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Evaluation of the performance of grade and crossbred ewes

Gerhard R. Eisele

To the Graduate Council:

I am submitting herewith a thesis written by Gerhard R. Eisele entitled "Evaluation of the performance of grade and crossbred ewes." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Husbandry.

Robert R. Shrode, Major Professor

We have read this thesis and recommend its acceptance:

S. A. Griffin, R. L. Murphree, G. M. Merriman

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 10, 1968

To the Graduate Council:

I am submitting herewith a thesis written by Gerhard R. Eisele entitled "Evaluation of the Performance of Grade and Crossbred Ewes." 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.

Robert R. Shrode
Major Professor

We have read this thesis and recommend its acceptance:

R. L. Murphree

Sumner C. Griffin

George M. Merriman

Accepted for the Council:

Hilton A. Smith
Vice President for
Graduate Studies and Research

EVALUATION OF THE PERFORMANCE OF GRADE AND CROSSBRED EWES

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Gerhard R. Eisele

June 1968

DEDICATION

This thesis is dedicated to Alfons and Marie Eisele whose love, knowledge, understanding and financial aid have made this graduate study possible. The author will always be greatly indebted to them.

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ABSTRACT

Data from 924 lambs were analyzed by least-squares technique to compare the performance of grade, mixed and crossbred ewes. Birth weight was significantly influenced ($P<.01$) by sex, type of birth, breeding of lamb and age of dam. Lambs whose breeding involved more breeds were heavier than lambs of grade and mixed breeding. Lambs from ewes over three years of age were heavier than lambs from ewes three years old and younger.

Weight of lambs at 120 days was significantly influenced ($P<.01$) by sex, breed of dam, breeding of lamb, type of birth and rearing and age of dam. Male lambs were heavier than females and lambs born and raised as singles surpassed lambs born as twins, whether raised as singles or as twins. Ewes 4 years old and older produced the heaviest lambs followed by 3-, 2- and 1-year-old dams. Lambs from crossbred ewes were heavier than lambs from grade ewes and ewes of mixed breeding.

Analyses of average daily gain, weaning weight and condition score gave results similar to those obtained from the analyses of the other variables studied. Effect of sex on condition score was not significant.

From these data it can be concluded that: (1) the performance of crossbred lambs excelled that of grade or mixed breeding (breed composition not precisely known) in all traits studied, (2) lambs

from crosses involving more breeds exceeded lambs from crosses involving fewer breeds, and (3) crossbred ewes surpassed ewes of grade and mixed breeding with respect to all traits studied.

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INTRODUCTION

One of the major breeding systems used today in commercial sheep flocks is crossbreeding. A reason for this type of breeding is to produce a flock which will be superior for lamb and wool production to that of the parent breeds. The breed of sire as well as the breeding of the ewe are important influences on the performance of the offspring.

Purebred flocks are maintained for the production of breeding animals which in turn are used by the commercial breeder to upgrade his flock. Thus, it is essential that we have purebred, grade and crossbred flocks in the sheep industry.

The objective of the present study was to evaluate and compare the performance of lambs from specific crosses and dams with respect to: (1) birth weight, (2) weaning weight, (3) average daily gain, (4) 120-day weight, and (5) condition score.

CHAPTER I

LITERATURE REVIEW

One of the early workers to evaluate crossbreeding of ewes was Miller (1935) at the California Experiment Station. He used Rambouillet ewes bred to Hampshire, Shropshire, Southdown, Suffolk, Romney and Rambouillet rams. The lambs sired by Hampshire and Suffolk rams grew more rapidly than lambs sired by Shropshire and Southdown rams. The larger rams (Hampshire and Suffolk) sired lambs that were heavier at birth and weighed more at approximately 3 1/2 to 4 months of age by 6 pounds (2.72 kg.) and 8 pounds (3.63 kg.), respectively. When final weights were adjusted to an equal-age basis, lambs from crossbred ewes weighed approximately 4 pounds (1.82 kg.) more than lambs from Rambouillet ewes. The Suffolk rams sired lambs having the highest weaning weight. Lambs from the Romney-Rambouillet ewes excelled in daily gains when compared to the Rambouillet lambs. However, in a comparison of dams, the Rambouillet ewes were superior to the Romney-Rambouillet ewes in earliness of both breeding and lambing (21 days earlier).

Leveck (1947) conducted work at the Mississippi Agricultural Experiment Station with native southern Mississippi ewes which were first crosses from Corriedale, Hampshire and Southdown rams. He reported that lambs sired by Southdown and Hampshire rams graded one-third of a market grade higher than lambs sired by Corriedale

rams and two-thirds of a grade higher than lambs sired by native rams. Lambs sired by Corriedale and Hampshire rams gained faster than lambs sired by Southdown rams.

Miller and Daily (1951) reported that Columbia and Hampshire ewes had a slightly higher lambing percentage when they were bred to a ram of another breed. Hampshire, Border Leicester and Columbia rams bred to Rambouillet ewes produced the fastest growing lambs. When the Shropshire, Hampshire and Columbia ewes were mated to rams of another breed, they produced lambs which were heavier at birth and had higher livability than the purebreds. This greater number of crossbred lambs born alive per ewe for the Hampshire and Columbia crosses led these authors to suggest a possible heterotic effect.

Sidwell, Everson and Terrill (1962), working with Hampshire, Shropshire, Southdown and Merino breeds, as well as their crosses, reported that fertility, prolificacy, lamb livability and overall reproductive ability were higher in the crossbred matings than in the purebred matings.

Sidwell, Everson and Terrill examined the possible heterotic effects of different crossbreeding systems. Lambs resulting from mating crossbred rams to purebred ewes surpassed lambs from purebred ewes bred to purebred rams. However, lambs resulting from mating purebred rams to crossbred ewes excelled the lambs from each of the other groups. Thus, the crossbred ewes appeared to contribute more to hybrid vigor than did the crossbred sires. These authors pointed out, however, and cited Terrill (1947) that when crossbreds are

interbred for several generations the hybrid vigor is gradually lost.

Sidwell et al. in their crossbreeding experiments also noted a greater sex effect in crossbreds than in purebreds in that crossbred ram lambs surpassed crossbred ewe lambs in weaning weight by 12.2 percent but that purebred ram lambs weighed only 9 percent more than purebred ewe lambs at weaning. There was an advantage of all crossbred lambs over purebred lambs in weaning weight, birth weight and gain from birth to weaning. When comparing average weaning weights of lambs from purebred ewes to those of lambs of the two-breed cross, three-breed cross and four-breed cross, the crosses had advantages of 5.2 pounds (2.36 kg.), 9.5 pounds (4.31 kg.) and 10.4 pounds (4.72 kg.), respectively.

Neville, Chapman and Pope (1958) reported that Shropshire-sired crossbred lambs were significantly lighter in birth weight and size than Hampshire- and Suffolk-sired lambs. At 120 days the Suffolk and Hampshire crossbred lambs weighed 70.8 pounds (32.1 kg.) and 67.9 pounds (30.8 kg.), respectively, and were significantly heavier than lambs from the Shropshire cross (63.1 pounds - 28.6 kg.). The ewes in this study were obtained from Montana and were of Rambouillet and Columbia breeding.

Carter and Henning (1951) used five purebred breeds of sheep (Merino, Hampshire, Shropshire, Dorset and Southdown) and five crosses (Dorset x Merino, Hampshire x Dorset-Merino, Southdown x Hampshire-Dorset-Merino, Southdown x Dorset-Merino, and Shropshire x Hampshire-Dorset-Merino) to determine if heterosis had an effect on the birth

weight of lambs. It was assumed that heterosis could be measured by the difference in birth weights of the purebred groups compared to the crossbred groups. Adjustments were made for the difference due to years and the numbers involved. The Southdown x Dorset-Merino cross showed a significant increase in birth weight while the Hampshire x Dorset-Merino cross showed a decrease. In conclusion, these authors stated that their data showed little effect of heterosis on birth weight and that the ewe may have a greater influence on this factor than could be accounted for by her contribution to the genotypic make-up of that offspring.

Other authors have also studied heterotic effects of crossbreeding. De Baca et al. (1956) concluded that greater heterosis results when wider crosses are made. Botkin and Paules (1965) found that crossbred ewes had a higher average lambing percent as well as more kilograms of lamb raised per ewe bred than either parent breed. It was concluded that this was a definite heterotic effect. When Suffolk rams were mated to Corriedale ewes, more and heavier lambs were produced than when Corriedale rams were mated to Corriedale ewes. These results agree with those obtained by Sidwell et al. (1962). Rae (1952) reported that lambs from three-breed crosses exceeded lambs from two-breed crosses in birth weight and average daily gain. Sidwell et al. (1962 and 1964) reported similar results; they stated that three-breed crosses out-produced two-breed crosses and that four-breed crosses produced better than three-breed crosses with respect to number and weight of lambs.

De Baca et al. (1956) used a basic flock of Lincoln x Rambouillet ewes bred to Romney, Border Leicester, Cheviot and Hampshire rams. These offspring were then bred to Suffolk and Southdown rams. Lambs sired by Suffolk rams tended to be heavier at weaning than those sired by Southdown rams, although the differences were not significant at a low level of probability. In dam comparison, the fastest growing lambs were produced by Hampshire (Lincoln x Rambouillet) ewes, and this increased growth could be due to the fact that Hampshire ewes may be able to produce more milk.

Bailey, Chapman and Pope (1961) conducted a two-year study using grade Hampshire ewes bred to Columbia, Corriedale, Hampshire and Suffolk rams. The Corriedale-sired lambs at approximately four months of age averaged 3 1/2 pounds (1.59 kg.) lighter than lambs sired by Hampshire, Suffolk or Columbia rams. Lambs sired by Suffolk rams tended to have a heavier carcass than the Columbia and Corriedale crosses, while the straightbred Hampshires were intermediate in carcass weight.

Singh et al. (1967), using Minnesota breeds (Minn. 100, 102, 103, 105, 106 and 107) bred to Hampshire, Suffolk and Minnesota rams, reported that the Suffolk-sired lambs were the heaviest at 100 days. Hampshire and Minnesota 106 lambs were not significantly different from each other, but were significantly lighter than the Suffolk-sired lambs. The crossbreds excelled the purebreds in birth weight and 100-day weight by 4.7 percent and 8.1 percent, respectively.

Price, Sidwell and Grandstaff (1951), studying yearling weight,

type, condition score, staple length, grease fleece weight and clean fleece weight, reported that the Navajo crossbred group was more desirable in all traits except staple length than grade Navajo sheep.

Carter et al. (1957), evaluating four kinds of ewes (Hampshire x Rambouillet, Suffolk x Rambouillet, Whiteface Crossbred type and grade Rambouillet), reported that the Suffolk x Rambouillet crossbred ewes produced the heaviest lambs at birth with the highest daily gain and some advantage in slaughter grade, carcass grade and dressing percentage.

In evaluating data of the present study, it is necessary to take into account the findings in several studies in which the breeding system was not crossbreeding. The following is a review of papers pertinent in this respect.

Type of Birth and Rearing

Phillips and Dawson (1937), working with Southdown lambs, reported that single lambs had a heavier birth weight than twins and that early lambs grew more rapidly than late lambs. These authors reported that at three months of age single lambs were heavier than twin lambs, and lambs that were heavier at birth tended to be heavier at three months of age. From a given birth date, each additional day decreased the average weight advantage of a single-born male by 0.14 pounds (63.50 gm.). Cassard and Weir (1956) stated that early lambs had an advantage in growth rate as well as weight from 70 to 120 days, declining by the 240th day and being unnoticeable in yearlings.

Price, Sidwell and Grandstaff (1953), comparing yearling single ewes and yearling twin ewes raised as twins, observed an advantage of 6.5 pounds (2.95 kg.) for the singles while a 1.47 pounds (0.67 kg.) advantage was observed for singles over twins raised as singles. Rempel et al. (1959), working with several lines of Minnesota ewes and single-cross lambs, reported that with respect to 100-day weight, singles exceeded twins by 8.61 pounds (3.91 kg.), and twins raised as singles weighed 2.45 pounds (1.11 kg.) more than those raised as twins. Similar results were obtained by Miller (1935), Nelson and Venkatachalam (1949), Karam, Chapman and Pope (1949 and 1953). Blackwell and Henderson (1955), Smith and Lidvall (1964), De Baca et al. (1956), Sidwell et al. (1964), Fredericksen, Price and Blackwell (1967), Singh et al. (1967), and others.

Sex of Lamb

Smith and Lidvall (1964) reported that male lambs were 0.41 pounds (185.97 gm.) heavier at birth, gained 0.05 pounds (22.68 gm.) more per day and were 6.18 pounds (2.80 kg.) heavier at 120 days than ewe lambs. Also, lambs born in December and January gained faster and were 2 pounds (0.91 kg.) to 5 pounds (2.27 kg.) heavier at 120 days of age. This is in agreement with Phillips and Dawson (1937), Karam, Chapman and Pope (1961), Bailey, Chapman and Pope (1961), Harrington, Whiteman and Morrison (1958), Botkin (1955), Blackwell and Henderson (1955), Rempel et al. (1959), Givens, Carter and Gains (1960), Botkin and Paules (1965), Sidwell et al. (1964), and others.

Age of Dam

Price, Sidwell and Grandstaff (1953), studying yearling traits of Navajo and Navajo crossbred ewes, reported that ewes from mature dams were approximately 3 pounds (1.36 kg.) heavier as yearlings than were ewes from two-year-old dams.

Blackwell and Henderson (1955), working with Dorsets, Hampshires, Shropshires and Corriedales reported a curvilinear relation between age of ewe and birth weight and weaning weight of lamb, these weights reaching a maximum when ewes were about five years of age. Smith and Lidvall (1964) reported the birth weight of lambs increased with age of dam up to approximately five years of age and then remained relatively constant to ten years of age.

Sidwell, Everson and Terrill (1964) reported also that lambs from dams three to six years of age were significantly heavier than those from dams seven years old and older or from two-year-old dams. With respect to birth weight, lambs from ewes four years old and older were significantly heavier than lambs from three-year-old ewes. Three-year-old ewes had heavier lambs than two-year-old ewes. Kincaid (1943) found that birth weight of lamb increased as the age of the ewe increased.

Ray and Smith (1966), evaluating body weight of ewes and succeeding lamb production, reported that twin ram lambs were 0.59 and 1.8 kilograms heavier at birth and weaning, respectively, than twin ewe lambs. In this experiment, sex and type of birth exerted the greatest influence on weight. An increase of 1 kilogram in ewe's weight resulted

in a 0.10 kilogram increase in weaning weight of lamb, the heavier ewes (59.5 to 63.6 kg.) producing more kilograms of lamb at weaning than the lighter ewes.

CHAPTER II

EXPERIMENTAL PROCEDURE

The data used in this study were collected over a nine year period, from 1958 to 1966, at the Plateau Experiment Station, Crossville, Tennessee. The total number of lambs included in the analyses was 924 and included only those for which there were complete data on all variables studied.

The following records were obtained from each lamb:

a. Date of birth

b. Sex

c. Birth weight

d. Type of birth (single, twin)

   Note: Triplets were removed because of extremely low frequency.

e. Sex combinations at birth

f. Type of birth and rearing (single-single, twin-single, twin-twin)

g. Weaning weight

h. Weaning age

i. Average daily gain

j. 120-day weight

k. Condition score (based on the condition of animal at 120 days of age).

Four experimental breeding groups consisting of 25 ewes each were first bred in 1957. These groups were as follows:

1. Rotational three-breed cross flock
2. Grade Hampshire flock
3. Three-breed cross flock
4. Two-breed cross flock.

The rotational three-breed cross flock consisted of Suffolk x Rambouillet (SxR) foundation ewes. These ewes were bred to performance-tested Hampshire (H), Rambouillet (R), and Suffolk (S) rams on a rotational basis. Replacement ewes were retained from the previous breeding season and a new breed of sire was then introduced.

The grade Hampshire foundation flock was selected on performance from old productive ewes at the station. Each year this group was bred to Hampshire rams. Replacement ewes from this flock were selected by using performance selection methods.

The three-breed cross foundation ewes of Suffolk x Rambouillet breeding were purchased in Texas. These ewes were bred to Hampshire rams each year, and the lambs were sold each year. Replacement ewes of the same breeding (SxR) were then obtained from outside sources.

The two-breed cross foundation flock was composed of grade yearling Rambouillet ewes. This flock also was bred to Hampshire rams each year, and replacement ewes of the same breeding were purchased yearly.

In each group, replacement ewes were selected on the basis of: (a) lambing date (for early lambing), (b) weaning weight, and (c) type

score at weaning. On the average, seven to eight ewe lambs were saved each year in each replacement group. All ewe lambs were bred to rams, and culling of ewes was based on the failure to lamb two out of three breeding seasons or the possession of physical defects which interfered or seemed likely to interfere with their performance.

Vasectomized rams were placed with the ewes for approximately two weeks (July 1 to July 15) prior to the introduction of fertile rams each year. The actual breeding season was from July 15 to October 15 with some yearly variation. All ewes were "flushed" two to three weeks before the start of each breeding season. Fertile rams were turned in with the ewes about July 15, and all ewes bred to Hampshire rams were run together during the breeding season. Ewes bred to rams of another breed were handled in separate groups. Four Hampshire rams were used to breed approximately 100 ewes. Fertile rams as well as the vasectomized rams were equipped with marking harnesses to mark the ewes serviced.

Throughout the years, the ewes were grazed as much as possible on good permanent or temporary pastures. Those ewes which were not in good condition by November 1, were fed at the rate of approximately 1/2 to 1 pound of concentrates per ewe daily. Those ewes which were in good strong condition by November 1 did not receive any grain before lambing time. When pasture was not available, either alfalfa hay or silage was fed. When silage was fed, it was supplemented with some concentrates, particularly four to six weeks before lambing began.

At the start of the lambing season the ewes were housed in a shed-type barn at night and returned to the pastures during the day. All ewes were placed in lambing pens equipped with heat lamps when considered necessary. The lambs were weighed and identified at birth. After lambing, mature ewes which were full-fed alfalfa hay or run on good pasture did not receive supplemental grain feeding unless they appeared to require it.

All ewes were drenched for internal parasites, using phenothiazine or copper sulfate-nicotine. All lambs which appeared infested were also treated.

Starting April 1, all ewes were sheared while rams were sheared approximately May 1, and at the start of the breeding season (July 15).

Since disproportionate subclass numbers caused the classes of effects to be nonorthogonal, the data were analyzed by the least-squares technique as described by Harvey (1960). The traits subjected to analysis were birth weight, weaning weight, condition score, average daily gain and 120-day weight.

The following mathematical models formed the basis for the analyses.

Model I

$$Y_{ijklmno} = \mu + A_i + B_j + C_k + D_l + S_m + F_n + G_o + E_{ijklmno}$$

where:

$Y_{ijklmno}$ = Observed value for birth weight in the i^{th} month, j^{th} year, k^{th} sex, l^{th} type of birth, m^{th} breed of sire, n^{th} breed of dam and o^{th} age of dam.

μ = The theoretical mean of the population.

A_i = The effect of the i^{th} month of birth, $i = 1, 2, 3, 4$ as follows:

1. January
2. February
3. March
4. December

B_j = The effect of the j^{th} year of birth, $j = 1, 2 \ldots, 9$ as follows:

1. 1958
2. 1959
3. 1960
4. 1961
5. 1962
6. 1963
7. 1964
8. 1965
9. 1966

C_k = The effect of the k^{th} sex, $k = 1, 2$ as follows:

1. Female
2. Male

D_l = The effect of the l^{th} type of birth, $l = 1, 2$ as follows:

1. Single
2. Twin

S_m = The effect of the m^{th} breed of sire, $m = 1, 2, 3$ as follows:

1. Hampshire
2. Suffolk
3. Rambouillet

F_n = The effect of the n^{th} breed of dam, $n = 1, 2 \ldots, 8$ as follows:

1. Mixed (M)
2. Hampshire x Mixed (HxM)
3. Hampshire x Hampshire-Mixed (HxHM)
4. Suffolk x Rambouillet (SxR)
5. Hampshire x Suffolk-Rambouillet (HxSR)
6. Rambouillet x Hampshire-Suffolk-Rambouillet (RxHSR)
7. Suffolk x Rambouillet-Hampshire-Suffolk-Rambouillet (SxRHSR)
8. Grade Rambouillet (G.R.)

G_o = The effect of the o^{th} age of dam, o = 1, 2 . . . , 5 as follows:

1. 1-year-old
2. 2-year-old
3. 3-year-old
4. 4-, 5-, and 6-year-old
5. 7-year old or older

$E_{ijklmno}$ = The random error forming a part of the $ijklmno^{th}$ observation.

Model II

$$Y_{ijklpo} = \mu + A_i + B_j + C_k + D_l + H_p + G_o + E_{ijklpo}$$

where:

Y_{ijklpo} = Observed value for birth weight in the i^{th} month, j^{th} year, k^{th} sex, l^{th} type of birth, p^{th} breed of lamb and o^{th} age of dam.

μ, A_i, B_j, C_k, D_l and G_o are defined as above.

H_p = The effect of the p^{th} breed of lamb, p = 1, 2 . . . , 13 as follows:

1. HxM
2. HxHM
3. HxHHM
4. HxSR
5. HxHSR
6. HxRHSR
7. HxSRHSR
8. HxG.R.
9. SxSR
10. SxRHSR
11. RxM
12. RxHM
13. RxHSR

E_{ijklpo} = The random error forming a part of the $ijklpo^{th}$ observation.

Model III

$$Y_{jklmno} = \mu + B_j + C_k + D_l + S_m + F_n + G_o + E_{jklmno}$$

where:

Y_{jklmno} = Observed value for the birth weight in the j^{th} year, k^{th} sex, l^{th} type of birth, m^{th} breed of sire, n^{th} breed of dam and o^{th} age of dam.

μ, B_j, C_k, D_l, S_m, F_n and G_o are defined as above.

E_{jklmno} = The random error forming a part of the $jklmno^{th}$ observation.

Model IV

$$Y_{ijkmnqo} = \mu + A_i + B_j + C_k + S_m + F_n + P_q + G_o + E_{ijkmnqo}$$

where:

$Y_{ijkmnqo}$ = Value for average daily gain or 120-day weight in the i^{th} month, j^{th} year, k^{th} sex, m^{th} breed of sire, n^{th} breed of dam, q^{th} type of birth and rearing and o^{th} age of dam.

μ, A_i, B_j, C_k, S_m, F_n and G_o are defined as above.

P_q = The effect of the q^{th} type of birth and rearing, $q = 1, 2, 3$ as follows:

1. Born single and raised as single
2. Born twin and raised as single
3. Born twin and raised as twin

$E_{ijkmnqo}$ = The random error forming a part of the $ijkmnqo^{th}$ observation.

Model V

$$Y_{ijkpqor} = \mu + A_i + B_j + C_k + H_p + P_q + G_o + Q_r + E_{ijkpqor}$$

where:

$Y_{ijkpqor}$ = Value for condition score, weaning weight, average daily gain or 120-day weight in the i^{th} month, j^{th} year, k^{th} sex, p^{th} breed of lamb, q^{th} type of birth and rearing, o^{th} age of dam and r^{th} weaning age.

μ, A_i, B_j, C_k, H_p, P_q and G_o are defined as above.

Q_r = The effect of the r^{th} weaning age, $r = 85, 86 \ldots, 194$.

$E_{ijkpqor}$ = The random error forming a part of the $ijkpqor^{th}$ observation.

Model VI

$$Y_{ijkmnqor} = \mu + A_i + B_j + C_k + S_m + F_n + P_q + G_o + Q_r + E_{ijkmnqor}$$

where:

$Y_{ijkmnqor}$ = Value for condition score, weaning weight, 120-day weight or average daily gain in the i^{th} month, j^{th} year, k^{th} sex, m^{th} breed of sire, n^{th} breed of dam, q^{th} type of birth and rearing, o^{th} age of dam and r^{th} weaning age.

μ, A_i, B_j, C_k, S_m, F_n, P_q, G_o and Q_r are defined as above.

$E_{ijkmnqor}$ = The random error forming a part of the $ijkmnqor^{th}$ observation.

Model VII

$$Y_{ijkpqo} = \mu + A_i + B_j + C_k + H_p + P_q + G_o + E_{ijkpqo}$$

where:

Y_{ijkpqo} = Value for average daily gain or 120-day weight in the i^{th} month, j^{th} year, k^{th} sex, p^{th} breed of lamb, q^{th} type of birth and rearing and o^{th} age of dam.

μ, A_i, B_j, C_k, H_p, P_q and G_o are defined as above.

E_{ijkpqo} = The random error forming a part of the $ijkpqo^{th}$ observation.

Duncan's Multiple Range Test, as modified by Kramer (1957), was used for separation of means when statistical significance was indicated by the analysis of variance.

CHAPTER III

RESULTS AND DISCUSSION

Overall means and their standard errors for (1) birth weight, (2) 120-day weight, (3) average daily gain, (4) weaning weight, and (5) condition score are shown in Table I.

The simple correlations for the various traits studied are shown in Table II. The highest overall correlation (r = .953) was between average daily gain and 120-day weight and was highly significant.

Birth Weight

In all analyses the effect due to sex was highly significant ($P<.01$). Male lambs were approximately 0.26 kg. (0.58 lb.) heavier than the females at birth. This agrees with Smith and Lidvall (1964), Rempel *et al*. (1959), Miller (1935), Phillips and Dawson (1937) and many others.

The effect due to type of birth (comparing single to twin births) was highly significant in all analyses. By the use of the multiple range test in each analysis, singles always exceeded twins by about 1.01 kg. (2.22 lb.). Similar findings were reported by Miller (1935), De Baca *et al*. (1956), Blackwell and Henderson (1955) and others.

The age-of-dam effect, the ewes being divided into five main classes according to their respective ages (1-year-old, 2-year-old, 3-year-old, 4-, 5-, 6-year-old, 7-year-old and older), was highly

TABLE I

OVERALL MEANS AND STANDARD ERRORS OF LAMB TRAITS (1958-1966)[a]

Trait	Mean		Standard Error	
	kg.	lb.	gm.	lb.
Birth Weight	4.09	9.02	28.6	0.063
Weaning Weight	36.50	80.48	186.9	0.412
Weaning Age	153.8 days		0.606	
Average Daily Gain	0.21	0.47	1.4	0.003
120-Day Weight	29.64	65.35	177.8	0.392
Condition Score	13.43		0.076	

[a]Includes 924 lambs.

TABLE II

CORRELATIONS INVOLVING LAMB PERFORMANCE TRAITS

	Birth Weight	Weaning Weight	Weaning Age	A.D.G.	120-Day Weight	Condition Score
Birth Weight	1.000	0.566**	-.176**	0.488**	0.582**	0.291**
Weaning Weight		1.000	0.098**	0.765**	0.751**	0.620**
Weaning Age			1.000	-.539**	-.511**	-.047
Average Daily Gain				1.000	0.953**	0.545**
120-Day Weight					1.000	0.534*
Condition Score						1.000

*P<0.01.

**P<0.005.

significant. The dams 7 years old and older produced the heaviest lambs at birth, weighing 4.63 kg. (10.2 lb.), followed by the 4-, 5- and 6-year-old dams and 3-year-old dams, producing lambs of 4.34 kg. (9.58 lb.) and 4.08 kg. (9.00 lb.), respectively. All of the above classes were statistically different from each other ($P<.05$ or less), whereas the 2- and 1-year-old groups were not significantly different from each other, but were significantly different from the groups mentioned above. These results are presented in Tables III through V in the appendix. Similar results were found by Price, Sidwell and Grandstaff (1949, 1953), Blackwell and Henderson (1955) and Ray and Smith (1966).

Suffolk rams produced lambs which were heaviest at birth, being significantly heavier than the Hampshire- and Rambouillet-sired lambs. However, the latter two groups were not significantly different from one another. Suffolk-sired lambs weighed approximately 4.33 kg. (9.54 lb.) while the Hampshire and Rambouillet lambs weighed 4.06 kg. (8.94 lb.) and 3.89 kg. (8.57 lb.), respectively.

Breeding of the dam had no significant effect with respect to birth weight. This result, although not in agreement with findings of Carter and Henning (1951), leads this author to believe that sire effect is more important than dam effect.

Comparison of breeding-of-lamb groups with respect to birth weight showed the groups enumerated to be superior according to Duncan's Multiple Range Test as modified by Kramer (1957). The symbols used to refer to the breeds in the remaining chapters will be by the first

initial of each respective breed, as noted in Chapter II. Lambs of SxRHSR, HxRHSR, SxSR, HxHSR, RxHSR, and HxSRHSR breeding were heaviest at birth but not significantly different from one another. It appears from these data that the five- and four-breed cross lambs were heavier at birth than the three-breed cross with the exception of SxSR lambs, though the difference was not always significant. These lambs were significantly heavier than the two-breed crosses involving grade and mixed dams, regardless of breed of sire used. Sidwell et al. (1962 and 1964), Rae (1952) and others concluded that the crosses involving more breeds were superior to crosses involving fewer breeds.

It is pointed out at this time that there was a significant difference between SxRHSR and HxHSR lambs in this first group. It is the author's contention that due to the large disproportionality of the numbers in these subclasses, results of this nature can happen. Similar results were noted also for month of birth and breed of dam (Figures 2 and 3 in the appendix).

120-Day Weight

From the analysis of variance (Tables VI and VIII in the appendix) all effects studied were highly significant. Males weighed 30.27 kg. (66.73 lb.) while the females weighed 29.02 kg. (63.97 lb.), an advantage of 1.25 kg. (2.76 lb.). The male-over-female advantage at birth retained by males at 120 days of age, could account in part for the greater weight of males at 120-day weight.

Rambouillet- and Hampshire-sired lambs were the heaviest at 120 days of age, while the Suffolk-sired lambs were the lightest.

Significant differences between the Rambouillet and Hampshire rams were found in several models, while in others the differences were not significant. A ranking of sires in order of merit would thus be Rambouillet, Hampshire and Suffolk with varying significance of differences between Hampshire and Rambouillet or Hampshire and Suffolk rams, according to which multiple range test was consulted.

The SxRHSR dams produced heavier lambs at 120 days followed by RxHSR and HxSR dams producing lambs averaging 32.54 kg. (78.35 lb.), 31.90 kg. (70.32 lb.) and 30.28 kg. (66.75 lb.), respectively. All three groups were significantly different from each other. The grade Rambouillet, HxHM and mixed dams produced the lowest weight lambs. The complete multiple range test is presented in Figure 6 in the appendix.

Lambs born and raised as singles had a weight advantage at 120 days of 2.32 kg. (5.12 lb.) over lambs born as twins but raised as singles and 3.86 kg. (8.50 lb.) over lambs born as twins and raised as twins. All these groups were significantly different from each other. Similar results were obtained by Price, Sidwell and Grandstaff (1949), Nelson and Venkatachalam (1949), Frederickson, Price and Blackwell (1967) and others.

Lambs born from dams 4, 5, 6 and 7 years old and older were not significantly different, producing at 120 days approximately the same total pounds of lamb, 31.61 kg. (69.68 lb.) and 31.68 kg. (69.85 lb.), respectively, but were significantly different in this respect from the 3-, 2- and 1-year-old dams. The 4-year-old and older ewes

consistently produced heavier lambs than the 3-year-old and younger ewes.

Lambs of HxSRHSR breeding were significantly heavier at 120 days then all other groups examined and were followed by RxHSR and HxRHSR lambs. The grade and mixed lambs regardless of breed of sire were the lightest. It can be concluded that the crossbred lambs when compared to grade and mixed lambs, regardless of sire, were always superior at 120 days of age (Figures 5 and 7 in the appendix).

With the removal of weaning age, as was done in the analysis for Tables VI and XII and Figures 4 and 7 in the appendix, the other effects were not changed appreciably except those of breed of dam and month of birth. Holding weaning age constant resulted in an increase in the error term which could give us these variations. This point is brought out solely for academic purposes and for interest which may bring about a more sophisticated explanation. An example of this occurrence is in breed of dam (Tables VI and X and Figures 4 and 6 in the appendix) where the SxRHSR dam in one model has the highest value while in the other it has the lowest value. In general, however, both analyses are in agreement with only slight variations from group to group.

Average Daily Gain

The effect of sex was highly significant in all analyses. Male lambs gained 0.22 kg. (0.48 lb.) and female lambs gained 0.21 kg. (0.46 lb.) per day with a difference of 0.01 kg. (0.02 lb.) per day in

favor of the male lambs. Similar results were obtained by Givens, Carter and Gaines (1960) and Smith and Lidvall (1964).

The age-of-dam effect was highly significant in all analyses for average daily gain. Lambs from dams 4, 5 and 6 years old had the highest average daily gain in all models, followed by lambs from the 7- and 3-year-old dams. Depending upon the model used, significance was between either the 4-, 5-, 6- and 7-year-old dams or between 7- and 3-year-old dams. The lambs of 2- and 1-year-old dams had the lowest average daily gain and were statistically different from each other except in one analysis.

The effect of type of birth and rearing was also highly significant in all analyses. Lambs born and raised as singles surpassed twins raised as singles and twins raised as twins by 0.01 kg. (0.026 lb.) and 0.03 kg. (0.060 lb.), respectively. A possible explanation for the single lambs' superior performance is that they were larger at birth and had more milk available from the ewe.

Ranking of sires with respect to average daily gain of lambs from high to low would be Rambouillet, Hampshire and Suffolk rams. All breeds of ram were significantly different from each other. Rambouillet-sired lambs average daily gain was 0.23 kg. (0.50 lb.), while the Hampshire- and Suffolk-sired lambs averaged 0.21 kg. (0.46 lb.) and 0.20 kg. (0.45 lb.), respectively.

Highly significant breed-of-dam differences were noted in each analysis. Lambs from dams of SxRHSR breeding had the highest average daily gain, 0.27 kg. (0.60 lb.), followed by the RxHSR 0.24 kg.

(0.52 lb.) and HxSR 0.22 kg. (0.48 lb.), the latter two being significantly different from each other. Grade Rambouillet, HxHM and mixed ewes produced lambs with the poorest average daily gains of 0.20 kg. (0.44 lb.), 0.19 kg. (0.42 lb.) and 0.19 kg. (0.42 lb.), respectively.

HxSRHSR lambs excelled all others in having an average daily gain of 0.27 kg. (0.59 lb.), while lambs with mixed and grade breeding, regardless of breed of sire, were significantly inferior to the other groups.

Weaning Weight

The average male weighed 37.34 kg. (82.33 lb.) compared to 35.67 kg. (78.63 lb.) for the female. Rambouillet rams sired lambs with the heaviest weaning weight followed by Hampshire and Suffolk rams, all being significantly different from each other. The five-breed cross dams (SxRHSR) produced lambs with the significantly highest weaning weight, while the grade Rambouillet, HxHM and mixed dams had the significantly lightest weaning weights of all lambs produced (Table XVI and Figure 9 in the appendix).

Lambs born and raised as singles significantly surpassed in weaning weights all other types of birth and rearing combinations by 2.86 kg. (6.30 lb., twin-single) and 4.71 kg. (10.39 lb., twin-twin). The age-of-dam effect on weaning weight of lambs was such that mature dams (4-, 5-, 6- and 7-year-old) were not different from each other but were significantly different from the other age-of-dam classes. With respect to breeding of the lamb, lambs from crosses

involving more breeds had higher weaning weights than lambs of crosses involving fewer breeds. The HxSRHSR, RxHSR and HxRHSR lambs were the heaviest and non-significantly different from each other. Lambs of grade and mixed breeding, regardless of sire, were significantly lighter.

Condition Score

Females averaged 13.52 points on condition score whereas the males averaged 13.34, a difference of 0.18, which was non-significant. Regardless of breed of sire or dam, single born and raised lambs excelled all other birth and rearing combinations statistically.

Hampshire rams produced lambs with the highest condition score, followed by Suffolk and Rambouillet rams. Suffolk and Rambouillet progeny groups were not statistically different from each other but scored significantly less than the Hampshire-sired lambs. The SxRHSR dams surpassed all other dams. No significant difference was observed among 7- and 4-, 5-, 6-year-old dams and 3-year-old dams in condition score. A significant difference was shown by one analysis between the 7- and 3-year-old groups.

The HxSRHSR lambs received the highest condition score being statistically different from all other breeding-of-lamb groups. Grade and mixed bred lambs were graded from 0.5 to 1.1 points lower than the overall mean (13.43) while the average score of HxSRHSR lambs exceeded the mean by 2.55 points.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The effects of crossbreeding and other factors on ewe performance were studied by means of least-squares analyses of data from 924 lambs, including various kinds of crossbreds, grades and lambs of mixed breeding.

Birth weight was significantly influenced ($P<.01$) by sex, type of birth, breeding of lamb and age of dam. Ram lambs were heavier than females at birth. Lambs whose breeding involved more breeds (SxRHSR, HxRHSR, SxSR, HxHSR, RxHSR and HxSRHSR) were heavier than lambs of grade and mixed breeding, regardless of the breed of sire. Lambs from ewes over three years of age were heavier than lambs from ewes three years old and younger. Breed of dam did not affect birth weight of lambs.

Weight of lambs at 120 days was significantly influenced ($P<.01$) by sex, breed of dam, breeding of lamb, type of birth and rearing and age of dam. Male lambs were 1.25 kg. (2.76 lb.) heavier than females. Lambs born and raised as singles surpassed lambs born as twins, whether raised as singles or as twins. Lambs born as twins and raised as singles surpassed those born as twins and raised as twins. Ewes 4 years old and older produced the heaviest lambs followed by 3-, 2- and 1-year-old dams, all being significantly different from each other. Lambs from crossbred ewes were heavier than lambs from grade ewes and ewes

of mixed breeding, regardless of breed of sire.

Analyses of average daily gain, weaning weight and condition score gave results similar to those obtained from the analyses of the other variables studied. The effect of sex on condition score was not significant. Lambs from ewes three years old and older received the highest condition score.

From these data it can be concluded:

1. The performance of crossbred lambs excelled those of grade or mixed breeding (breed composition not precisely known) in all traits studied.

2. Lambs from crosses involving more breeds exceeded lambs of crosses involving fewer breeds.

3. Crossbred ewes surpassed ewes of grade and mixed breeding with respect to all traits studied.

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APPENDIX

TABLE III

ANALYSIS OF VARIANCE OF BIRTH WEIGHT OF LAMBS
MODEL I

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	26	1,401.22	---	---
Month	3	19.11	6.37	2.880*
Year	8	100.87	12.61	5.701**
Sex	1	78.38	78.38	35.442**
Type of Birth	1	926.27	926.27	418.841**
Breed of Sire	2	13.78	6.89	3.116*
Breed of Dam	7	28.65	4.09	1.851
Age of Dam	4	84.34	21.09	9.535**
Error	897	1,982.37	2.21	---

*P<0.05.

**P<0.01.

TABLE IV

ANALYSIS OF VARIANCE OF BIRTH WEIGHT OF LAMBS
MODEL II

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	29	1,403.26	---	---
Month	3	19.66	6.55	2.957*
Year	8	102.78	12.85	5.796**
Sex	1	78.65	78.65	35.483**
Type of Birth	1	915.01	915.01	412.790**
Breed of Lamb	12	72.00	6.00	2.707**
Age of Dam	4	85.21	21.30	9.610**
Error	894	1,984.68	2.22	---

*P<0.05.

**P<0.01.

TABLE V

ANALYSIS OF VARIANCE OF BIRTH WEIGHT OF LAMBS
MODEL III

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	23	1,382.12	---	---
Year	8	96.08	12.01	5.397**
Sex	1	78.41	78.41	35.237**
Type of Birth	1	947.09	947.09	425.590**
Breed of Sire	2	16.37	8.19	3.679*
Breed of Dam	7	25.13	3.59	1.613
Age of Dam	4	91.14	22.78	10.238**
Error	900	1,998.00	2.22	---

*P<0.05.

**P<0.01.

TABLE VI

ANALYSIS OF VARIANCE OF 120-DAY WEIGHT OF LAMBS
MODEL IV

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	27	3.44	---	---
Month	3	2,438.86	812.95	10.186**
Year	8	9,738.38	1,217.30	15.252**
Sex	1	3,080.65	3,080.65	38.599**
Breed of Sire	2	313.06	156.53	1.961
Breed of Dam	7	6,727.40	961.06	12.041**
Type of Birth and Rearing	2	25,609.05	12,804.53	160.432**
Age of Dam	4	4,159.94	1,039.98	13.030**
Error	896	3.58	79.81	---

*P<0.05.

**P<0.01.

TABLE VII

ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN IN LAMBS
MODEL IV

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	27	3.44	---	---
Month	3	0.18	0.06	13.777**
Year	8	0.60	0.08	17.267**
Sex	1	0.18	0.18	41.363**
Breed of Sire	2	0.03	0.02	3.707*
Breed of Dam	7	0.46	0.06	14.927**
Type of Birth and Rearing	2	1.25	0.62	142.682**
Age of Dam	4	0.26	0.06	15.015**
Error	896	3.94	0.0044	---

*P<0.05.

**P<0.01.

TABLE VIII

ANALYSIS OF VARIANCE OF 120-DAY WEIGHT OF LAMBS
MODEL V

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	31	77,760.99	---	---
Month	3	2,461.42	820.48	13.677**
Year	8	9,955.18	1,244.40	20.743**
Sex	1	1,688.06	1,688.06	28.138**
Breed of Lamb	12	5,548.70	462.39	7.708**
Type of Birth and Rearing	2	11,293.17	5,646.58	94.123**
Age of Dam	4	3,753.96	938.49	15.644**
Weaning Age	1	17,614.68	17,614.68	293.619**
Error	892	53,511.08	59.99	---

*P<0.05.

**P<0.01.

TABLE IX

ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN OF LAMBS
MODEL V

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	31	4.54	---	---
Month	3	0.13	0.04	14.176**
Year	8	0.62	0.08	24.706**
Sex	1	0.10	0.10	30.790**
Breed of Lamb	12	0.39	0.03	10.365**
Type of Birth and Rearing	2	0.50	0.25	78.621**
Age of Dam	4	0.22	0.05	17.357**
Weaning Age	1	1.08	1.08	340.741**
Error	892	2.68	0.003	---

*P<0.05.

**P<0.01.

TABLE X

ANALYSIS OF VARIANCE OF 120-DAY WEIGHT OF LAMBS
MODEL VI

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	28	77,598.74	---	---
Month	3	2,345.55	781.85	13.037**
Year	8	10,106.98	1,263.37	21.066**
Sex	1	1,703.06	1,703.06	28.398**
Breed of Sire	2	588.37	294.18	4.905**
Breed of Dam	7	4,923.05	703.29	11.727**
Type of Birth and Rearing	2	11,484.81	5,742.41	95.752**
Age of Dam	4	3,796.72	949.18	15.827**
Weaning Age	1	17,837.35	17,837.35	297.429**
Error	895	53,673.15	59.97	---

*P<0.05.

**P<0.01.

TABLE XI

ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN OF LAMBS
MODEL VI

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	28	4.54	---	---
Month	3	0.13	0.04	13.761**
Year	8	0.64	0.08	25.129**
Sex	1	0.10	0.10	31.215**
Breed of Sire	2	0.05	0.03	8.403**
Breed of Dam	7	0.34	0.05	15.472**
Type of Birth and Rearing	2	0.50	0.25	79.303**
Age of Dam	4	0.24	0.06	18.737**
Weaning Age	1	0.01	0.01	345.112**
Error	895	2.68	0.003	---

*P<0.05.

**P<0.01.

TABLE XII

ANALYSIS OF VARIANCE OF 120-DAY WEIGHT OF LAMBS
MODEL VII

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	30	60,146.31	---	---
Month	3	2,098.60	699.53	8.783**
Year	8	9,648.07	1,206.01	15.141**
Sex	1	3,045.18	3,045.18	38.232**
Breed of Lamb	12	7,552.68	629.39	7.902**
Type of Birth and Rearing	2	25,140.08	12,570.04	157.817**
Age of Dam	4	4,151.23	1,037.81	13.030**
Error	893	71,127.45	79.65	---

*P<0.05.

**P<0.01.

TABLE XIII

ANALYSIS OF VARIANCE OF AVERAGE DAILY GAIN IN LAMBS
MODEL VII

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	30	3.46	---	---
Month	3	0.16	0.05	12.060**
Year	8	0.60	0.07	17.152**
Sex	1	0.18	0.18	40.842**
Breed of Lamb	12	0.52	0.04	9.910**
Type of Birth and Rearing	2	1.23	0.62	141.193**
Age of Dam	4	0.25	0.06	14.087**
Error	893	3.57	0.004	---

*P<0.05.

**P<0.01.

TABLE XIV

ANALYSIS OF VARIANCE OF WEANING WEIGHT OF LAMBS
MODEL V

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	31	69,360.11	---	---
Month	3	4,432.24	1,477.41	17.548**
Year	8	14,653.15	1,831.64	21.756**
Sex	1	3,023.94	3,023.94	35.918**
Breed of Lamb	12	8,245.80	687.15	8.162**
Type of Birth and Rearing	2	16,977.81	8,488.90	100.829**
Age of Dam	4	5,430.79	1,357.70	16.126**
Weaning Age	1	105.14	105.14	1.249
Error	892	75,097.48	84.19	---

*P<0.05.

**P<0.01.

TABLE XV

ANALYSIS OF VARIANCE OF CONDITION SCORE OF LAMBS
MODEL V

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	31	2,453.30	---	---
Month	3	94.20	31.40	11.084**
Year	8	436.92	54.61	19.278**
Sex	1	6.15	6.15	2.171
Breed of Lamb	12	202.71	16.89	5.963**
Type of Birth and Rearing	2	378.15	189.08	66.742**
Age of Dam	4	79.73	19.93	7.036**
Weaning Age	1	11.91	11.91	4.205*
Error	892	2,524.36	2.83	---

*P<0.05.

**P<0.01.

TABLE XVI

ANALYSIS OF VARIANCE OF WEANING WEIGHT OF LAMBS
MODEL VI

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	28	69,279.25	---	---
Month	3	4,361.51	1,453.84	17.308**
Year	8	14,770.66	1,846.33	21.980**
Sex	1	3,035.36	3,035.36	36.135**
Breed of Sire	2	855.37	427.69	5.092**
Breed of Dam	7	7,125.00	1,017.86	12.117**
Type of Birth and Rearing	2	17,110.70	8,555.35	101.850**
Age of Dam	4	5,745.17	1,436.29	17.099**
Weaning Age	1	94.79	94.79	1.128
Error	895	75,180.00	84.00	---

*P<0.05.

**P<0.01.

TABLE XVII

ANALYSIS OF VARIANCE OF CONDITION SCORE OF LAMBS
MODEL VI

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Total	923	---	---	---
Total Reduction in Sum of Squares	28	2,437.59	---	---
Month	3	96.81	32.27	11.359**
Year	8	436.19	54.52	19.192**
Sex	1	7.05	7.05	2.482
Breed of Sire	2	86.03	43.02	15.141**
Breed of Dam	7	103.30	14.76	5.194**
Type of Birth and Rearing	2	383.70	191.85	67.529**
Age of Dam	4	83.86	20.97	7.380**
Weaning Age	1	11.41	11.41	4.015*
Error	895	2,541.80	2.84	---

*P<0.05.

**P<0.01.

Variable		Ranking of Discrete Sub-Groups[a]
Birth Weight	(Month)	January December February March[b]
	(Year)	'66 '58 '59 '61 '65 '60 '62 '63 '64
	(Sex)	Male Female
	(Type B.&R.)	Single twin
	(Sire Breed)	Suffolk Hampshire Rambouillet
	(Dam Breed)	RxHSR HxSR SxRHSR HxHM HxM SxR Mixed Grade Rambouillet
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year

FIGURE 1. Multiple range test results for means[c] involved in analysis according to Model I (birth weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Significance between January-December and January-February.
[c]Constants are deviations from the least-squares means.

Variable		Ranking of Discrete Sub-Groups[a]
Birth Weight	(Month)	January December February March[b]
	(Year)	'66 '58 '59 '61 '65 '60 '62 '63 '64
	(Sex)	Male Female
	(Type B.&R.)	Single Twin
	(Lamb Breed)	SxRHSR HxRHSR SxSR HxHSR RxHSR HxSRHSR HxHHM HxHM HxSR HxM RxM HxG.R. RxHM[c]
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year

FIGURE 2. Multiple range test results for means[d] involved in analysis according to Model II (birth weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Significance between January-December and January-February.
[c]Significance between SxRHSR-HxHSR, SxSR-HxSR, SxSR-HxM, HxHSR-HxSR and HxSR-HxG.R.
[d]Constants are deviations from the least-squares means.

Variable		Ranking of Discrete Sub-Groups[a]
Birth Weight	(Year)	'66 '59 '58 '61 '65 '60 '63 '62 '64
	(Sex)	Male Female
	(Type B.&R.)	Single Twin
	(Sire Breed)	Suffolk Hampshire Rambouillet
	(Dam Breed)	RxHSR HxSR HxHM HxM SxR SxRHSR Mixed Grade Rambouillet[b]
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year

FIGURE 3. Multiple range test results for means[c] involved in analysis according to Model III. (birth weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Significance between RxHSR-SxR and HxSR-SxR.
[c]Constants are deviations from the least-squares means.

Variable		Ranking of Discrete Sub-Groups[a]
A.D.G.	(Month)	March February January December
	(Year)	'66 '59 '63 '65 '61 '58 '64 '62 '60
	(Sex)	Male Female
	(Sire Breed)	Rambouillet Hampshire Suffolk
	(Dam Breed)	SxRHSR RxHSR HxSR HxM SxR Grade Rambouillet Mixed HxHM
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year 7+ year 3 year 2 year 1 year
120-Day Weight	(Month)	March February January December
	(Year)	'66 '59 '63 '65 '61 '58 '64 '62 '60
	(Sex)	Male Female
	(Sire Breed)	Rambouillet Hampshire Suffolk
	(Dam Breed)	RxHSR HxSR SxR HxM Grade Rambouillet HxHM Mixed SxRHSR
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year +7 year 3 year 2 year 1 year

FIGURE 4. Multiple range test results for means[b] involved in analysis according to Model IV (average daily gain, 120-day weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Constants are deviations from the least-square means.

Variable		Ranking of Discrete Sub-Groups[a]
A.D.G.	(Month)	December January February March
	(Year)	'66 '63 '59 '58 '65 '64 '61 '62 '60
	(Sex)	Male Female
	(Lamb Breed)	HxSRHSR RxHSR HxRHSR RxHM SxRHSR HxHSR HxHM HxSR RxM HxG.R. SxSR HxHHM HxM[b]
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year 7+ year 3 year 2 year 1 year
120-Day Weight	(Month)	December January February March
	(Year)	'66 '63 '59 '58 '65 '61 '64 '62 '60
	(Sex)	Male Female
	(Lamb Breed)	HxSRHSR RxHSR HxRHSR SxRHSR RxHM HxHSR HxHM HxSR SxSR HxG.R. RxM HxHHM HxM[c]
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year

FIGURE 5. Multiple range test results for means[d] involved in analysis according to Model V (average daily gain, 120-day weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]No significance between HxHSR-RxM.
[c]Significance between HxRHSR-SxRHSR, RxHM-SxSR, RxHM-HxG.R., HxHM-HxG.R., and HxSR-HxG.R.; no significance between HxHSR-RxM.
[d]Constants are deviations from the least-square means.

Variable		Ranking of Discrete Sub-Groups[a]
A.D.G.	(Month)	December January February March
	(Year)	'66 '63 '59 '58 '65 '64 '61 '62 '60
	(Sex)	Male Female
	(Sire Breed)	Rambouillet Hampshire Suffolk
	(Dam Breed)	SxRHSR RxHSR HxSR HxM SxR Grade Rambouillet HxHM Mixed
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year 7+ year 3 year 2 year 1 year
120-Day Weight	(Month)	December January February March
	(Year)	'66 '63 '59 '58 '65 '61 '64 '62 '60
	(Sex)	Male Female
	(Sire Breed)	Rambouillet Hampshire Suffolk
	(Dam Breed)	SxRHSR RxHSR HxSR SxR HxM Grade Rambouillet HxHM Mixed
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year

FIGURE 6. Multiple range results for means[b] involved in analysis according to Model VI (average daily gain, 120-day weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Constants are deviations from the least-squares means.

Variable		Ranking of Discrete Sub-Groups[a]
A.D.G.	(Month)	March February January December
	(Year)	'66 '59 '63 '65 '61 '58 '64 '62 '60
	(Sex)	Male Female
	(Lamb Breed)	HxSRHSR RxHSR HxRHSR SxRHSR RxHM HxHSR HxHM HxSR SxSR HxG.R. RxM HxM HxHHM[b]
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year 7+ year 3 year 2 year 1 year
120-Day Weight	(Month)	March February January December
	(Year)	'66 '59 '63 '65 '61 '58 '64 '62 '60
	(Sex)	Male Female
	(Lamb Breed)	HxSRHSR RxHSR HxRHSR SxRHSR HxHSR RxHM HxHM HxSR SxSR HxG.R. RxM HxM HxHHM[c]
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year 7+ year 3 year 2 year 1 year

FIGURE 7. Multiple range test results for means[d] involved in analysis according to Model VII (average daily gain, 120-day weight).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Significance between RxHM-HxG.R., SxSR-HxM, HxHM-HxG.R., and HxSR-HxG.R.
[c]Significance between HxHSR-HxSR, HxHM-HxG.R., HxSR-HxG.R., and SxSR-HxM.
[d]Constants are deviations from the least-squares means.

Variable		Ranking of Discrete Sub-Groups[a]
Weaning Weight	(Month)	December January February March
	(Year)	'66 '63 '59 '58 '65 '61 '64 '62 '60
	(Sex)	Male Female
	(Lamb Breed)	HxSRHSR RxHSR HxRHSR SxRHSR RxHM HxHSR HxHM HxSR RxM SxSR HxG.R. HxHHM HxM[b]
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year
Condition Score	(Month)	December January February March
	(Year)	'63 '65 '64 '66 '62 '61 '58 '60 '59
	(Sex)	Female Male
	(Lamb Breed)	HxSRHSR HxHSR HxHM HxRHSR HxHHM HxSR SxRHSR HxG.R. SxSR HxM RxHM RxHSR RxM
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	4,5,6 year 7+ year 3 year 2 year 1 year

FIGURE 8. Multiple range test results for means[c] involved in analysis according to Model V (weaning weight, condition score).

[a]Lines under groups indicate no significance; no line indicate significance.
[b]Significance between HxHSR-HxHM and HxHSR-HxSR.
[c]Constants are deviations from the least-squares means.

Variable		Ranking of Discrete Sub-Groups[a]
Weaning Weight	(Month)	December January February March
	(Year)	'66 '63 '59 '58 '65 '64 '61 '62 '60
	(Sex)	Male Female
	(Sire Breed)	Rambouillet Hampshire Suffolk
	(Dam Breed)	SxRHSR RxHSR HxSR HxM SxR Grade Rambouillet HxHM Mixed
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year
Condition Score	(Month)	December January February March
	(Year)	'63 '65 '64 '66 '61 '62 '58 '60 '59
	(Sex)	Female Male
	(Sire Breed)	Hampshire Suffolk Rambouillet
	(Dam Breed)	SxRHSR RxHSR HxSR HxM HxHM SxR Grade Rambouillet Mixed
	(Type B.&R.)	Single-Single Twin-Single Twin-Twin
	(Dam Age)	7+ year 4,5,6 year 3 year 2 year 1 year

FIGURE 9. Multiple range test results for means[b] involved in analysis according to Model VI (weaning weight, condition score).

[a]Lines under groups indicate no significance; no line indicates significance.
[b]Constants are deviations from the least-squares means.

VITA

Gerhard Eisele was born in Nenningen, Germany, on September 24, 1943. Upon entering the United States in 1950, he became a citizen during 1955, residing in Philadelphia, Pennsylvania.

After completion of high school in the Philadelphia area, he entered Delaware Valley College of Science and Agriculture, Doylestown, Pennsylvania, pursuing a B.S. in Animal Husbandry. Graduating in 1966, he entered the University of Tennessee Graduate School to attain a Master's Degree in Animal Husbandry.

Mr. Eisele is a member of Delta Tau Alpha Honorary Society and American Society of Animal Science. Presently he is pursuing his Ph.D. while on an assistantship working at the Oak Ridge National Laboratory and U.T.-A.E.C.