A COMPARISON OF THE PERFORMANCE
OF SPRING-BORN AND FALL-BORN
LAMBS

By

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CHAPTER I

INTRODUCTION

Most Oklahoma sheepmen prefer to produce fall-born lambs to be marketed during the spring. There are several advantages to this type of production schedule. Normally, prices paid for lamb during the spring are higher than at other times in the year, parasite problems are minimized and heat stress problems are avoided. However, there are some disadvantages to this type of production system. Many breeds readily available in this area will not breed efficiently in the spring, thus greatly reducing the choice of breeds available for producing fall-born lambs. Also, under any type of once-yearly lambing schedule, the ewe is actively producing for a relatively short time in a year.

Currently, there is research being undertaken in an effort to perfect some type of multiple lambing scheme whereby each ewe would produce more lambs each year. Regions where these studies are being conducted include Oklahoma, Utah and Indiana. Production systems receiving study are varied. Lambing every eight months, thus producing three lamb crops within a two-year period or lambing every six months to produce two lamb crops within one year are two systems under investigation. Under either of the above types of lambing schemes, some lambs would be produced during seasons other than fall, thus some lambs would have to be fed during times other than cold or cool weather seasons.

Performance of fall-born lambs has been well documented in Oklahoma while performance of spring-born lambs has received little attention in this area. It is not known whether lambs fed during hot seasons grow as efficiently as lambs fed during cooler seasons. Also, it is not known if sources of variation associated with lamb growth within fall and spring seasons have equal effects on this lamb performance in both seasons.

In 1963 a program was initiated at the Fort Reno Livestock Research Station, El Reno, Oklahoma, to identify and evaluate problems associated with twice-a-year lambing. Lambs were produced in the early fall from September 15 to November 15 and during the spring from March 15 to the middle of May. From information available on these lambs, the following comparisons of lambs produced in these two seasons were made. Lamb birth weight, rate of gain from birth to 70 days of age, 70-day weight, and rate of gain from 70 days of age to market.

This study was undertaken in an effort to make the following comparisons:

1. To compare the overall performance of lambs born in the fall and spring seasons by estimating the difference in the performance of lambs born in the two seasons.

2. To compare the performance of lambs born in the spring and fall by comparing the relationships of the associated variables (sources of variation associated with lamb performance) in the two seasons.

CHAPTER II

LITERATURE REVIEW

The following literature review deals with lamb birth weights and subsequent lamb performance for lambs born in the fall and spring seasons. Most of the studies reviewed were designed to determine what environmental factors influenced lamb birth weight and performance in either the spring or fall season. Some of the studies reviewed were designed to determine heritability estimates of growth, but contained lamb performance data. Studies comparing growth performance of fall-born and spring-born lambs were limited.

Lambs Born from Late Winter to Early Spring

Frederiksen et al. (1967) reported that 222 ram lambs were significantly ($P < .01$) heavier at birth than were 229 ewe lambs. These Rambouillet lambs were born in April and May and ram lambs were .63 pounds heavier at birth than females. Single-born lambs weighed 1.64 pounds more at birth than did twin-born lambs and lambs out of two-year-old ewes were significantly ($P < .01$) lighter at birth than lambs born to older ewes. Single-born lambs were two pounds heavier when weaned at 120 days of age than were twin-born lambs raised either as twins or singles and ram lambs were significantly ($P < .01$) heavier at weaning than were ewe lambs. However, from 120 days of age to market, only sex was a significant ($P < .01$) source of variation associated with this growth period.

Bogart et al. (1957) reported that breed of dam, sex and birth type influenced birth weight of 280 March and April born lambs. Single-born lambs were from 1.92 to 2.40 pounds heavier at birth than twin-born lambs, and ram lambs were .31 pounds heavier at birth than were females. Lambs born to Hampshire-Rambouillet cross ewes and Border Leicester-Rambouillet cross ewes were significantly ($P < .05$) heavier at birth than were lambs born to Cheviot-Rambouillet cross ewes. All lambs were sired by Suffolk or Southdown rams, but breed of sire did not significantly influence the birth weight of the lambs in this study.

Blackwell and Henderson (1955) reported results from a study designed to determine what environmental factors influenced birth weight of lambs out of 90 Corriedale, 242 Dorset, 152 Hampshire and 176 Shropshire ewes lambing in the early spring. Also, some of the Dorset ewes lambed in the fall season, producing 226 lambs. There were 270 Corriedale, 485 Dorset, 481 Hampshire and 503 Shropshire lambs born in early spring. Season of birth was a significant source of variation influencing the birth weight of Dorset lambs. Age of dam, sex of lamb, type of birth and breed of lamb were all sources of variation associated with lamb birth weight in both seasons. Age of dam, sex of lamb, and type of rearing were all associated with growth rate of lambs out of Corriedale, Hampshire and Shropshire dams from birth to weaning. Season of birth, sex and type of rearing were sources of variation influencing growth from birth to weaning for lambs born to Dorset ewes.

To evaluate sources of variation associated with weaning weight of lambs weaned at 157 days of age, Shelton (1962) used information on 3,440 spring-born Rambouillet lambs out of 110 different sires. From birth to weaning, male lambs grew 7.2 percent faster than did females. Single-born lambs grew 4.6 percent faster than twin-born lambs raised as singles and 10 percent faster than twin-born lambs raised as twins. Lambs born to ewes three to seven years of age grew significantly ($P< .01$) faster from birth to weaning than did lambs born to two-year-old ewes or lambs born to ewes over seven years old. Breed of sire could not be evaluated since only Rambouillet rams were used.

Using records on 2,183 lambs, Hazel and Terrill (1945) reported that sex, age of dam, type of birth and year were significant ($P< .05$) sources of variation associated with growth from birth to weaning for straight Rambouillet lambs born in April and May. Male lambs were 8.3 pounds heavier at weaning than females, and single-born lambs were 9.2 pounds heavier at weaning than were twin-born lambs. Two-year-old ewes gave birth to lambs that were 6.1 pounds lighter at weaning than lambs born to mature ewes. Single-born lambs were 2.5 pounds heavier at weaning than were twins raised as singles, but this was attributed to the difference in birth weights of the lambs.

Cassard and Weir (1956) evaluated environmental factors associated with growth rate from birth, in the spring, to weaning under farm flock conditions. Using straight Suffolk lambs weaned at 120 days of age, they found that sex, type of birth and rearing, and age of dam were sources of variation that influenced growth from birth to weaning.

Single-born lambs grew faster from birth to 70 days of age but slower from 70 to 120 days than did lambs born and reared as twins. Both sex and age of dam were significant ($P< .01$) sources of variation associated with growth rate from birth to weaning. Variation associated with age of dam and type of birth and rearing were not significant in lamb growth rates from 120 to 240 days of age while sex of the lamb continued to be significantly ($P < .01$) related to lamb growth rate.

Neville et al. (1958) reported that breed of sire was a significant ($P < .05$) source of variation associated with lamb growth from birth to 120 days of age. Suffolk, Hampshire, Shropshire and Oxford rams were mated to Rambouillet-Columbia cross two-year-old ewes. Lambs sired by Suffolk or Hampshire rams were three to eight pounds heavier at 120 days of age than were lambs sired by either Shropshire or Oxford rams.

In a study designed primarily to compare productivity of crossbred ewes to straightbred ewes, Botkin and Paules (1965) found that year, age of dam, sex and type of birth and rearing significantly ($P < .05$) influenced lamb growth from birth to weaning at 120 days of age. The ewe flock consisted of straightbred Corriedale and Suffolk ewes and Corriedale-Suffolk cross ewes with all lambs born in March and April. Wether lambs were four pounds heavier at weaning than were ewe lambs. Singles and twins raised as singles were 3.1 pounds heavier at weaning than were twin-born and raised lambs. One hundred twenty nine lambs born to Corriedale ewes were significantly ($P < .05$) lighter at weaning than were 280 lambs out of Suffolk or crossbred ewes.

In a similar study, Botkin (1964) used 707 Corriedale and Columbia lambs to estimate sources of variation associated with gain from weaning at 120 days of age to market, and sex of the lambs proved to be a significant source of variation associated with lamb gain during this period. Male lambs gained an average of .60 pounds compared to .40 for female lambs. Though weaning weight and initial feedlot weight were not significant sources of variation influencing lamb gain on feed, both were closely correlated with final feedlot weight.

DeBaca et al. (1956) reported that lamb birth weight was the greatest source of variation influencing lamb growth rate from birth in the spring to weaning at 120 days of age, but breed of sire was also significantly associated with this gain. The regression of weaning weight on birth weight ranged from 2.5 pounds ± .65 to 5.96 pounds ± .76 pounds increase in weaning weight for each pound increase at birth. Suffolk and Hampshire sired lambs (186) were heavier at weaning than were 96 Southdown and Cheviot sired lambs. All lambs were born to ewes that were 75 percent of the sire breed and 25 percent fine wool breeding.

Lambs Born from Late Fall to Early Winter

Thrift and Whiteman (1969) reported on a study designed to compare production performances of Western and Dorset-Western crossbred ewes when lambing was in October and November. All ewes were bred to either Dorset, Hampshire or Suffolk rams, and 1,884 lamb birth weight records were used for analysis. The variables year, age of dam, sex and type of birth were significantly ($P < .01$) associated with lamb birth weight and these factors accounted for 33 percent of the total variation of the lamb birth weights. Lambs born to two-year-old ewes were lightest at birth while lambs out of ewes three to seven years of age were heaviest at birth. When a ewe reached eight years of age, her lambs again became lighter at birth. Single-born lambs were 1.5 pounds heavier at birth than twins and male lambs were .58 pounds heavier at birth than were females.

Utilizing 1,590 lamb records, it was determined that year, age of dam, type of birth and rearing, and sex were also significantly ($P < .01$)

associated with lamb gain from birth to 70 days of age. Lambs born to ewes three to six years old grew most rapidly while lambs out of ewes older than seven years grew slowest and lambs out of two-year-old ewes were intermediate in growth rate. Single-born and twin-born lambs raised as singles gained from .62 to .66 pounds per day compared to .54 pounds per day gain for twin-born and reared lambs while male lambs gained .03 pounds more per day than females.

Utilizing 1,420 lamb records, it was determined that year, type of birth and rearing, age of dam and sex were sources of variation significantly ($P < .05$) associated with rate of gain of lambs born to crossbred ewes from 70 days to market weight at approximately 90 pounds while only year and sex were significant ($P < .01$) for lambs born to Western ewes. Male lambs from both types of ewes gained .58 pounds during this period compared to a gain of .52 pounds per day for females.

Some studies have revealed that atmospheric temperatures may be associated with lamb birth weight. In a study by Yeates (1956) designed to determine the effect of high air temperature on birth weight of lambs born to Merino ewes, ten ewes were exposed to 98^{o}F. temperatures for seven hours a day from breeding to lambing, while another group of ten ewes were managed normally. Lambs born to the heat treated ewes were 1.75 pounds lighter at birth than were lambs born to the control ewes. In a similar study, Yeates (1953) exposed eight Merino ewes to temperatures of 94^{o}F. for seven hours a day for the last 66 percent of gestation, while another group of eight ewes was exposed to temperatures of 94^{o}F. for seven hours a day the last 33 percent of gestation and eight ewes were control ewes. Lambs born to the control ewes weighed 9.5 pounds at birth while the lambs born to the ewes exposed to high temperatures the last 66 percent of gestation averaged 7.9 pounds at birth. Lambs born to ewes exposed to high temperatures the last 33 percent of gestation weighed 6.8 pounds at birth. Results by Shelton (1964) were quite similar. Fifty-one Rambouillet ewes were exposed to temperatures of 100°F. from breeding to lambing while 52 ewes were maintained in a chamber at 75°F. during gestation. Lambs born to the ewes exposed to high temperatures weighed 4.52 pounds at birth compared to 8.20 pounds for lambs born to ewes maintained at 75°F. during gestation.

From a study designed to determine relationships between lamb birth weights and death losses, Shelton (1964) used data from 2,368 lambs born to Rambouillet and Delaine-Merino ewes in the late fall. There were 1,116 singles born that averaged 8.5 pounds and 1,252 twins born that averaged 6.95 pounds at birth. Lambs born to Rambouillet ewes averaged 7.65 pounds at birth while lambs out of Delaine Merino ewes were slightly smaller. Lambs sired by Hampshire and Suffolk rams averaged 8.51 pounds while Dorset sired lambs weighed 7.4 pounds at birth. Through combined influence of death loss and post-weaning gains, it was estimated that an increase of 6.8 pounds at 120 days of age was associated with each one pound increase in lamb birth weight.

Harrington et al. (1958) indicated that lamb birth weight was a major factor influencing subsequent lamb gains. The ewe flock consisted of grade Rambouillet and Rambouillet-Panama backcross ewes bred to Dorset rams and 300 lambs were produced for use in this study. Regression of subsequent lamb weights on birth weight increased steadily from 1.5 pounds at 45 days of age to 2.6 pounds at 135 days of age. Birth weight alone accounted for 34 to 44 percent of the variation at

45 days of age. However, sex and type of birth were also associated with lamb weights at different ages. Coefficients of determination indicated that from 29 to 59 percent of the total variation in lamb weights at different ages could be accounted for by sex, type of birth and rearing, and lamb birth weights.

Brothers and Whiteman (1960) used records from 330 lambs and found that birth weight, breed of dam, type of birth, sex, type of rearing, year and breed of sire accounted for 35 percent of the variation in growth from 50 to 90 pounds for fall-born lambs out of Dorset-Western crossbred ewes. All lambs were sired by either Hampshire, Suffolk or Dorset rams. Eight percent of the total variation was attributable to sire and 27 percent was removed by birth weight, breed of dam, type of birth, type of rearing, year and sex.

Studies comparing both fall and spring-born lambs on the basis of birth weights and subsequent growth are very limited. However, Allden (1956) bred 300 Border Leicester-Merino crossbred ewes at three different times each year. One hundred were bred December 15 to January 25, 100 from January 25 to March 7, and 100 from March 7 to April 17. All ewes were bred to Southdown rams. In all lambings, singles were heavier at birth than were twins. Ewes bred in late summer and early fall (March 7 to April 17) gave birth to heavier lambs and these lambs gained more rapidly than lambs from the December through February mating periods.

Dun et al. (1960) studied the annual reproduction rhythm in Merino sheep as related to the choice of mating time in Trangie in central western New South Wales. Birth weight, growth from birth to weaning and growth from weaning to 17 months of age were recorded on 495 Merino lambs born in both the spring and fall seasons. Even though twinning was more prevalent in spring lambing ewes, birth weights and weaning weights were heavier for the lambs born in the spring than for lambs born in the fall. But, after the lambs were 17 months old, this seasonal variation no longer existed.

This literature review indicated that there may be several sources of variation associated with lamb birth weights and subsequent lamb growth patterns that may be common to lambs born both in the fall and spring seasons. However, studies designed primarily to compare fall and spring-born lambs are quite limited and these few studies do not determine the extent of influence these sources of variation have in the two seasons.

CHAPTER III

MATERIALS AND METHODS

Flock Composition and Management Procedures

The breeding flock, Table I, consisted of 301 ewes of which 60 were of Dorset breeding, 123 of the Rambouillet breed and 118 were Dorset-Rambouillet crossbred ewes. Sixty Dorsets, 60 Rambouillet and the 62 crossbred ewes were maintained on a twice-yearly lambing schedule from first mating as yearlings until present. The remaining 63 rambouillet ewes and 56 crossbred ewes were lambed once a year until they were three years old, at which time they were then combined into the twice-yearly lambing flock. All ewes were bred first as yearlings. Figure 1 illustrates the breeding and lambing schedule. Breeding was at night only with all ewes exposed to either Dorset or black-faced (Suffolk or Hampshire) rams on alternating nights. Following each breeding season, the ewes were maintained on wheat pasture in the fall and Bermuda grass in the spring.

Shearing

The ewes were sheared about one week prior to lambing in the spring and were tagged and faced about one week before lambing in the fall.

TABLE I

BREED COMPOSITION, NUMBER OF EWES IN EACH GROUP, SEASON AND YEAR PURCHASED AND SEASON AND YEAR INITIATED ON TWICE-YEARLY LAMBING

Breed Composition	No. of Ewes	Season and Year Purchased	Season and Year Initiated on Twice Yearly Lambing
Rambouillet	20	Fall 1963	Fall 1963
Dorset-Rambouillet	22	Fall 1963	Fall 1963
Dorset	20	Fall 1963	Fall 1963
Rambouillet	20	Spring 1964	Spring 1964
Dorset-Rambouillet	20	Spring 1964	Spring 1964
Dorset	20	Spring 1964	Spring 1964
Rambouillet	20	Fall 1964	Fall 1964
Dorset-Rambouillet	20	Fall 1964	Fall 1964
Dorset	20	Fall 1964	Fall 1964
Rambouillet	63	Fall 1963	Fall 1966
Dorset-Rambouillet	56	Fall 1966	Fall 1966

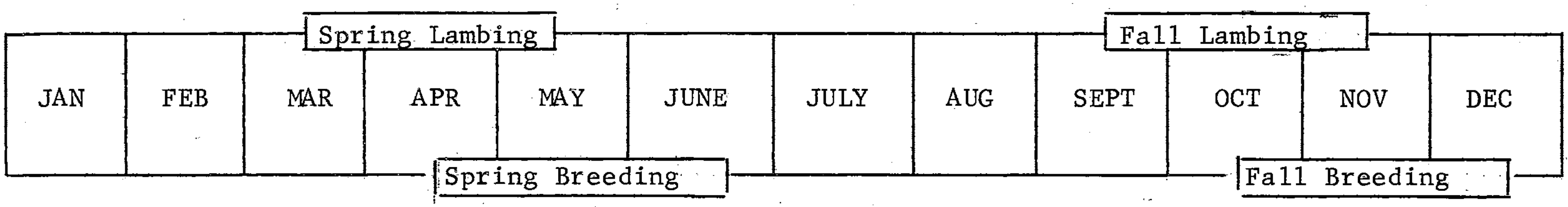

Figure 1. Breeding and Subsequent Lambing Periods Associated with a Twice-Yearly Lambing Program

Breeding, Lambing and other Practices

Approximately four weeks before each lambing season, the ewes were fed at the rate of one-third pound per day of grain (cracked milo). This amount was gradually increased to one pound per day by the start of the lambing season. Until weaning, the ewes received this level of grain plus two pounds of alfalfa hay per day. As each ewe lambed, she was placed in an individual lambing pen in a central lambing barn. Lamb birth weight to the nearest one-tenth pound, lambing date, sex of the lamb(s) and lamb identification were recorded within eight hours after birth. After two to three days, the ewe and her lamb(s) were moved to a larger area with about ten other ewes and their lambs. Here the lambs were docked and retained for about a week, after which time the group was released with the ewes that had already lambed. A creep area was available to all lambs within ten days after their birth. The creep feed consisted of about five percent molasses, 55 percent cracked milo, ten percent soybean meal and 30 percent ground alfalfa hay.

All lambs born in the fall were allowed to graze wheat pasture along with their dams; however, in an effort to reduce internal parasite infestation in the lambs, lambs born in the spring were never allowed out of the dry lot. These lambs were separated from their dams twice a day for two-hour periods, at which time the ewes were allowed to graze wheat pasture when it was available or Bermuda grass with the lambs remaining in the dry lot.

When the oldest lamb reached about 45 days of age, a biweekly weighing schedule was initiated and continued until all lambs were marketed. All lambs were weaned when they attained a minimum age of 66 days and weight of 55 pounds, and all male lambs were castrated at about 30 days of age.

As the lambs were weaned, they were moved to a lamb feeding area. Fall-born lambs were allowed to graze wheat pasture, but spring-born lambs were confined to dry lot. All lambs had access to the creep ration. Two weeks postweaning, the soybean meal was removed from the creep ration and replaced with ground alfalfa, making the ration 55 percent cracked milo, 40 percent ground alfalfa hay and five percent molasses. All lambs were shipped to market at a minimum weight of 93 pounds.

Data Studied

Recording lamb birth weights within eight hours of lambing allowed birth weight comparisons to be made on the basis of sex of the lamb, breed of dam, lamb face color, age of dam and type of birth (single or twin-born). Weighing lambs on a biweekly basis after the lambs were 45 days old provided a means of calculating rates of gain from birth to 70 days, 70-day weights and rate of gain from 70 days of age to market. The 70-day weights were calculated by the linear interpolation method as described by Taylor and Hazel (1955). These various rates of gain and 70-day weights were compared considering lamb sex, breed of dam, lamb face color, age of dam, type of birth and type of rearing in the model. Lamb face color, either white-faced or black-faced, was determined by breed of sire. White-faced lambs were sired by Dorset rams and were compared to black-faced lambs which were sired by either Suffolk or Hampshire rams. Thrift (1968) and Neville et al. (1958) reported that lambs sired by either Suffolk or Hampshire rams weigh essentially the same at birth and subsequent growth of these lambs does not differ significantly. DeBaca *et al.* (1956) reported similar results.

Statistical Analyses

In order to accomplish analyses involving unequal subclass numbers and multiple classification, the data were analyzed by use of the least squares method of fitting constants as outlined by Harvey (1960). Estimates of the least squares constants were computed by using normal equations as illustrated by:

$$[X'X]\,\hat{\beta} = [X'Y]$$

where,

X was the observation matrix,

X' was the transpose of the observation matrix,

Y was the vector of observations, and

$\hat{\beta}$ was the vector of least squares constants.

Since the normal equations were not independent, the restriction that the sum of the least squares constants for each effect equaled zero was imposed for all analyses. Thus, the least squares constants for each effect was expressed as a deviation from zero. The procedures involved in constructing the observation matrix are outlined in detail by Cundiff (1966), Cunningham (1967) and Cunningham (1968).

Solving the above equation for $\hat{\beta}$ yields:

$$\hat{\beta} = [X'X]^{-1}\,[X'Y]$$

and from this equation, least squares constants were computed. Least squares means were obtained by adding the least squares constants to the overall mean for each variable considered.

Sums of squares for all analyses of variance were computed by:

$$R(\hat{\beta}_i,\hat{\beta}_j \mid \hat{\beta}\ldots) = [\hat{\beta}_i \cdot \hat{\beta}_j] \begin{bmatrix} c_{ii} & c_{ij} \\ c_{ji} & c_{jj} \end{bmatrix}^{-1} \begin{bmatrix} \hat{\beta}_i \\ \hat{\beta}_j \end{bmatrix}$$

or, if only one least squares constant was considered:

$$R(\hat{\beta}_i \mid \hat{\beta}\ldots) = \frac{\hat{\beta}_i^{\,2}}{c_{ii}}$$

where $\hat{\beta}_i$ and $\hat{\beta}_j$ were the least squares constants of interest, c_{ii} and c_{jj} were the corresponding diagonal inverse elements, and c_{ij} was the off-diagonal inverse element. Thus, all sums of squares in the analyses were adjusted for all other sources of variation in the model regardless of where the source appeared in the model. Standard errors of the individual least squares estimates were calculated as follows (Snedecor and Cochran, 1967):

$$S_{\hat{\beta}_i} = \sqrt{c_{ii}\,\hat{\sigma}^2}$$

where c_{ii} was the diagonal inverse element corresponding to $\hat{\beta}_i$ and $\hat{\sigma}^2$ was the residual mean square obtained from the analysis of variance.

Tests for statistical significance of the difference between two constants in the same season were obtained by:

$$t(\hat{\beta}_i - \hat{\beta}_j) = \frac{\hat{\beta}_i - \hat{\beta}_j}{\sqrt{(c_{ii} + c_{jj} - 2c_{ij})\hat{\sigma}^2}}$$

where the denominator was also the standard error of the difference between estimates of $\hat{\beta}_i$ values in the same season.

The data were grouped such that all analyses were done within season. All spring records were pooled over the years 1965 through 1968 while all fall records were pooled over the years 1964 through 1968 inclusive. Year association with various lamb performance traits was not determined because it was considered to be a random effect for all lambs. Comparisons between constants for the different seasons were obtained by comparing the various $\hat{\beta}_i$ values of the fall-born lambs with the appropriate $\hat{\beta}_i$ values of the spring-born lambs.

$$t = \frac{\hat{\beta}_i \text{ spring} - \hat{\beta}_i \text{ fall}}{\sqrt{(c_{ii} \text{ spring} + c_{ii} \text{ fall}) \cdot \hat{\sigma}^2 \text{ pooled}}}$$

where c_{ii} spring was the diagonal inverse element corresponding to $\hat{\beta}_i$ in the spring season and c_{ii} fall was the diagonal inverse element corresponding to $\hat{\beta}_i$ in the fall season. Also, the denominator was taken as the standard error of the difference in $\hat{\beta}_i$ values from different seasons. The standard error of the difference was determined in this manner because the covariance [$\hat{\beta}_i$ spring, $\hat{\beta}_i$ fall] of two $\hat{\beta}_i$ values in different seasons was not determinable since analyses were done on a within season basis. The estimate of $\hat{\sigma}^2$ pooled was determined by:

$$\hat{\sigma}^2 \text{ pooled} = \frac{\text{SS error spring} + \text{SS error fall}}{\text{df spring} + \text{df fall}}$$

Lamb Birth Weight

There were 1,100 spring-born lambs and 484 fall-born lambs for birth weight analyses. There were 407 fall-born lamb records available to calculate 70-day weights and rate of gain from birth to 70 days of age. There were 980 spring-born lamb records from which 70-day weights and rates of gain from birth to 70 days of age were obtained. There were 924 spring-born lamb records available from which rate of gain from 70 days of age to market weight was calculated, and there were 395 fall-born lamb records from which rate of gain from 70 days of age to market was calculated. Total lamb numbers are presented in Tables VI, VII and VIII of the appendix.

Lamb birth weight was considered to be the sum of the effects represented by the following model:

$$Y_{ijklmn} = \mu + A_i + B_j + C_k + D_l + E_m + F_n + e_{ijklmn}$$

where,

Y_{ijklmn} is an individual observation of a lamb birth weight.

μ is an effect common to the birth weight of every lamb and is the overall birth weight mean with the effects of the associated variables equalized.

A_i is an effect for the ith breed of dam.

(A_1 = Dorset, A_2 = X-bred, A_3 = Rambouillet)

B_j is an effect for the jth face color of the lamb.

(j_1 = white-faced, j_2 = black-faced)

C_k is an effect for the kth sex of the lamb.

(K_1 = male, K_2 = female)

D_l is an effect for the lth type of birth

(L_1 = single, L_2 = twin)

E_m is an effect for the mth condition at birth.

(m_1 = alive, m_2 = dead)

F_n is an effect for the nth age of dam.

n_1 = ewes under 18 months of age

n_2 = ewes 18 to 24 months of age

n_3 = ewes over 24 months of age

e_{ijklmn} is the failure of the above model to estimate lamb birth weight.

Using this model, the assumption was made that no interactions existed among the effects considered and the failure of this model to accurately estimate lamb birth weight was a function of the errors of the individual observations.

Lamb Performance from Birth to Market

Rate of gain from birth to 70 days of age, 70-day weight and rate of gain from 70 days of age to market weight were considered to be the sum of the effects represented by the following model:

$$Y_{ijklmn} = \mu + A_i + B_j + C_k + D_l + E_m + F_n + e_{ijklmn}$$

μ is an effect common for rate of gain from birth to 70 days, 70-day weight and rate of gain from 70-day weight to market weight for every lamb and is the mean for each trait after the effects of the associated variables are equalized.

A_i is an effect for the ith breed of dam.

(A_1 = Dorset, A_2 = X-bred, A_3 = Rambouillet)

B_j is an effect for the jth lamb face color.

(B_1 = white-faced, B_2 = black-faced)

C_k is an effect for the kth sex of the lamb.

(C_1 = male, C_2 = female)

D_l is an effect for the lth type of birth.

(D_1 = single, D_2 = twin)

E_m is an effect of the mth type of rearing (single or twin).

(E_1 = single, E_2 = twin)

F_n is an effect for the nth age of dam.

n_1 = ewes under 18 months old

n_2 = ewes 18 to 24 months old

n_3 = ewes over 24 months old

e_{ijklmn} is the failure of the above model to estimate rate of gain from birth to 70 days, 70-day weight and rate of gain from 70 days to market weight.

All models were constructed under the assumption that no interactions existed among the effects considered within season (Thrift, 1968).

Analyzing the data by means of the least squares method of fitting constants, the following information was obtainable:

1. Estimates of association between each associated variable and the trait (birth weight, rate of gain from birth to 70 days of age, 70-day weight or rate of gain from 70 days of age to market) under consideration were obtained.

2. Least squares constants (partial regression coefficients or $\hat{\beta}_i$ values) which were estimates of association between each particular associated variable and the trait under consideration were obtained. These least squares constants were adjustment factors for each associated variable and were used in determining least squares means.

3. Least squares means were calculated and were actually the means of each trait studied adjusted for each associated variable in each model.

4. The standard error of each adjustment factor (least squares constant) in both seasons for each trait studied was calculated.

5. The standard error of the difference between adjustment factors in the two seasons was calculated.

6. Comparisons of the performance of lambs in the two seasons were made on the basis of birth weight, rate of gain from birth to 70 days of age, 70-day weight, and rate of gain from 70 days of age to market. These comparisons were accomplished by calculating the differences between the overall average means, for each trait studied, for the two seasons and determining statistical significance of these differences.

7. Calculations to indicate if the adjustment factor for each associated variable considered for each trait studied, was the same or different for the spring and fall seasons were made. This was accomplished by calculating the difference between seasons for each associated variable ($\hat{\beta}_i$ value or adjustment factor) for each trait studied and testing the difference for statistical significance.

CHAPTER IV

RESULTS AND DISCUSSION

Data on all lambs were analyzed on a pooled (over all years) within season (spring or fall) basis with the same statistical model used for each season. Each main source of variation (estimated by analysis of variance) included in the model was tested to determine its association with lamb performance within each season. But since variables associated with lamb growth within both the spring and fall have been studied extensively and documented in numerous publications, discussion involving sources of variation as they are associated with lamb performance on a within season basis will be limited.

The data were not handled to determine if associated variables such as sex, were associated with lamb performance in the two seasons. The data were analyzed to facilitate the following:

1. To compare the performance of lambs in the two seasons. In Table II, the overall average birth weight means are presented for both seasons. These birth weight means for the two seasons were compared to determine if lambs performed differently in the two seasons. Other lamb performance traits, subsequent to birth weight, studied were rate of gain from birth to 70 days of age, 70-day weight, and rate of gain from 70 days of age to market.

2. To determine if the associated variables studied were associated with lamb performance differently in the two seasons. The associ-

ated variables considered were breed of dam, lamb face color, type of birth, condition at birth, type of rearing, sex and age of dam.

These comparisons were accomplished by calculating the differences in $\hat{\beta}_i$ values (a $\hat{\beta}_i$ value is an adjustment factor for each associated variable and estimates the relationship of the associated variable to lamb performance within a season and was derived as a least squares constant, or a partial regression coefficient) for the two seasons. If the difference between seasons [$\hat{\beta}_{ij}$ spring - $\hat{\beta}_{ij}$ fall = difference] for an individual associated variable was significant, this was evidence to suggest that the associated variable was related to the trait studied differently [season by associated variable interaction] in the two seasons. If the difference between seasons was not significant, this indicated that the associated variable was related to the trait under consideration the same in both seasons [no season by associated variable interaction].

Birth Weight

The respective analyses of variance of birth weight for both spring and fall seasons are presented in Tables IX and X of the appendix. Within both seasons, breed of dam, condition at birth (alive or dead), sex, type of birth and age of dam were all significant ($P < .01$) sources of variation associated with lamb birth weight while lamb face color (breed of sire) was significant ($P < .01$) only in the spring.

In Table II, sources of variation associated with lamb birth weight are listed in the first column. In the second and third columns, the individual $\hat{\beta}_i$ values [adjustment factors] are listed for the two seasons while the standard errors of the difference between seasons for

TABLE II

MEAN BIRTH WEIGHTS OF SPRING VS FALL LAMBS AND ESTIMATES OF $\hat{\beta}_i$ OF ASSOCIATED VARIABLES

Sources of Variation[a]	Spring	Fall	Differences[b]	S.E.[d]
Mean (μ)[c]	9.48	7.41	2.07**	0.068
Breed of dam effect: $\hat{\beta}_1$				
$\hat{\beta}_{11}$: Dorset dam	-.923	-1.100	0.177	0.166
$\hat{\beta}_{12}$: X-bred dam	0.733	0.870	-.137	0.136
$\hat{\beta}_{13}$: Rambouillet dam	0.190	0.231	-.041	0.096
Face color effect: $\hat{\beta}_2$				
$\hat{\beta}_{21}$: White-faced	-.288	-.211	-.077	0.100
$\hat{\beta}_{22}$: Black-faced	0.288	0.211	0.077	0.100
Type of birth effect: $\hat{\beta}_3$				
$\hat{\beta}_{31}$: Single born	1.160	1.030	0.130	0.098
$\hat{\beta}_{32}$: Twin born	-1.160	-1.030	-.130	0.098
Condition at birth effect: $\hat{\beta}_4$				
$\hat{\beta}_{41}$: Born alive	0.982	0.731	0.251	0.208
$\hat{\beta}_{42}$: Born dead	-.982	-.731	-.251	0.208
Sex of lamb effect: $\hat{\beta}_5$				
$\hat{\beta}_{51}$: Female	-.303	-.350	0.047	0.237
$\hat{\beta}_{52}$: Male	0.303	0.350	-.047	0.237
Age of dam effect: $\hat{\beta}_6$				
$\hat{\beta}_{61}$: Under 18 mo.	-.394	-1.353	0.959**	0.223
$\hat{\beta}_{62}$: 18 to 24 mo.	-.082	0.226	-.308	0.185
$\hat{\beta}_{63}$: Over 24 mo.	0.476	1.127	-.651**	0.160

**$P < .01$

[a]Sources of variation associated with lamb birth weight.

[b]The difference between spring and fall, significance indicating possible season by associated variable interaction.

[c]Average lamb birth weight in spring and fall seasons with the effects of the associated variables equalized.

[d]Standard error of the difference between seasons.

the adjustment factors are listed in column five. Differences between adjustment factors for the two seasons [$\hat{\beta}_i$ spring - $\hat{\beta}_i$ fall = difference] are presented in column four of Table II. The mean (μ) in Table II is an effect common to the birth weight of every lamb and is the overall average lamb birth weight with the effects of the associated variables equalized. Statistically significant differences between adjustment factors (associated variables) in the spring and fall are indicated in the fourth column of Table II.

Least squares means for birth weight are presented in Table XVII of the appendix. These were calculated by either adding or subtracting the adjustment factors (least squares constants or $\hat{\beta}_i$ values) to (from) the overall mean. Estimated standard errors of the associated variables for spring and fall appear in Tables XXI and XXII of the appendix.

Mean

When comparing spring and fall-born lambs on the basis of birth weight, the estimated least squares mean (μ) in the model was the average lamb birth weight when the effects of the associated variables were equalized. Spring and fall-born lambs weighed an average of 9.48 and 7.41 pounds at birth respectively. Spring-born lambs were significantly ($P < .01$) heavier at birth than fall-born lambs. These figures are presented in Table II. During gestation of spring-born lambs, atmospheric temperatures were normally much lower than during gestation of fall-born lambs. Shelton (1964) and Yeates (1956) indicated that ewes subjected to high temperatures during gestation gave birth to smaller lambs than did ewes subjected to lower temperatures. Dun et al. (1960) and Allden (1956) indicated that spring-born lambs out of Merino or Merino-cross ewes were heavier at birth than were fall-born lambs born to Merino or Merino-cross ewes.

Breed of Dam

From Table II, it is seen that in both spring and fall seasons, lambs out of Dorset ewes were lightest at birth while lambs out of crossbred ewes were heaviest and lambs born to Rambouillet ewes were intermediate in birth weight. However, none of the differences between seasons [$\hat{\beta}_{ij}$ spring - $\hat{\beta}_{ij}$ fall = difference] for any of the three breed of dam classifications proved significant indicating no detectable breed of dam by season of birth interactions.

Lamb Face Color (Breed of Sire)

White-faced lambs (Dorset sires) in both seasons were lighter at birth than were black-faced lambs (Hampshire or Suffolk sires). However, no season by lamb face color interaction was detected in that the difference between seasons for either white-faced or black-faced lambs was nonsignificant.

Type of Birth

Single-born lambs in both seasons were heavier at birth than were twin-born lambs. Figures from Table II show that the difference between single-born lambs in the two seasons was nonsignificant as was the difference between twin-born lambs in the two seasons. These figures indicated no detectable season by type of birth interaction. Dun *et al.* (1960) indicated that both single and twin-born lambs were heavier at birth in the spring than in the fall. However, no significance levels were indicated.

Condition at Birth (Alive or Dead)

Lambs born alive in both seasons were heavier at birth than were lambs born dead. The difference between seasons for lambs born alive was nonsignificant as was the difference between seasons for lambs born dead, indicating no apparent interaction between season of birth and condition at birth.

Lamb Sex

Female lambs in both the spring and fall seasons were lighter at birth than were male lambs. However, the difference between seasons for either female or male lambs was nonsignificant. This was evidence indicating no sex by season of birth interaction and the same adjustment factors for sex could be used for both seasons.

Age of Dam

Lambs born to ewes under 18 months of age in both seasons were lighter at birth than lambs out of older ewes. In the spring, lambs out of ewes under 18 months old were 0.394 pounds lighter at birth than the average spring-born lamb, and in the fall, lambs out of ewes under 18 months old were 1.353 pounds lighter at birth than the average fall-born lamb. The difference of 0.959 pounds between the two seasons was significant ($P < .01$) and was evidence to indicate a season of birth by age of dam (under 18 months old) interaction. This interaction indicated that when estimating lamb birth weights in the two seasons, the adjustment factor for dams under 18 months of age should be different for the two seasons. In the spring, a smaller adjustment factor (0.394 pounds) should be used than in the fall (1.353 pounds). This would further mean that to effectively compare lambs born in the two seasons with age of dam (under 18 months old) difference eliminated, different adjustment factors should be used.

Lambs out of dams 18 to 24 months old, in both seasons, were intermediate in birth weight to lambs out of either younger or older ewes. The difference in birth weights (0.308 pounds) between the two seasons was nonsignificant which was evidence indicating no detectable interaction between season of birth and age of dam (18 to 24 months old). This suggested that it would be appropriate to use the same age of dam (18 to 24 months old) adjustment factors for the two seasons.

Lambs born to ewes over 24 months old, in both seasons, were heavier at birth than lambs from younger ewes. In the spring, lambs were 0.476 pounds heavier than the average spring-born lamb and in the fall they were 1.127 pounds heavier than the average fall-born lamb. The difference between the seasons (0.651 pounds) was significant ($P < .01$) and this was evidence indicating a season of birth by age of dam (over 2 years old) interaction. This interaction suggested that the same age of dam (over 2 years old) adjustment factors should not be used for both seasons. In the spring and fall, birth weights from dams over 2 years old should be decreased 0.476 and 1.127 pounds respectively to eliminate or at least reduce the age of dam (over 2 years old) effect.

Rate of Gain from Birth to 70 Days of Age

The respective analyses of variance of rate of gain from birth to 70 days of age for both spring and fall are presented in Tables XI and XII of the appendix. The associated variables, breed of dam, lamb face color, lamb sex, type of birth, type of rearing and age of dam were all significantly ($P < .01$) associated with rate of gain from birth to 70 days of age in both seasons. These results appeared to agree with results reported by other researchers.

Results of analysis of rate of gain from birth to 70 days of age data are presented in Table III. In the first column of Table III, sources of variation thought to be associated with lamb rate of gain from birth to 70 days of age are listed. The adjustment factors ($\hat{\beta}_i$ values or least squares constants) for the two seasons appear in columns two and three while the standard errors of the differences between adjustment factors in the two seasons are presented in column five of Table III. Differences between adjustment factors for the two seasons and statistical significance appear in column four of Table III. The mean (μ) in Table III is the average daily gain from birth to 70 days of age after equalizing the effects of the associated variables. Estimated least squares means appear in Table XVIII of the appendix while estimated standard errors of least squares constants are presented in Tables XXIII and XXIV of the appendix.

Mean

Comparing spring and fall-born lambs on the basis of rate of gain from birth to 70 days of age, the estimated least squares mean was the

TABLE III

MEAN RATES OF GAIN OF SPRING VS FALL LAMBS AND ESTIMATES OF $\hat{\beta}_i$ OF ASSOCIATED VARIABLES FOR RATE OF GAIN FROM BIRTH TO 70 DAYS

Sources of[a] Variation	Spring	Fall	Difference[b]	S.E.[d]
Mean (μ)[c]	0.72	0.67	0.05**	0.006
Breed of dam: $\hat{\beta}_1$				
$\hat{\beta}_{11}$: Dorset dam effect	-.015	-.036	0.021	0.028
$\hat{\beta}_{12}$: X-bred dam effect	0.011	0.017	-.006	0.020
$\hat{\beta}_{13}$: Rambouillet dam effect	0.004	0.014	-.010	0.022
Face color: $\hat{\beta}_2$				
$\hat{\beta}_{21}$: White-faced effect	-.007	-.019	0.012	0.016
$\hat{\beta}_{22}$: Black-faced effect	0.007	0.019	-.012	0.016
Type of birth: $\hat{\beta}_3$				
$\hat{\beta}_{31}$: Single effect	0.012	0.016	-.004	0.035
$\hat{\beta}_{32}$: Twin effect	-.012	-.016	0.004	0.035
Sex: $\hat{\beta}_4$				
$\hat{\beta}_{41}$: Female effect	-.006	-.022	0.012	0.036
$\hat{\beta}_{42}$: Male effect	0.006	0.022	-.012	0.036
Type of rearing: $\hat{\beta}_5$				
$\hat{\beta}_{51}$: Single effect	0.025	0.020	0.005	0.015
$\hat{\beta}_{52}$: Twin effect	-.025	-.020	-.005	0.015
Age of dam: $\hat{\beta}_6$				
$\hat{\beta}_{61}$: Under 18 mo. effect	-.006	-.056	0.050*	0.025
$\hat{\beta}_{62}$: 18 to 24 mo. effect	0.006	0.002	0.004	0.024
$\hat{\beta}_{63}$: Over 24 mo. effect	0.009	0.058	-.042*	0.020

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

[a]Sources of variation associated with rate of gain from birth to 70 days.

[b]The difference between spring and fall, significance indicating possible season by associated variable interaction.

[c]A source of influence common to every lamb and is the average daily gain with the effects of the associated variables equalized.

[d]Standard error of the difference between seasons.

average daily gain during this growth period after the effects of all associated variables were equalized. The average daily gain for lambs in the spring was 0.72 pounds per day and in the fall, lambs gained 0.67 pounds per day. These figures are presented in Table III. The difference between the two seasons was significant ($P < .01$), indicating that lambs in the spring gained significantly faster than lambs in the fall. Allden (1956) and Dun et al. (1960) indicated that spring-born lambs gained more rapidly than fall-born lambs from birth to weaning at 120 days of age.

Breed of Dam

In both seasons, lambs out of Dorset dams gained the slowest while lambs from crossbred dams gained the fastest and lambs born to Rambouillet ewes were intermediate in their rate of gain from birth to 70 days of age. The difference between seasons for gain of lambs out of crossbred or Rambouillet dams was nonsignificant indicating no apparent season by breed of dam (Rambouillet or crossbred) interactions. Also, the difference between seasons for lambs born to Dorset dams was nonsignificant, which was evidence suggesting the same breed of dam (Dorset) relationships with rate of gain from birth to 70 days of age for the two seasons. The nonsignificant differences between seasons indicated that the same breed of dam adjustment factors could be used for lambs in the two seasons. Blackwell and Henderson (1955) reported that spring-born lambs out of Dorset ewes gained faster than fall-born lambs born to Dorset ewes. However, no significance levels were indicated.

Lamb Face Color (Breed of Sire)

In both seasons, white-faced lambs (Dorset sires) gained slower from birth to 70 days of age than did black-faced (Hampshire or Suffolk sires) lambs. This lamb face color relationship to gain during this period was significant ($P < .01$) within both seasons but the difference between seasons [$\hat{\beta}_{2j}$ spring - $\hat{\beta}_{2j}$ fall = 0.012 pounds per day] was nonsignificant. This was evidence suggesting that the relationship between face color and lamb gain in this period was the same in the two seasons. Thus, the same lamb face color adjustment factors could be used for the two seasons in order to compare lambs from the two seasons.

Type of Birth

Lambs born as singles, in both seasons, gained significantly faster from birth to 70 days of age than did lambs born as twins. However, the differences between seasons were nonsignificant, indicating no detectable type of birth by season interaction. Thus, the same type of birth adjustment factors could be used for both seasons.

Lamb Sex

Lamb sex, within both seasons, was significantly ($P < .01$) associated with rate of gain from birth to 70 days of age. In both seasons male lambs gained faster than did females but the differences between seasons (0.012 pounds per day) was not significant. This was evidence to indicate no detectable season by lamb sex interaction. Thus, the same lamb sex adjustment factors could be used for the two seasons to compare spring-born and fall-born lambs. Also, to estimate rates of gain for lambs in both seasons, the same adjustment factors could be used for lambs born in either the spring or fall.

Type of Rearing

Lambs raised as singles, in both seasons, gained significantly faster than did twin-raised lambs. However, the difference between seasons for either twin-raised or single-raised lambs was nonsignificant and this indicated no detectable season by type of rearing interactions. Thus, the same type of rearing adjustment factors could be used for both seasons.

Age of Dam

Within both seasons, age of dam was significantly ($P < .01$) associated with lamb rate of gain from birth to 70 days of age. In both seasons, lambs born to dams under 18 months old gained the slowest while lambs out of dams over 24 months of age gained the fastest. Lambs from dams 18 to 24 months old gained at rates intermediate to either younger or older dams. When differences between seasons [$\hat{\beta}_{6j}$ spring - $\hat{\beta}_{6j}$ fall = difference] were calculated, some age of dam relationships to lamb rate of gain during this period appeared different for the two seasons.

The difference between seasons (0.05 pounds per day) for rate of gain of lambs born to dams under 18 months old was significant ($P < .05$). This was evidence suggesting that the relationship between age of dam (under 18 months old) and rate of gain during this period were different in the two seasons, thus the same age of dam (under 18 months) adjustment factor could be used for both seasons.

The difference between seasons for lambs born to dams over 24 months old was significant ($P < .05$) and this indicated that the relationship between age of dam (over 24 months) and lamb rate of gain was different in the two seasons. Thus, different age of dam (over 24 months) adjustment factors in the two seasons could be used to more accurately compare lambs in the two seasons.

The difference between seasons for lambs from dams 18 to 24 months old was nonsignificant. Thus, no interaction was apparent and this suggested that the same age of dam (18 to 24 months old) adjustment factor could be used for both seasons.

70-Day Weight

Basically, lamb 70-day weight and rate of gain from birth to 70 days of age were estimates of similar traits with lamb birth weight the only difference. Thus, results from 70-day weight data are discussed very briefly. The respective analyses of variance for the two seasons appear in Tables XIII and XIV of the appendix. All within season and between season comparisons are presented in Table IV. In column one of Table IV, variables associated with lamb 70-day weights are presented. Adjustment factors ($\hat{\beta}_i$ values) for both seasons appear in columns two and three while standard errors of the differences between seasons for these $\hat{\beta}_i$ values are presented in column five of Table IV. Differences between seasons for adjustment factors and statistical significance are listed in column four. The means (μ) in Table IV are the average 70-day weights with the effects of all associated variables equalized. Estimated least squares means are also

TABLE IV

MEAN 70-DAY WEIGHT OF SPRING VS FALL LAMBS AND ESTIMATES OF $\hat{\beta}_i$ OF ASSOCIATED VARIABLES OF 70-DAY WEIGHTS

Sources of[a] Variation	Spring	Fall	Difference[b]	S.E.[d]
Mean (μ)[c]	59.88	54.27	5.61**	0.214
Breed of dam: $\hat{\beta}_1$				
$\hat{\beta}_{11}$:Dorset dam effect	-2.71	-4.04	1.33	1.038
$\hat{\beta}_{12}$:X-bred dam effect	1.47	2.42	-.95	0.772
$\hat{\beta}_{13}$:Rambouillet dam effect	1.14	1.72	-.58	0.728
Face color: $\hat{\beta}_2$				
$\hat{\beta}_{21}$:White-faced effect	-.97	-2.21	1.24	0.837
$\hat{\beta}_{22}$:Black-faced effect	0.97	2.21	-1.24	0.837
Type of birth: $\hat{\beta}_3$				
$\hat{\beta}_{31}$:Single effect	2.33	2.61	-.28	1.181
$\hat{\beta}_{32}$:Twin effect	-2.33	-2.61	0.28	1.181
Sex: $\hat{\beta}_4$				
$\hat{\beta}_{41}$:Female effect	-.74	-2.49	1.75	1.194
$\hat{\beta}_{42}$:Male effect	0.74	2.49	-1.75	1.194
Type of rearing: $\hat{\beta}_5$				
$\hat{\beta}_{51}$:Single effect	2.42	2.01	0.41	0.522
$\hat{\beta}_{52}$:Twin effect	-2.42	-2.01	-.41	0.522
Age of dam: $\hat{\beta}_6$				
$\hat{\beta}_{61}$:Under 18 mo. effect	-2.92	-5.61	2.69**	1.190
$\hat{\beta}_{62}$:18 to 24 mo. effect	1.38	0.48	0.90	0.819
$\hat{\beta}_{63}$:Over 24 mo. effect	1.54	5.13	-3.59**	0.878

**$P < .01$

[a]Sources of variation associated with 70-day weights.

[b]The difference between the spring and fall, significance indicating possible season by associated variable interaction.

[c]A source of influence common to every lamb and is the average 70-day weight in both seasons with the effects of the associated variables equalized.

[d]Standard error of the difference between seasons.

presented in Table XIX of the appendix and estimated standard errors of the least squares constants appear in Tables XXV and XXVI of the appendix.

Average 70-Day Weight (Mean)

Results of 70-day weight data are presented in Table IV. Spring-born lambs averaged 59.88 pounds at 70 days of age and fall-born lambs weighed 54.27 pounds at 70 days of age. As with rate of gain from birth to 70 days of age, the difference between seasons (59.88 pounds - 54.27 pounds = 5.61 pounds) was significant ($P < .01$), indicating that lambs at 70 days of age were significantly heavier in the spring than in the fall.

The estimates of adjustment factors ($\hat{\beta}_i$ values) for all associated variables and differences between seasons ($\hat{\beta}_{ij}$ spring - $\hat{\beta}_{ij}$ fall = difference) are presented in Table IV. Also, results of 70-day weight tests of significance, which appear in Table IV, between seasons for adjustment factors agreed closely with results of rate of gain from birth to 70 days of age.

Rate of Gain from 70 Days of Age to Market

The analysis of variance of rate of gain from 70 days of age to market in the spring is presented in Table XV of the appendix while the analysis of variance for fall-born lambs appears in Table XVI of the appendix. Within both seasons, breed of dam, lamb face color, and lamb sex were significantly ($P < .05$) associated with lamb rate of gain from 70 days of age to market. The remaining associated variables did not exhibit significant relationships with rate of gain during this period.

In Table V, sources of variation thought to be associated with lamb rate of gain from 70 days of age to market are listed in column one. In columns two and three of Table V, adjustment factors ($\hat{\beta}_i$ values or least squares constants) appear for both seasons while the standard error of the difference between seasons of these $\hat{\beta}_i$ values appear in column five. Differences between seasons in the adjustment factors and statistical significance of these differences are presented in column four of Table V. The means (μ) in Table V are the average daily gains from 70 days of age to market in both seasons with the effects of the associated variables equalized. Estimated least squares means appear in Table XX of the appendix and estimated standard errors of least squares constants are presented in Tables XXVII and XXVIII of the appendix.

Mean

The estimated least squares mean was the average daily gain from 70 days of age to market weight after the effects of the associated variables were equalized. In the spring, lambs averaged 0.40 pounds per day while in the fall, lambs averaged 0.52 pounds per day. The difference (0.12 pounds per day) between the seasons was significant ($P < .01$) and indicated that lambs in the fall gained more rapidly from 70 days of age to market than lambs in the spring.

Breed of Dam

In both seasons, lambs out of Dorset dams gained the slowest from

TABLE V

MEAN RATES OF GAIN OF SPRING VS FALL LAMBS AND ESTIMATES OF $\hat{\beta}_i$ OF ASSOCIATED VARIABLES FOR RATE OF GAIN FROM 70 DAYS TO MARKET

Sources of Variation[a]	Spring	Fall	Difference[b]	S.E.[d]
Mean (μ)[c]	0.40	0.52	-.12**	0.003
Breed of dam: $\hat{\beta}_1$				
$\hat{\beta}_{11}$: Dorset dam effect	-.027	-.031	0.004	0.011
$\hat{\beta}_{12}$: X-bred dam effect	0.005	0.010	-.005	0.008
$\hat{\beta}_{13}$: Rambouillet dam effect	0.022	0.021	0.001	0.009
Face color: $\hat{\beta}_2$				
$\hat{\beta}_{21}$: White-faced effect	-.009	-.019	0.010	0.037
$\hat{\beta}_{22}$: Black-faced effect	0.009	0.019	-.010	0.037
Type of birth: $\hat{\beta}_3$				
$\hat{\beta}_{31}$: Single effect	0.002	0.004	-.002	0.006
$\hat{\beta}_{32}$: Twin effect	-.002	-.004	0.002	0.006
Sex: $\hat{\beta}_4$				
$\hat{\beta}_{41}$: Female effect	-.017	-.024	0.007	0.014
$\hat{\beta}_{42}$: Male effect	0.017	0.024	-.007	0.014
Type of rearing: $\hat{\beta}_5$				
$\hat{\beta}_{51}$: Single effect	0.015	0.009	0.006	0.007
$\hat{\beta}_{52}$: Twin effect	-.015	-.009	-.006	0.007
Age of dam: $\hat{\beta}_6$				
$\hat{\beta}_{61}$: Under 18 mo. effect	-.055	-.047	-.008	0.015
$\hat{\beta}_{62}$: 18 to 24 mo. effect	0.031	0.024	0.007	0.006
$\hat{\beta}_{63}$: Over 24 mo. effect	0.024	0.023	0.001	0.011

**$P < .01$

[a]Sources of variation associated with rate of gain from 70 days to market.

[b]The difference between the spring and fall, significance indicating possible season by associated variable interaction.

[c]A source of influence common to every lamb and is the average rate of gain with the effects of the associated variables equalized.

[d]Standard error of the difference between seasons.

70 days of age to market while lambs born to Rambouillet ewes gained the fastest. Lambs from crossbred dams gained at rates intermediate to lambs out of either Dorset or Rambouillet dams. But in no instance was the difference between seasons significant and thus, no breed of dam by season interaction was detected.

Lamb Face Color

Within both seasons, black-faced lambs gained significantly ($P < .05$) faster than did white-faced lambs from 70 days of age to market. However, the difference between seasons was nonsignificant. This was evidence to indicate that the same lamb face color to lamb rate of gain relationships existed in both seasons and thus, the same face color adjustment factors could be used in both seasons.

Type of Birth

Type of birth was not significantly associated with rate of gain from 70 days of age to market within either season and the difference between seasons for the adjustment factors ($\hat{\beta}_i$ values) was also nonsignificant. This was evidence indicating no season by type of birth interaction. However, in both seasons, single-born lambs gained slightly faster from 70 days of age to market than did twin-born lambs.

Lamb Sex

Lamb sex within both seasons was significantly ($P < .05$) associated with rate of gain from 70 days of age to market. Male lambs gained more rapidly in both the spring and fall than females. However, no sex by season interaction was detected in that differences in adjustment factors ($\hat{\beta}_i$ values) between seasons were nonsignificant.

Type of Rearing

Type of rearing was not significantly related to lamb rate of gain from 70 days of age to market in either season and when differences between seasons were determined, none were significant. This was evidence to suggest that no type of rearing by season interaction existed and thus, the same type of rearing adjustment factors could be used for both seasons.

Age of Dam

Within both seasons, age of dam was nonsignificantly associated with rate of gain from 70 days of age to market. However, some trends were evident. Within both seasons, lambs born to ewes under 18 months of age gained the slowest while lambs out of older ewes (18 to 24 months old and over 24 months old) gained the fastest.

The differences between seasons for all three age of dam classifications were nonsignificant, suggesting no detectable season by age of dam interactions.

Atmospheric temperature may have been an important factor contributing to rates of gain from 70 days of age to market. Lambs born in the fall were normally fed during the winter months and attained market weight before the onset of hot weather. The feeding period from 70 days of age to market for spring-born lambs was normally during the summer months. Thus, warmer temperatures may have depressed the gain of lamb fed during the summer.

CHAPTER V

SUMMARY

A comparison was made between all fall and spring-born lambs at the Fort Reno Livestock Research Station born from 1964 through 1968 inclusive. The comparison was made in an effort to determine if lambs performed differently in the two seasons and also to determine if sources of variation associated with lamb performance were of equal intensity in both seasons. Spring-born and fall-born lambs were compared on the basis of birth weight, rate of gain from birth to 70 days of age, 70-day weight and rate of gain from 70 days of age to market. In the spring, lambs were born from March 15 to May 15 each year while in the fall the lambing season ran from September 15 to November 15 each year.

Birth Weight

Spring-born lambs were significantly ($P < .01$) heavier at birth than fall-born lambs. Spring-born lambs were 2.07 pounds heavier than fall-born lambs and the standard error of this difference was 0.068 pounds. For the associated variables, lamb face color, breed of dam, type of birth, condition at birth and lamb sex, no associated variable differences between seasons were detected. However, for all three age of dam classifications, the differences between seasons were either significant or approached significance. These differences suggested that age of dam was associated with lamb birth weight differently in the two seasons [age of dam by season interactions indicated]. Lambs born to dams under 18 months of age in the spring were 0.394 pounds lighter than the average spring-born lamb while fall-born lambs were 1.353 pounds lighter than the average fall-born lamb. The difference of 0.959 pounds ± 0.223 pounds [standard error] was significant ($P < .01$). Lambs born to ewes 18 to 24 months old in the spring were 0.082 pounds lighter at birth than the average spring-born lamb while fall-born lambs were 0.226 pounds lighter than the average fall-born lamb. The difference between seasons [-.308 pounds difference ± 0.185 pounds] was nonsignificant. Spring-born lambs born to dams over 24 months of age were 0.476 pounds heavier than the average spring-born lamb while fall-born lambs were 1.127 pounds heavier than the average fall-born lamb. The difference between seasons [0.476 pounds - 1.127 pounds = -.651 pounds ± 0.160 pounds] was significant ($P < .01$). The differences between seasons for the various ages of dams suggested that different age of dam adjustment factors could be used for the two seasons for dams under 18 months and dams over 24 months old.

Rate of Gain from Birth to 70 Days of Age and 70-Day Weight

Results of analyses of rate of gain from birth to 70 days of age and 70-day weight data were very similar. Spring-born lambs gained 0.72 pounds per day and fall-born lambs gained 0.67 pounds per day from birth to 70 days of age. The difference between seasons [0.72 pounds per day - 0.67 pounds per day = 0.05 pounds per day ± 0.006] was significant ($P < .01$) and indicated that spring-born lambs gained faster during this growth period than fall-born lambs. Spring-born lambs were also significantly (P< .01) heavier at 70 days of age than fall-born lambs. The difference between seasons for lamb 70-day weights [59.88 pounds - 54.27 pounds = 5.61 pounds ± 0.214 pounds] was significant (P< .01).

Several associated variables appeared to be related to rate of gain from birth to 70 days of age and lamb 70-day weight differently in the two seasons [season by associated variable interactions suggested]. The differences between seasons for the associated variable dams under 18 months old were significant (P< .05) for both rate of gain from birth to 70 days of age and lamb 70-day weight. Spring-born lambs out of dams under 18 months old gained 0.006 pounds per day less than the average spring-born lamb while fall-born lambs gained 0.056 pounds per day less than the average fall-born lamb. The difference between the two seasons [0.050 pounds per day difference ± 0.025 pounds per day] indicated that different age of dam [under 18 months old] adjustment factors could be used for the two seasons. Spring-born lambs out of dams under 18 months of age weighed 2.92 pounds less at 70 days of age than the average spring-born lamb while fall-born lambs from dams under 18 months old weighed 5.61 pounds less at 70 days of age than the average fall-born lamb. The difference between seasons for lamb 70-day weights [2.69 pounds difference ± 1.19 pounds] indicated that different age of dam [under 18 months old] adjustment factors could be used to more accurately compare lambs in the two seasons on the basis of 70-day weight.

The differences between seasons for the associated variable dams over 24 months old were also significant (P< .05) for both rate of gain from birth to 70 days of age and 70-day weight. Spring-born lambs from dams over 24 months old gained slightly faster [0.009 pounds per day faster] than the average spring-born lamb and fall-born lambs from dams over 24 months old also gained faster [0.058 pounds per day faster] than the average fall-born lamb. The difference between seasons [-.042 pounds per day difference ± 0.020 pounds per day] for rate of gain from birth to 70 days of age was significant (P< .05), suggesting that different age of dam [over 24 months old] adjustment factors could be used when comparing lambs in the two seasons. Spring-born lambs out of dams over 24 months old were 1.54 pounds heavier at 70 days of age than the average spring-born lamb while fall-born lambs were 5.13 pounds heavier at 70 days of age than the average fall-born lamb. The difference in 70-day weights between the two seasons [-3.59 pounds difference ± 0.878 pounds] for lambs from dams over 24 months old was significant (P< .05) and indicated that different age of dam [over 24 months old] adjustment factors could be used to compare lambs in the two seasons on the basis of 70-day weight.

All remaining associated variables appeared to be related to rate of gain from birth to 70 days of age and 70-day weight the same in both seasons. Thus, the same associated variable adjustment factors could be used for lambs in both seasons.

Rate of Gain from 70 Days of Age to Market

Spring-born lambs gained 0.40 pounds per day while fall-born lambs gained 0.52 pounds per day. The difference between rates of gain in the two seasons [-0.12 pounds per day difference ± 0.003 pounds per day] was significant (P< .01) and indicated that fall-born lambs gained faster from 70 days of age to market than spring-born lambs. However, differences between seasons for all associated variable adjustment factors were nonsignificant. This was evidence suggesting that the same associated variable adjustment factors could be used for lambs in the two seasons for each associated variable considered.

Thus, the results from this study indicate that for most of the associated variables considered, the same adjustment factors could be used for both spring-born and fall-born lambs.

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APPENDIX

TABLE VI

OBSERVATION MATRIX: NUMBER OF OBSERVATIONS IN EACH CLASSIFICATION FOR BIRTH WEIGHT

	μ	A_1	A_2	A_3	B_1	B_2	C_1	C_2	D_1	D_2	F_1	F_2	G_2	G_3	G_4	H_1	H_2	H_3
	1584	306	683	595	847	737	776	808	475	1109	1100	484	156	487	941	180	187	1217
A_1		306	0	0	142	164	152	154	107	199	208	98	49	103	154	41	60	205
A_2			683	0	356	327	321	362	181	502	464	219	55	190	438	94	76	513
A_3				595	349	246	303	292	187	408	428	167	52	194	349	45	51	499
B_1					847	0	411	436	232	615	635	212	99	235	513	107	72	668
B_2						737	365	372	243	494	465	272	57	252	428	73	115	549
C_1							776	0	234	542	542	234	71	241	464	84	98	594
C_2								808	241	567	558	250	85	246	477	96	89	623
D_1									475	0	285	190	44	423	8	116	74	285
D_2										1109	815	294	112	64	933	64	113	932
F_1											1100	0	90	306	704	86	138	876
F_2												484	66	181	237	94	49	341
G_2													156	0	0	38	8	110
G_3														487	0	104	80	303
G_4															941	38	99	804
H_1																180	0	0
H_2																	187	0
H_3																		1217

μ = overall mean; A_1 = Dorset; A_2 = X-bred; A_3 = Rambouillet; B_1 = black face; B_2 = white face; C_1 = male; C_2 = female; D_1 = single born; D_2 = twin born; F_1 = spring; F_2 = fall; G_2 = dead; G_3 = single, alive; G_4 = twin, alive; H_1 = dams under 18 mo.; H_2 = dams 18 to 24 mo.; H_3 = dams over 24 mo.

TABLE VII

OBSERVATION MATRIX: NUMBERS IN EACH CLASSIFICATION FOR
70-DAY WEIGHT AND GROWTH FROM BIRTH TO 70-DAYS

	μ	A_1	A_2	A_3	B_1	B_2	C_1	C_2	D_1	D_2	F_1	F_2	G_3	G_4	H_1	H_2	H_3
μ	1387	248	610	529	724	663	682	705	416	971	980	407	474	913	138	172	1077
A_1		248	0	0	109	139	126	122	84	162	182	66	100	148	26	52	170
A_2			610	0	308	302	290	320	162	448	416	193	184	426	73	72	465
A_3				529	307	222	266	263	170	359	382	147	190	339	39	48	442
B_1					724	0	348	376	193	531	554	170	227	497	78	65	581
B_2						663	333	330	223	440	426	237	247	416	60	107	496
C_1							682	0	206	475	482	199	234	447	70	91	520
C_2								705	210	496	498	208	240	466	68	81	557
D_1									416	0	255	161	410	6	94	69	253
D_2										971	725	246	64	907	44	103	824
F_1											980	0	300	680	72	130	778
F_2												407	174	233	66	42	299
G_3													474	0	102	77	295
G_4														913	36	95	782
H_1															138	0	0
H_2																172	0
H_3																	1077

μ = overall mean; A_1 = Dorset; A_2 = X-bred; A_3 = Rambouillet; B_1 = black face; B_2 = white face; C_1 = male; C_2 = female; D_1 = single born; D_2 - twin born; F_1 = spring; F_2 = fall; G_3 = single raised; G_4 = twin raised; H_1 = dams under 18 mo.; H_2 = dams 18 to 24 mo.; H_3 = dams over 24 mo.

TABLE VIII

OBSERVATION MATRIX: NUMBERS IN EACH CLASSIFICATION FOR RATE OF GAIN FROM 70-DAYS TO MARKET

	μ	A_1	A_2	A_3	B_1	B_2	C_1	C_2	D_1	D_2	F_1	F_2	G_3	G_4	H_1	H_2	H_3
μ	1319	235	571	513	693	626	640	679	399	920	924	395	457	862	133	155	1031
A_1		235	0	0	104	131	119	116	81	154	169	66	97	138	26	47	162
A_2			571	0	289	282	264	307	151	420	387	183	173	398	68	62	441
A_3				513	300	213	257	256	167	346	368	145	187	326	39	46	428
B_1					693	0	325	368	186	507	525	168	220	473	75	61	557
B_2						626	315	311	213	413	399	227	237	389	58	94	474
C_1							640	0	195	445	448	191	224	416	68	83	489
C_2								679	204	475	476	204	233	446	65	72	542
D_1									399	0	243	156	393	6	91	62	246
D_2										920	681	239	64	856	42	93	785
F_1											924	0	288	636	69	117	738
F_2												395	169	226	64	38	293
G_3													457	0	99	70	288
G_4														862	34	85	743
H_1															133	0	0
H_2																155	0
H_3																	1031

μ = overall mean; A_1 = Dorset; A_2 = X-bred; A_3 = Rambouillet; B_1 = blackface; B_2 = whiteface; C_1 - male; C2 = female; D_1 = single born; D_2 = twin born; F_1 = spring; F_2 = fall; G_3 = single raised; G_4 = twin raised; H1 = dams under 18 mo.; H_2 = dams 18 to 24 mo.; H_3 = dams over 24 mo.

TABLE IX

ANALYSIS OF VARIANCE OF BIRTH WEIGHT OF SPRING-BORN LAMBS

Source	d.f.	M.S.
Total	1100	
Breed of dam	2	250.7048**
Face color	1	32.9349**
Sex	1	105.6354**
Type of birth	1	927.8525**
Condition at birth	1	178.4308**
Age of dam	2	38.29742**
Error	1092	3.1088

**P< .01

TABLE X

ANALYSIS OF VARIANCE OF BIRTH WEIGHT OF FALL-BORN LAMBS

Source	d.f.	M.S.
Total	484	
Breed of dam	2	159.2285**
Face color	1	1.2862
Sex	1	55.0713**
Type of birth	1	301.6787**
Condition at birth	1	73.6331**
Age of dam	2	208.4932**
Error	476	3.3483

**P< .01

TABLE XI

ANALYSIS OF VARIANCE OF RATE OF GAIN FROM BIRTH TO 70 DAYS FOR SPRING-BORN LAMBS

Source	d.f.	M.S.
Total	980	
Breed of dam	2	.3394**
Face color	1	.2729**
Sex	1	.4250**
Type of birth	1	.0119
Type of rearing	1	.8521**
Age of dam	2	.5988**
Error	972	.0721

**P< .01

TABLE XII

ANALYSIS OF VARIANCE OF RATE OF GAIN FROM BIRTH TO 70 DAYS FOR FALL-BORN LAMBS

Source	d.f.	M.S.
Total	407	
Breed of dam	2	.6211**
Face color	1	.7530**
Sex	1	1.4851**
Type of birth	1	.0555
Type of rearing	1	2.7532**
Age of dam	2	1.7300**
Error	399	.0610

**P< .01

TABLE XIII

ANALYSIS OF VARIANCE OF 70-DAY WEIGHT
FOR SPRING-BORN LAMBS

Source	d.f.	M.S.
Total	980	
Breed of dam	2	1146.197**
Face color	1	492.230**
Sex	1	644.010**
Type of birth	1	10.911
Type of rearing	1	13941.500**
Age of dam	2	911.480**
Error	972	80.35

**P< .01

TABLE XIV

ANALYSIS OF VARIANCE OF 70-DAY WEIGHT
FOR FALL-BORN LAMBS

Source	d.f.	M.S.
Total	407	
Breed of dam	2	1154.55**
Face color	1	952.71**
Sex	1	1809.18**
Type of birth	1	17.730
Type of rearing	1	4701.30**
Age of dam	2	5741.19**
Error	399	72.03

**P< .01

TABLE XV

ANALYSIS OF VARIANCE OF RATE OF GAIN FROM 70 DAYS TO MARKET FOR SPRING-BORN LAMBS

Source	d.f.	M.S.
Total	924	
Breed of dam	2	.2133*
Face color	1	.0242*
Sex	1	.2458*
Type of birth	1	.0099
Type of rearing	1	.0033
Age of dam	2	.0086
Error	916	.0113

*P< .05

TABLE XVI

ANALYSIS OF VARIANCE OF RATE OF GAIN FROM 70 DAYS TO MARKET FOR FALL-BORN LAMBS

Source	d.f.	M.S.
Total	395	
Breed of dam	2	.0971*
Face color	1	.0728*
Sex	1	.2040*
Type of birth	1	.0013
Type of rearing	1	.0618
Age of dam	2	.0252
Error	387	.0115

*P< .05

TABLE XVII

ESTIMATED LEAST SQUARES MEANS FOR BIRTH WEIGHT OF LAMBS BORN IN THE FALL AND SPRING

Sources of Variation	Spring Mean	Fall Mean
Overall mean	9.48	7.41
Breed of dam		
Dorset	8.56	6.31
X-bred	10.21	8.28
Rambouillet	9.67	7.64
Face color		
White	9.19	7.19
Black	9.76	7.62
Sex		
Female	9.18	7.05
Male	9.78	7.76
Type of birth		
Single	10.64	8.44
Twin	8.34	6.38
Condition at birth		
Alive	10.46	8.24
Dead	8.50	6.68
Age of dam		
Under 18 mo.	9.09	6.06
18 to 24 mo.	9.40	7.64
Over 24 mo.	9.96	8.54

TABLE XVIII

ESTIMATED LEAST SQUARES MEANS FOR RATE OF GAIN FROM BIRTH TO 70 DAYS IN THE SPRING AND FALL

Sources of Variation	Fall Mean	Spring Mean
Overall mean	0.67	0.72
Breed of dam		
Dorset	0.64	0.71
X-bred	0.69	0.73
Rambouillet	0.68	0.72
Face color		
White	0.65	0.71
Black	0.69	0.73
Sex		
Female	0.65	0.71
Male	0.69	0.72
Type of birth		
Single	0.68	0.73
Twin	0.65	0.71
Type of rearing		
Single	0.69	0.74
Twin	0.67	0.70
Age of dam		
Under 18 mo.	0.63	0.70
18 to 24 mo.	0.67	0.73
Over 24 mo.	0.71	0.73

TABLE XIX

ESTIMATED LEAST SQUARES MEANS FOR 70-DAY WEIGHT FOR SPRING AND FALL-BORN LAMBS

Source of Variation	Fall Mean	Spring Mean
Overall mean	54.27	59.88
Breed of dam		
Dorset	50.13	57.27
X-bred	56.69	61.35
Rambouillet	55.99	61.02
Face color		
White	52.09	58.91
Black	56.48	60.85
Sex		
Female	51.78	59.14
Male	56.76	60.62
Type of birth		
Single	56.88	62.21
Twin	51.66	57.55
Type of rearing		
Single	56.28	62.30
Twin	52.26	57.46
Age of dam		
Under 18 mo.	48.66	56.96
18 to 24 mo.	54.75	61.26
Over 24 mo.	59.40	61.42

TABLE XX

ESTIMATED LEAST SQUARES MEANS FOR RATE OF GAIN FROM 70-DAYS TO MARKET FOR SPRING AND FALL-BORN LAMBS

Sources of Variation	Fall Mean	Spring Mean
Overall mean	0.52	0.40
Breed of dam		
Dorset	0.49	0.37
X-bred	0.53	0.41
Rambouillet	0.54	0.42
Face color		
White	0.50	0.39
Black	0.54	0.41
Sex		
Female	0.50	0.38
Male	0.54	0.42
Type of birth		
Single	0.52	0.40
Twin	0.52	0.40
Type of rearing		
Single	0.53	0.42
Twin	0.51	0.38
Age of dam		
Under 18 mo.	0.47	0.35
18 to 24 mo.	0.54	0.43
Over 24 mo.	0.54	0.42

TABLE XXI

ESTIMATED LEAST SQUARES CONSTANTS [$\hat{\beta}$ VALUES] ASSOCIATED WITH BIRTH WEIGHT OF SPRING-BORN LAMBS

Source	Constants	S.E.
Mean [μ]	9.48	0.144
Breed of dam effect		
Dorset	-.923	0.093
X-bred	0.733	0.054
Rambouillet	0.190	0.070
Face color effect		
White	-.287	0.056
Black	0.287	0.056
Sex effect		
Female	-.303	0.053
Male	0.303	0.053
Type of birth effect		
Single	1.160	0.065
Twin	-1.160	0.065
Condition at birth effect		
Alive	0.982	0.126
Dead	-.982	0.126
Age of dam effect		
Under 18 mo.	-.394	0.076
18 yo 24 mo.	-.082	0.022
Over 24 mo.	0.476	0.096

TABLE XXII

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH BIRTH WEIGHT OF FALL-BORN LAMBS

Source	Constants	S.E.
Mean [μ]	7.41	0.213
Breed of dam effect		
Dorset	-1.101	0.141
X-bred	0.870	0.082
Rambouillet	0.213	0.115
Face color effect		
White	-.211	0.086
Black	0.211	0.086
Sex effect		
Female	-.350	0.084
Male	0.350	0.084
Type of birth effect		
Single	1.030	0.087
Twin	-1.030	0.087
Condition at birth effect		
Alive	0.731	0.205
Dead	-.731	0.205
Age of dam effect		
Under 18 mo.	-1.353	0.138
18 to 24 mo.	0.226	0.190
Over 24 mo.	1.127	0.130

TABLE XXIII

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH RATE OF GAIN FROM BIRTH TO 70 DAYS IN THE SPRING

Source	Constants	S.E.
Mean [μ]	0.72	0.004
Breed of dam effect		
Dorset	-.015	0.004
X-bred	0.011	0.003
Rambouillet	0.004	0.003
Face color effect		
White	-.007	0.002
Black	0.007	0.002
Sex effect		
Female	-.006	0.003
Male	0.006	0.003
Type of birth effect		
Single	0.012	0.007
Twin	-.012	0.007
Type of rearing effect		
Single	0.025	0.006
Twin	-.025	0.006
Age of dam effect		
Under 18 mo.	-.015	0.014
18 to 24 mo.	0.006	0.021
Over 24 mo.	0.009	0.005

TABLE XXIV

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH RATE OF GAIN FROM BIRTH TO 70 DAYS IN THE FALL

Source	Constants	S.E.
Mean [μ]	0.67	0.005
Breed of dam effect		
Dorset	-.031	0.011
X-bred	0.017	0.005
Rambouillet	0.014	0.006
Face color effect		
White	-.019	0.004
Black	0.019	0.004
Sex effect		
Female	-.022	0.013
Male	0.022	0.013
Type of birth effect		
Single	0.016	0.008
Twin	-.016	0.008
Type of rearing effect		
Single	0.020	0.009
Twin	-.020	0.009
Age of dam effect		
Under 18 mo.	-.042	0.012
18 to 24 mo.	0.002	0.008
Over 24 mo.	0.040	0.005

TABLE XXV

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH 70-DAY WEIGHT IN THE SPRING

Source	Constants	S.E.
Mean [μ]	59.88	0.46
Breed of dam effect		
Dorset	-2.61	0.50
X-bred	1.47	0.40
Rambouillet	1.14	0.38
Face color effect		
White	-.97	0.29
Black	0.97	0.29
Sex effect		
Female	-.74	0.28
Male	0.74	0.28
Type of birth effect		
Single	2.33	0.68
Twin	-2.33	0.68
Type of rearing effect		
Single	2.42	0.65
Twin	-2.42	0.65
Age of dam effect		
Under 18 mo.	-2.92	0.62
18 to 24 mo.	1.38	0.65
Over 24 mo.	1.54	0.52

TABLE XXVI

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH 70-DAY WEIGHT IN THE FALL

Source	Constants	S.E.
Mean [μ]	54.27	0.62
Breed of dam effect		
Dorset	-4.14	0.76
X-bred	2.42	0.59
Rambouillet	1.72	0.56
Face color effect		
White	-2.21	0.43
Black	2.21	0.43
Sex effect		
Female	-2.49	0.44
Male	2.49	0.44
Type of birth effect		
Single	2.61	0.94
Twin	-2.61	0.94
Type of rearing effect		
Single	2.01	0.95
Twin	-2.01	0.95
Age of dam effect		
Under 18 mo.	-5.61	1.90
18 to 24 mo.	0.48	0.96
Over 24 mo.	5.13	0.68

TABLE XXVII

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH RATE OF GAIN FROM 70 DAYS TO MARKET IN THE SPRING

Source	Constants	S.E.
Mean [μ]	0.40	0.006
Breed of dam effect		
Dorset	-.027	0.006
X-breed	0.005	0.005
Rambouillet	0.022	0.004
Face color effect		
White	-.009	0.004
Black	0.009	0.004
Sex effect		
Female	-.017	0.003
Male	0.017	0.003
Type of birth effect		
Single	0.002	0.001
Twin	-.002	0.001
Type of rearing effect		
Single	0.015	0.008
Twin	-.015	0.008
Age of dam effect		
Under 18 mo.	-.055	0.009
18 to 24 mo.	0.031	0.008
Over 24 mo.	0.024	0.006

TABLE XXVIII

ESTIMATED LEAST SQUARES CONSTANTS ($\hat{\beta}$ VALUES) ASSOCIATED WITH RATE OF GAIN FROM 70 DAYS TO MARKET IN THE FALL

Source	Constants	S.E.
Mean [μ]	0.52	0.008
Breed of dam effect		
Dorset	-.031	0.010
X-breed	0.010	0.008
Rambouillet	0.021	0.007
Face color effect		
White	-.019	0.006
Black	0.019	0.006
Sex effect		
Female	-.024	0.005
Male	0.024	0.005
Type of birth effect		
Single	0.004	0.002
Twin	-.004	0.002
Type of rearing effect		
Single	0.009	0.013
Twin	-.009	0.013
Age of dam effect		
Under 18 mo.	-.047	0.011
18 to 24 mo.	0.024	0.012
Over 24 mo.	0.023	0.009

VITA

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