Growth of Targhee and Targhee Crossbred Lambs on Utah Rangelands

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GROWTH OF TARGHEE AND TARGHEE CROSSBRED LAMBS

ON UTAH RANGELANDS

by

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Holly Ann George

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ABSTRACT

Growth of Targhee and Targhee Crossbred Lambs

on Utah Rangelands

by

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Growth data were collected on 1848 Targhee and Targhee crossbred lambs from the Utah Agricultural Experiment Station flock at Cedar City for 1981 and 1982. The study objectives were to establish growth curves for seven lamb genotypes and examine within genotype growth differences among four grazing treatments (sheep alone, sheep and cattle mixed, both continuous and rotation).

Body weights were measured at birth, and at mean ages of 56, 120, and 154 (weaning) days of age. Linear, quadratic, and cubic regressions of weight on age were used to establish growth curves. Among genotype comparisons of entire growth curves were impossible as nonlinear components were significant ($p < .05$). Thus, weights per weigh period and average daily gain between weigh periods were examined to determine differences. Rearing type, birth type, genotype, and pasture treatment were 50.9%, 22.7%, 12.4%, and 6.1%, respectively, of the total variance accounted for by the effects on weaning weights examined.

Overall growth patterns were the same for all genotypes with the most rapid gains occurring between 56 and 120 days of age (combined mean .66 pounds). Suffolk-sired lambs from Suffolk-Targhee and Targhee-Finn-Targhee ewes were faster gaining ($p < .05$) than straightbred Targhee lambs as well as those from Suffolk sires bred to Finn-Targhee, Targhee-Suffolk-Targhee, and Finn-Suffolk-Targhee ewes.

The second most rapid gains (combined mean .56 pounds) occurred between birth and 56 days. All crossbred lambs had higher average daily gains than Targhee lambs ($p < .05$). The slowest rate of gain (mean .16 pounds) occurred in the 34 days prior to weaning.

Not all differences in body weight among pastures can be attributed to grazing treatments as three genotypes exhibited a significant ($p < .05$) effect of pasture assignment on weight prior to treatment implementation. Despite initial weight imbalances, genotypes responded similiarly to pasture treatments. Sheep rotation pastures had the lightest ($p < .05$) lambs for most genotypes exhibiting differences in grazing treatments at 120 days and in all genotypes at weaning. The fastest gains and heaviest lambs were in mixed species pastures. In sheep alone pastures, lamb performance was better in continuously grazed pastures than in the rotation pastures.

(67 pages)

INTRODUCTION

The job of the American sheep producer is to produce quality meat and wool in the most efficient method possible. The more pounds of lamb weaned per unit of time, the higher the efficiency of the flock and the greater the chance of economic success for the producer. One of the factors affecting the level and efficiency of sheep production is weight per age of lamb which measures rate of gain and size of lamb. Weight per age of lamb is influenced by genetics and management.

In recent years there has been an increase in crossbreeding to reap the benefits of heterosis and improve efficiency. The Targhee range flock at Utah State University Experimental Station, like many flocks in the Intermountain Region, has been crossed with Finnsheep to improve fecundity and with Suffolks to improve growth rate and meat characteristics. The overall goal of the experimental station flock is to improve production and efficiency per ewe.

Currently, there are five crossbred genotypes in addition to straightbred Targhees which comprise the ewe flock. Targhee and Suffolk rams are used to sire the lamb crop. Lambs are referred to by genotype, sire listed first: 1) Targhee (TxT), 2) Suffolk x Suffolk-Targhee (SxST), 3) Suffolk x Targhee (SxT), 4) Suffolk x Targhee-Finn-Targhee (SxTFT), 5) Suffolk x Targhee-Suffolk-Targhee (SxTST), 6) Suffolk x Finn-Targhee (SxFT), and 7) Suffolk x Finn-Suffolk-Targhee (SxFST). In the case of crossbred dams, the first breed listed contributed half the genes.

The research reported here examines lamb productivity in terms of increases in body weight from birth to weaning for seven different genotypes at the Utah State University Experimental Station in Cedar City. Lamb performance on the four grazing treatments (sheep alone, sheep and cattle mixed, both continuous and rotation) implemented at the summer experimental grazing site on Cedar Mountain was also evaluated.

It is hoped that the findings herein will aid Utah State and surrounding sheep producers in management decisions regarding their crossbreeding and summer grazing programs.

Objectives

1. Establish lamb growth curves for the seven genotypes in the Utah State University Experimental Station range flock.
2. Determine for each genotype if there are any significant differences among the grazing treatments: sheep alone, and sheep and cattle mixed, with continuous and rotation grazing.

REVIEW OF LITERATURE

Introduction

The level and efficiency of sheep production is determined by: 1) age at first parturition, 2) lambing interval, 3) prolificacy, 4) age at last lambing, and 5) weight per age of lamb (Foote et al., 1982). The more pounds of lamb produced per ewe per unit of time the lower the cost of maintenance and investment. The total weight of lamb weaned per ewe exposed to rams is affected by growth and survival rates of lambs and fertility and prolificacy of ewes (Vesely and Peters, 1981). This review examines some factors affecting variation in growth and weight per age of lambs as well as animal performance on different grazing treatments. Growth, herein, refers to an increase in body weight.

Growth, Growth Rate, and Growth Curves

Brody (1945) defined growth as the aspect of development concerned with an increase in living substance and includes one or all of three processes: 1) cell multiplication, 2) cell enlargement, and 3) incorporation of material from the environment. Growth to a large extent is an increase in protein storage (Hafez and Dyer, 1969).

Growth rate is an increase in weight per unit of time (Brody, 1945) and does not proceed at a uniform rate from conception to maturity. An average growth rate calculated from these two points has limited value. Increases in weight over shorter periods of time are necessary to give a better picture of actual growth patterns.

The heritability estimate of growth rate in feeder lambs is reported to be about 30% (Foote et al., 1982). Results from the 1980 Cedar City Station 120-day individual gain test indicate considerable variability in average daily gain (.45 to .88 pounds) among lambs (Matthews, 1981).

The ability of lambs to grow rapidly is an important economic trait (Matthews, 1981). First, faster gaining lambs are usually more efficient feed converters and reach market weight earlier on fewer days of feed. Second, lambs marketed earlier are a savings in interest to the producer. Investment capital can be turned over more quickly and the potential for profit is increased.

According to Fitzhugh (1976) growth curves reflect lifetime interrelationships between an individual's inherent impulse to grow and mature in all body parts and the environment in which these impulses are expressed. The environment is framed by: 1) individual level of productivity, 2) quantity and quality of food consumed, and 3) effort required to locate, consume, and digest this food.

The term "growth curve" usually evokes the image of a sigmoid curve depicting a lifetime sequence of measures (Fitzhugh, 1976). More general terminology would be size-age or weight-age curves.

Two primary objectives for fitting growth curves are descriptive and predictive. A common characteristic of growth models is that they utilize size and rate parameters. In addition, a third parameter is often used to partition the growth curve into two stages which Brody (1945) called "self accelerating" and "self inhibiting" stages during which growth rate velocity is increasing and decreasing respectively.

Transition between these two stages establishes the last point of inflection on the sigmoid curve when about 30% to 50% of mature body weight has been attained (Brody, 1945). This point is associated with important physiological changes and functions. Puberty occurs near this time and the ability of the animal to fatten as compared to depositing protein tissue is increased. This is the point were gains are most rapid and perhaps most economical.

Factors Affecting Variation in Growth

In cattle the major factors affecting weaning weight are milk production of dam and genetic growth ability of the calf (Bennett, 1983). This differs somewhat from sheep where many researchers (deBaca et al., 1956; Dickerson and Laster, 1975; Harrington et al., 1958; Hunter, 1956; and Phillips and Dawson, 1937) have reported birth weight as the most influential variable affecting weaning weight in both straightbred and crossbred lambs. Hunter's 1956 work with Border Leicester and Welsh Mountain ewes at Cambridge University showed that maternal influence is capable of limiting the size of genetically large lambs as well as increasing the size of genetically small lambs when embryos from one breed were transferred to the other breed.

A study at Ft. Reno Experiment Station showed the difference between males and females was highly significant ($p<.01$) (Harrington et al., 1958). The difference in males over females increased from 1.9 pounds at 45 days to 5.1 pounds at 135 days of age. This is somewhat lower than the 8 to 10 pound advantage for males reported by Hazel and Terrill (1945, 1946); but, their males were not castrated and weaning weights were not corrected for birth weights. In another study, birth weight was the largest single source of variation affecting weaning weight of the traits measured, accounting for 34-44% of the variation at 45 days and 23-33% at 135 days of age (Harrington et al., 1958).

Work at Kansas State (Dickerson et al., 1972) involving seven breeds of sheep found that ewe breed influenced birth weight and pre-weaning gain with a range of 8 pounds in weights at weaning (10 weeks). Prenatal maternal influence was measured as birth weight; postnatal maternal influence was measured as growth from birth to weaning; and individual growth potential was measured as growth from weaning to 26 weeks of age. The relative impact of breed differences relative to size was apparent at birth, except for Corriedales which were relatively larger at birth than at weaning or later. Type of birth and rearing had significant effects on weight at all ages.

Dickerson et al. (1972) found that prenatal and postnatal maternal influences limited expression of individual lamb growth potential in Suffolk sheep since relative size increased from an index of 108 at birth to 111 at weaning to 115 at 4 and 16 weeks postweaning. In Dorsets there was no change in relative size (85) between birth, weaning, and later dates. Postnatal maternal influences (milk production) was relatively higher than prenatal or postweaning growth for Targhees, Coarse Wools and Rambouillets, but was lower for Hampshires.

deBaca et al. (1956) reported a range of increase in weaning weight from 2.5 to 5.96 pounds for each pound increase in birth weight and suggested that within a breed or breedcross selection be geared towards individuals which produce heavier lambs at birth indicating rapid growth rates resulting in larger lambs at weaning.

Studies at Clay Center (Dickerson and Laster, 1975) showed that within a breed or breedcross preweaning competition among twins and triplets reduced lamb weights by 8 to 11 pounds at 70 (weaning), 160, and 230 days of age and by about 7 pounds at puberty, but delayed puberty only one week. Age of dam strongly influenced preweaning growth of ewe lambs, but did not significantly affect age or weight at puberty. Their results indicate that lamb growth rates are more sensitive to preweaning environment than is age at puberty.

Phillips and Dawson's (1937) work with Southdowns showed a positive relationship between birth weight and weight at six months of age. They also found that type and time of birth had a significant effect on weaning weight. On the average they expected a 4.3 pound increase at three months for each one pound increase at birth. Also, animals were expected to weigh .14 pounds less on the average at three months for each day's increase in birth date. For example, a single ram weighing 10 pounds at birth would weigh between 12-13 pounds more at 3 months of age than one weighing 7 pounds. In addition, a ram lamb born March 1 would be expected to weigh about 8.5 pounds more at three months of age than one born May 1 would at the same age. This is somewhat different from observations made by Magid et al. (1981) where they noted that lambs born later in the season tended to have higher birth weights but gained more slowly than earlier born lambs.

The differences due to birth date favored early lambs in that they had a more favorable environment for growth and were not hindered by hot weather and parasites during an early stage in their growth (Phillips and Dawson, 1937).

Work at Beltsville with four purebred groups (Hampshire, Merino, Shropshire, and Southdown), 7 groups of first cross lambs, 15 groups of 3-breed cross lambs, and 6 groups of 4-breed cross lambs showed the average of all crossbred lambs had a 7 pound advantage over all purebred lambs for weaning weight (Sidwell et al., 1964). This included a .63 pound advantage in birth weight and 6.5 pound advantage in gain from birth to weaning. The average gains in weaning weight over the purebreds were 5.2 pounds for 2-breed crosses, 9.5 pounds for 3-breed crosses, and 10.4 pounds for 4-breed crosses. This work also showed that crossbred rams mated to purebred ewes excelled purebred rams, but were not superior to purebred rams mated to crossbred ewes.

University of Minnesota studies with Columbia, Suffolk, and Targhee breeds as straightbreds and crossbred combinations showed that 3-way cross lambs were superior to 2-way cross and straightbred lambs. The performance traits measured were: birth weight, preweaning average daily gain, weaning weight at 70 days of age, post weaning average daily gain, and age at market weight, approximately 110-120 pounds, (Rastogi et al., 1975,1982). Among the 3-breed crosses there were significant differences for the measured traits suggesting that combining abilities vary and specific breed combinations should be taken into account when breeding decisions are made. Increases in body weight due to crossbreeding were more evident in weaning weight and gain from birth to weaning than in birth weight (Sidwell and Miller, 1971).

An eight year study at the Cedar City, Utah, Station examined straightbred Targhees, Targhee ewes bred to Suffolk sires and crossbred Suffolk-Targhee ewes bred to Suffolk sires (Matthews et al., 1977). Crossbred ewes had a higher lamb production than the other two groups at birth and at weaning. The crossbred ewes had a greater proportion of twins (58.9%) compared to straightbred Targhees (45.6%) and Targhee ewes bred to Suffolk sires (41.8%). Differences between straightbred Targhees and Targhee ewes bred to Suffolk sires were nonsignificant for the production traits measured. "The crossbreeding of ewes had a greater influence on the pounds of lamb born than crossbreeding of the lamb when measured at both birth and weaning." (Matthews et al., 1977, p. 172)

This is in agreement with work by Vesely and Peters (1974) where they reported that 3-breed cross lambs from crossbred ewes exceeded the mean of two-breed cross lambs from straightbred dams by 10% in weaning weight at 110 days of age. They attributed this difference mainly to the superior maternal ability of the crossbred dams. In total weight of lambs weaned per ewe exposed to rams, the production of 3 and 4-breed cross lambs surpassed the production of purebred lambs by 26% and 30%, respectively (Vesely and Peters, 1979).

Other studies show variations in the live weight of lambs from birth to eight months of age (Hunter, 1956). Maternal influence is the sum of factors which influence growth prior to birth (in utero) and postnatal milking ability.

Breeds of sheep which differ greatly in size provide different maternal environments for their offspring. The supposition is that crossbred lambs will have similar genetic makeup regardless of which way the crosses were made. However, as stated earlier, the size of the dam influenced the weight of lambs at birth and weaning when embryos were placed in dams of the reciprocal cross (Hunter, 1956).

Barnicoat et al. (1949) noted that differences in gain from milk consumption were significant ($p < .01$) for the first two months of life, but were not significant during the third and fourth months of lactation. This is somewhat contrary to Hunter's (1956) results.

Barnicoat et al. (1949) illustrated a good linear relationship between live weight gains and milk consumption for the first 8 weeks of lactation after which live weight increased more rapidly than total milk consumption. Within breeds, Barnicoat et al. (1949) found a significant relationship between total milk yield and lambing date. Yields of late lambers were lower than early lambers. He suggested differences between early and late lambers were due to qualitative and quantitative changes in pasture during lactation and could possibly be offset by supplemental feeding. In addition, Barnicoat et al. (1949) indicated that hormonal changes affecting milk secretion may have been brought about by changes in photoperiod.

Age of ewe affects milk production especially during the second and third months of lactation. Twelve week yields of mature and first-time lambers within the New Zealand Romney breed showed a 15% advantage to mature ewes (Barnicoat et al., 1949).

Hunter (1956) found that the total milk yield from ewes with twins was 1.36 times that of ewes with singles. Therefore, the mean milk consumption of twins was 68% of the amount consumed by singles. It seems logical therefore, that twin bands should be run separately, provided the best pastures, and possibly given creeps to compensate for the reduced milk consumption per lamb in hopes of reducing the weight differences between singles and twins at weaning.

The effect of litter size on weight of lambs increased during the first month and then decreased (Hunter, 1956). This is somewhat different from the relationship Phillips and Dawson (1937) found between birth weight and weight at six months of age where birth weight was correlated with sex and birth type. Phillips et al. (1940) working with range sheep at Dubois found that twins tended to "catch up", but never quite reach the same weight level as singles.

Grazing Systems

The ultimate aim of grazing management is to efficiently and economically maximize animal production from the grazing enterprise without damaging the range resource (Merrill and Taylor, 1975).

Available data seem to support the idea that the rangeland will "improve" (Heady, 1961) and that livestock will produce more (Kothmann et al., 1975) under a system which allows some sort of periodic rest from grazing. However, there is no clear consensus in the literature to support the stand that livestock are more productive under rotational grazing systems than continuous grazing. Pieper (1980) reviewed several rotation and continuous grazing studies in the western United

States and Canada and found 14 studies showing an advantage for continuous grazing over some type of rotation, six with an advantage for rotation over continuous and four with no difference in animal response.

Herbel (1971, p. 17) stated, "animal performance per unit area is more important than performance of individual animals." The decision to maximize production per animal or per unit area is one producers make based on economics. Where are net returns the highest?

Livestock operators must be able to produce enough additional income to overcome the costs and inconveniences of implementing the grazing system either by running more animals on the same area without deteriorating the range or reaping higher gains on a per head basis.

Grazing systems providing greater individual animal response than continuous grazing must provide adequate nutrition, possibly resulting from improved range condition (Heady, 1961). Studies showing an advantage of continuous grazing over other grazing systems are probably influenced by stocking rate effects and increased stocking pressure resulting in less available herbage per animal unit (Pieper, 1980).

Performance of sheep and cattle grazed separately and together at the Rutherglen Research Station in Victoria, Australia, showed that animal production was generally higher when sheep and cattle grazed together than when they grazed separately (Hamilton and Bath, 1970). Production differences were mainly associated with increases in the final liveweight of lambs and clean wool production of ewes. The liveweight changes of steers was variable. This is in agreement with work at Canberra, Australia, for sheep and cattle grazing subterranean clover-phalaris mixture (Clark, 1963).

A later study by Hamilton (1976) at Rutherglen Research Station investigated the performance of sheep and cattle grazed together in different ratios. In three years of good precipitation, the annual performance of steers was unaffected by mixed stocking while lamb performance benefited to an increasing degree as the sheep to cattle ratio decreased. In one year of drought, the effect of mixed stocking depressed steer performance; but, did not alter sheep performance from years of adequate precipitation.

MATERIALS AND METHODS

Targhee and Targhee crossbred sheep provided by the Utah Agricultural Experiment Station at Cedar City were used for this study. Data were collected on a total of 1848 lambs for 1981 and 1982. Seven different lamb genotypes were analyzed. Genetic type and number of lambs in each genotype are listed in table 1.

TABLE 1. LAMB GENOTYPES USED IN THIS STUDY

Genotype[a]		Number of Lambs
1	TxT	295
2	SxST	553
3	SxT	178
4	SxTFT	413
5	SxTST	181
6	SxFT	123
7	SxFST	105
Total		1848

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

Ewes were bred on wheatgrass and alfalfa pastures near the Southern Utah State College (SUSC) Valley Farm. A 35 day breeding period was initiated the second week in November for all breeding groups. Following breeding, the ewes were placed in one band and wintered on a sagebrush-grass desert range near the Utah-Nevada border. Near the end of March ewes were trailed to the SUSC Valley Farm for shearing and shed lambing which commences the first week in April.

Following lambing, ewes and lambs were grazed on improved grass pastures at the SUSC Valley Farm until they were trucked to the experimental summer range site on Cedar Mountain. In 1981 the sheep were moved to the summer range on June 11-12 and June 14-16 in 1982.

The experimental summer range site (figure 1) consists of 3229 acres fenced into 18 pastures each consisting of approximately 165 acres. All pastures have an adequate water supply either as free flowing water or in stock ponds. Rock and(or) crushed salt was used in all pastures as an aid to livestock distribution.

The grazing groups: sheep continuous (sc), cattle continuous (cc), sheep rotation (sr), cattle rotation (cr), sheep and cattle mixed continuous (mc), and sheep and cattle mixed rotation (mr) were randomly assigned to pastures in 1979 for the duration of the 10 year grazing study. To reduce confounding factors livestock were randomly assigned to a grazing group by age and genotype of dam.

The grazing period used in this study was from approximately June 10 to October 20. Lambs were weaned, trucked to the Valley Farm, and weighed September 22, 1981 and September 16, 1982. Ewes, cows, and calves remained on the grazing site until approximately October 20 when they were trailed back to Cedar City.

Hereford and Hereford-Angus crossbred cows and their calves, owned by a local cattleman, were used in the grazing study, but no cattle data were collected for this particular study.

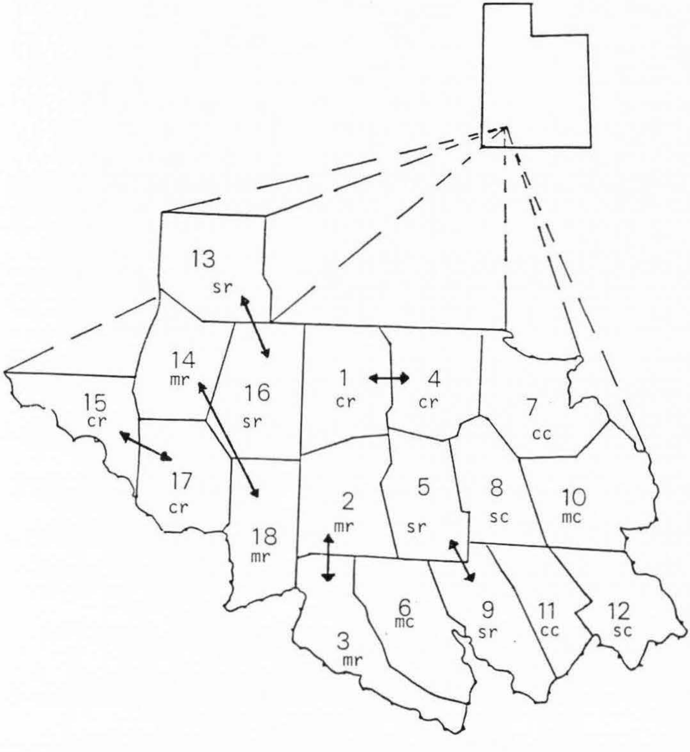

FIGURE 1. DIAGRAM OF EXPERIMENTAL SUMMER GRAZING SITE

The main emphasis of this study was to examine growth in terms of weight gain from birth to weaning of the seven genotypes. Body weight of lambs was measured at:

1. Birth (April-May)
2. Pre-summer range (mid-June)
3. Mid-summer (at rotation)
4. Weaning (mid-September)

Within each lamb genotype, growth relative to the different grazing treatments was evaluated.

For each genotype, weights were plotted against age for weigh periods (WP) two, three, and four. Mean ages per WP within genotype were calculated and values more than four standard deviations from the mean were removed before regressions were run. This was necessary to remove extremely young animals and weaning weights for ten lambs in 1982 that were missed during weaning.

All genotypes were combined to determine the overall average age per WP across all genotypes. The linear additive method was then used to adjust actual weights to the overall average age per WP which was: 0 for WP 1; 56 days for WP 2; 120 days for WP 3; and 154 days for WP 4.

To reduce environmental effects, age adjusted body weights within each lamb genotype were further adjusted for sex of lamb, type of birth, type of rearing (determined at WP 2), year, and age of dam.

Harvey's (1960) computational program for least-squares analysis of variance with unequal subclasses was used to test for differences among the seven genotypes at the four weigh periods. Where main effects were shown to be significant, least significant difference (LSD) analyses were performed.

Statistical Models

Seven different but similar models were used for analyses. These are:

I. $Y_{ijklmnoq} = M + G_i + T_j + S_k + H_l + R_m + P_n + W_o + (TP)_{jn} + (GW)_{io} + (TW)_{jo} + (PW)_{no} + (SW)_{ko} + (HW)_{lo} + (RW)_{mo} + b_1D_{ijklmnoq} + b_2D^2_{ijklmnoq} + E_{ijklmnoq}$

II. $Y_{ijklmnq} = M + G_i + T_j + S_k + H_l + R_m + P_n + (TP)_{jn} + b_1D_{ijklmnq} + b_2D^2_{ijklmnq} + E_{ijklmnq}$

III. $Y_{ijknq} = M + G_i + T_j + S_k + P_n + (TP)_{jn} + b_1D_{ijknq} + b_2D^2_{ijknq} + E_{ijknq}$

IV. $Y_{jklmnq} = M + T_j + S_k + H_l + R_m + P_n + W_o + (TP)_{jn} + (RW)_{mo} + (TW)_{jo} + (PW)_{no} + (SW)_{ko} + (HW)_{lo} + b_1D_{jklmnq} + b_2D^2_{jklmnq} + E_{jklmnq}$

V. $Y_{jklmnq} = M + T_j + S_k + H_l + R_m + P_n + (TP)_{jn} + b_1D_{jklmnq} + b_2D^2_{jklmnq} + E_{jklmnq}$

VI. $Y_{jklq} = M + T_j + S_k + H_l + b_1D_{jklq} + b_2D^2_{jklq} + E_{jklq}$

VII. $Y_{jknq} = M + T_j + S_k + P_n + (TP)_{jn} + b_1D_{jknq} + b_2D^2_{jknq} + c_1A_{jknq} + c_2A^2_{jknq} + c_3A^3_{jknq} + f_1X_{jknq} + E_{jknq}$

where:

$Y_{ijklmnoq}$ = estimate of the dependent variable (e.g. body weight, ADG between weigh periods, etc.)

M = the mean

G_i = the effect of the ith genotype

T_j = the effect of the jth year

S_k = the effect of the kth sex

H_l = the effect of the lth birth type

R_m = the effect of the mth rearing type

P_n = the effect of the nth pasture treatment

W_o = the effect of the oth weigh period (WP)

$(TP)_{jn}$ = interaction of the jth year with the nth pasture

$(GW)_{io}$ = interaction of the ith genotype with the oth WP

$(TW)_{jo}$ = interaction of the jth year with the oth WP

$(PW)_{no}$ = interaction of the nth pasture with the oth WP

$(SW)_{ko}$ = interaction of the kth sex with the oth WP

$(HW)_{lo}$ = interaction of the lth birth type with the oth WP

$(RW)_{mo}$ = interaction of the mth rearing type with the oth weigh period

b_1D = linear effect of age of dam

b_2D^2 = quadratic effect of age of dam

c_1A = linear effect of age of lamb

c_2A^2 = quadratic effect of age of lamb

c_3A^3 = cubic effect of age of lamb

f_1X = linear effect of birth weight

$E_{ijklmnoq}$ = error or failure of above constants to estimate the dependent variable

Models I, II, and III combined genotypes for analyses while models IV, V, VI, and VII were used for analyses within genotypes. Model I was used to analyze body weight by weigh period and pasture treatment. Model II was used to estimate variance components affecting weaning weights. Model III was used to determine pounds of lamb weaned per ewe at weaning.

Model IV was used to analyze weights per weigh period and to obtain regression coefficients to construct growth curves. Average daily gain between two weigh periods was analyzed using model V. Model VI was used to analyze birth weights. Weaning weights adjusted for birth weights were analyzed using model VII.

Climate

Precipitation data was recorded at the SUSC Ranch in Cedar Canyon, elevation 8135 feet. This site is approximately 6 air miles from the experimental grazing site and is considered to be representative of the climate at the experimental range site (Bowns, 1982). Annual and seasonal (July-September) recorded precipitation was higher in both study years than the previous 10 year average. The annual mean for 1981 was 29.8 inches and 37.8 inches for 1982 while the 1970-80 average was 27.7 inches. Seasonal values were 6.8 inches for 1981, 9.4 inches for 1982, and 5.2 inches for the 1970-80 average.

Vegetation

Work by Bowns (1982), table 2, shows the major vegetation types and relative amounts in each pasture on the grazing site where lambs

TABLE 2. MAJOR VEGETATION TYPES IN ACRES AND PERCENT

Pasture	OAK ac	OAK (%)	GRASSLAND ac	GRASSLAND (%)	ASPEN/GRASS ac	ASPEN/GRASS (%)	ASPEN/SNOWBERRY ac	ASPEN/SNOWBERRY (%)	SNOWBERRY ac	SNOWBERRY (%)	SAGEBRUSH ac	SAGEBRUSH (%)	CHOKECHERRY ac	CHOKECHERRY (%)	RIPARIAN ac	RIPARIAN (%)	RABBITBRUSH ac	RABBITBRUSH (%)	OTHER ac	OTHER (%)
cr 1	40	23	102	58	102	58			23	13					2	1				
mr 2	32	16	100	51	4	2	14	7	44	22			1	.5	3	2				
mr 3	86	46	22	12			5	3	34	18	7	4	8	4			15	8	9	5
cr 4	41	21	70	35	19	9	40	20	29	15	4	2								
sr 5	48	26	103	57					30	16										
mc 6	19	10	75	38	4	2	14	7	74	38	1	.5	9	5						
cc 7	32	19	4	2	10	6	45	26	78	46			2	1.2						
sc 8	81	38	93	41	2	1	8	4	5	2	35	16								
sr 9	84	44	12	9	1	.5			16	9	77	40	1	.5						
mc 10	54	30	15	8	31	17	30	16	39	22	4	2	9	5						
cc 11	80	42	52	27	7	4	5	3	18	10	27	14	2	1						
sc 12	98	48	19	9			33	17	12	6	30	15	12	6						
sr 13	5	3	35	25	99	70									2	1				
mr 14	32	23	20	14	55	50	4	4												
cr 15	35	24	27	18	20	14	26	18	29	20									7	5
sr 16	35	14	25	13	5	3	85	45	32	17			1	.5	4	2			1	.
cr 17	41	28	22	15	20	14	45	31	11	8									8	5
mr 18	37	20	36	20	5	3	33	18	56	31			13	7					3	2
TOTALS	880	27.4	832	25.9	292	9	387	12	530	16.5	185	5.8	58	1.8	11	.3	15	.5	28	.

spent approximately 64% of the duration of the experimental period, on the average, 98 out of 154 days.

Stocking Rate

The average stocking rate for the entire experimental grazing site was 2.76 acres/animal unit month in 1981 and 2.96 acres/animal unit month in 1982 (Bowns, 1983). Sheep and cattle were grazed at a 5 to 1 ratio established by Schlunt (1980). The rotation pastures were grazed until approximately 50% utilization was achieved then moved to the second pasture for the remainder of the grazing season. The next year the deferred pasture was the first pasture grazed.

Livestock Measurements

Lambs were weighed, ear tagged, docked, and castrated within 24 hours after birth. Pre-summer range weights were taken in mid-June at the SUSC Valley Farm prior to trucking animals to the grazing site. When pastures had attained approximately 50% utilization animals were brought into the working corrals and weighed on a portable sheep scale. After weighing, animals in continuous pastures returned to the same pastures while those on rotation were transferred to the deferred pasture for the remainder of the grazing period.

At weaning, ewes and lambs were brought into the working corrals where they were separated. Lambs were loaded on trucks and taken to the SUSC Valley Farm approximately 30 miles away where weaning weights were taken. This study examined growth patterns (weight gains) among the different lamb genotypes so weights were not adjusted for shrink.

It should be noted, however, that all weaning weights would have been somewhat higher had weights been taken prior to trucking.

Pounds of lamb weaned per ewe at weaning was calculated by multiplying the average within genotype weaning weight adjusted for year, pasture, sex of lamb, and age of dam by the number of lambs weaned per genotype divided by the number of ewes in a particular genotype at weaning. No adjustments were made for birth type, rearing type, and birth weight in this analysis.

RESULTS AND DISCUSSION

Model II accounted for 55.7% of the variation in weaning weight. Rearing type, birth type and genotype were 50.9%, 22.7%, and 12.4% respectively of the total variance accounted for by the effects examined in weaning weights.

For the seven lamb genotypes under study, body weights were measured at birth and the average ages of 56, 120, and 154 days. Adjustments for year, sex, age of dam, type of birth, and type of rearing were made on a lamb genotype basis as not all ewe genotypes have the inherent capability of producing equal number of lambs (Foote, et al., 1982).

Attempts were made to linearize growth curves so that entire curves could be compared to denote any differences, but non-linear components were significant ($p<.05$), so among genotype comparisons were made on body weight at each weigh period (WP) and average daily gain (ADG) between weigh periods in an attempt to identify any differences in growth rates. Within WP the least significant difference (LSD) method of testing unequally replicated means was used to identify real differences in weight among lamb genotypes.

Weights Per Weigh Period

The four sets of weights per WP were combined in one analysis (Model IV) to obtain regression equations for growth from birth to weaning. Least squares means of weights per WP are presented in table 3. These values were used to construct the histogram in figure 2.

TABLE 3. LEAST SQUARES MEANS AND STANDARD ERRORS OF BODY WEIGHT (POUNDS) BY WEIGH PERIOD(WP) AND GENOTYPES FROM COMBINED ANALYSIS*

Lamb Genotype		WP 1 Mean	SE	WP 2 Mean	SE	WP 3 Mean	SE	WP 4 Mean	SE
1	TxTa	9.3b	1.0	36.5b	1.0	75.2b	1.0	80.2b	1.0
2	SxST	10.3b	.7	43.8c	.7	87.5c	.7	92.9c	.7
3	SxT	10.2b	.9	42.3cd	.9	85.3cd	.9	91.6cd	.9
4	SxTFT	9.9b	.7	40.8de	.7	83.4cd	.7	89.1e	.7
5	SxTST	10.0b	2.2	42.2cde	2.2	83.def	2.2	88.7def	2.2
6	SxFT	9.5b	1.2	40.8de	1.2	82.3ef	1.2	87.4e	1.2
7	SxFST	8.3b	1.3	39.0be	1.3	76.9b	1.3	83.2bf	1.3

* Within genotypes, 4 sets of wts/wp were combined in one analysis.

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within weigh period differences ($p < .05$) among genotypes are denoted by different lower case letters.

This combined (4 sets of weights/WP) analysis computed standard errors for weights within genotypes on the basis of the mean weight at the mean age (82.5 days) for the entire experiment. This presented a problem in LSD tests of weight per WP, particularly at WP1 where the range of birth weights was much less than that of weights at other weigh periods. Among genotype comparisons for birth weight yielded no significant differences using standard errors from the combined analysis.

A separate analysis (Model VI) with only birth weights (adjusted for year, sex, type of birth, and age of dam) was run to obtain more reasonable standard errors. Results of a LSD test for birth weight

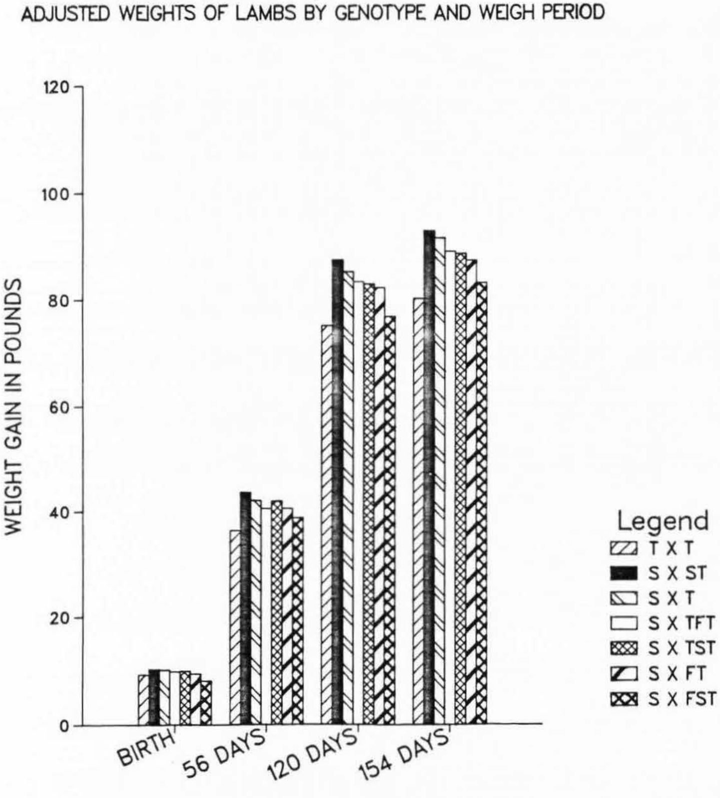

FIGURE 2. HISTOGRAM OF ADJUSTED WEIGHTS OF LAMBS BY GENOTYPE AND WEIGH PERIOD

among genotypes revealed some differences ($p<.05$) that were not apparent using standard errors from the combined analysis, table 4.

TABLE 4. LEAST SQUARES MEANS AND STANDARD ERRORS FOR BIRTH WEIGHT OF LAMBS FROM BIRTH WEIGHT ALONE ANALYSES

Genotype	Birth Weight Mean	SE
1 TxT[a]	9.9[bc]	.15
2 SxST	10.4[d]	.09
3 SxT	10.2[bd]	.18
4 SxTFT	9.7[c]	.12
5 SxTST	10.6[d]	.20
6 SxFT	9.3[e]	.18
7 SxFST	7.5[f]	.20

a Sires followed by dams (T=Targhee S=Suffolk F=Finnsheep).

b Among genotype differences ($p<.05$) are denoted by different lower case letters.

LSD test results among genotypes for birth weight using values from the analysis containing only birth weights showed that lambs from 1/2 Finn dams were lighter ($p<.05$) than those from straightbred Targhees. In addition, lambs from Suffolk crossbred ewes were heavier ($p<.05$) than TxT lambs. There were no statistical differences in birth weights between two-way comparisons of TxT and SxTFT or TxT and SxT.

At WP2 (mean age 56 days) some changes in the relative ranking of genotypes by weight occurred, the most noticeable of which was TxT lambs dropping from the middle position at birth to the lightest at WP2.

Changes in the relative ranking of the three heaviest genotypes occurred between birth and WP2 as a result of average daily gain (ADG) differences. However, weight differences among SxST, SxT, and SxTST lambs were not significant at WP2.

At WP3 (mean age 120 days) more distinct differences among genotypes appeared. SxST lambs at 87.5 pounds were heavier ($p<.05$) than SxTST lambs at 83.0 pounds while differences among SxT, SxTFT, and SxTST lambs were nonsignificant. SxTFT and SxTST lambs traded places in the relative ranking of weights per weigh period and remained as such to weaning. Differences between these two genotypes were nonsignificant at all WP except birth where SxTST lambs were heavier ($p<.05$).

The relative ranking of genotypes did not change from WP3 to WP4 (mean age 154 days). SxST and SxT lambs were not significantly different from one another yet they were heavier ($p<.05$) than all other genotypes under study except SxTST which were statistically the same as SxT lambs. TxT and SxFST lambs remained the lightest.

Average Daily Gain (ADG) Between Weigh Periods

Within genotypes, ADG among weigh periods was different ($p<.05$). All genotypes exhibited the same basic growth pattern. The most rapid gains occurred between WP2-WP3 with a mean rate of .66 pounds per day. Rate of gain during this period (56-120 days of age) opposed to the first two months of life is influenced more by the quantity and quality of feed consumed than the amount of milk produced by the dam (Barnicoat et al., 1949). Abundant high quality forage was available both years between WP2-WP3.

The second fastest ADG occurred between WP1-WP2 with a mean rate of .56 pounds per day. The slowest gains occurred in the 34 days prior to weaning where the mean rate was .16 pounds per day. Weaning weights and ADG between WP3-WP4 would have been higher had animals been weighed at weaning prior to trucking.

Least squares mean values for ADG between WP are presented in table 5. Table 6 shows changes that occurred in the relative ranking of genotypes for ADG between weigh periods.

TABLE 5. LEAST SQUARES MEANS AND STANDARD ERRORS FOR AVERAGE DAILY GAIN (POUNDS) BETWEEN WEIGH PERIODS (WP) BY GENOTYPE

	Lamb Genotype	WP1-WP2 Mean	SE	WP2-WP3 Mean	SE	WP3-WP4 Mean	SE	WP1-WP4 Mean	SE
1	TxT[a]	.50b	.01	.61b	.01	.12b	.02	.46b	.01
2	SxST	.58c	.01	.69c	.01	.16cd	.01	.53c	.01
3	SxT	.57cd	.01	.67cd	.01	.18c	.02	.53cd	.01
4	SxTFT	.55d	.01	.68c	.01	.17b	.01	.52de	.01
5	SxTST	.52bd	.03	.63bdef	.03	.19bcd	.05	.51cde	.02
6	SxFT	.56cd	.02	.64de	.02	.20cd	.03	.51e	.01
7	SxFST	.54d	.02	.60bef	.01	.16bcd	.02	.48b	.01

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Among genotype differences (p<.05) between weigh periods are denoted by different lower case letters.

TABLE 6. RELATIVE RANKING OF GENOTYPES BY WEIGH PERIOD FOR AVERAGE DAILY GAIN[a]

Rank	WP1-WP2	WP2-WP3	WP3-WP4	WP1-WP4
1	SxST(.58)	SxST(.69)	SxFT(.20)	SxST(.53)
2	SxT(.57)	SxTFT(.68)	SxTST(.19)	SxT(.53)
3	SxFT(.56)	SxT(.67)	SxT(.18)	SxTFT(.52)
4	SxTFT(.55)	SxFT(.64)	SxTFT(.17)	SxFT(.51)
5	SxFST(.54)	SxTST(.63)	SxST(.16)	SxTST(.51)
6	SxTST(.52)	TxT(.61)	SxFST(.16)	SxFST(.48)
7	TxT(.50)	SxFST(.60)	TxT(.12)	TxT(.46)

a ADG in pounds.

Between birth and WP2 (56 days) ADG varied from a low of .50 pounds for TxT lambs to a high of .58 pounds for SxST lambs. SxST lambs gained the fastest (.69 pounds) while SxFST lambs were the slowest (.60 pounds) for the 64 day period between WP2 and WP3. ADG varied from .12 pounds for TxT lambs to .20 pounds for SxFT lambs for the 34 day period between WP3 and and WP4. The ranking for overall rate of gain (WP1-WP4) corresponded closely with the ranking of adjusted weaning weights.

Weaning Weights Adjusted for Birth Weights

Actual weaning weights of all lambs within a genotype were adjusted for deviations from the average birth weight of that genotype. Results of this analysis (Model VII) differ somewhat from the overall adjusted weight per weigh period analysis (Model IV), table 7.

TABLE 7. LEAST SQUARES ESTIMATED MEANS AND STANDARD ERRORS FOR WEANING WEIGHTS ADJUSTED FOR BIRTH WEIGHTS

Genotype	Weaning Weight Adjusted for Birth Weight Mean	SE
1 TxT[a]	85.8[b]	1.0
2 SxST	95.2[c]	.6
3 SxT	91.6[d]	.8
4 SxTFT	89.3[e]	.5
5 SxTST	94.4[c]	1.2
6 SxFT	82.4[f]	1.1
7 SxFST	83.4[bd]	1.5

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Significant differences ($p<.05$) are denoted by different lower case letters.

Weaning weights adjusted for birth weights were higher than overall adjusted weaning weights for TxT, SxST, and SxTST lambs. This suggests lower actual growth rates for smaller lambs within these genotypes as weaning weights from smaller lambs at birth were adjusted upward more than heavier lambs at birth were adjusted downward. Within the SxFT group, lambs with heavier birth weights were lowered more at weaning than lighter lambs were raised. The remaining three genotypes showed no differences in adjusted weaning weights between the two types of analyses.

The relative ranking of genotypes from heaviest to lightest for weaning weights adjusted for birth weights was: 1) SxST, 2) SxTST, 3) SxT, 4) SxTFT, 5) TxT, 6) SxFST, 7) SxFT. SxST lambs were still the heaviest at 95.2 pounds, yet they were not significantly different than SxTST lambs at 94.4 pounds. Two-way comparisons of TxT and SxFST lambs as well as SxFT and SxFST lambs showed no significant differences. All other genotype comparisons yielded statistically significant differences.

Pounds of Lamb Weaned per Ewe at Weaning

Pounds of lamb weaned per ewe at weaning (Model III) was used to determine overall lamb production, table 8. There were no significant differences among SxST, SxFT, and SxTFT in pounds of lamb weaned per ewe at weaning. The values were 150.9, 150.5, and 148.2, respectively. These three genotypes weaned more ($p<.05$) than any other genotype under study. Straightbred Targhees weaned 121.4 pounds which was significantly lighter ($p<.05$) than all crossbred groups.

TABLE 8. POUNDS OF LAMB WEANED PER EWE AT WEANING (ADJUSTED FOR YEAR, SEX, PASTURE, AND AGE OF DAM)

	Genotype[a]	WW[b]	No.Lambs	No.Ewes	Lbs/Ewe[c]	Rank[d]
1	TxT	86.54	289	206	121.41e	7
2	SxST	95.58	551	349	150.90f	1
3	SxT	92.05	176	125	129.61g	6
4	SxTFT	89.64	410	248	148.20f	3
5	SxTST	94.47	180	129	131.82gh	5
6	SxFT	81.99	123	67	150.52f	2
7	SxFST	82.57	104	64	134.18h	4

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Weaning weights adjusted for year, pasture, age of dam and sex but not for birth weight, birth type and rearing type.

c Differences ($p<.05$) are denoted by different lower case letters.

d Ranking is from highest to lowest.

Growth Curves

Within genotypes, the four sets of weights per weigh period were included in one least squares analysis to obtain regression coefficients. The regression equation used to draw growth curves is as follows: $Y_i = b_o + b1(X_i - M) + b2(X_i - M)^2 + b3(X_i - M)^3$. Where Y_i is the predicted weight at a given age, X_i is age, M is the mean age (82.5 days), b_o is the mean weight at the mean age, and b1, b2, b3 are the non-orthogonal regression coefficents for the linear, quadratic, and cubic components. Values used to establish growth curves are in table 9. Figures 3, 4, and 5 depict lamb growth patterns for the seven lamb genotypes under study.

TABLE 9. NON-ORTHOGONAL REGRESSION COEFFICIENTS USED TO ESTABLISH GROWTH CURVES

Genotype	b_o	b_1	b_2	b_3
1 TxT[a]	54.54	.6624	-.1629-2	$-.360^{-4}$
2 SxST	64.45	.7511	-.2116-2	-.396-4
3 SxT	62.34	.7336	-.1859-2	$-.375^{-4}$
4 SxTFT	60.71	.7300	-.1848-2	-.393-4
5 SxTST	61.44	.6976	-.195-2	$-.346^{-4}$
6 SxFT	60.32	.7132	-.195-2	-.380-4
7 SxFST	56.72	.6444	-.173-2	$-.294^{-4}$

a Sire first followed by dam (T=Targhee S=Suffolk F=Finn).

The TxT growth curve (figures 3-5) starts to level off at an earlier age than those of crossbred lambs. Heterosis is thought to be responsible for sustained higher rates of gain in crossbred lambs.

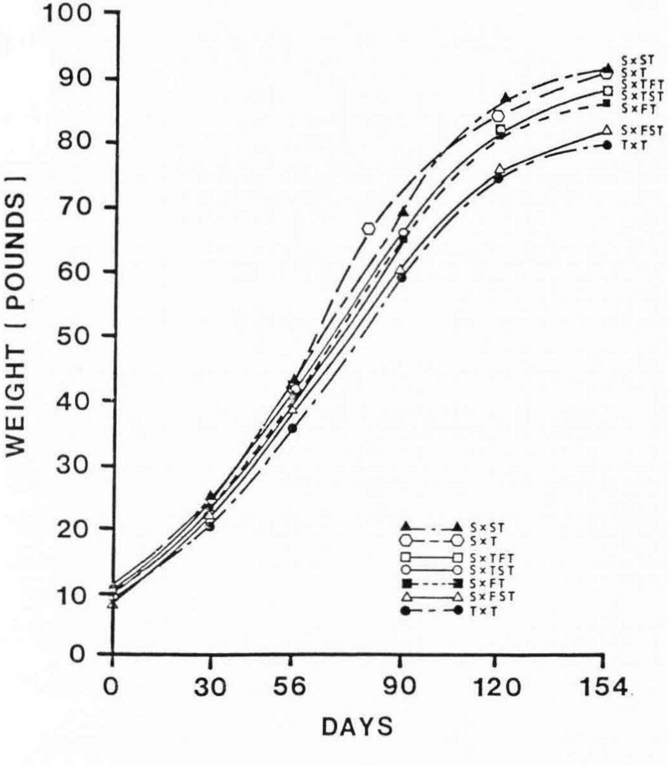

FIGURE 3. GROWTH CURVES OF TARGHEE AND TARGHEE CROSSBRED LAMBS UNDER STUDY (1981-1982)

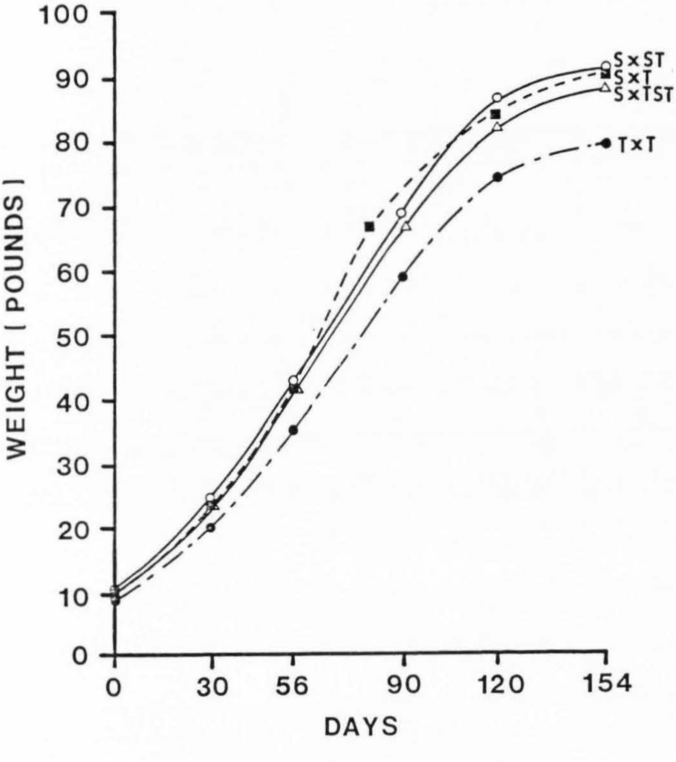

FIGURE 4. GROWTH CURVES OF STRAIGHTBRED TARGHEE AND SUFFOLK-TARGHEE CROSSBRED LAMBS

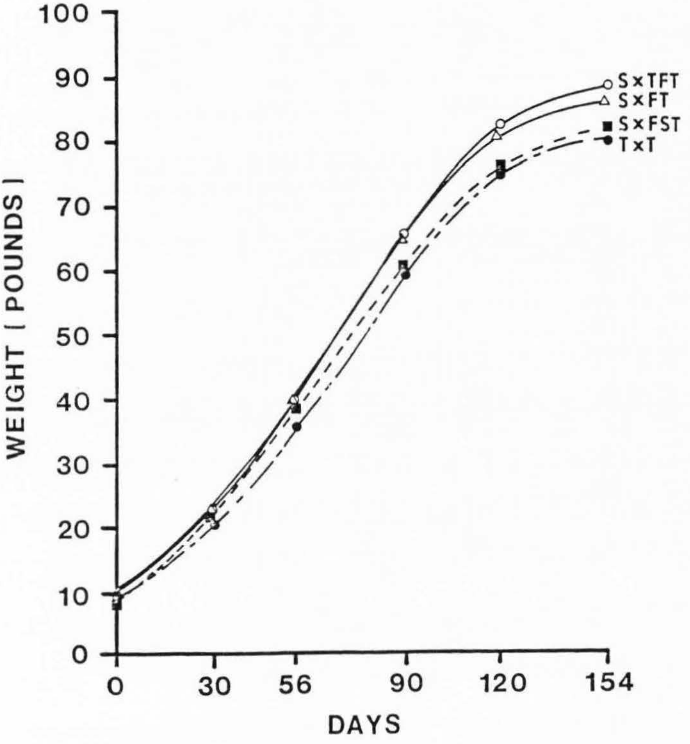

FIGURE 5. GROWTH CURVES OF STRAIGHTBRED TARGHEE AND FINN-TARGHEE CROSSBRED LAMBS

Lamb Performance of Finn Crossbreds Compared to Targhees

Individual body weights among Finn crossbred lambs (SxTFT, SxFT, SxFST) were not significantly different at WP2 nor did they change relative ranking from birth to WP2. Weight differences between SxFST and TxT lambs were nonsignificant while weights of the other two genotypes with Finn blood (SxTFT and SxFT) were heavier ($p<.05$) than TxT lambs. In addition, weight differences among these two genotypes and SxTST and SxT were nonsignificant.

Between birth and WP2 there were no significant differences in ADG among the three genotypes containing Finnsheep blood (SxTFT, SxFT, SxFST). All three were faster ($p<.05$) gaining than straightbred Targhees. During the fastest gaining period (WP2-WP3) ADG for SxTFT lambs was higher ($p<.05$) than the other Finn crossbreds and TxT. SxFST and TxT lambs showed no significant differences in ADG from WP2 to weaning. Adjusted weights per weigh period and overall ADG from birth to weaning were not significantly different between TxT and SxFST lambs. However, the SxFST group weaned more ($p<.05$) pounds of lamb per ewe at weaning than TxT, 134.2 and 121.4 pounds, respectively.

There were no significant differences between SxFT and SxTFT for adjusted weight per weigh period, overall rate of gain, and pounds of lamb weaned per ewe at weaning. Both genotypes were superior to TxT and SxFST for the above mentioned traits. The SxFST group did not perform as well as the author expected, possibly due to poor combining abilities in the genetic makeup of the parents.

Lamb Performance of Suffolk Crossbreds Compared to Targhees

There were no significant differences between SxST and SxT lambs for ADG between weigh periods and weight per weigh periods. The SxST group weaned more ($p<.05$) pounds of lamb per ewe at weaning than the SxT group possibly due to heterosis of the crossbred dam. Performance of SxST and SxT lambs for observed traits was significantly higher ($p<.05$) than that of TxT lambs. The SxTST group was better ($p<.05$) than the TxT group for all traits except ADG between two consecutive weigh periods where there was no significant difference. Overall ADG from birth to WP4 was higher ($p<.05$) for SxTST lambs than TxT lambs. Differences between SxT and SxTST were nonsignificant for all observed performance traits.

Pasture Treatments

Pasture treatment accounted for only 6.1% of the variation for observed effects in weaning weights (Model II). The experimental design assumed no significant differences among groups within a genotype assigned to the four pasture treatments (sheep continuous, sheep rotation, mixed continuous, and mixed rotation) as pasture treatments did not go into effect until after WP2 and all animals were managed on the same grass pastures from birth to WP2.

However, results of a LSD test within genotypes for body weight by pasture assignment at WP2 revealed this assumption was not realized for three of the seven genotypes (TxT, SxTFT, and SxFT). Therefore, not all differences in body weights among pastures can be attributed to pasture treatments.

In spite of initial imbalances at WP2, the tendency at WP3 was for the heaviest lambs to be in mixed rotation(mr) pastures and the lightest lambs in sheep rotation(sr) pastures. Sheep rotation pastures had the lightest lambs for five of the six genotypes indicating differences (p<.05) in pasture treatments. SxFST lambs revealed no significant differences in pasture treatments at any weigh period. Differences in lamb weights between mixed continuous(mc) and mixed rotation(mr) pastures were nonsignificant. Lambs from mixed species pastures were heavier (p<.05) than lambs from sheep rotation pastures.

At weaning two genotypes (SxTST, and SxFST) exhibited no significant differences among pasture treatments. For the remaining five genotypes, the heaviest lambs were from mixed continuous pastures. Within genotype weight differences between the two mixed pasture treatments were nonsignificant except for SxTFT lambs where weights from mixed rotation pastures were lighter (p<.05) than mixed continuous weights. Again, as at WP3, sheep rotation pasture weights were lighter (p<.05) than either of the mixed species pasture treatments. Lambs from sheep continuous pastures were heavier (p<.05) than those from sheep rotation pastures for three (TxT, SxST, SxTFT) of the five genotypes showing pasture treatment differences at weaning.

Least squares means of weight per weigh period by genotype and pasture treatment are presented in tables 11, 12, and 13 of the appendix. Comparisons of ADG between weigh periods by pasture treatments are also in the appendix, presented in tables 14, 15, and 16.

As all genotypes responded similarly to pasture treatments a combined analysis (Model I) was examined to determine if more observations per treatment yielded any different results. There were no differences and the relative ranking of lambs from heaviest to lightest was the same as that of individual genotype analyses. Least squares mean weights by WP and pasture treatment from the combined genotype analysis are presented in table 10. Figure 6 illustrates pasture treatment effects on weights per WP.

TABLE 10. LEAST SQUARES MEANS AND STANDARD ERRORS FOR WEIGHT (POUNDS) PER WEIGH PERIOD[a] BY PASTURE TREATMENT

Weigh Period	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1	9.9^{b}	.5	9.7^{b}	.4	9.9^{b}	.7	9.9^{b}	.5
2	41.1^{b}	.5	39.7^{c}	.4	40.32^{bc}	.7	40.8^{b}	.5
3	81.0^{b}	.5	77.8^{c}	.4	83.1^{d}	.7	84.8^{d}	.5
4	86.3^{b}	.5	82.7^{c}	.4	90.9^{d}	.7	89.5^{d}	.5

a All genotypes were combined in one analysis.

b Among pasture treatment differences ($p<.05$) within weigh periods are denoted by different lower case letters.

Higher performance of lambs from mixed species pastures compared to single species is in agreement with results from studies in Texas (Merrill, 1967) and Australia (Hamilton, 1976) where lambs gained faster in mixed species pastures. Merrill (1967) observed that sheep grazed with cattle and goats "always" made better gains than sheep grazed alone. Hamilton and Bath (1970) found that a greater quantity of nutrients were utilized when sheep and cattle grazed together than when they grazed separately. Nutrient consumption data were not

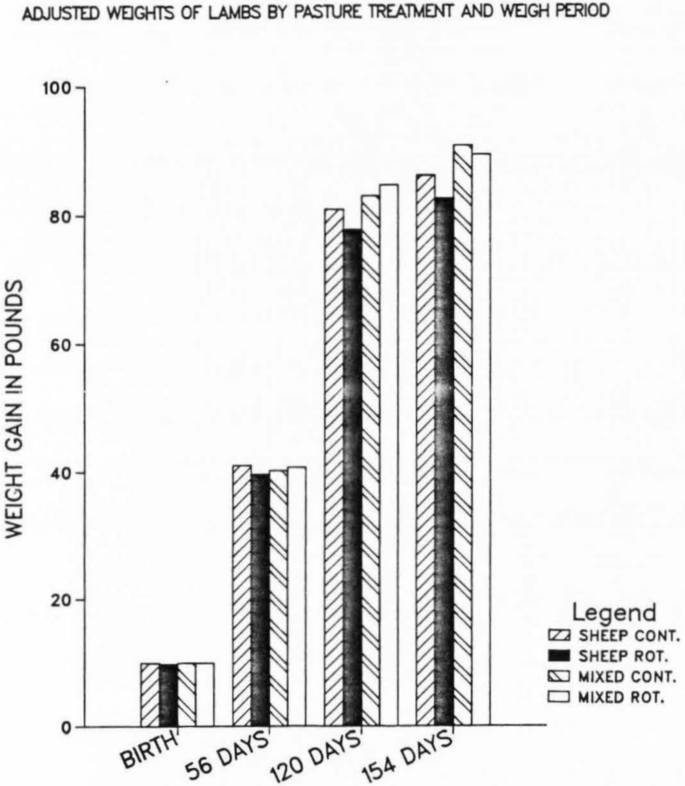

FIGURE 6. HISTOGRAM OF ADJUSTED WEIGHTS OF LAMBS BY PASTURE TREATMENT AND WEIGH PERIOD

collected as a part of this study so the concept of greater nutrient utilization is merely a possible explanation for increased lamb production in the mixed species pastures.

It is possible that key forage species are different in sheep alone pastures than in mixed species pastures and that sheep alone pastures may be overutilized, from the animal performance standpoint, prior to rotation. Perhaps sheep rotation pastures should be rotated earlier or more than once during the grazing season to allow adequate availability of "preferred" forage species.

A review of diet selection studies (Dudzinski and Arnold, 1973) showed a lack of consistency in forage selection differences between sheep and cattle mainly due to changes over time in the physical and chemical characteristics of the vegetation being grazed. Diet selection was not observed for sheep and cattle among the pasture treatments.

Bowns (1983) provided a brief forage utilization summary, table 17 of the appendix. This information was not included in any statistical analyses, but merely presented as an aid to understanding lamb performance differences due to pasture treatments.

In mixed species pastures it is possible that cattle are using mature grasses thus enabling sheep in the mixed pastures to consume a higher percentage of "sheep preferred vegetation" (Malechek, 1983). If there is a difference in diet preferences between sheep and cattle, it seems logical there would be less competition for "sheep preferred vegetation" in mixed species pastures stocked at the same rate than in sheep alone pastures.

Bowns (1983) noted that the mixed species pastures have improved more rapidly in range condition than the single species pastures on the Cedar Mountain site. This is probably due to more uniform utilization of forage species as well as a more uniform use of the entire pasture than in single species pastures.

Merrill (1967) showed deferred rotation systems with moderate grazing made as much or more vegetation improvement than pastures grazed with less than half as many livestock or with no grazing. Results of yearly vegetation surveys suggested that deferred rotation systems allow "better" forage plants to increase in number and become more vigorous than continuous grazing (Merrill, 1967). The lower amount of "good" plants in exclosure pastures suggests that decreaser plants need some type of grazing in order to remain vigorous and productive.

The literature is inconsistent in regard to animal performance from continuous and rotational grazing studies. In sheep alone pastures, the results of this two year study indicate an advantage to continuous grazing.

CONCLUSIONS

Results of this study indicate the highest performance for lamb growth in terms of average daily gain and weight per weigh periods were from the SxST and SxT breeding groups. Recommendations to sheep producers in the Cedar City area with similar management practices would be to utilize the SxST breeding system and reap the benefits of high individual lamb performance as well as maximize the pounds of lamb weaned per ewe at weaning.

Increases in body weight due to crossbreeding and heterosis were more evident in weaning weight and gain from birth to weaning than in birth weights. Crossbred lambs out performed TxT lambs for all traits observed even though lambs from Finn crossbred ewes started out lighter ($p<.05$) at birth. Finn crossbred lambs maintained higher rates of gain and weaned more pounds of lamb on an individual basis as well as total pounds of lamb per ewe at weaning than TxT lambs. Performance differences among SxTFT, SxTST, and SxFT lambs were nonsignificant, yet the SxTST group weaned less ($p<.05$) pounds of lamb per ewe at weaning.

If weaning weights had been measured prior to trucking or adjusted for shrink growth curves would not have leveled off as rapidly. ADG between WP3-WP4 would have been greater and environmental effects might have been less.

Recommendations for livestock producers on deeded range raising both sheep and cattle would be to graze them together for the best lamb gains with the added benefit of possibly improving range condition. Perhaps, sheepmen could work out an agreement with neighboring cattlemen to graze the two species together. Producers operating on public lands may not have this option due to rules and restrictions set by governing agencies.

Suggestions from this study should not be applied to all sheep producers, only those with similar management practices and operating in the same type of environment. It is quite possible that the lamb genotypes in this study would perform differently under herded conditions and(or) in a harsher environment where range lambing is practiced and animals have to compete for available forage.

This study did not investigate the economic aspects of implementing rotational grazing schemes, but it is understood that for producers to change to a "better" grazing system they must know the economic and managerial advantages and disadvantages of the "new system" compared to their current system. Are the additional costs of implementing a rotational grazing system offset by actual increases in animal production either in weight gains per head with current stocking rates or increased weight gains per unit area? Can "benefical" grazing systems be implemented in phases so as to reduce the initial cost impact, yet still allow the producer to take advantage of improved range condition, better management, and increased animal production?

It is virtually impossible to include all variables affecting preweaning lamb growth in one study. In doing the analyses of this study additional factors which may affect suckling lamb growth came to mind.

It is felt the following areas warrant consideration for future studies:

1. Evaluate practices for selecting replacement ewe lambs. Many producers run all their lambs together and select for size which is negatively correlated with reproductive efficiency or pounds of lamb weaned per ewe exposed to rams. An effective yet easy to use system needs to be devised so lambs from multiple births and(or) high producing dams can be identified at weaning or when decisions to keep replacements are made. Possibly, lambs from multiple births could be ear notched or branded in a different manner than single lambs to help avoid direct size comparisons.
2. Obtain milk production data and establish lactation curves for crossbred ewes. Do differences in lactation patterns affect lamb growth trends to the extent that certain breeds or breedcrosses need to be managed differently?
3. Do certain breeds or breedcrosses tolerate stress (trailing, shearing, lambing, trucking, etc.) better than others? Do less stress-tolerant breeds secrete above-normal rates of adrenal hormones to overcome stress conditions at the expense of milk production and lamb gains?
4. Compare body condition of ewes at lambing to milk production and lamb growth patterns.

Many areas of livestock production and management need to be examined. The author hopes readers of this study will find recommendations applicable and questions worthy of additional research.

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APPENDIX

TABLE 11. LEAST SQUARES MEANS AND STANDARD ERRORS OF BODY WEIGHT (POUNDS) AT 56 DAYS OF AGE BY GENOTYPE AND PASTURE ASSIGNMENT

Lamb Genotype	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1 TxTa	36.3b	1.5	34.4b	1.1	36.8bc	1.8	38.6b	1.4
2 SxST	43.9b	.8	43.9b	.7	42.8b	1.5	44.6b	1.0
3 SxT	41.7b	1.5	41.1b	1.4	42.2b	1.6	44.3b	1.5
4 SxTFT	43.2b	1.0	40.3c	.8	40.1c	1.3	39.6c	1.0
5 SxTST	43.9b	2.2	41.7b	2.5	41.7b	3.3	41.5b	2.8
6 SxFT	38.5b	2.1	39.0b	1.7	44.0c	2.9	38.0c	2.8
7 SxFST	40.2b	2.1	39.0b	1.7	38.6b	2.9	38.0b	1.5

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within genotype differences ($p < .05$) between pasture assignments are denoted by different lower case letters.

TABLE 12. LEAST SQUARES MEANS AND STANDARD ERRORS OF BODY WEIGHT (POUNDS) AT 120 DAYS OF AGE BY GENOTYPE AND PASTURE TREATMENT

Lamb Genotype	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1 TxTa	74.7b	1.5	69.4c	1.1	76.7bd	1.8	79.9d	1.4
2 SxST	86.4b	.8	84.3c	.7	88.0b	1.5	91.5d	1.0
3 SxT	82.9b	1.5	80.9b	1.4	87.7c	1.6	89.6c	1.5
4 SxTFT	84.4b	1.0	80.3c	.8	85.2b	1.3	83.8b	1.0
5 SxTST	84.4b	2.2	79.3c	2.4	83.5bc	3.3	85.0a	2.8
6 SxFT	76.1b	1.8	77.0b	1.5	87.2c	2.0	88.9c	1.8
7 SxFST	77.4b	2.1	76.6b	1.7	74.2bb	2.9	79.3b	1.5

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within genotype differences ($p < .05$) between pasture treatments are denoted by different lower case letters.

TABLE 13. LEAST SQUARES MEANS AND STANDARD ERRORS OF BODY WEIGHT (POUNDS) AT 154 DAYS OF AGE BY GENOTYPE AND PASTURE TREATMENT

Lamb Genotype	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1 TxT[a]	78.2[b]	1.5	74.0[c]	1.1	85.4[d]	1.8	83.3[d]	1.4
2 SxST	91.8[b]	.8	88.3[c]	.7	95.1[d]	1.5	96.3[d]	1.0
3 SxT	88.0[b]	1.5	86.6[b]	1.4	97.0[c]	1.6	94.7[c]	1.5
4 SxTFT	90.1[bd]	1.0	85.4[b]	.8	92.4[b]	1.3	88.6[d]	1.1
5 SxTST	89.5[b]	2.2	86.3[b]	2.4	89.7[b]	3.2	89.3[b]	2.7
6 SxFT	81.0[b]	1.8	80.8[b]	1.5	95.3[c]	2.0	92.8[c]	1.8
7 SxFST	83.9[b]	2.1	82.2[b]	1.7	81.9[b]	2.9	84.7[b]	1.5

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within genotype differences ($p<.05$) between pasture treatments are denoted by different lower case letters.

TABLE 14. LEAST SQUARES MEANS AND STANDARD ERRORS FOR AVERAGE DAILY GAIN (POUNDS) BETWEEN BIRTH AND 56 DAYS OF AGE BY GENOTYPE AND PASTURE ASSIGNMENT

Lamb Genotype[a]	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1 TxT	$.51^{b}$	.02	$.49^{b}$	.01	$.51^{b}$	.02	$.50^{b}$	.02
2 SxST	$.59^{b}$	.01	$.58^{b}$	.01	$.55^{b}$	.02	$.59^{b}$	.01
3 SxT	$.58^{b}$	.02	$.56^{b}$	.02	$.57^{b}$	.02	$.59^{b}$	.02
4 SxTFT	$.58^{b}$	.01	$.55^{c}$	.01	$.52^{d}$	.02	$.52^{d}$	.01
5 SxTST	$.59^{b}$	.03	$.59^{b}$	.03	$.59^{b}$	.04	$.56^{b}$	.04
6 SxFT	$.53^{b}$	.03	$.52^{b}$	.02	$.60^{c}$	.03	$.61^{c}$	.03
7 SxFST	$.57^{b}$	.03	$.55^{b}$	.03	$.52^{b}$	.04	$.52^{b}$	.02

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within genotype differences ($p<.05$) between pasture treatments are denoted by different lower case letters.

TABLE 15. LEAST SQUARES MEANS AND STANDARD ERRORS FOR AVERAGE DAILY GAIN (POUNDS) BETWEEN 56-120 DAYS OF AGE BY GENOTYPE AND PASTURE TREATMENT

Lamb Genotype[a]	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1 TxT	$.62^{b}$	.02	$.54^{c}$	.01	$.64^{b}$	.02	$.65^{b}$	.02
2 SxST	$.68^{b}$	.01	$.63^{c}$	.01	$.72^{d}$	.02	$.72^{d}$	.01
3 SxT	$.65^{bc}$	.02	$.62^{b}$	.02	$.70^{cd}$	.02	$.72^{d}$	.02
4 SxTFT	$.67^{b}$	.01	$.62^{c}$	.01	$.73^{d}$	.02	$.69^{b}$	.01
5 SxTST	$.65^{b}$	.03	$.56^{c}$	.03	$.64^{bc}$	.04	$.66^{b}$	.03
6 SxFT	$.59^{b}$	.02	$.61^{bc}$	.02	$.65^{cd}$	.03	$.70^{d}$	.03
7 SxFST	$.60^{b}$	.02	$.59^{b}$	.02	$.56^{b}$	.03	$.65^{c}$	.02

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within genotype differences ($p<.05$) between pasture treatments are denoted by different lower case letters.

TABLE 16. LEAST SQUARES MEANS AND STANDARD ERRORS FOR AVERAGE DAILY GAIN (POUNDS) BETWEEN 120-154 DAYS OF AGE BY GENOTYPE AND PASTURE TREATMENT

Lamb Genotype[a]	Sheep cont. Mean	SE	Sheep rot. Mean	SE	Mixed cont. Mean	SE	Mixed rot. Mean	SE
1 TxT	.05[b]	.03	.11[c]	.02	.21[d]	.03	.12[c]	.03
2 SxST	.14[b]	.01	.14[b]	.01	.21[c]	.02	.13[b]	.02
3 SxT	.14[b]	.03	.17[b]	.03	.27[c]	.03	.13[b]	.03
4 SxTFT	.15[b]	.01	.16[b]	.01	.19[b]	.02	.16[b]	.02
5 SxTST	.12[b]	.05	.21[b]	.06	.25[b]	.08	.16[b]	.06
6 SxFT	.14[b]	.04	.13[b]	.04	.32[c]	.05	.19[b]	.05
7 SxFST	.13[b]	.04	.18[b]	.03	.20[b]	.05	.14[b]	.03

a Sire followed by dam (T=Targhee S=Suffolk F=Finnsheep).

b Within genotype differences ($p<.05$) between pasture treatments are denoted by different lower case letters.

TABLE 17. VEGETATION UTILIZATION SUMMARY (IN PERCENT) OF PASTURES AT THE CEDAR MOUNTAIN GRAZING SITE

Treatment	Year	Stocking Rate	Grass[a]	St/Poa[b]	Symp[c]	Mean[d]
Sheep cont	1981	2.82ac/aum	61	72	37	57
Sheep cont	1982	2.85ac/aum	52	63	37	51
Sheep rotA[e]	1981	2.71ac/aum	70	68	39	57
Sheep rotA	1982	2.59ac/aum	53	57	31	48
Sheep rotB	1981	2.95ac/aum	63	73	37	60
Sheep rotB	1982	3.27ac/aum	39	44	43	42
Mixed cont	1981	2.81ac/aum	55	69	23	49
Mixed cont	1982	2.58ac/aum	50	54	26	43
Mixed rotA	1981	2.58ac/aum	54	56	31	47
Mixed rotA	1982	2.75ac/aum	46	52	27	42
Mixed rotB	1981	2.96ac/aum	68	70	36	58
Mixed rotB	1982	3.15ac/aum	48	55	36	46

a Four to six different species.

b *Stipa lettermanii* and *Poa pratensis*.

c *Symphoricarpos oreophillus*.

d Mean utilization for entire pasture.

e *A* represents first half of rotation and *B* the second half.

TABLE 18. LEAST-SQUARES ANALYSIS OF VARIANCE
FOR STRAIGHTBRED TARGHEE LAMBS

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	2	4932.01	63.56	*
Linear	1	9704.41	125.07	*
Quadratic	1	159.62	2.06	NS
Year	1	6.70	.09	NS
Pasture	3	2462.67	31.74	*
Sex	1	1004.29	12.94	*
Birth Type	2	1302.04	16.78	*
Linear	1	2590.05	33.38	*
Quadratic	1	14.04	.18	NS
Weigh Period	3	85539.96	1102.40	*
Linear	1	251432.79	3240.34	*
Quadratic	1	1536.41	19.80	*
Cubic	1	3650.69	47.05	*
YR X Pasture	3	43.40	.56	NS
RT X WP	6	605.68	7.81	*
YR X WP	3	292.08	3.76	*
Pasture X WP	9	443.41	5.71	*
Sex X WP	3	100.88	1.30	NS
BT X WP	6	89.82	1.16	NS
Age of Dam				
Linear	1	2.88	.04	NS
Quadratic	1	5162.12	66.53	*
Error	1116	77.59		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at $p<.05$.
NS=not significant.

TABLE 19. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LAMBS FROM SUFFOLK SIRES AND TARGHEE-SUFFOLK EWES

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	2	6559.82	85.99	*
Linear	1	13081.31	171.47	*
Quadratic	1	38.32	.50	NS
Year	1	293.76	3.85	NS
Pasture	3	1766.40	23.15	*
Sex	1	3673.75	48.16	*
Birth Type	2	5252.29	68.85	*
Linear	1	9231.77	121.01	*
Quadratic	1	1272.81	16.68	*
Weigh Period	3	251759.32	3300.10	*
Linear	1	738665.35	9682.52	*
Quadratic	1	7216.33	94.59	*
Cubic	1	9396.28	123.17	*
YR X Pasture	3	215.45	2.82	*
RT X WP	6	680.29	8.92	*
YR X WP	3	596.69	7.82	*
Pasture X WP	9	534.05	7.00	*
Sex X WP	3	288.18	3.78	*
BT X WP	6	263.20	3.45	*
Age of Dam				
Linear	1	181.75	2.38	NS
Quadratic	1	9414.21	123.40	*
Error	2150	76.29		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at p<.05.
NS=not significant.

TABLE 20. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LAMBS FROM SUFFOLK SIRES AND TARGHEE EWES

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	1	4005.05	53.92	*
Linear	1	4005.05	53.92	*
Year	1	235.25	3.17	NS
Pasture	3	987.73	13.30	*
Sex	1	1511.80	20.36	*
Birth Type	2	954.13	12.85	*
Linear	1	1776.26	23.92	*
Quadratic	1	131.98	1.78	NS
Weigh Period	3	134173.94	1806.49	*
Linear	1	395014.11	5318.38	*
Quadratic	1	2821.48	37.99	*
Cubic	1	4686.22	63.09	*
YR X Pasture	3	166.60	2.24	NS
RT X WP	3	674.08	9.08	*
YR X WP	3	184.56	2.49	NS
Pasture X WP	9	277.08	3.73	*
Sex X WP	3	123.23	1.66	NS
BT X WP	6	16.18	.218	NS
Age of Dam				
Linear	1	270.26	3.64	NS
Quadratic	1	2945.94	39.66	*
Error	666	74.27		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at $p < .05$.
NS=not significant.

TABLE 21. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LAMBS FROM SUFFOLK SIRES AND 3/4 TARGHEE 1/4 FINN EWES

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	2	3526.46	52.27	*
Linear	1	7052.88	104.53	*
Quadratic	1	.04	.001	NS
Year	1	70.60	1.05	NS
Pasture	3	923.19	13.68	*
Sex	1	3496.38	51.78	*
Birth Type	2	2640.20	39.13	*
Linear	1	4675.90	69.30	*
Quadratic	1	604.50	8.96	*
Weigh Period	3	198827.96	2946.82	*
Linear	1	584448.65	8662.10	*
Quadratic	1	4154.05	61.57	*
Cubic	1	7881.19	116.81	*
YR X Pasture	3	792.57	11.75	*
RT X WP	6	420.23	6.23	*
YR X WP	3	543.79	8.06	*
Pasture X WP	9	235.46	3.49	*
Sex X WP	3	434.14	6.43	*
BT X WP	6	108.00	1.60	NS
Age of Dam				
Linear	1	158.02	2.34	NS
Quadratic	1	6829.51	101.22	*
Error	1599	67.47		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at p<.05.
NS=not significant.

TABLE 22. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LAMBS FROM SUFFOLK SIRES AND 3/4 TARGHEE 1/4 SUFFOLK EWES

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	2	1736.69	16.74	*
Linear	1	3457.69	32.80	*
Quadratic	1	15.69	.15	NS
Year	1	95.66	.91	NS
Pasture	3	335.21	3.18	*
Sex	1	2313.68	21.95	*
Birth Type	2	1765.35	16.75	*
Linear	1	3288.19	31.19	*
Quadratic	1	242.52	2.30	NS
Weigh Period	3	30112.26	285.64	*
Linear	1	88512.63	839.62	*
Quadratic	1	865.83	8.21	*
Cubic	1	958.31	9.09	*
YR X Pasture	3	108.19	1.03	NS
RT X WP	6	226.57	2.15	*
YR X WP	3	246.70	2.34	NS
Pasture X WP	9	85.91	.82	NS
Sex X WP	3	192.21	1.82	NS
BT X WP	6	85.85	.81	NS
Age of Dam				
Linear	1	377.51	3.58	NS
Quadratic	1	3894.51	36.94	*
Error	676	105.42		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at p<.05.
NS=not significant.

TABLE 23. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LAMBS FROM SUFFOLK SIRES AND TARGHEE-FINN EWES

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	2	1931.80	31.43	*
Linear	1	3585.76	58.34	*
Quadratic	1	277.84	4.52	*
Year	1	317.36	5.16	*
Pasture	3	1912.03	31.11	*
Sex	1	732.70	11.92	*
Birth Type	2	757.38	12.32	*
Linear	1	1211.97	19.72	*
Quadratic	1	302.79	4.93	*
Weigh Period	3	62438.09	1015.08	*
Linear	1	183259.93	2981.45	*
Quadratic	1	1637.86	26.65	*
Cubic	1	2416.48	39.31	*
YR X Pasture	3	184.34	3.00	*
RT X WP	6	349.23	5.68	*
YR X WP	3	142.95	2.33	NS
Pasture X WP	9	299.49	4.87	*
Sex X WP	3	98.92	1.61	NS
BT X WP	6	24.82	.404	NS
Age of Dam				
Linear	1	1181.01	19.21	*
Quadratic	1	53.12	.864	NS
Error	447	61.47		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at p<.05.
NS=not significant.

TABLE 24. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LAMBS FROM SUFFOLK SIRES AND 1/2FINN 1/4SUFFOLK 1/4TARGHEE EWES

Source[a]	D.F.	Mean Squares	F Value	Significance[b]
Rearing Type	2	2196.58	38.60	*
Linear	1	3984.96	70.02	*
Quadratic	1	408.19	7.17	*
Year	1	7.56	.13	NS
Pasture	3	32.45	.57	NS
Sex	1	493.63	8.67	*
Birth Type	2	492.70	8.66	*
Linear	1	894.53	15.72	*
Quadratic	1	90.86	1.60	NS
Weigh Period	3	43981.72	772.84	*
Linear	1	129645.81	2278.11	*
Quadratic	1	1168.09	20.53	*
Cubic	1	1131.26	19.88	*
YR X Pasture	2	94.20	1.66	NS
RT X WP	6	271.57	4.77	*
YR X WP	3	155.20	2.73	*
Pasture X WP	9	33.44	.59	NS
Sex X WP	3	112.16	1.97	NS
BT X WP	6	13.95	.25	NS
Age of Dam				
Linear	1	700.98	12.32	*
Quadratic	1	1943.16	34.15	*
Error	372	56.91		

a YR=Year.
RT=Rearing Type.
WP=Weigh Period.
BT=Birth Type.

b * denotes significance at $p<.05$.
NS=not significant.

VITA

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in

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