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To the Graduate Council:

I am submitting herewith a thesis written by K. Govindan Nambiar entitled "Influence of Sex, Type of Birth and Rearing on Daily Gain of Lambs." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Harold J. Smith
Major Professor

We have read this thesis
and recommend its acceptance:

Charles M. Hobbs

O. Glen Hall

Accepted for the Council:

Dale Wantling
Dean of the Graduate School

INFLUENCE OF SEX, TYPE OF BIRTH AND REARING ON DAILY GAIN OF LAMBS

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

K. Govindan Nambiar

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K. Govindan Nambiar

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CHAPTER I

INTRODUCTION

The variance in the traits of economic importance in sheep is due to genetic differences, tangible environment and also to intangible environment or accident. An accurate estimate of the environmental contribution to these traits is necessary to calculate the heritability of these traits. Both induced and natural environmental factors operate to conceal genetic merit, thereby confusing the breeder and obstructing his efforts to select those animals having the greatest breeding value. In many instances, variation due to environment can be eliminated or controlled but in others only adjustment and correction for major environmental effects are capable of placing animals on a comparable basis. For example, two animals which have equal breeding value may differ widely in phenotype because of differences in time of birth, favorable conditions of development, age of dam, twinning, etc.

A considerable proportion of the error of heritability estimates can be eliminated if proper factors are available to estimate the correct environmental variance. Some of the factors which influence this in case of sheep are type of birth and rearing, age of dam, and years. Information is needed on the extent and magnitude of these effects in order to adjust weaning weight or average daily gain before computing an estimate of heritability or repeatability. In addition, it would be useful in adjusting the average daily gain in an actual breeding program.

The objectives of this study were to evaluate the influence of sex, type of birth and rearing on average daily gain of lambs and to determine correction factors or constants to be used to adjust average daily gain for differences in type of birth and rearing and sex.

CHAPTER II

REVIEW OF LITERATURE

Phillips and Dawson (1939) stated that selection based on phenotypic appearance should be more effective if the effects of environmental factors on selection could be reduced to a minimum. This might be accomplished by (1) eliminating comparison of animals differing in age by making observation at a definite age for all the characteristics upon which selection is based and (2) making allowances for environmental factors which one knows affects any of the characteristics by the use of correction factors. For example, correcting weight at three months of age by the regression coefficients for date of birth and adding the difference in weight of singles and twins to the weight of the twins. These correction factors may vary with breed, climatic conditions and methods of management.

In the selection of breeding animals, single lambs are favored over twins, early lambs over late lambs and lambs heavy at birth over light ones, even though no conscious effort has been made to favor any of these groups.

Several workers have found a positive relationship between birth weight and subsequent weight in the growing period in swine (Cole and Kehlman, 1928; Lush et al., 1931). Kusner (1936) reported a positive correlation between birth weight and weight at 18 months in cattle.

The work of Schneider and Hundt (1932) with sheep as quoted by Phillips (1937) indicated a positive relationship between birth weight

and weight at one year.

Phillips and Dawson (1939) found from their studies that type and time of birth are factors which result in different environments for single and twin lambs or early and late lambs. The data presented by the authors showed that the early lambs developed more rapidly than late ones, even though no genetic differences favoring more rapid development of the single and early groups were known to exist. Therefore, type and time of birth are considered to be environmental in so far as their relation to development and selection is concerned.

Phillips and Dawson (1940) indicated that attention should be given to the effects of non-genetic factors like type of birth and date of birth either by standardizing environmental conditions or by making proper allowance and correction for the effects of such factors in interpreting experimental results. In this study they found that males were significantly heavier than females at birth and the differences tended to become more pronounced with increasing age.

Some data on the growth of sheep in body weight have been reported by Foster (1926), Phillips (1928), Hammond (1932), Bell, Spencer and Hardy (1936) and Phillips and Brier (1940).

Data presented by Phillips and Dawson (1940) showed that twins tend to catch up with singles in the Hampshire, Shropshire and Southdown breeds. While the singles were somewhat heavier on the average at one year of age, the differences were not sufficiently large to be significant with the numbers available for the study. Stoehr (1940) as cited by Phillips et al. (1940) found similar differences between singles and twins

for the Columbia, Corriedale, Rambouillet and Targhee breeds and the twins tended to catch up with the singles but never quite reached the same weight level.

Price et al. (1951) found that type of birth influenced weanling traits more than any other factor studied. Phillips and Dawson (1937) showed differences due to birth type even when weaning weights were adjusted for birth weights. An advantage in birth weight of 20, 22, and 29 per cent for singles over twins was found by Stark (1944), Nelson and Venkatachalam (1949) and Hammond (1952), respectively.

DeBaca et al. (1950) found differences in maturity and growth rate existing between sexes. Weight differences in favor of ram and wether lambs have been demonstrated by Karam et al. (1949), Hazel and Terrill (1945 and 1946) and Phillips and Dawson (1937).

Ragab et al. (1953) studied the phenotypic correlation between birth weight and weaning weight, birth weight and marketing weight and weaning weight and marketing weight and obtained correlations of 0.594, 0.480 and 0.860, respectively. This study showed that the genetic correlation between birth weight and marketing weight was 0.957.

Sidwell (1956) found that age of the dam, sex of the lamb and age of the lamb have an influence on weaning weight. Terrill and Stohr (1939) obtained a highly significant difference in weight of lambs weaned between ewes with single and ewes with twin lambs. The difference varied with years and there was a significant interaction between types of birth and years. This tended to favor selection for single lambs as they were larger and had more weight for age. In crossbred lambs, a greater per

cent of singles than twins reached weaning age, but this was not true for the Navajos. The crossbred twin lambs had a higher death rate than the Navajos. Navajo ewes had a 10 per cent advantage in the number of ewes having twins. Wright and Stevens (1953) reported that ewes born as twins had more multiple births at all ages except at five years of age. Ewes born as singles and twins showed no difference in the average number of lambs raised or born.

Johanson and Hanson (1943) as cited by Rea (1956) concluded that the hereditary part of the total variance within a breed is low, and of the order of about 10 to 15 per cent. Rea (1956) stated that the heritability of prolificacy may be low due to relatively large effects of dominance and epistasis. Hazel and Terrill (1945) found the differences in weaning weight between ram lambs and ewe lambs, single lambs and twin lambs, and lambs from mature ewes and two-year olds were 8.3, 9.2 and 6.1 pounds, respectively. The estimate of heritability of weaning weight was 0.30 $\pm$ 0.04. Ewe lambs, single lambs, and lambs from mature ewes had higher body type and condition scores than the contrasting groups. Ram lambs had more neck folds, and heavier wool on their faces. Phillips et al. (1945) found that measurements on the live, sheared animal had more accuracy in measuring characteristics experimenters might want to study. The most accurate measurements were height at the wither, length from the mid-front of scapula to the pinbones, width of shoulders, depth of chest at the middle and circumference of the fore shank. Blunn (1945) obtained 14.2 per cent for Navajos as compared to 37.4 per cent for crossbreds as the per cent of total variations in weight due to difference between years.

Terrill (1945) observed that ewes which were heavier as yearlings produced more pounds of lambs during their lifetime. A one pound increase in yearling weight of Rambouillet ewes gave a half pound increase in the weaning weight of lambs. Ten pounds additional yearling weight would give an expected 15 pounds increase of lamb produced over the average of the flock during the ewe's first three productive years. Ewes that had a lamb the first year, but did not raise it, averaged 14 more pounds of lamb for each of the next three years than ewes that were barren the first year. Ewes that raised a lamb the first year averaged 16 more pounds of lamb the next three years than ewes that were barren the first year. Ewes with twins the first year, regardless of whether they raised them or not, averaged 19 more pounds the following three years than ewes that were barren the first year.

Botkin et al. (1950) found that ram lambs were 9 pounds heavier than ewe lambs when weaned at 129 days and 15 pounds heavier than ewe lambs when weaned at 202 days. Single lambs were 14 pounds heavier than twin lambs in the group weaned early as compared to 8 pounds for the late group. Twins raised as singles made gains about the same as single lambs. These data indicated that sex differences increase with age. Two-year-old ewes had lower lamb production than mature ewes largely because of less twinning.

DeBaca et al. (1956) stated that birth weight was one of the most influential variables on weaning weight and differences between breeds were partly due to differences in birth weights. They found a regression of 2.5 $\pm$ 0.65 to 5.96 $\pm$ 0.76 pounds increase in weaning weight for each

pound increase in birth weight.

These authors also stated that type of birth had the greatest effect on lamb growth. They found single lambs weighed 17 pounds more at weaning than lambs raised as twins. Estimates were similar in good years and indicated a large proportion of the difference is established at birth. Jamison (1946) found that the breed of ewes did not greatly influence the size of the head or chest circumference. Cossard et al. (1956) found that twins had larger chest depth than singles but were smaller in other measurements. The offspring of two-year-old ewes were not significantly different in their measurements as compared to lambs from mature ewes. Terrill (1951) obtained greater progress in improvement of weaning traits by sire selection than from selection of dams.

According to Chapman and Lush (1932) approximately 25 to 30 per cent of the variance in the birth weights of lambs is due to genetic differences, 30 to 35 per cent tangible environment and 40 to 45 per cent to intangible environment or accident. Phillips et al. (1940) stated that the influence of type of birth may enable the single lamb to develop more rapidly than the twin lambs, possibly because the single lamb generally starts off with an advantage in growth and vigor over the twin lamb. Twin lambs enter into intrauterine competition for nourishment and room to grow. Time of birth, birth weight and sex behave as environmental factors. Approximately 30 per cent of the differences in birth weights are attributed to genetic influences. Seventy per cent of the differences in later weight are associated with differences in birth weight.

Kincaid (1943) found an average increase of 0.63 pounds in the birth weight of lambs as the age of ewes increased from two to six years. No significant deviation from linearity was found. Lambs sired by Hampshire rams averaged 1.05 pounds heavier at birth than lambs sired by Southdown rams. This difference was highly significant. He also reported that lambs at birth from the same ewes were 1.15 pounds heavier at the third lambing than they were at the first lambing. There was less difference between the first and third lambings with ewes that had lambed first as yearlings compared with ewes lambing first at 10 to 12 months of age. Kincaid also stated that 7.8 per cent of the variation in lamb birth weights was due to breed of sire.

Nelson and Venketachalam (1949) reported that the birth weights of males were 5 per cent heavier than females, lambs from mature ewes were 10 per cent heavier than lambs from two-year-old ewes and single lambs at birth were 22 per cent heavier than twins. At weaning the differences were 6, 5, and 17 per cent, respectively. Estimates were obtained for each breed and then combined for a weighted average.

According to Bogart and Hedrick (1955) as cited by DeBaca (1958) lamb growth is linear up to 135 days of age and a correction for weight was made to 120 days of age using the following formula: Corrected weight (120 days) = $\frac{\text{(Actual weight - birth weight)}}{\text{Actual age in days}}$ 120 + birth weight.

Karam et al. (1949) studied the effects of type of birth (single or twin), sex, year, flock and sire on body weight at 25 weeks of age, daily gain from birth to market weight, daily gain on feed, type and condition using data from 437 lambs raised in farm flocks. These lambs

were sired by 23 rams, leased to 13 commercial lamb producers during the period 1944-1947. For body weight at 25 weeks and daily gain from birth to market weight, single lambs were 6.2 pounds heavier and gained 0.02 pound faster, respectively, than twin lambs and wether lambs were 3.5 pounds heavier and gained 0.02 pound faster, respectively, than ewe lambs. These differences were highly significant statistically. Since type of birth, sex, year and flock had highly significant effects on nearly all characteristics studied, it was suggested that adjustment for them should be made before comparing lambs from different sires under such conditions.

Phillips (1940) stated that weight at a constant age up to twenty weeks can be estimated more accurately along the slope of the growth curve in the vicinity of that age, than by the use of estimated average weekly gain. He suggested the following formula as the most accurate:

$$\frac{Z\ (20^{*} - A)}{(X - A)} = Y$$

where Y = estimated weight
Z = actual weight
A = age intercept
X = actual age

*20 (constant age) varies for age being used.

Kean and Henning (1949) found males to be 0.6 pounds heavier at birth than females and singles 1.4 pounds heavier than twin lambs. The average birth weight of all lambs was 8.5 pounds and single lambs gained 0.15 of a pound more per day than twins. The average daily gain of all lambs slaughtered was 0.53 pound. Males gained 0.03 of a pound more than the females. This was not a significant difference. They stated there tends to be a correlation between birth weight and average daily gain. Sidwell and Grandstaff (1949) obtained 59.4 pounds as the average unadjusted weaning weight at approximately 139 days with a standard

deviation of 9.8 pounds. Year of birth, age of dam, breeding of sire, type of birth, type of rearing, sex and age of lambs at weaning were the important environmental factors which affected the weaning weight of lambs. Two-year-old ewes weaned the smaller lambs and four to seven-year-olds the heaviest; while the three-year-olds and eight to eleven-year-old groups weaned the intermediate lambs. Single lambs were 11.2 pounds heavier than twins raised as singles to weaning time. Ewe lambs weighed 4.4 pounds less at weaning than ram lambs. The per cent of lambs weaned in proportion to the ewes bred was definitely higher for ewes from four to nine years old than ewes from two to three years old.

Blackwell and Henderson (1955) found that the differences associated with years, age of dam, age of lamb, sex and type of birth and rearing were important sources of variation in weaning weights in the Corriedale, Hampshire and Shropshire breeds. Year of birth, age of dam, sex and type of birth affected birth weight significantly in all breeds. In addition to weaning weight and birth weight data, in the Dorsets the season of birth was an additional source of variation. Age of dam was found to have no significant effect on the weaning weight of Dorset lambs. Breed differences were large for all traits concerned.

Sidwell and Grandstaff (1949) showed that in Navajo lambs 56 per cent of the variance in weaning weight was due to the measurable environmental factors in comparison with 49.5 per cent reported by Hazel and Terrill (1945) for Rambouillet lambs.

Blackwell and Henderson (1955) used the following formulae in adjusting for weaning and birth weights. Weaning weight = general mean +

breed + year + sex of lamb + type of birth and rearing + age of dam + age of lamb at weaning + random element peculiar to the weight of each lamb. Birth weight = general mean + breed + year + sex of lamb + type of birth + age of dam + random element peculiar to the birth of each lamb. The relationship between age of ewes and the weight of their lambs was curvilinear for the Corriedales, Hampshires and Shropshires. The linear and quadratic regressions were 0.71 and -0.06 pound per year, respectively, for all breeds. A positive linear regression line was found to fit the Dorset birth weight data best at 0.57 pound per day.

Hazel and Terrill (1946) studied the effects of sex, age of dam, type of birth, age at weaning and per cent inbreeding on weaning weight using data from 478 Columbia, 238 Corriedale and 366 Targhee lambs reared in 1941-42 at the U. S. Sheep Experiment Station, Dubois, Idaho. They found that the differences in weaning weight between ram lambs and ewe lambs from mature and two-year-old dams and single and twin lambs were 10.8, 8.7, and 11.7 pounds, respectively. Ewe lambs, lambs from mature dams and single lambs had larger staple length and were given higher type and condition scores than the contrasting groups. Face covering and neck folds were not strongly influenced by any of the factors. Merit in each of the traits increased with age at weaning. Inbreeding had a noticeably detrimental effect upon weaning weight, body type and condition but not upon length of staple.

Bogart et al. (1957) found that type of birth constituted the most consistent effect on birth weight. Singles were from 1.92 $\pm$ 0.68 to 2.40 $\pm$ 0.60 pounds heavier at birth than twins. The difference between

the birth weight of ram and ewe lambs was consistent. The trend in all cases was for ram lambs to be heavier; however, significance resulted in only one of four analyses. Interactions between type of birth and sex were inconsistent and unimportant.

Torell et al. (1956) reported the results of a three-year study which showed that the average live weight at weaning in Suffolk x Corriedale wether and ewe lambs was higher than that of purebred Suffolk wether and ewe lambs by 8.0 and 6.5 pounds, respectively; the difference being statistically significant at the 1 per cent level. Wether lambs were heavier than the ewe lambs in both the crossbred and purebreds, the difference in weaning weight being 5.5 and 3.0 pounds, respectively.

Donald and Purser (1955) studied the birth weights of 822 pairs of twin lambs with respect to the difference between males and females. Data were obtained during five lambing seasons from various breeds and crosses in five flocks. The sex distribution of twin pairs came close to the ratio 1 ♂♂: 2 ♂♀: 1 ♀♀. Analyses made within season and within major breed categories showed that sex differences were small relative to other sources of variation but that there was a significant effect of sex of co-twin on birth weight. The following average differences were found (the sex of co-twin being indicated in brackets): male (female) - female (male), 0.566 pound; male (male) - female (female), 0.270 pound; female (female) - male (female), 0.128 pound; and male (female) - male (male), 0.177 pound. These differences had an average standard error of 0.078 pound. The sex difference of male-female in litters of mixed sex was twice as large as obtained from like-sex

litters. The data for particular flocks and seasons suggests that in addition to these average effects, there may be some interaction between sex and breed or season which can cause deviation from the average. These results were interpreted to mean that there is competition between twins for some element of growth in limited supply and for the twins of mixed sex, the results tend to favor the males.

Judin and Brigis (1956) reported the results of a series of experiments carried out at the stud farm, Kara-kum, and they showed that ewes producing a high per cent of elite and first class lambs at first lambing produce a higher per cent of such lambs at subsequent lambing when mated with the same ram as at first mating than when they are mated with other rams.

Carter et al. (1957) adjusted data for differences due to type of birth (single or multiple), type of rearing (single or twin), sex (ewe or wether) and year of birth by conventional least square methods. The various observations on each lamb were adjusted to a single, male, 1953 birth year basis for analysis. In this study no adjustment was made for differences due to age of dam since it was desired to estimate the effect of age on the relative performance of the different kind of ewes.

The adjustment factors for various environmental effects on average daily gain were as follows:

Adjustment	Average daily gain
1951 to 1953	.139
1952 to 1953	.054
1953	.000

Adjustment	Average daily gain
1954 to 1953	.066
1955 to 1954	.039
Twins to single	.075
Ewes to wether	.047

Estimate of the mean in this study was 0.582 pound.

Kincaid and Carter (1953) reported that the differences among the performance of lambs during the years 1947-1949 were not significant. Since the sexes were divided approximately equally in the offspring of the different ewe groups, no corrections were made for sex.

In this study singles gained 0.07 of a pound faster than twins and this difference was significant. This correction factor was used to adjust the data to a single lamb basis.

Felts (1958), in order to obtain estimates of genetic and phenotype parameters necessary for the construction of an index for sheep, worked out constants for age of dam and type of birth effects. The constants for age of dam effects were -15.7, -1.9, 3.6, 4.5, 4.8,3.1 and 1.6 for ewes from one to seven years of age. The constants for type of birth effects were obtained by pooling the within flock year differences between constants. They were 7.9, -2.3, 1.9, 2.8, -1.7, and 3.2 for the following type of birth classifications for 120-day lamb weight: male single; female single; female twin raised as twin; female twin raised as a single; male twin raised as twin; and male twin raised as a single.

CHAPTER III

PROCEDURE

Source of Data

The data used in this study were obtained from the records of sheep flocks maintained by the Plateau Experiment Station, Crossville and the Middle Tennessee Experiment Station, Spring Hill. Complete data for both stations for all years from 1952 through 1958 were available for 1372 lambs.

Data were available for 545 lambs from native, California, Northwestern and Southwestern ewes for the years 1952 through 1957 and for lambs from Suffolk x Rambouillet ewes and grade Rambouillet ewes for 1958 at the Plateau Experiment Station, Crossville. Records were available for 827 lambs from native (S_1), California (S_2) and Northwestern (S_3) ewes for the years 1952 through 1957, Northwestern (S_4) ewes for the years 1953 through 1957, native mixed breeding (S_{1A}), native mixed breeding (S_5), and Southwestern (S_6) ewes for years 1955 through 1957 and Southwestern (S_7) ewes for the year 1957 at the Middle Tennessee Experiment Station, Spring Hill.

The lambs at Crossville included in this study were from six kinds of ewes: California, Northwestern, Southwestern, native, Suffolk x Rambouillet and grade Rambouillet. Ewes of native breeding were bred first as yearlings in 1951. There were originally 21 ewes in the Northwestern and native groups and 35 ewes in the California group. California and Northwestern ewes were bred first as yearlings in 1951.

The Northwestern ewes originated in Montana and were mostly black-face ewes of Hampshire x Rambouillet breeding. The California ewes were largely brown or mottled-faced ewes of Hampshire x Rambouillet breeding and were obtained from shipment of ewes originating in California. The native ewes were primarily black-face ewes of Hampshire x native breeding and were produced from light, late lambs raised on the station, grown out and bred as yearlings. The Southwestern ewes were grade Rambouillet ewes. These and the Suffolk x Rambouillet ewes originated in Texas. The native (S_1), California (S_2), Northwestern (S_3) and Southwestern (S_6) ewes which produced the lambs at Spring Hill were similar in breeding to the ewes at Crossville. Native (S_1) ewes were purchased as large, early, growthy ewe lambs in 1951. Native (S_{1A}) ewes were of mixed breeding, produced on the station and these ewes lambed first in 1955. Northwestern ewes designated as S_4 were of the same breeding as S_3 ewes (HxR) but these ewes were bred first as yearlings in the summer of 1952 and lambed in 1953. S_5 ewes of mixed breeding which were produced on the station and lambed first in 1956. S_7 ewes were of Suffolk x Rambouillet breeding and lambed first in 1957.

During the first three years included in this study (1951 through 1953) the ewes at both locations were bred in single sire groups. Individual groups for each ram were used the entire breeding season of approximately 90 days in 1951. In 1952 rams were in individual ewe groups for about 53 days at Spring Hill and for 90 days at Crossville. In 1953 the rams were in individual ewe groups 50 days at Spring Hill and 48 days at Crossville.

All ewes and rams were run together for the remainder of the breeding season. In order to try to prevent breeding failures because of "shy breeding" rams in individual ewe groups, two rams were used in each breeding group during the remainder of the years included in this study (1954-1958).

At the Plateau Experiment Station, Crossville, all sources of ewes were allotted for breeding in the summer of 1954 and following years on the basis of type, weight and breeding into three ram breeding groups. Two rams were used in each ram breeding group because of the difficulty experienced in the past with "shy breeding" rams in single ram groups. The breeding season began about August 1 to 20 and extended for about 90 days.

At the Middle Tennessee Experiment Station all ewes were allotted for breeding in the summer of 1954 and subsequent years into six ram breeding groups of approximately 30-35 ewes per group. Two rams were used in each group. The breeding season at this station began about July 1 and continued for about 90 days.

During the 1956 and 1957 breeding seasons the ewe flocks at both the Middle Tennessee Experiment Station and the Plateau Experiment Station were randomly divided within ewe source and breeding groups into control and teased groups of ewes two weeks before the beginning of the breeding season. Sterile vasectomised rams were run with the teased groups of ewes for two weeks preceding the breeding season. As a result average lambing dates were one to two weeks earlier in teased groups of ewes than in control groups.

Feeding and Management

All ewes at the Plateau Experiment Station were culled if they failed to lamb two years in succession or two out of three years and for various physical defects. Ewes at the Middle Tennessee Experiment Station were handled in a similar manner. The ewes were bred to lamb primarily in December, January and February. All lambs were docked and male lambs castrated at one to two weeks of age. They were left with their dams on a winter pasture of small grain or rye grass and crimson clover or other permanent pastures for approximately five months. The lambs were weighed at birth and every 28 days afterwards. They were weaned as they reached approximately 80 pounds in weight and marketed directly off their dams. The ewes were dried up by placing them on poor permanent pasture, usually consisting of Bermuda and bluegrass. They were kept in good thrifty condition, free from parasites and then placed on good clean pasture two weeks prior to breeding. Good quality legume hay was used to supplement pasture when needed and some grain was fed from two to four weeks before and after lambing. If the weather permitted, the ewes were sheared from mid-April to mid-May. They were tagged approximately two weeks before the lambing season began, and before breeding, if needed.

Analysis of Data

Average daily gain for each lamb was computed from birth to approximately 120 days of age. In most cases 120-day weights fell within the period which included the last two weeks in May and the first week in June.

The growth rate of lambs from birth to weaning is essentially linear where adverse environmental conditions do not affect growth during the later part of the growing season. Conditions are usually nearly optimum for maximum growth up to about the first week in June at the two locations included in this study. After this time, hot weather and other adverse conditions severely hamper lamb growth. The inclusion of growth data after this date would tend to give early lambs an undue advantage over late-born lambs.

The average daily gains of males and females were calculated for the following types of birth and rearing: (1) male born as twin with co-twin female and reared as a twin, (2) female born as a twin with co-twin male and reared as a twin, (3) male twins born and reared as twins, (4) female twins born and reared as twins, (5) male born as twin and reared as single, (6) female born as twin and reared as single, (7) male born and reared as single and (8) female born and reared as single. Average daily gains for each of these classifications were calculated on a weighted average basis because of the unequal subclass numbers for different types of birth and rearing. The only exception was that for male and female twins born and reared as co-twins where the males and females were equal in number. The average daily gains for the first two classifications were calculated on a within ewe basis. An average was computed for each breed type for all years at each location. An overall average was then computed by pooling the data from both locations.

Average daily gains of males and females for classifications 3-8 and the differences between them were calculated on a weighted average

basis since the number of males and females in these classifications each year was not equal. For this purpose, the lambs were classified on a within year basis for each breed type. Data for males and females were excluded where male and female comparisons were not available within years. Weighted averages for average daily gain were calculated for all breed types at each location and then combined for both locations.

The formula applied to calculate the weighted average was $\frac{n_1 \, n_2}{n_1 + n_2}$, wherein n_1 is the number of males and n_2 is the number of females within year and breed type of ewe. Differences between the males and females for the various types of birth and rearing were determined from these weighted averages.

In order to derive correction factors to place all males and females for different types of birth and rearing on a comparable basis (male born and reared single) the average daily gain of males born and reared as singles was divided by the respective average daily gains for males and females for different types of birth and rearing.

Statistical analyses of the applicable data were according to techniques described by Snedecor (1956).

CHAPTER IV

RESULTS AND DISCUSSION

The average daily gains of lambs from birth to approximately 120 days of age were examined in this study according to the following types of birth and rearing: (1) male born as twin with co-twin female, (2) female born as twin with co-twin male, (3) male born as twin with co-twin male and reared as such, (4) female born with co-twin female and reared as such, (5) male born as twin with co-twin either male or female but raised as single male, (6) female born as twin with co-twin either male or female but raised as single female, (7) male born as single and reared as single and (8) female born and raised as single. The differences among various combinations of these classifications were also determined in order to derive correction factors to be applied for different types of birth and rearing for both males and females to adjust the average daily gain of lambs to an equivalent basis (male lamb born and raised as a single).

The detailed average daily gains for each breed type at the two locations, Crossville and Spring Hill, for all years are presented in Appendix Tables I-XIV. The means and standard errors for the average daily gains of different breed types along with the average differences are given in Table I and II. The summary for the combined data at both locations is presented in Table III.

A significant difference was observed between the average daily gains of the males and females born and reared as co-twins (Table III).

The average daily gains of male and female co-twins were .509 ± .008 and .457 ± .008 pound respectively, with a difference of .052 ± .008 pound. No information is available in the literature relative to the difference between the average daily gains of males and females classified according to this type of birth and rearing. This difference indicates that the male grows faster than the female and this difference is a permanent feature, irrespective of the genetic constitution.

There was a significant difference of .033 ± .005 pound between the average daily gains of like sex twins (MM - FF) born and reared as such. The average daily gains of male lambs born and reared as twins (MM) and female lambs born and reared as twins (FF) were .533 ± .003 and .500 ± .006 pound, respectively. There is no information available in the literature concerning the average daily gains of lambs classified according to these types of birth and rearing and the difference between them.

The average daily gains of male and female lambs born twin but raised single were .574 ± .016 and .504 ± .052 pound, respectively (Table III). The difference of .070 ± .016 pound was statistically highly significant. This difference between the growth rate of the sexes was more than the difference obtained in other comparisons. This difference was also more than the difference between male and female lambs which were born and raised single. The reasons for this greater difference are not apparent from the data. The difference between male and female lambs which were born and raised single would be expected to be as great as the difference between males and females of other types of birth and rearing. This difference was not due to a faster rate of gain in case of males

TABLE I

WEIGHTED AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS ACCORDING TO TYPE OF BIRTH BY BREED TYPES AT THE PLATEAU EXPERIMENT STATION, CROSSVILLE

Breed types	Unlike sex co-twins born and raised (M-F)		Like sex twins born and raised (MM-FF)		Born twin but raised as single		Born and raised as single	
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)
Native (Hampshire)								
Male	15	.418 ± .027	12	.538 ± .033	8	.537 ± .041	24	.527 ± .016
Female	15	.433 ± .041	12	.470 ± .016	4	.435 ± .022	25	.512 ± .021
Difference (M-F)		-.015 ± .035		.068 ± .026		.102 ± .032		.015 ± .019
California (H x R)								
Male	23	.495 ± .018	20	.534 ± .022	9	.561 ± .028	27	.531 ± .022
Female	23[a]	.448 ± .018	14	.510 ± .022	7	.430 ± .039	25	.482 ± .006
Difference (M-F)		.047 ± .018		.024 ± .022		.131 ± .034		.049 ± .014
Northwestern (H x R)								
Male	12	.572 ± .022	18	.527 ± .016	4	.442 ± .075	11	.630 ± .119
Female	12[a]	.499 ± .015	26	.475 ± .012	3	.531 ± .016	14	.578 ± .032
Difference (M-F)		.073 ± .019		.052 ± .014		-.089 ± .046		.052 ± .075
Southwestern (grade Rambouillet)								
Male	11	.457 ± .013	12	.468 ± .028	1	.548 ± .050	25	.557 ± .024
Female	11	.443 ± .031	18	.480 ± .021	5	.558 ± .072	22	.552 ± .020
Difference (M-F)		.014 ± .023		-.012 ± .025		-.010 ± .061		.005 ± .022

[a]One female born as triplet omitted from the study and remaining number of lambs is given.

TABLE I (CONTINUED)

WEIGHTED AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS ACCORDING TO TYPE OF BIRTH BY BREED TYPES AT THE PLATEAU EXPERIMENT STATION, CROSSVILLE

Breed types	Unlike sex co-twins born and raised (M-F)		Like sex twins born and raised (MM-FF)		Born twin but raised as single		Born and raised as single	
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)
Suffolk x Rambouillet								
Male	3	.422 ± .023	----	----	1	.429	16	.461 ± .024
Female	3	.369 ± .066	2	.340 ± .030	3	.408 ± .033	15	.437 ± .012
Difference (M-F)		.053 ± .049				.021 ± .033		.024 ± .018
Grade Rambouillet								
Male	----	----	----	----	----	----	12	.464 ± .014
Female	----	----	----	----	1	.443	10	.394 ± .017
Difference (M-F)		----		----	----	----		.070 ± .016
Total								
Male	64	.473 ± .012	62	.516 ± .005	32	.533 ± .022	115	.528 ± .011
Female	64	.438 ± .012	72	.485 ± .028	23	.479 ± .024	111	.499 ± .010
Difference (M-F)		.035 ± .012		.031 ± .017		.054 ± .023		.029 ± .011

TABLE II

WEIGHTED AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS ACCORDING TO TYPE OF BIRTH BY BREED TYPES AT THE MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

Breed types	Unlike sex co-twins born and raised (M-F)		Like sex twins born and raised (MM-FF)		Born twin but raised as single		Born and raised as single	
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)
S_1 - Native (Hampshire)								
Male	18	.558 ± .013	28	.560 ± .015	8	.674 ± .054	35	.618 ± .015
Female	18	.510 ± .021	18	.474 ± .015	6	.588 ± .037	41	.554 ± .012
Difference (M-F)		.048 ± .017		.086 ± .015		.086 ± .045		.064 ± .014
S_{1A}- Native (Mixed Breeding)								
Male	1	.317	-	-	1	.531	8	.599 ± .044
Female	1	.407	-	-	-	-	10	.527 ± .031
Difference (M-F)		-.090	-	-		-		.072 ± .038
S_2 - California (H x R)								
Male	17[a]	.553 ± .020	14	.541 ± .024	7	.582 ± .039	28	.619 ± .023
Female	17	.503 ± .018	24	.538 ± .028	5	.554 ± .036	44	.547 ± .016
Difference (M-F)		.050 ± .019		.003 ± .026		.028 ± .038		.072 ± .020
S_3 - Northwestern (H x R)								
Male	22[a]	.544 ± .019	30	.549 ± .012	9	.634 ± .067	46	.644 ± .013
Female	22	.482 ± .019	32	.506 ± .008	6	.493 ± .055	29	.610 ± .016
Difference (M-F)		.062 ± .019		.043 ± .010		.041 ± .061		.054 ± .020

[a]One male born in triplet omitted from this study and remaining number is given.

TABLE II (CONTINUED)

WEIGHTED AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS ACCORDING TO TYPE OF BIRTH BY BREED TYPES AT THE MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

Breed types	Unlike sex co-twins born and raised (M-F)		Like sex twins born and raised (MM-FF)		Born twin but raised as single		Born and raised as single	
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)
S_4 - Northwestern (H x R)								
Male	13[a]	.616 ± .033	16	.536 ± .015	3	.602 ± .021	25	.678 ± .010
Female	13	.523 ± .036	18	.547 ± .013	4	.581 ± .041	29	.594 ± .010
Difference (M-F)		.093 ± .035		-.011 ± .014		.021 ± .031		.084 ± .010
S_5 - Native (Mixed Breeding)								
Male	3	.540 ± .036	2	.480 ± .007	-	-	12	.560 ± .039
Female	3	.405 ± .066	4	.470 ± .016	1	.544	16	.556 ± .023
Difference (M-F)		.135 ± .051		.010 ± .063		-		.004 ± .031
S_6 - Southwestern (grade Rambouillet)								
Male	8	.455 ± .090	8	.582 ± .063	-	-	30	.573 ± .020
Female	8	.426 ± .018	2	.461 ± .012	4	.459 ± .011	32	.531 ± .013
Difference (M-F)		.029 ± .054		.121 ± .038		-		.042 ± .017
S_7 - Suffolk x Rambouillet								
Male	1	.528	4	.423 ± .038	-	-	9	.582 ± .020
Female	1	.450	2	.521 ± .091	-	-	8	.554 ± .034
Difference (M-F)		.078		-.098 ± .064		-		.028 ± .017

[a]One male born in triplet omitted from this study and remaining number is given.

TABLE II (CONTINUED)

WEIGHTED AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS ACCORDING TO TYPE OF BIRTH BY BREED TYPES AT THE MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

Breed types	Unlike sex co-twins born and raised (M-F)		Like sex twins born and raised (MM-FF)		Born twin but raised as single		Born and raised as single	
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)
Total								
Male	83	.544 ± .010	102	.543 ± .002	28	.628 ± .019	193	.620 ± .008
Female	83	.475 ± .010	100	.510 ± .009	26	.537 ± .018	209	.563 ± .006
Difference (M-F)		.069 ± .010		.033 ± .006		.091 ± .019		.057 ± .007

TABLE III

WEIGHTED AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS ACCORDING TO TYPE OF BIRTH AND REARING FOR COMBINED DATA AT THE PLATEAU AND MIDDLE TENNESSEE EXPERIMENT STATIONS

	Unlike sex co-twins born and raised (M-F)		Like sex twins born and raised (MM-FF)		Born twin but raised as single		Born and raised as single	
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)
Male	147[a]	.509 ± .008	164	.533 ± .003	60	.574 ± .016	308	.586 ± .021
Female	147[b]	.457 ± .008	172	.500 ± .006	49	.504 ± .015	320	.539 ± .005
Difference (M-F)		.052 ± .008		.033 ± .005		.070 ± .016		.047 ± .013

[a]Three males omitted from this study and remaining number is given. Each was born in triplets.

[b]Two females omitted from this study and remaining number is given. Each was born in triplets.

born twin and reared single as compared to males which were born and raised single (.574 ± .016 and .586 ± .021 pound, respectively). However, the average daily gain of females born twin but raised single was .504 ± .015 pound as compared to .539 ± .005 pound for female lambs which were born and raised single. One possible explanation may be the difference in birth weight of male and female lambs born as twins or singles. Phillips and Dawson (1940) have shown a significant relationship between birth weight and subsequent growth rate. They stated:

> Early male lambs survive better than late ones. The difference between the early and late female lambs is in the same direction but is too small to be significant. Lambs born early in the season are heavier at three months of age than late lambs. Male lambs that are heavy at birth survive better than light ones. A higher percentage of heavy females survive also, but the difference is not statistically significant.

Observation of data included in this study indicate that many of the females born twin and raised as single were late lambs; whereas, many of the males born twin and reared single were early lambs. Donald and Purser (1955) found that the greatest differences in birth weight of lambs born as twins existed between male (female) - female (female); i.e., .270 of a pound. Since birth weight influences subsequent growth and average daily gain, this may also provide a possible explanation for the greater difference in daily gain between male and female lambs which are born twin and raised single than between male and female lambs which are born and reared as singles. Average daily gains of male and female lambs irrespective of the type of birth and rearing are shown in Table IV. The average daily gain for males was .542 ± .004 pound and .491 ± .004 pound for females with a difference of .051 ± .004 pound. Kean and

TABLE IV

AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR MALE AND FEMALE LAMBS BORN AND RAISED AS SINGLES

Location	Male		Female		Difference (M-F)
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	Av. daily gain (pound)
P.E.S., Crossville	273	.533 ± .006	270	.490 ± .005	.043 ± .006
M.T.E.S., Spring Hill	406	.543 ± .006	688	.490 ± .005	.053 ± .006
Weighted average for both locations	679	.542 ± .004	688	.491 ± .004	.051 ± .004

Henning (1949) obtained daily gains of .54 and .51 pound for male and female lambs, respectively, but the difference between them was not significant. In this study the difference between average daily gains of males and females of .051 ± .004 pound was highly significant. The estimate of the mean in the study by Kean and Henning (1949) was .53 as compared to .517 in this study. A total of 1367 lambs (679 males and 688 females) were available in this study compared to 787 lambs (423 males and 364 females) in the study by Kean and Henning (1949).

Carter et al. (1957) found a difference of .047 pound between the average daily gains of ewe and wether lambs. The estimate of the mean in their study was .582 pound as compared to .517 pound in this study.

The average daily gains of twins and singles irrespective of sex are presented in Table V. The average daily gain for twins was .500 ± .001 pound and the average daily gain for singles was .560 ± .004 pound. The difference was .060 ± .003. This is in close agreement with the value reported by Carter et al. (1957) for the difference between twins and singles of .075 pound. Kean and Henning (1949) obtained average daily gains of .45 and .60 pound, respectively, for twins and singles. Their data included 317 twins and 443 singles as compared to 630 twins and 737 singles in this study.

The average daily gains of lambs born as twins but raised as singles and lambs born and raised as singles are given in Table VI. The difference was only .023 ± .012 pound (.539 ± .011 pound for lambs born as twins and .562 ± .004 pound for lambs born and raised as singles). This is in agreement with the findings of Botkin et al. (1956). He stated that weaning weights of lambs born twin but raised

TABLE V

AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR SINGLE AND TWIN LAMBS

Location	Single		Twin		Difference
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	(Single minus twin) (pound)
P.E.S., Crossville	281	.512 ± .007	262	.479 ± .005	.033 ± .066
M.T.E.S., Spring Hill	456	.600 ± .002	368	.518 ± .001	.082 ± .002
Weighted average for both locations	737	.560 ± .004	630	.500 ± .001	.060 ± .003

TABLE VI

AVERAGE DAILY GAINS, STANDARD ERRORS AND DIFFERENCES FOR LAMBS BORN TWIN AND RAISED SINGLE AND LAMBS BORN AND RAISED SINGLE

Location	Born twin and raised single (1)		Born and raised single (2)		Difference (2 - 1)
	No.	Av. daily gain (pound)	No.	Av. daily gain (pound)	(pound)
P.E.S., Crossville	55	.506 ± .017	226	.513 ± .007	.007 ± .012
M.T.E.S., Spring Hill	54	.538 ± .015	402	.592 ± .005	.009 ± .010
Weighted average for both locations	109	.539 ± .011	628	.562 ± .004	.023 ± .012

single were very similar to those of lambs born and raised as singles. However, Sidwell and Grandstaff (1949) reported a deviation of 4.7 pounds from the mean weaning weight for singles and 1.80 pounds for twins raised as singles.

The results of this study show that single lambs grow more rapidly than lambs reared as twins and male lambs more rapidly than female lambs even though no genetic differences favoring more rapid growth of single and male lambs are known to exist. Therefore, sex and type of birth and rearing are considered to be environmental in so far as their relationship to development and selection are concerned. The correction factors derived from this study to be applied to adjust lamb records to a single male lamb basis are presented in Table VII. These factors were derived from data presented in Table III for males and females for the various types of birth and rearing. The average daily gain of .586 for males born and reared as singles was used as a base. The correction factors are 1.151, 1.282, 1.099, 1.172, 1.021, 1.163 and 1.087 for (1) males born twin with co-twin female, (2) females born twin with co-twin male, (3) male born twin and raised with co-twin male, (4) female born and raised with like sex co-twin female, (5) male born as twin and raised as single, (6) female born as twin and raised as single and (7) female born and raised as single. The average daily gains of male and female lambs in the various categories would be multiplied by the respective factors to adjust gains to a comparable basis (male born and reared as a single).

TABLE VII

CORRECTION FACTORS FOR ADJUSTING AVERAGE DAILY GAIN OF LAMBS FROM BIRTH TO WEANING FOR SEX, TYPE OF BIRTH AND REARING

Sex	Multiply daily gain by the following to adjust to a single male lamb born and raised: Born and raised as unlike sex twin	Born and raised as like sex twin	Born twin and raised as single	Born and raised as single
Male	1.151	1.099	1.021	1.000
Female	1.282	1.172	1.163	1.087

Correction factors are necessary to place performance records on a comparable basis so that environmental variance is eliminated and the remaining variance can be attributed to genetic differences. Use of correction factors permits adjustment of records so that selection in sheep in an actual breeding program becomes more accurate and as a consequence animals with greater genetic worth are selected for breeding and propagation. This would bring about greater progress in the improvement of animals in the traits concerned than selection based upon uncorrected or unadjusted data.

CHAPTER V

SUMMARY AND CONCLUSION

The data from 1,372 lambs of different breed types for the years 1952-1958 at the Plateau Experiment Station, Crossville, and Middle Tennessee Experiment Station, Spring Hill, were analyzed in this study.

The average daily gains of lambs from birth to approximately 120 days for the following types of birth and rearing were examined in this study: (1) male born as twin with co-twin female and raised as such, (2) female born as twin with co-twin male and raised as such, (3) male born twin with co-twin male and raised as such, (4) female born twin with co-twin female and reared as such, (5) male born as twin with co-twin either male or female but reared as single male, (6) female born as twin with co-twin either male or female but raised as single female, (7) male born and raised as single and (8) female born and raised single. Average differences among various types of birth and rearing were determined. Correction factors to adjust average daily gains of lambs to a comparable basis (male born and reared as a single) were also determined.

The weighted average daily gains within breed type and location for the various types of birth and rearing were .500 $\pm$ .008, .457 $\pm$ .008, .533 $\pm$ .003, .500 $\pm$ .006, .574 $\pm$ .016, .504 $\pm$ .015, .586 $\pm$ .021, and .539 $\pm$ .005 pound, respectively.

The weighted differences between the average daily gains of males and females within breed type and location according to different types of birth and rearing were .052 $\pm$ .008, .033 $\pm$ .005, .070 $\pm$ .016 and

.047 ± .013 pound, respectively. These differences were significant and indicate that males grow faster than females even though there are no genetic differences existing between them.

The difference between the average daily gains of male and female lambs irrespective of the type of birth and rearing was .051 ± .004 pound with average daily gains for males and females of .542 ± .004 and .491 ± .004, respectively. This difference was also significant.

The difference between average daily gains of twins and singles was .060 ± .003 pound with average daily gains for twins and singles of .500 ± .001 and .560 ± .004 pound, respectively. This difference was significant and indicates that singles grow faster than twins.

The average daily gains of lambs born as twins but raised as singles and lambs born and raised as singles were .539 ± .011 and .023 ± .004 pound, respectively, with a nonsignificant difference of .023 ± .012 pound. This indicates that the growth rate of lambs born twin but raised as single is very similar to that of lambs born and raised as singles.

The correction factors derived in this study to adjust average daily gains to a comparable basis (male born and reared as a single) for the following types of birth and rearing were, respectively: (1) male born twin with co-twin female, 1.151; (2) female born twin with co-twin male, 1.282; (3) male born twin and raised with co-twin male, 1.099; (4) female born twin and raised with co-twin female, 1.172; (5) male born as twin and raised as single, 1.021; (6) female born as twin and raised as single, 1.163; and (7) female born and raised as single, 1.087.

The results obtained in this study indicate the importance and magnitude of environmental effects including type of birth and rearing and sex on performance records (average daily gain). Correction factors are necessary to eliminate environmental influences and to place performance records on a comparable basis. Adjustment of performance records for environmental influences should increase the accuracy of evaluation and selection and lead to more rapid progress in breeding programs.

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APPENDIX

TABLE I

AVERAGE DAILY GAINS OF LAMBS FROM NATIVE EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT THE PLATEAU EXPERIMENT STATION, CROSSVILLE

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1952	Number	4	4	4	-	2	-	6	3		
	Av. daily gain, lb.	.370	.279	.359	-	.507	-	.490	.459	.030	.024
1953	Number	2	2	4	2	2	1	3	5		
	Av. daily gain, lb.	.447	.553	.478	.474	.612	.398	.478	.551	.149	-.073
1954	Number	2	2	-	4	1	-	5	3		
	Av. daily gain, lb.	.411	.488	-	.503	.602	-	.576	.484	.072	.045
1955	Number	-	-	-	-	-	-	2	2		
	Av. daily gain, lb.	-	-	-	-	-	-	.518	.459	-	.059
1956	Number	4	4	-	4	2	3	3	6		
	Av. daily gain, lb.	.383	.366	-	.417	.693	.468	.499	.487	.095	-.002
1957	Number	3	3	4	2	2	-	5	6		
	Av. daily gain, lb.	.480	.478	.599	.466	.693	-	.578	.583	.081	.039
Average for all years, lb.		.418	.433	.479	.465	.577	.433	.423	.504	.080	.032

TABLE II

AVERAGE DAILY GAINS OF LAMBS FROM CALIFORNIA EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT THE PLATEAU EXPERIMENT STATION, CROSSVILLE

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1952	Number	1	1	2	-	-	1	7	9		
	Av. daily gain, lb.	.218	.174	.369	-	-	.250	.431	.374	.108	.053
1953	Number	5	5	2	2	1	-	10	8		
	Av. daily gain, lb.	.566	1525	.546	.516	.462	-	.550	.543	.065	.048
1954	Number	6	6	4	2	4	2	5	3		
	Av. daily gain, lb.	.527	.497	.607	.490	.531	.456	.622	.520	.020	.075
1955	Number	5	5	6	4	2	2	2	2		
	Av. daily gain, lb.	.532	.477	.512	.519	.633	.461	.610	.501	.030	.132
1956	Number	4	4	4	4	1	1	1	3		
	Av. daily gain, lb.	.491	.469	.468	.432	.595	.321	.612	.554	.045	.025
1957	Number	2	2	2	2	1	1	2	-		
	Av. daily gain, lb.	.633	.546	.608	.662	.595	.321	.641	-	-.015	.037
Average for all years, lb.		.495	.448	.518	.524	.536	.389	.578	.498	.042	.062

TABLE III

AVERAGE DAILY GAINS OF LAMBS FROM NORTHWESTERN EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT PLATEAU EXPERIMENT STATION, CROSSVILLE

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1952	Number	-	-	-	4	2	1	2	4		
	Av. daily gain, lb.	-	-	-	.412	.442	.531	.550	.444	.054	.057
1953	Number	2	2	6	8	1	-	2	4		
	Av. daily gain, lb.	.545	.476	.529	.474	.683	-	.627	.645	.144	.041
1954	Number	4	4	2	6	1	-	3	2		
	Av. daily gain, lb.	.534	.502	.584	.514	.328	-	.588	.509	-.007	.031
1955	Number	2	2	4	2	-	2	1	2		
	Av. daily gain, lb.	.566	.504	.461	.414	-	.579	.704	.538	.011	.026
1956	Number	3	3	4	4	-	-	-	1		
	Av. daily gain, lb.	.509	.470	.534	.486	-	-	-	.658	.175	-.016
1957	Number	1	1	2	2	-	-	3	1		
	Av. daily gain, lb.	.708	.542	.509	.481	-	-	.774	.841	.153	.089
Average for all years, lb.		.572	.499	.523	.464	.484	.555	.649	.606	.124	.038

TABLE IV

AVERAGE DAILY GAIN OF LAMBS FROM SOUTHWESTERN EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT PLATEAU EXPERIMENT STATION, CROSSVILLE

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1955	Number	2	2	2	-	1	-	8	7		
	Av. daily gain, lb.	.426	.419	.374	-	.527	-	.505	.546	.118	-.044
1956	Number	1	1	4	2	4	2	9	5		
	Av. daily gain, lb.	.503	.477	.475	.396	.434	.435	.553	.548	.057	.018
1957	Number	2	2	4	8	3	2	5	4		
	Av. daily gain, lb.	.472	.537	.553	.557	.730	.738	.747	.630	.166	.054
1958	Number	6	6	2	8	2	1	3	6		
	Av. daily gain, lb.	.425	.340	.321	.422	.450	.478	.454	.481	.078	.001
Average for all years, lb.		.457	.443	.431	.458	.535	.550	.561	.551	.105	.007

TABLE V

AVERAGE DAILY GAIN OF LAMBS FROM SUFFOLK X RAMBOUILLET EWES ACCORDING TO TYPE OF BIRTH AND REARING FOR THE YEAR 1958 AT PLATEAU EXPERIMENT STATION, CROSSVILLE

	1958	
	Number	Average daily gain (pound)
Unlike sex co-twins born and raised		
Male	3	.422
Female	3	.369
Like sex twins born and raised		
Male	-	-
Female	2	.340
Born twin but raised single		
Male	1	.429
Female	3	.408
Born and raised single		
Male	16	.461
Female	15	.437
Single minus twins		.063
Male minus female		.038

TABLE VI

AVERAGE DAILY GAIN OF LAMBS FROM GRADE RAMBOUILLET EWES ACCORDING TO TYPE OF BIRTH AND REARING FOR THE YEAR 1958 AT PLATEAU EXPERIMENT STATION, CROSSVILLE

	1958	
	Number	Average daily gain (pound)
Unlike sex co-twins born and raised		
Male	-	-
Female	-	-
Like sex twins born and raised		
Male	-	-
Female	-	-
Born twins but raised single		
Male	-	-
Female	-	-
Born and raised single		
Male	12	.464
Female	10	.394
Single minus twins		-
Male minus female		.070

TABLE VII

AVERAGE DAILY GAIN OF LAMBS FROM NATIVE (S_1) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1952	Number	0	-	4	-	-	2	8	8		
	Av. daily gain, lb.	-	-	-	-	-	.556	.618	.531	.082	-
1953	Number	4	4	4	4	1	2	4	6		
	Av. daily gain, lb.	.592	.537	.634	.473	.612	.574	.643	.603	.072	.053
1954	Number	2	2	10	6	1	-	6	15		
	Av. daily gain, lb.	.555	.469	.529	.476	.362	-	.585	.543	.023	.036
1955	Number	6	6	6	4	2	2	4	6		
	Av. daily gain, lb.	.573	.506	.560	.461	.715	.597	.693	.558	.088	.094
1956	Number	4	4	6	4	2	-	5	4		
	Av. daily gain, lb.	.559	.588	.545	.484	.769	-	.605	.584	.040	.083
1957	Number	2	2	2	-	2	-	8	2		
	Av. daily gain, lb.	.513	.450	.487	-	.679	-	.558	.517	.076	.088
Average for all years, lb.		.558	.510	.551	.474	.627	.576	.617	.556	.064	.067

TABLE VIII

AVERAGE DAILY GAIN OF LAMBS FROM NATIVE MIXED (S_{1A}) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1955	Number	1	1	-	-	-	-	4	4		
	Av. daily gain, lb.	.317	.407	-	-	-	-	.545	.535	.0178	-.010
1956	Number	-	-	-	-	-	-	3	2		
	Av. daily gain, lb.	-	-	-	-	-	-	.586	.465	-	.121
1957	Number	-	-	-	-	1	-	1	4		
	Av. daily gain, lb.	-	-	-	-	.531	-	.753	.599	-	.043
Average for all years, lb.		.600	.407	-	-	.531	-	.628	.533	.178	.051

TABLE IX

AVERAGE DAILY GAIN OF LAMBS FROM CALIFORNIA (S_2) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1952	Number	-	-	-	2	1	1	6	10		
	Av. daily gain, lb.	-	-	-	.510	.455	.581	.598	.443	-.007	.122
1953	Number	2	2	2	4	1	-	3	8		
	Av. daily gain, lb.	.558	.520	.647	.535	.791	-	.619	.649	.095	.034
1954	Number	5	5	4	2	1	3	7	12		
	Av. daily gain, lb.	.530	.474	.577	.541	.620	.572	.592	.546	.056	.024
1955	Number	2	2	4	4	2	-	6	5		
	Av. daily gain, lb.	.582	.528	.499	.575	.626	-	.655	.503	.049	.063
1956	Number	5	5	2	8	1	1	2	6		
	Av. daily gain, lb.	.554	.504	.499	.539	.652	.497	.769	.638	.121	.038
1957	Number	3	3	2	4	1	-	4	3		
	Av. daily gain, lb.	.540	.487	.515	.481	.659	-	.549	.636	.088	.022
Average for all years, lb.		.553	.503	.547	.530	.634	.550	.630	.569	.067	.053

TABLE X

AVERAGE DAILY GAINS OF LAMBS FROM NORTHWESTERN (S_3) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1952	Number	4	4	-	4	3	1	16	6		
	Av. daily gain, lb.	.581	.450	-	.483	.666	.312	.658	.581	.123	.144
1953	Number	2	2	8	2	2	1	6	1		
	Av. daily gain, lb.	.571	.552	.597	.568	.629	.649	.668	.632	.066	.024
1954	Number	4	4	10	8	1	1	5	10		
	Av. daily gain, lb.	.595	.506	.546	.496	.660	.566	.624	.569	.048	.049
1955	Number	1	1	-	8	2	1	9	5		
	Av. daily gain, lb.	.571	.447	-	.471	.588	.505	.685	.633	.169	.129
1956	Number	5	5	4	6	1	2	2	4		
	Av. daily gain, lb.	.481	.503	.511	.488	.628	.475	.759	.632	.142	.019
1957	Number	6	6	8	4	-	-	8	3		
	Av. daily gain, lb.	.464	.436	.559	.502	-	-	.643	.678	.157	.051
Average for all years, lb.		.544	.482	.553	.501	.634	.501	.673	.621	.119	.070

TABLE XI

AVERAGE DAILY GAINS OF LAMBS FROM NORTHWESTERN (S_4) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1953	Number	-	-	2	2	1	-	6	4		
	Av. daily gain, lb.	-	-	.573	.523	.549	-	.700	.730	.152	-.012
1954	Number	3	3	6	6	1	-	9	8		
	Av. daily gain, lb.	.540	.478	.537	.527	.620	-	.634	.547	.064	.062
1955	Number	3	3	8	8	1	2	2	6		
	Av. daily gain, lb.	.745	.622	.526	.567	.602	.581	.649	.608	.026	.007
1956	Number	5	5	-	-	-	-	4	5		
	Av. daily gain, lb.	.608	.468	-	-	-	-	.719	.454	.034	.321
1957	Number	2	2	-	2	-	2	4	6		
	Av. daily gain, lb.	.572	.523	-	.516	-	.540	.712	.651	.116	.078
Average for all years, lb.		.616	.523	.545	.533	.590	.561	.683	.600	.079	.091

TABLE XII

AVERAGE DAILY GAINS OF LAMBS FROM NATIVE MIXED (S_5) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1956	Number	1	1	-	2	-	1	4	11		
	Av. daily gain, lb.	.468	.318	-	.420	-	.544	.536	.549	.135	.064
1957	Number	2	2	2	2	-	-	8	5		
	Av. daily gain, lb.	.593	.491	.480	.470	-	-	.583	.562	.068	.042
Average for all years, lb.		.540	.405	.480	.445	-	.544	.560	.556	.102	.053

TABLE XIII

AVERAGE GAIN OF LAMBS FROM SOUTHWESTERN (S_6) EWES ACCORDING TO TYPE OF BIRTH AND REARING BY YEARS AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

		Unlike sex co-twins born and raised		Like sex twins born and raised		Born twins and raised single		Born and raised single		Single minus twin	Male minus female
		Male	Female	Male	Female	Male	Female	Male	Female		
1955	Number	1	1	-	-	-	-	10	15		
	Av. daily gain, lb.	.437	.354	-	-	-	-	.580	.517	.146	.060
1956	Number	1	1	2	-	-	1	11	13		
	Av. daily gain, lb.	.437	.451	.539	-	-	.457	.563	.543	.057	.020
1957	Number	6	6	6	2	-	3	9	4		
	Av. daily gain, lb.	.492	.474	.582	.461	-	.461	.579	.534	.034	.069
Average for all years, lb.		.455	.426	.561	.461	-	.459	.574	.531	.079	.050

TABLE XIV

AVERAGE DAILY GAIN OF LAMBS FROM SOUTHWESTERN (S_7) EWES ACCORDING TO TYPE OF BIRTH AND REARING FOR THE YEAR 1957 AT MIDDLE TENNESSEE EXPERIMENT STATION, SPRING HILL

	1957	
	Number	Average daily gain (pound)
Unlike sex co-twins born and raised		
Male	1	.528
Female	1	.450
Like sex twins born and raised		
Male	4	.423
Female	2	.521
Born twins but raised single		
Male	-	-
Female	-	-
Born and raised single		
Male	9	.582
Female	8	.554
Single minus twins		.105
Male minus female		-.007