lost was between day 31 and day 90 postpartum (4.6 kg). The average birth weight of those lambs surviving through weaning time was 4.9 kilograms.

Ewe disposals and losses are presented in table 36. The majority of the causes were undetermined (28.5%), spoiled udders (19.2%), poor teeth (15.4%) and ewes unaccounted for (13.8%). Those unaccounted for could probably fall under one of the following classifications: lost identification, killed by predator, mixed in with another flock, wandered off or lost in a winter storm.

Economics

It was found (table 29) that ewes bearing and rearing Suffolk-Targhee cross lambs produced 2.81 kg (6.18 lb) more lamb at 90 days than ewes bearing and rearing straightbred Targhee lambs. This amounted to 281 kg (618 lb) more lamb per 100 ewes. This study concluded that breeding Targhee ewes with Suffolk rams is more profitable under range conditions than breeding for straightbred Targhee lambs. The exception would be when straightbred lambs used for flock replacements are selling at a premium.

TABLE 36. RANGE EWE DISPOSALS AND LOSSES

Cause	No.	Percent
Dry	8	6.2
Spoiled udder	25	19.2
Difficult birth	2	1.5
Rupture	2	1.5
Vaginal prolapse	5	3.8
Poor teeth	20	15.4
Injured during shearing	1	.8
Crippled	1	.8
Wool blindness	1	.8
Poor condition	2	1.5
Lumpy jaw	1	.8
Drowned	2	1.5
Sickness	4	3.1
Blood poisoning	1	.8
Undetermined	37	28.5
Missing	18	13.8
Total	130	100.0

SUMMARY

A comparison between crossbred and straightbred lamb production for Targhee range ewes was analyzed for the years 1971-75. Two hundred sixty-one yearling ewes were purchased in 1970. The ewes were randomly allotted into two groups with one group bred to Suffolk and the other to Targhee rams. The groups were rotated every year. Ewes were first bred to lamb as 2-year-olds and no replacements were added. One hundred thirty-one ewes remained at the end of the investigation.

The mean lambing percent was 93.35. The average number of lambs born per ewe exposed to rams and per ewe which lambed were 1.42 and 1.52, respectively. A multiple regression of ewe (lambed) breeding weight on lamb production showed a .0027 lamb gain with each kilogram increase in breeding weight. There was a direct increase in lambing performance as a ewe advanced in age from 2 through 6 years. The number of lambs weaned per ewe exposed to rams and per ewe which lambed increased directly with age of ewe through 4 years and thereafter it decreased. The average number of lambs weaned per ewe exposed and per ewe which lambed were 1.13 and 1.21, respectively.

No significant difference was found for lambing date between the different age groups of ewes.

Crossbred lambs were heavier by .44 kg at birth, 2.14 kg at weaning, 4.52 kg at the July weighing and 4.09 kg at the August weighing than straightbred lambs ($P < .01$). Crossbred twin lambs outweighed straightbred twins by .31 kg at birth and by 1.74 kg at weaning ($P < .01$).

The average total birth weight for ewes bearing crossbreds was .55 kg greater ($P < .01$) than that for ewes bearing straightbreds. Ewes rearing crossbreds produced 1.89 and 1.56 more kg ($P < .01$) actual and adjusted total weaning weight, respectively, than ewes rearing straightbreds. There was a crossbred advantage at weaning of 281 kg of lamb per 100 ewes.

Male lambs weighed more at birth (.41 kg) and at weaning (1.22 kg) than the female lambs ($P < .01$). Males with male co-twins, males with female co-twins, females with female co-twins and females with male co-twins were the heaviest in that order at both parturition and weaning.

Single-born lambs outweighed ($P < .01$) twin-born lambs by 1.04 kilograms. The mean total birth weight for ewes bearing multiples was 3.5 kg greater ($P < .01$) than that for ewes bearing singles.

Single reared lambs were heavier by 5.44 kg at weaning, 6.27 kg at the July weighing and 6.21 kg at the August weighing than multiple reared lambs ($P < .01$). Two-year-old ewes produced the lightest ($P < .05$) lambs at birth and weaning. Likewise, they also produced lambs with the lightest total birth and weaning weights. Confounding age of dam with year tended to mask out the true age of dam effects for all other age groups.

A somewhat linear growth rate from birth through 150 days postpartum was noted for male lambs raised under range conditions.

Fleece weight increased directly with age of ewe through 4 years of age and then decreased with further aging. For each kilogram increase in ewe breeding weight, .0232 kg more fleece was produced per ewe.

Of total lamb losses, 25.57% occurred at birth, 55.08% by day 10 and 66.23% by day 30 postpartum.

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