WESTERN VS. DORSET X WESTERN CROSSBRED EWES FOR FALL LAMB PRODUCTION IN OKLAHOMA

By

FREDERICK A. THRIFT

Bachelor of Science
University of Florida
Gainesville, Florida
1962

Master of Science
University of Georgia
Athens, Georgia
1965

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Name: Frederick A. Thrift Date of Degree: May, 1968

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Scope of Study: A comparison was made between the lifetime performance of two ewe breed groups involved in a fall-lambing program in Oklahoma. The two breed groups compared were Western ewes [Panama, 3/4 Rambouillet x 1/4 Merino, Rambouillet, 3/4 Rambouillet x 1/4 Columbia and "Whiteface Market" (part Columbia, Panama or Corriedale mixed with Rambouillet)] and Dorset x Western ewes [Dorset x Rambouillet and Dorset x (3/4 Rambouillet x 1/4 Panama)]. These two breed groups (120 ewes each) were compared on the basis of the growth performance of their lambs (birth weight, rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market, market age), their reproductive performance (percent ewes lambing, lambing rate, lambs reared per 100 ewes, lambing date) and their wool production (grease and clean fleece weights). The regular breeding season for these ewes began on May 20 and continued for 40 days. A "cleanup" breeding period was permitted from August 20 to September 20 for those ewes failing to conceive during the regular breeding season. This breeding procedure resulted in fall (Oct. 15-Nov. 25) and winter (Jan. 15-Feb. 15) lambing.

Findings and Conclusions: The results of this study indicate that each of the lamb growth variables were similar for both breed groups. During the fall, a higher percentage (7.7%, $P<.05$) of the Dorset x Western ewes lambed, they had a higher lambing rate (0.19, $P<.001$), reared more lambs per 100 ewes in the flock (22.6, $P<.05$) and consistently lambed about three days earlier ($P<.01$) than the Western ewes. During the winter, 4.3 percent fewer Dorset x Western ewes lambed than the Western ewes but the lambing rate was similar for both breed groups. The high lambing rate of the Dorset x Western ewes was due to a large number of multiple births. During the two seasons, the Dorset x Western ewes gave birth to 722 twins and 39 triplets; whereas, the Western ewes gave birth to 470 twins and 15 triplets. The Western ewes consistently produced grease

fleeces that were about two pounds heavier ($P<.01$) than those of the Dorset x Western ewes, but the clean fleece weights were quite similar for both breed groups.

ADVISER'S APPROVAL ______________________________

WESTERN VS. DORSET X WESTERN CROSSBRED

EWES FOR FALL LAMB PRODUCTION

IN OKLAHOMA

Thesis Approved:

Joe V. Whiteman
Thesis Adviser

I. T. Omtvedt

Robert D. Morrison

Dale E. Weibel

N. Durham
Dean of the Graduate College

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INTRODUCTION

Most Oklahoma sheepmen produce fall-born lambs to be marketed during the spring when prices for fed lambs are usually highest. This practice has generally been favorable under Oklahoma conditions especially for those producers who are willing to utilize wheat pasture for winter grazing. In recent years, there has been some concern as to what is the most productive ewe from the standpoint of lamb and wool production under this type of management system.

Oklahoma sheepmen, who produce fall-born lambs to be sold during the spring, have traditionally purchased replacement ewes for their flocks from the west Texas and New Mexico area rather than raising their own replacements. This procedure has been practiced since raised ewe lambs are usually worth more as fat slaughter lambs at five months of age than purchased yearling ewes cost. Furthermore, the purchased ewes generally breed well in the spring (a necessary requirement for fall-lambing), are relatively long-lived and shear heavy fleeces. Many of these purchased replacements, generally referred to as "Western" ewes, are grade Rambouillets or various mixtures of Rambouillet with Merino, Columbia, Panama or Corriedale. Ewes of the Dorset breed also breed well in the spring and it has generally been recognized that these ewes are fairly prolific under conditions less severe than those of the range areas. However, the acceptability of the Dorset ewes as replacements under Oklahoma conditions has been rather limited due to their unavailability and relative lack of hardiness and certain other qualities considered necessary for an acceptable level of production.

One of the primary reasons for crossbreeding of livestock has been to combine the desirable traits of one breed with those of another breed in order to develop a more productive individual for a particular purpose under a given locality. Consequently, through the practice of crossbreeding, it may be possible to combine the hardiness and longevity of the Western ewes with the prolificacy of the Dorset breed and result in a more productive ewe from the standpoint of lamb and wool production.

During the spring of 1955, an experimental ewe flock was established at the Fort Reno Livestock Research Station, El Reno, Oklahoma to answer the question: can Oklahoma sheepmen raise a more productive ewe for fall-lamb production than they can purchase? The initial flock was composed of 100 grade Rambouillet and 100 3/4 Rambouillet x 1/4 Panama yearling ewes purchased from the west Texas area. These ewes were mated to purebred Dorset rams from 1956 through 1958 resulting in the production of Dorset x Rambouillet and Dorset x (3/4 Rambouillet x 1/4 Panama) crossbred ewes.

The purpose of this study was to compare the lifetime performance of 120 purchased Western ewes with the lifetime performance of 120 raised Dorset x Western crossbred ewes (described above) when both breed groups were managed similarly under a fall-lambing program in Oklahoma. The two breed groups were compared on the basis of growth performance of their lambs, reproductive performance and wool production. The lamb growth variables were: birth weight, rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market and market age. The reproduction and wool traits were: percent ewes lambing, lambing rate, lambs reared per 100 ewes in the flock, lambing date, grease fleece weight and clean fleece weight. The performance of the two breed groups was compared and the percent advantage for the crossbred ewes over the Western ewes was determined for each of these traits. Also, certain environmental factors were investigated to determine if their influences were different for the lamb growth, lambing date and wool traits of both breed groups.

LITERATURE REVIEW

The following literature review deals with type of ewe for lamb and wool production. Most of the studies reviewed were designed to compare various types of ewes for their suitability as flock replacements at a given locality. In some of these studies, a comparison was made between various purebred or high-grade ewes only; whereas, other studies compared the performance of various crossbred, native and purebred or high-grade ewes for lamb and wool production.

Hunt (1935) compared the production of mutton-type (purebred Hampshire), fine-wool-type (grade Delaine-Merino) and crossbred ewes (Dorset x grade Delaine-Merino). The Hampshire ewes were found to be more productive than the Delaine-Merino or crossbred ewes. This increased productivity of the mutton-type ewes was attributed to their heavier weight, since the average weight per ewe was 145 pounds for the Hampshires, 100 pounds for the grade Delaine-Merinos and 112 pounds for the crossbred ewes.

Seventy-seven Rambouillet ewes were compared (4 years data, 1927-1930) with 80 first-cross Romney x Rambouillet ewes for spring lamb production by Miller (1935). The Rambouillet ewes were superior to the crossbreds in earliness of breeding (breeding began on July 1) and produced 76.1 percent twins while the Romney x Rambouillet ewes produced only

61.6 percent twins, based on the ewes that actually lambed. In final weight, the lambs from the Rambouillet ewes were nine pounds per head heavier primarily because the lambs from the Rambouillet ewes were, on an average, 21 days older than those from the Romney x Rambouillet ewes. This was due to a difference in the average breeding date for the two ewe breed groups (August 1 for the Rambouillets and August 21 for the Romeny x Rambouillet ewes). With respect to average daily gain, the lambs out of the Romney x Rambouillet ewes excelled (0.599 lb. for the lambs from the Romney x Rambouillet ewes compared to 0.561 lb. for lambs out of the Rambouillet ewes).

Bell *et al.* (1936) reported that American Merino sheep of the smooth-bodied to moderately-wrinkled-type were found to produce an average of from 3.68 pounds to 5.05 pounds more of unscoured wool per head in 12 months than Tasmanian Merino sheep kept under similar conditions. However, when the weight of unscoured wool produced was calculated on the basis of unscoured wool per 100 pounds live weight of sheep, the American Merino out-sheared the Tasmanian Merinos only by an average of from 1.68 to 2.46 pounds.

Duncan *et al.* (1948) reported on an eight-year comparison at the Middle Tennessee Station among (a) 29 Northwest ewes (Hampshire x Rambouillet), (b) 39 grade Hampshire ewes raised from selected ewe lambs from the station flocks and (c) 32 mountain ewes (mostly blackfaced ewes) from the Cumberland Plateau. In most of the eight years of the experiment based on gross returns per ewe from lambs and wool, the Northwest ewes were most productive and the mountain ewes were second.

Miller (1942) compared three kinds of Western ewes on the basis of farm flock production records in Kentucky. Miller found that: (a) Hampshire crosses with range ewes produced the best lambs and had fleeces ranging from eight to 10 pounds grease weight. (b) Crossbreds (presumably Columbia, Corriedale or longwool crosses with grade range ewes) were about as prolific and hardy as Hampshire crosses and produced slightly heavier fleeces, but their lambs were somewhat rangier and slower to mature or fatten with carcass yields of one to two percent less than lambs from Hampshire crosses. (c) Range Rambouillet ewes were the hardiest and earliest breeding of the three kinds but were not as prolific as the crossbreds. Their fleeces were about equal in weight to the Hampshire crosses but the wool was finer and had greater scouring loss. These Rambouillet ewes were most useful for producing very early or out of season lambs.

Gorman *et al.* (1942) reported the results of five years of crossing purebred rams representing the Columbia, Corriedale, Lincoln and Romney breeds with 70 grade Rambouillet ewes of the medium-fine-wool type. Some of the first-cross ewes were retained and backcrossed to rams representing the same breed as their sires and observations regarding the resultant second-cross lambs were recorded. The number of lambs born per 100 first-cross ewes was lower than the number of lambs born per 100 original, grade Rambouillet ewes. During the course of this experiment, the first-cross Corriedale ewes gave birth to 121 second-cross lambs per 100 ewes. The first-cross Romney ewes gave birth to 112 second-cross lambs per 100 ewes, the first-cross Lincoln ewes gave birth to 109 second-cross lambs per 100 ewes and the first-cross Columbia ewes had 107 lambs per 100 ewes. In number of lambs reared per 100 ewes, based on the total number of first-cross ewes at lambing time, the Corriedales led with 108 lambs, the Romneys were second with 100 lambs, the Lincolns were third with 95 lambs and Columbias were fourth with 78 lambs per 100 ewes. In weight of lambs reared per ewe based on the total number of ewes that reared lambs, the first-cross Columbias led with 82.5 pounds per ewe followed by Romneys with 77.3 pounds, Corriedales with 76.7 pounds and Lincolns with 71.9 pounds of live lamb per ewe. A summary of the wool studies indicates that in character of fleece, the Corriedales ranked highest; in length of staple produced in 12 months, the Lincoln ranked highest; in pounds of grease wool produced in 12 months, the Columbia ranked highest. The mean difference in fleece weights between the various crossbreds was not as great as the individual variation within any one crossbred group. The average weight of wool produced by the crossbreds at one, two, three and four years of age was not significantly greater than the weight of wool produced by the original grade Rambouillet ewes of similar ages. The staple length of all the first-cross ewes was much greater than that of the original grade Rambouillet ewes.

Sims and Webb (1945) investigated breeds and crosses for the production of fat lambs in the Mallee area in Victoria. Riverina Merino ewes were mated to rams of the Border-Leicester, Dorset Horn and Corriedale breeds and the results compared over a four-year period. The so-called "halfbred" ewes from the above crosses were retained for breeding and compared when mated to Dorset Horn rams. Lambs from Border-Leicester "halfbred" ewes were heaviest at birth and at all stages of growth and were graded highest for carcass quality. Lambing percentages were fairly even, although the Dorset Horn-cross ewes were generally higher. The Corriedale x Merino ewe gave the greatest wool return as a lamb, as a weaner and as a lambing ewe. Taking both wool and lamb production into consideration, the Border-Leicester-cross ewes gave the highest gross returns. They were followed by the Corriedales with the Dorset Horn being last.

Further experimental evidence on the value of the "halfbred" as an ewe for the production of fat lambs has been derived from sheep breeding experiments carried out at Askham Bryan and Garforth in Yorkshire (Bywater, 1945a; Bywater, 1945b; Boaz et al., 1946). Using the total live weight of lambs per ewe put to the ram as an index of commercial value, the results were summarized as follows: halfbred (128.3 lb.) compared with the Lincoln (91.4 lb.) when mated to rams of various breeds; halfbred (143.0 lb.) compared with the

Cheviot (107.0 lb.) when mated to Suffolk rams; halfbred (125.1 lb.) compared with the Kerry Hill (110.7 lb.) when mated to Suffolk and Hampshire rams; halfbred (135.3 lb.) compared with Suffolk x Swaledale (131.9 lb.), Masham (128.7 lb.) and Border-Leicester x Swaledale (120.1 lb.) when mated to Hampshire rams.

Whitehurst et al. (1947) mated Columbia rams to 38 Columbia and 25 native ewes that had been raised in Florida. F_1 rams and 71 F_1 ewes from the use of Columbia rams on native ewes were interbred and 55 F_2 ewes were produced. Hence, there were available for comparison Columbia, native, F_1 and F_2 ewes, all of which had been reared in Florida. Native ewes produced somewhat more lambs than Columbias, but Columbia and native ewes did not differ materially in weight of their lambs at weaning (140 days). The majority of the lambs from the native ewes were sired by Columbia rams, so this may have given the native ewes an undue advantage in this comparison. F_1 and F_2 ewes exceeded both parental types with regard to number of lambs produced and in weight of lambs at weaning. In grease weight of wool, the Columbias were more than twice as high as the native ewes and the F_1 and F_2 ewes were intermediate. There was no material difference in length of staple between Columbia, F_1 and F_2 ewes and the native wool was only slightly shorter than that from Columbia ewes. The results indicate that, under the conditions of this experiment, the Columbia sheep did not reproduce very efficiently under Florida conditions. However, ewes produced by mating Columbia rams to native ewes reproduced at a level superior to either parent strain and their fleeces were considerably heavier than those of native ewes.

Leveck (1947) reported on comparisons carried out at the Mississippi Station among ewes which were first-crosses of Corriedale, Hampshire and Southdown rams with native Southern Mississippi ewes. Lambs from the Corriedale and Hampshire crossed ewes were about equal in growth rate and gained faster than lambs from Southdown x native ewes. The Corriedale x native ewes lambed earlier and sheared heavier fleeces. Leveck also reported results from a second experiment comparing: (a) 30 Hampshire x Rambouillet ewes from Montana, (b) 29 Hampshire x Rambouillet ewes from Texas and (c) 18 Corriedale x native ewes produced in Mississippi. The Texas and Corriedale x native ewes lambed earlier (Jan. 10 and Jan. 20, respectively) and were more prolific than the Montana ewes. Lambs from the Montana ewes had slightly faster growth rates. Slaughter grades of lambs from the Montana and Texas ewes were about equal and both were substantially higher than those from the Corriedale x native ewes. The wool clip from the Montana ewes was the highest (7.7 lb.), while the Texas ewes were last (7.2 lb.).

Grandstaff (1948) evaluated the performance of 173 Corriedale x Navajo and 110 Romney x Navajo ewes and compared the lamb production of these crosses with that of Navajo ewes bred to Navajo rams. Data on a total of 1947 matings of Navajo ewes and rams during the six years from 1937 to 1942 showed an average of 88.6 percent of ewes lambing, which is comparable to the figures reported for the Corriedale (89.1 percent) and Romney (88.8 percent) crosses. Percentage lambs born of ewes lambing and the percentage of lambs weaned of live lambs born were 127.3, 138.4, 128.5; 99.5, 112.2, 92.4; respectively, for the Navajo, Corriedale and Romney crosses. Navajo lambs exceeded those from the Corriedale and Romney crosses in livability, but the percentage of Navajo lambs reared was between the values obtained for the two crosses. Average weaning weight and pounds of lamb weaned per ewe bred for the Navajo strain were approximately 57.0 pounds, which compares with the values for the Romney-cross (53.4 lb.), but were significantly lower than the values observed for the Corriedale-cross (68.6 lb.). The Corriedale-cross ewes sheared heavier fleeces which yielded more clean wool, although they had a higher shrinkage than the fleeces of the Romney crosses. The grease fleece weights showed an increase of from 25 percent for the Romney-cross to 47 percent for the Corriedale-cross over that of the Navajo ewes.

A highly specialized form of lamb production is that of producing "hothouse" lambs which are marketed in the large Eastern cities. Henning and Mackenzie (1927) and Henning _et al._ (1930) define such a lamb as being marketed at from five to 14 weeks of age and at live weights of 25 to 60 pounds. The lambs are born usually in the autumn or winter months. Kean and Henning (1949) studied 10 crosses for the production of these "hothouse" lambs. The two variables studied were birth weight and average daily gain. They found that lambs produced by the crossing of Dorset Horn rams on Corriedale x Merino ewes had the heaviest birth weights, made the most rapid gains and produced a high percentage of top quality carcasses. These authors further stated that since out-of-season breeding is required, the Merino ewe base is necessary.

Results reported by Miller and Killeen (1949) on a comparison of 100 Border-Leicester x Merino, 100 Romney x Merino, 100 Corriedale x Merino and 100 Polworth ewes showed that the Border-Leicester x Merino ewes produced the best and heaviest lambs, but in seasons of high wool prices, the Corriedale x Merino ewes were equally remunerative, the quality and production of wool making up for the smaller number of lambs and their slower growth rate.

Woehling and Henning (1949) studied fleece weight records collected from sheep maintained at Pennsylvania State College during a 12-year period (1936-1947). These authors compared the fleece weights of Merino-cross ewes [Hampshire x (Dorset x Merino); Dorset x Merino; Dorset x (Columbia x Merino); Corriedale x Merino] with purebred Merinos. The fleeces from the purebred Merino ewes averaged 3.33 pounds heavier than those from the Merino-cross ewes.

Barrentine (1952) compared the following kinds of ewes at the Mississippi Station: (a) home raised grade Corriedales, (b) Hampshire x Rambouillet ewes from the Northwest, (c) Columbia x Rambouillet ewes from the Northwest, (d) Suffolk x Rambouillet ewes from the Southwest and (e) Corriedale x Rambouillet ewes from the Southwest. The locally raised grade Corriedales lambed earlier than any of the Western types but their lambs were lighter at market. Four years' results indicated that the two Southwest groups were better adapted to Mississippi conditions than were the Hampshire x Rambouillet ewes from the Northwest. Three years' results indicated that the Columbia x Rambouillet ewes were superior to the Hampshire x Rambouillet group. Ewes of Columbia or Corriedale breeding produced the heaviest fleeces and the Suffolk x Rambouillet ewes produced the lightest.

Goode et al. (1952) compared (a) purebred Hampshire ewes, (b) Hampshire x Rambouillet ewes from the Northwest and (c) native ewes produced in a continuous crossbreeding scheme using rams of several mutton breeds in rotation. The native crossbreds and Northwest ewes were about equal in performance. The native crossbreds were somewhat more prolific but the Northwest ewes sheared heavier fleeces and had heavier and higher grading lambs at 120 days of age. The purebred Hampshire ewes were distinctly poorer than the other two types in number of lambs weaned, fleece weight and grade of lambs, but they were equal to the native crossbreds in 120-day weight of lambs.

Kincaid and Carter (1963) reported the results of a four-year (1946-1949) experiment comparing yearling ewes from three sources with respect to lamb and wool production. The three ewe sources were: (a) 47 selected native ewes produced by keeping back the most promising ewe lambs from the experimental flock each year, (b) 136 Northwest blackface crossbreds sold as first-crosses of Hampshire rams with grade range ewes and (c) 97 commercial native ewes produced from late or low quality ewe lambs purchased on auction or other markets. The number of lambs raised to weaning or market per ewe bred was the most important difference among the three ewe sources. The average was: selected natives, 1.02; Northwest, 0.95 and commercial natives, 0.64. The rank and average in birth weights of lambs were as follows: Northwest ewes, 9.2 pounds; selected natives, 9.0 pounds and commercial natives, 8.7 pounds. Northwest ewes ranked first in average daily gain of lambs with 0.52 pounds per day; selected natives followed closely, averaging 0.51 pounds and commercial natives averaged 0.49 pounds per day. Selected native ewes by Corriedale or Columbia rams sheared the heavier fleeces, averaging 10.0 pounds grease wool; Northwest ewes followed with 9.1 pounds; selected natives by Hampshire or other medium-wool breeds of rams averaged 7.8 pounds and commercial natives averaged 6.6 pounds. The authors concluded that although selected natives were generally better, both selected natives and Northwest ewes were considered to be satisfactory replacement ewes for Virginia conditions; whereas, the commercial native ewes were considered to be unsatisfactory.

Four types of Western ewes were compared for suitability as flock replacements in a five-year (1950-1955) experiment at the Virginia Station by Carter *et al*. (1957). The four types of ewes were 30 "Texas" Suffolk x Rambouillet, 30 "Northwest blackface" Hampshire x Rambouillet ewes, 30 "whiteface crossbreds" produced in the Northwest by crossing Columbia, Corriedale or Lincoln rams on range ewes and 30 grade Rambouillet ewes from the Northwest. The four types of ewes were quite similar in number of lambs raised to weaning or market age per ewe bred in the fall. The average productivity was: Suffolk x Rambouillet, 1.02; Hampshire x Rambouillet, 1.04; whiteface crossbred, 1.02 and grade Rambouillet, 1.01. The Suffolk x Rambouillet ewes had the earliest average lambing date (Feb. 1) followed by the Hampshire x Rambouillet and Rambouillet (each averaging Feb. 3) and the whiteface crossbreds lambed the latest (Feb. 8). Lambs from the Suffolk x Rambouillet ewes were heavier at birth averaging 11.0 pounds, followed by those from the Rambouillet ewes at 10.7 pounds and the Hampshire x Rambouillet and whiteface crossbreds at 10.6 pounds each. The rank and average in daily gain from birth to weaning were by type of ewe: Suffolk x Rambouillet, 0.60; Hampshire x Rambouillet, 0.59; whiteface crossbred, 0.57 and Rambouillet, 0.56 pounds per day. The whiteface crossbred ewes sheared the heaviest fleeces, averaging 9.2 pounds per ewe and these were followed by the Rambouillet with 8.8 pounds, the Hampshire x Rambouillet with 7.9 pounds and the Suffolk x Rambouillet ewes were last with 6.5 pounds. The authors concluded that the Suffolk x Rambouillet, the Hampshire x Rambouillet and Columbia or Corriedale-cross ewes are all satisfactory ewes for lamb production under Virginia conditions and should perhaps be ranked in the order named. The rank in wool production is just the reverse and tends to more nearly equalize their value.

Neumann et al. (1951) compared 50 2-year-old Western ewes with high-grade Hampshire and Suffolk ewes for lamb and wool production in Arkansas. Purebred Hampshire and Suffolk rams were mated to similar numbers of Western ewes and high-grade ewes of their respective breeds. No definite trend was observed in lamb livability when the Western ewes were compared with the Hampshire ewes. The Western ewes reared 75.0 and 89.6 percent of the two lamb crops (1949-1950) studied, as compared to 66.6 and 73.6 percent reared by the Suffolk ewes. With respect to wool production, the fleeces from the Western ewes were heavier in grease than the Hampshire or Suffolk ewes but lighter when scoured. These authors stated that the fleeces from all groups of ewes were about equal in value, and from the standpoint of wool production no one type of ewe has an advantage over the others.

Price et al. (1953) analyzed the fleece records on 917 Navajo and Navajo crossbred yearling ewes born in 1948, 1949 and 1950. The traits studied were staple length, grease fleece and clean fleece weight. The Navajo ewes were less desirable in all traits except staple length when compared with the Navajo crossbred ewes.

Livesay and Cunningham (1957) compared 65 native Hampshire-type ewes with 65 Western Corriedale-type ewes for lamb and wool production and longevity at the West Virginia Station. The work was actively started with the breeding season (Sept. 15 to Nov. 15) of 1942 and closed with the marketing of the 1952 lamb and wool crop. From the standpoint of total lamb production, the Western ewes were more productive as evidenced by their increased number of lambs born and marketed. The weight of fleece, per ewe clipped, was approximately 100 percent heavier for the Western ewes. The longevity of the Western ewes was also found to be superior to that of the native ewes. There was a much heavier loss of native ewes as they reached seven to eight years of age.

deBaca _et al_. (1956) divided a flock of 120 Lincoln x Rambouillet ewes into four groups and mated each group to rams of the Romney, Border-Leicester, Cheviot and Hampshire breeds. Hampshire-cross ewes produced the fastest growing lambs of the breeds compared. Lambing percentages were 134, 127, 124 and 115 for Hampshire, Cheviot, Border-Leicester and Romney-cross ewes, respectively, and lamb mortality was 6.4, 5.7, 4.8 and 14.8 percent in the same order.

Bogart _et al_. (1957) reported on a study in which the objective was to ascertain which of several breed crosses would be most adapted for optimal production under Western Oregon conditions. The first-cross ewes referred to in this study were the result of mating Lincoln x Rambouillet ewes to Hampshire, Border-Leicester, Cheviot and Romney rams. Second-cross ewes were derived by backcrossing the first-cross ewes to rams of their respective sire breed. The sires of the lambs were either of the Southdown or Suffolk breeds. Lambs from the Border-Leicester-cross ewes were significantly heavier at birth than those from the Cheviot-cross ewes. Hampshire-cross ewes produced lambs which were heavier than those from Cheviot-cross ewes when all lambs were sired by Suffolk rams. There were no significant differences among birth weights of lambs from Hampshire, Border-Leicester and Romney-cross ewes or between those from Romney and Cheviot-cross ewes.

Bell (1960) reported on the development of the flock of Targhee sheep at the Ohio Station. In the experimental program, several types of sheep were tested and numerous crosses were made. The best results obtained came as a result of crossing small size Merinos with large size Columbia rams and then crossing this crossbred ewe with a large size mutton-type sire. The authors stated that this Columbia x Merino ewe seemed to possess more of the necessary characteristics such as: long life, increased growth-rate potential, improved milk production, higher fertility level and heavy shearing qualities.

Comparisons were made between 16 purebred and 16 crossbred ewe lambs for percent ewes lambing, percent of multiple births and average lambing date by Fox and McArthur (1962).

The genetic background of the crossbred ewes was Hampshire rams crossed with Columbia or Targhee ewes. When bred as ewe lambs, 94 percent of the crossbred ewes lambed and produced 143 percent lambs. Only 43 percent of the purebred ewes lambed, produced no multiple births and lambed 17 days later than the crossbreds. The average lambing date for the purebreds was 3-1-61 as compared to 2-13-61 for the crossbred ewes. When bred as yearlings, 94 percent of the crossbred ewes lambed and produced 169 percent lambs. One hundred percent of the purebred ewes lambed, produced 125 percent lambs and lambed two days earlier than the crossbreds. Average lambing date for the purebreds was 1-21-62 compared to 1-23-62 for the crossbreds. The authors stated that the higher percent of crossbred ewes lambing when bred as lambs indicated that these ewe lambs were in estrus at an earlier age than the purebred ewe lambs.

In a similar study, Fox et al. (1964) compared 38 crossbred and 81 purebred females for percent of ewes lambing, percent of multiple births and average lambing date when each group was bred as lambs and reared under two different post-weaning environments. The purebreds were Columbia, Targhee and Hampshire and the crossbreds were the result of Hampshire rams being mated to Columbia or Targhee ewes. The two post-weaning environmental conditions were altitudes of 251 and 2765 feet above sea level at the Corvallis and Union Stations, respectively, in Oregon. Seventy percent of the crossbred ewes lambed at the Corvallis Station and 61 percent lambed at the Union Station, as contrasted with values of 64 and 53 percent at Corvallis and Union, respectively, for the purebreds. The crossbreds that lambed produced a 164 percent lamb crop at both stations and the purebreds produced 148 percent at Corvallis and 154 percent at the Union Station. The average lambing date was March 1 for the purebreds and March 4 for the crossbred ewes. For the percent of ewes lambing and the percent of multiple births there was a 10 percent advantage for the crossbred females when compared with the purebred females.

Differences in fertility, prolificacy and livability were studied with Hampshire, Shropshire, Southdown and Merino breeds of sheep and their crosses and with the Columbia-Southdale strain of sheep (Sidwell et al., 1962). This eight-year (1952-1959) study included a total of 3620 lambs born and 2646 lambs weaned from 2962 ewes bred. Traits studied were: fertility, measured by percent ewes lambing of ewes bred; prolificacy, measured by percent lambs born of ewes lambing; lamb livability, measured by percent lambs born alive of lambs born and percent lambs weaned of lambs born alive and the overall measure of reproductive ability by percent lambs weaned of ewes bred. In purebred matings, Hampshires, Merinos and Columbia-Southdales excelled over the Shropshires and Southdowns in percent of lambs weaned of ewes bred. Hampshires and Columbia-Southdales ranked highest in prolificacy and Merinos ranked highest in fertility and lamb livability among the breeds studied. Fertility, prolificacy, lamb livability and overall reproductive ability were generally higher for crossbred than for purebred matings. Furthermore, there was an upward trend with an increase in the number of breeds involved in the cross. Two-breed crosses tended to rank in somewhat the same order as the dam breed and were not significantly greater than the purebred matings for any of the traits studied. Consistent effects of breeds or breed combinations were not readily apparent in reproductive traits of three and four-breed crosses. Average increases in percent lambs weaned by ewes bred were 2.1, 14.9 and 27.1 for two, three and four-breed crosses, respectively, over the comparable averages of the purebred parents.

A comparison of three-breed crosses and backcross lambs at the Southwest Virginia Station was reported by Carter and McClaugherty (1963). In this study 60 ewes (30 Hampshire x Western range ewes and 30 Suffolk x Western range ewes) and two rams each of the Hampshire and Suffolk breeds were used each year. The rams were replaced each year and three samples of each kind of ewe were used, each ewe group rearing at least two lamb crops. The authors reported little difference between the two kinds of crossbred ewes in lamb production.

A study covering six years of comparison between crossbred and purebred ewes for lamb and wool production was reported by Botkin and Paules (1965). The breeds involved were Suffolk and Corriedale and their cross. Lambing percents were highest for crossbred ewes (122 percent) and lowest for the Suffolk ewes (not reported). Corriedale ewes mated to Suffolk rams produced more and heavier lambs than did the crossbred or Suffolk ewes. Suffolks were lowest both in quantity and quality of wool produced. In terms of total productivity (measured by kilograms of lamb raised per ewe bred at 44¢/kg. plus kilograms of wool per ewe at $1.36/kg.), Corriedale ewes mated to Suffolk rams ranked first, while the crossbred ewes mated to Corriedale or Suffolk rams ranked second and third, respectively. Straightbred Corriedales were fourth and straightbred Suffolks were below all other groups.

Matthews _et al_. (1965) compared the productivity of crossbred and straightbred ewes from three different breeds. This study involved data taken from 136 lambs produced by Rambouillet, Columbia and Targhee ewes and different crosses between these breeds. No statistically significant differences were found among the different breed groups (Rambouillet, Columbia, Targhee, Rambouillet x Targhee, Rambouillet x Columbia, Targhee x Columbia, Rambouillet x Targhee x Columbia) for birth weight or average daily gain from birth to weaning.

Madsen _et al_. (1965) compared the wool production of Columbia, Rambouillet, Targhee and crosses of these three breeds under Utah range conditions. Wool production records of 464 yearling Rambouillet, Columbia, Targhee and the two-way and three-way-cross ewes of these breeds were collected during 1963 and 1964. These workers noted very little difference in either grease fleece or clean fleece weight among the various groups. They suggested that the small differences observed resulted from the considerable similarity in the genetic ancestry of the three breeds used in this study, since the Rambouillet breed was used in the development of the Columbia and Targhee sheep.

Shelton et al. (1966) summarized results from various sheep experiments conducted in the Southern Region of the United States. This information is presented in Table I by breed or type of ewe. Using reproductive efficiency as an index, it would appear that the Florida native is best adapted to the Southern Region. However, Loggins et al. (1964) reported the Florida natives are relatively unsatisfactory for a commercial program because of low fleece weight and weight and grade of their lambs. Following the Florida natives in overall reproductive efficiency were ewes of Rambouillet breeding, which performed creditably in respect to fleece and lamb weights. The fine-wool x medium-wool ewes were next in order of importance. Included in this group were ewes of various types which were purchased as replacements from the range areas as well as specific crosses produced in the various experimental programs. The other purebred groups are somewhat variable in response and the authors suggested that this may be due to small numbers and the location at which the data were collected. The authors further stated that for the production of fat lambs in the Southern

TABLE I

PERFORMANCE BY BREED OR TYPE OF EWE FOR THE ENTIRE SOUTHERN REGION OF THE UNITED STATES (SHELTON *ET AL.*, 1966)

Breed or type	No. of ewes	Percent ewes lambing	Lambing rate	Percent lamb mortality	Lambs weaned per-100 ewes bred	Birth wt. (lb.)	120-day wt. (lb.)	Fleece wt. (lb.)
Hampshire	2146	75.5	1.33	25.3	74.9	8.7	69.3	6.6
Suffolk	339	72.6	1.46	20.3	84.4	9.9	83.2	6.9
Southdown	387	80.8	1.37	30.0	77.8	6.9	48.3	4.5
Merino	152	68.4	1.22	22.1	65.1	5.5	55.3	12.5
Florida Native	192	91.7	1.18	11.1	96.4	6.8	51.0	4.2
Rambouillet	2650	83.2	1.33	17.9	90.7	8.7	66.9	9.7
Fine wool crossbred	821	81.0	1.29	15.2	88.8	8.5	66.1	7.9

Region, ewes should have a high fertility and lambing rate and be capable of producing a lamb having a rapid growth rate and an acceptable carcass grade. Ewes should also produce a good merchantable fleece and be able to carry out these functions efficiently under the environmental conditions of this region. The authors concluded that no breed or type of sheep now available in the Southern Region meets all of these requirements.

Singh *et al*. (1967) evaluated the performance of some breeds of sheep developed at the University of Minnesota when crossed among themselves and with the Hampshire and Suffolk breeds. In this study, the Minnesota 106 (purebred Columbia) ewes produced and reared a higher percentage of twins than did the other breed groups. With respect to lamb growth data, weights on 5466 lambs at birth and 4906 lambs at weaning were studied. The heterotic effects expressed as a percent over the parental means for all combinations were 4.7 and 8.1 percent, respectively, for birth and 100-day weight of lambs. The authors concluded that the magnitude of heterotic effect justifies the recommendation of crossbreeding for commercial lamb production.

This literature review indicates quite variable results have been reported by various workers with respect to type of ewe for lamb and wool production. Some workers have shown an advantage for the various crossbred ewes over their parental breeds, especially with respect to reproductive ability.

MATERIALS AND METHODS

During the fall seasons of 1956, 1957 and 1958, 40 ewe lambs (20 Dorset x Rambouillet and 20 Dorset x 3/4 Rambouillet x 1/4 Panama) were raised and the following spring seasons, 40 yearlings, considered to be typical of these normally purchased by Oklahoma sheepmen as replacements, were purchased for comparison with the raised replacements under a fall-lambing program at the Fort Reno Livestock Research Station, El Reno, Oklahoma. In each year, the raised replacements were usually the first 20 open-faced ewe lambs to reach market weight (about 95 lb.) from each group of original ewes (Rambouillet and 3/4 Rambouillet x 1/4 Panama). The purchased yearlings were Rambouillet, 3/4 Rambouillet x 1/4 Merino, Panama, 3/4 Rambouillet x 1/4 Columbia and a group referred to as "Whiteface Market" ewes purchased on the Oklahoma City Stockyards (these were part Columbia, Panama or Corriedale mixed with Rambouillet).

The breed composition, number of ewes involved in each breed group and the season and year the ewes were purchased or raised are presented in Table II. For the purposes of this study, all purchased ewes were combined together and collectively referred to as "Western" ewes and the raised replacements referred to as "crossbred" ewes.

Since the Western ewes were born during the spring of

TABLE II

BREED COMPOSITION, NUMBER OF EWES INVOLVED IN EACH BREED GROUP AND THE SEASON AND YEAR THE EWES WERE PURCHASED OR RAISED FOR LIFETIME COMPARATIVE PURPOSES UNDER A FALL-LAMBING PROGRAM IN OKLAHOMA

Breed composition	No. of ewes	Season and year purchased	Season and year raised
Dorset x Rambouillet	20		Fall 1956
Dorset x (3/4 Rambouillet x 1/4 Panama)	20		Fall 1956
Panama	20	Spring 1957	
3/4 Rambouillet x 1/4 Merino	20	Spring 1957	
Dorset x Rambouillet	20		Fall 1957
Dorset x (3/4 Rambouillet x 1/4 Panama)	20		Fall 1957
Rambouillet	20	Spring 1958	
Whiteface Market[a]	20	Spring 1958	
Dorset x Rambouillet	20		Fall 1958
Dorset x (3/4 Rambouillet x 1/4 Panama)	20		Fall 1958
Rambouillet	20	Spring 1959	
3/4 Rambouillet x 1/4 Columbia	20	Spring 1959	

[a]Part Columbia, Panama or Corriedale mixed with Rambouillet.

the same year that the crossbred ewes were born during the fall, the Western ewes had an age advantage of about seven months over the crossbred ewes to which they were to be compared. The age at lambing expressed in months for the three groups of purchased Western ewes and the three groups of raised crossbred ewes within each year is presented in Table III. The lambing ages are further expressed in months for the two ewe breed groups separately and in years and coded form for the two breed groups combined in Table IV. Throughout this study all age of dam effects for the various variables are illustrated through use of the coded ewe age as presented in Table IV, with the exception of the two classifications represented by the numbers 9 and 10. Preliminary analyses of the lamb growth data indicated that the last two age of dam groups should be combined due to the small numbers represented in each of these age groups. Therefore, the last age of dam effect for each lamb growth variable is represented by the number and symbol, 9^+, which merely indicates that the last two age groups were combined into one classification.

Each year the managerial practices were similar for the Western and crossbred ewes and were as follows:

A. Shearing:

1. All ewes were sheared from five to 10 days (May 10-May 15) before the beginning of the spring breeding season. The fleece weights for each year were obtained during the spring of the following year. For example, the 1957 fleece

TABLE III

AGE AT LAMBING EXPRESSED IN MONTHS FOR THE THREE GROUPS OF PURCHASED WESTERN EWES AND THE THREE GROUPS OF RAISED CROSSBRED EWES

Year	W[a]	C[b]	W[c]	C[d]	W[e]	C[f]
57	19	12				
58	31	24	19	12		
59	43	36	31	24	19	12
60	55	48	43	36	31	24
61	67	60	55	48	43	36
62	79	72	67	60	55	48
63	91	84	79	72	67	60
64	103	96	91	84	79	72
65	115	108	103	96	91	84
66	127	120	115	108	103	96

[a]W = Western ewes purchased during spring of 1957.
[b]C = Crossbred ewes raised during fall of 1956.
[c]W = Western ewes purchased during spring of 1958.
[d]C = Crossbred ewes raised during fall of 1957.
[e]W = Western ewes purchased during spring of 1959.
[f]C = Crossbred ewes raised during fall of 1958.

TABLE IV

AGE AT LAMBING EXPRESSED IN MONTHS FOR THE WESTERN AND CROSSBRED EWES SEPARATELY AND EXPRESSED IN YEARS AND CODED FORM FOR THE TWO BREED GROUPS COMBINED

Ewe age at lambing (months)		Ewe age at lambing (years)[b]	Coded ewe age at lambing
W[a]	C	W and C combined	W and C combined
19	12	$1 \leq AOD < 2$	1
31	24	$2 \leq AOD < 3$	2
43	36	$3 \leq AOD < 4$	3
55	48	$4 \leq AOD < 5$	4
67	60	$5 \leq AOD < 6$	5
79	72	$6 \leq AOD < 7$	6
91	84	$7 \leq AOD < 8$	7
103	96	$8 \leq AOD < 9$	8
115	108	$9 \leq AOD < 10$	9
127	120	$10 \leq AOD < 11$	10

[a]W = Western ewes, C = Crossbred ewes;

[b]AOD = Age of dam.

weights were collected during the spring of 1958.

2. As each ewe was sheared, her grease fleece weight was recorded and the fleece was squeezed using a "squeeze" machine described by Neale *et al.* (1958). Using this "squeeze" machine reading and a conversion table, each individual clean fleece weight was estimated.

3. After the ewes were shorn, they were individually weighed and given a condition score (degree of fatness) ranging from one to 9, with a score of one representing an

extremely thin ewe; whereas, a score of 9 indicated an extremely fat ewe. While the ewes were on the scales, they were paint branded on the back with individual numbers taken from their ear tags for identification purposes.

4. All ewes were tagged (crutched) and had their faces sheared about two weeks (Oct. 1) before fall-lambing began.

B. Breeding:

1. At the time the ewes were shorn, they were also paint branded on their rumps with a single number indicating the breeding group to which they were being assigned. The ewes were randomly assigned to these breeding groups on the basis of breed, age and past reproductive performance. The ewes were then moved to small breeding pastures and the breeding season started.

2. Each breeding group was composed of 40 to 50 ewes and these ewes were mated to one blackface (Suffolk or Hampshire) and one whiteface (Dorset or Rambouillet) ram. The Rambouillet rams were used only during the years 1960-1963.

3. The two rams per breeding group were alternated, one breeding one night and the other the next night (night breeding was practiced throughout most of this study). The rams breeding the previous night were removed from the breeding groups each morning and allowed to rest in a shaded area until their next breeding period began.

4. Gross microscopic examination was made on the semen of all rams prior to each breeding season and any ram with questionable semen was not utilized for breeding.

5. Breeding for fall-lambing began on approximately May 20 and had an average duration of 40 days, except during 1957 when a 32-day breeding season was commenced on June 1. A 30-day "cleanup" breeding period beginning on August 20 was permitted for those ewes failing to conceive during the regular breeding season. In most instances, only blackface (Hampshire or Suffolk) rams were utilized for the "cleanup" breeding so that the lambs born to these matings would possibly have a faster rate of growth and be shipped to market before the advent of hot weather. The complete breeding dates for the 10-year period of this study are presented in Table V. With the exception of 1957 and the "cleanup" breeding of 1958 and 1966, these breeding dates and the respective lambing dates are illustrated in Figure 1. The poor spring breeding performance that resulted in 1957 caused a change in management so that the breeding season was extended to 40 days during subsequent years. The "cleanup" breeding was lengthened to 30 days after 1958 and moved toward the fall when most effective breeding is generally accomplished in sheep. No "cleanup" period was permitted during 1966, at which time the project was being terminated.

6. At the end of the breeding season, all ewes were pooled together and maintained on pasture until the lambing season began (about Oct. 15).

C. Lambing and Other Practices:

1. Approximately six weeks before the lambing season, the ewes were fed at the rate of about one-half pound per

TABLE V

DATE OF BEGINNING DURATION AND "CLEANUP" YEARLY BREEDING DATES FOR THE FORT RENO EXPERIMENTAL SHEEP FLOCK

Year	Beginning	Duration	"Cleanup"
57	June 1	32 Days	Aug. 1 - Aug. 20
58	May 20	40 "	Aug. 11 - Aug. 30
59	May 21	40 "	Aug. 20 - Sept. 21
60	May 20	40 "	Aug. 22 - Sept. 20
61	May 22	40 "	Aug. 21 - Sept. 22
62	May 21	40 "	Aug. 20 - Sept. 19
63	May 20	40 "	Aug. 20 - Sept. 19
64	May 20	40 "	Aug. 20 - Sept. 19
65	May 20	40 "	Aug. 20 - Sept. 19
66	May 20	40 "	None

day of grain (cracked milo). This was gradually increased to about one pound per day as lambing time approached.

2. All ewes were lambed out in individual pens in a central lambing barn. The ewes remained in these pens until their lambs were strong enough to follow their dams, which was usually two to three days.

3. As each ewe lambed, the date of lambing, sex of the lamb(s) and birth weight of the lamb(s) were recorded. The lamb(s) were given the same number as their dam (paint branded and ear tagged). In the case of twins, usually the stronger, more vigorous lamb received the same number as its dam, but a bar(-) was used to precede the second lambs' number to keep the two twins separate for later weighing. All birth weights were recorded to the nearest one-tenth of a

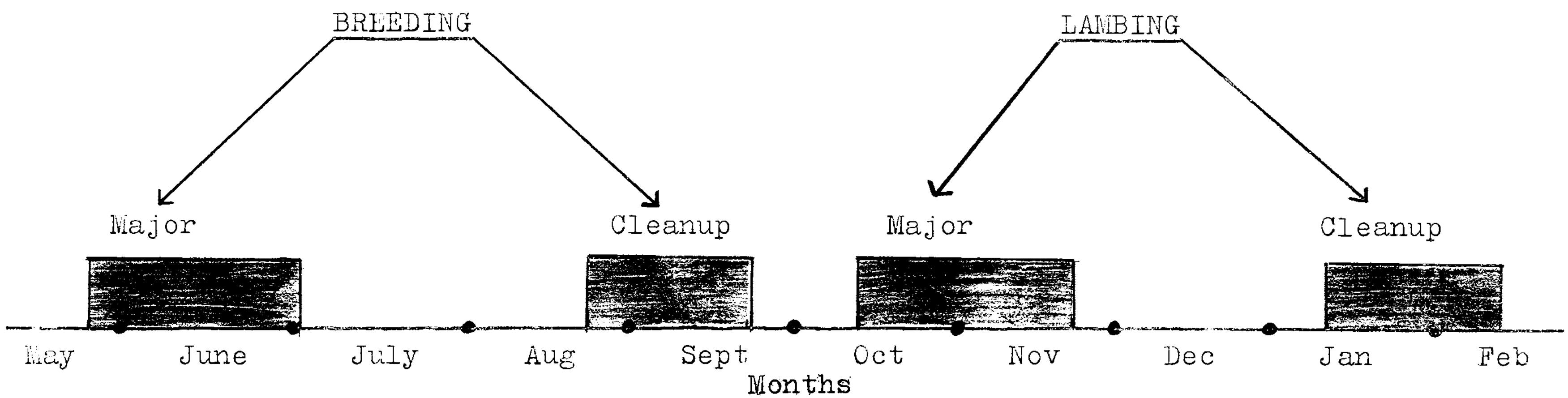

Figure 1. Breeding and Lambing Schedule Used from 1958 through 1966, except no "Cleanup" Breeding was Permitted during 1966

pound.

4. All lambs were docked one to two days after birth and the male lambs were castrated usually within a month after birth.

5. Approximately two weeks after lambing, the ewes and their lambs were transferred from the lambing barn to wheat pasture. In addition to wheat pasture, the ewes were fed grain at the rate of about a pound per day for about two months after lambing and also received about one pound per day of grass hay. Supplemental alfalfa hay was made available during inclement weather and periods of wheat pasture shortage. The lambs were allowed to run with their dams on wheat pasture until weaned (about 10 weeks of age) and had access to a free-choice creep feed mixture consisting of 63 percent cracked milo, 5 percent molasses and 32 percent chopped alfalfa hay. In 1963 a protein supplement in the form of soybean oilmeal was added to this creep ration and the resulting mixture consisted of 10 percent soybean oilmeal, 55 percent cracked milo, 5 percent molasses and 30 percent chopped alfalfa hay. After the lambs were weaned, the soybean oilmeal was gradually removed from the creep-ration over a three to four week period, except during 1964 when the oilmeal was removed abruptly after the lambs were weaned.

6. All ewes rearing twin lambs were separated on wheat pasture from the remaining ewes and lambs so their daily intake of grain could be increased to help compensate for

their increased level of productivity.

7. As the lambs were weaned, the ewes were removed from the wheat pasture, placed on dry grass pasture and remained there with supplemental hay during the remaining part of the winter and the following spring until shearing time. All ewes failing to lamb were also placed on dry grass pasture as soon as it was evident they were not going to lamb.

8. When the wheat pasture started active growth (usually during late March), the lambs were enclosed in a drylot feeding area and remained there with creep-feed until shipped to market at an average weight of about 95 pounds.

9. During each lambing season when the oldest lambs were about 45 days old, all lambs were weighed at two week intervals until shipped to market at about 95 pounds. These successive weights taken at biweekly intervals provided a means of calculating rates of gain from birth to 70 days, 70-day weights, rates of gain from 70 days to market and market ages utilized in this study. The 70-day weights were calculated by the linear interpolation method as described by Taylor and Hazel (1955).

10. No culling was practiced among the ewes unless their teeth deteriorated or they became severely emaciated.

Statistical Analysis of the Lamb Growth, Lambing Date, Wool and Ewe Reproduction Data

In the analyses of the lamb growth, lambing date and wool data, the least squares method of obtaining constants

(Harvey, 1960) was used to contend with the multiple classification and unequal subclass numbers. Estimates of the least squares constants were computed through use of normal equations illustrated by the following symbols: $(X'X)\hat{\beta} = (X'Y)$ where: X = observation matrix; X' = transpose of observation matrix; Y = vector of observations; $\hat{\beta}$ = vector of least squares constants.

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

$$\hat{\beta} = (X'X)^{-1}(X'Y)$$

Since the normal equations were not independent, the restriction that the sum of the least squares constants for each main effect equals zero was imposed for all analyses. Thus the number of parameters to be estimated for each main effect was reduced to the number of degrees of freedom available for each main effect and the least squares constants obtained were expressed as deviations from a zero mean for each effect. The procedure for determining the observation matrices is outlined in considerable detail by Cundiff (1966) and Cunningham (1967). All models for the lamb growth, lambing date and wool data were constructed under the assumption that no interactions existed among the effects illustrated in each model and that all errors were normally and independently distributed about a zero mean with common variance, σ^2. Least squares means were obtained by adding the least squares constants to the overall mean (μ) for each variable. Standard errors on all least squares constants were calculated as follows (Steel and Torrie,1960):

Standard Error = $\sqrt{C_{ii}\sigma^2}$ where: C_{ii} = appropriate $(X'X)^{-1}$ element; σ^2 = appropriate error mean square obtained from analysis of variance.

Statistical significance of the ewe reproduction data was assessed through use of the nonparametric sign test as outlined and described by Siegel (1956).

Lamb Growth Data

Records for this study were available on 2227 lambs of which 1980 were fall-born and 247 were winter-born lambs. The distribution of all fall lambs born within each week of the lambing season is presented in Figure 2. This figure illustrates that a large percentage of the fall lambs were born during the second (Oct. 17 - Oct. 23) and fourth (Oct. 31 - Nov. 6) week of the seven week lambing season.

Included among these 2227 lambs were 54 triplets (45 fall-born and 9 winter-born) and 26 ram (all fall-born) lambs. The rams were retained to serve either as teaser rams or to be utilized in a study comparing the carcass quality of ewes, wethers and rams when slaughtered at approximately 100 pounds. These ram lambs together with the triplets and all winter-born lambs were eliminated from the lamb growth data. It was not possible to analyze the growth data on the winter-born lambs due to incomplete data. Preliminary analyses indicated that the small number (22) of lambs born during the fall of 1957 should likewise be eliminated from the lamb growth data. Records on three other lambs

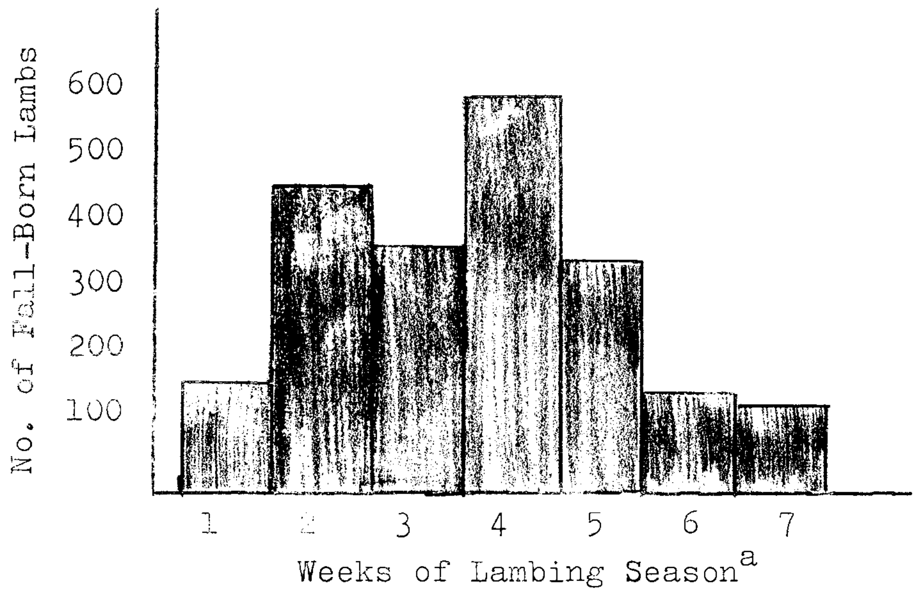

Figure 2. Distribution of All (Singles, Twins, Triplets) Fall Lambs Born within each Week of the Lambing Season from 1957 through 1966. [a]1 = Oct. 10 - Oct. 16; 2 = Oct. 17 - Oct. 23; 3 = Oct. 24 - Oct. 30; 4 = Oct. 31 - Nov. 6; 5 = Nov. 7 - Nov. 13; 6 = Nov. 14 - Nov. 20; 7 = Nov. 21 - Dec. 1.

were also eliminated because these lambs were born at an odd time during the lambing season in relation to the other lambs. Two of the lambs were born early (Oct. 2) and the other lamb was born very late (Dec. 28) during the lambing season.

With the elimination of the previously mentioned lambs, the following number of records was available for each of the five variables: birth weight, 1884; rate of gain from birth to 70 days and 70-day weight, 1590; rate of gain from 70 days to market and market age, 1420. These records are further classified according to sex of lamb and type of birth and rearing for the Western and crossbred ewes in Tables VI, VII and VIII.

TABLE VI

NUMBER OF BIRTH WEIGHT RECORDS AVAILABLE ON LAMBS FROM THE WESTERN AND CROSSBRED EWES CLASSIFIED ACCORDING TO SEX AND TYPE OF BIRTH

Ewe breed group	Sex of lamb				Total
	Females		Males		
	S[a]	T	S	T	
Western	239	192	234	182	847
Crossbred	182	329	201	325	1037
Total	421	521	435	507	1884

[a]S = Single; T = Twin

TABLE VII

NUMBER OF RECORDS ON RATE OF GAIN FROM BIRTH TO 70 DAYS AND 70-DAY WEIGHT AVAILABLE ON LAMBS FROM THE WESTERN AND CROSSBRED EWES CLASSIFIED ACCORDING TO SEX AND TYPE OF BIRTH AND REARING

Ewe breed group	Sex of lamb						Total
	Females			Males			
	SS[a]	TS	TT	SS	TS	TT	
Western	208	14	154	192	9	141	718
Crossbred	155	11	268	164	20	254	872
Total	363	26	422	356	29	395	1590

[a]SS = Single reared as single; TS = Twin reared as single; TT = Twin reared as twin.

TABLE VIII

NUMBER OF RECORDS ON RATE OF GAIN FROM 70 DAYS TO MARKET AND MARKET AGE AVAILABLE ON LAMBS FROM THE WESTERN AND CROSSBRED EWES CLASSIFIED ACCORDING TO SEX AND TYPE OF BIRTH AND REARING

Ewe breed group	Sex of lamb						Total
	Females			Males			
	SS[a]	TS	TT	SS	TS	TT	
Western	188	13	109	189	9	127	635
Crossbred	145	11	226	159	19	225	785
Total	333	24	335	348	28	352	1420

[a]SS = Single reared as single; TS = Twin reared as single; TT = Twin reared as twin.

The lamb growth data were analyzed separately for each breed group. Rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market or market age of a lamb from either the Western or crossbred ewes were considered to be the sum of the effects represented by the following model: $Y_{ijklm} = \mu + \beta_1(X_1-\bar{X}_1) + \beta_2(X_1^2-\bar{X}_1^2) + \beta_3(X_2-\bar{X}_2) + \beta_4(X_2^2-\bar{X}_2^2) + A_i + B_j + C_k + D_l + e_{ijklm}$

where: Y_{ijklm} = rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market or market age.

μ = overall mean for rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market or market age.

β_1 = a regression coefficient for the linear effect of the lamb's birth date, X_1, a covariable.

β_2 = a regression coefficient for the quadratic effect of the lamb's birth date, X_1, a covariable.

β_3 = a regression coefficient for the linear effect of the lamb's birth weight, X_2, a covariable.

β_4 = a regression coefficient for the quadratic effect of the lamb's birth weight, X_2, a covariable.

A_i = a constant for the i^{th} year (i = 58, 59, --, 66).

B_j = a constant for the j^{th} age of dam (i = 1, 2, ---, 9^+).

C_k = a constant for the k^{th} type of birth and rearing (k_1 = single/single; k_2 = twin/single; k_3 = twin/twin).

D_l = a constant for the l^{th} sex of lamb (l_1 = females; l_2 = male).

e_{ijklm} = failure of the above model to estimate rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market or market age.

The same model was utilized to describe the birth weight data except the birth weight covariable was deleted and the lambs were classified according to type of birth without any regard for type of rearing. The percent of variation accounted for by the model describing each variable was determined by dividing total corrected sum of squares into corrected sum of squares due to the model (Steel and Torrie, 1960). This same procedure was also followed for the lambing date and wool data.

Ewe Reproduction Data

Records were available on both breed groups during each year as to the number of ewes lambing and the number of lambs born and reared in both the fall and winter seasons. In this study, any lamb alive at two weeks of age was considered to be reared.

Tables IX and X show the number of Western and crossbred ewes lambing according to the number of lambs born and reared during each year for the fall and winter seasons, respectively. The information presented in Tables IX and X made it possible to calculate the following measures of reproductive performance for the two breed groups during each year for each season separately: percent ewes lambing, lambing rate (number of lambs born per ewe lambing) and lambs reared per 100 ewes in the flock. It was not possible to obtain an accurate estimate of the number of lambs weaned because several lambs were sold for various nutrition studies from both breed groups before the lambs had reached weaning age.

Lambing Date Data

Seven hundred eighty-five lambing dates were available for the Western ewes (680 fall and 105 winter-lambing dates) and 810 lambing dates were available for the crossbred ewes (742 fall and 68 winter-lambing dates). The lambing date data were analyzed separately for each breed group (Western ewes, fall lambing; Western ewes, winter lambing; crossbred ewes, fall lambing; crossbred ewes, winter lambing). Each fall-lambing date observation for either the Western or crossbred ewes was considered to be the sum of the effects represented by the following model: $Y_{ijkl} = \mu + A_i + B_j + C_k + e_{ijkl}$

TABLE IX

NUMBER OF WESTERN AND CROSSBRED EWES LAMBING DURING THE FALL OF EACH YEAR ACCORDING TO NUMBER OF LAMBS BORN AND REARED

Year	Number of lambs born and reared[a]														Total	
	1,0		1,1		2,0		2,1		2,2		3,2		3,3			
	W[b]	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C
57		3	11	6						1					11	10
58	2	1	57	35			2	2	3	12					64	50
59	5	2	57	41		2		5	16	35	1				79	85
60	5	5	55	56	3		2	4	22	36				1	87	102
61	5	7	60	50			2	5	12	38		1		1	79	102
62	4	6	60	51	1	3	5	3	15	32					85	95
63	5	6	57	34	4	4	1	6	28	36		1		2	95	89
64	4	3	28	25	3	1	5	2	33	42			2	3	75	76
65	6	5	27	32	2	2	3	5	22	24		1	1	1	61	70
66	1	4	36	22		5	1	2	6	30					44	63
Total	37	42	448	352	13	17	21	34	157	286	1	3	3	8	680	742

[a] 1,0 = one lamb born, none reared; 1,1 = one lamb born, one reared; etc.
[b] W = Western ewes; C = Crossbred ewes.

TABLE X

NUMBER OF WESTERN AND CROSSBRED EWES LAMBING DURING THE WINTER OF EACH YEAR ACCORDING TO NUMBER OF LAMBS BORN AND REARED

	Number of lambs born and reared[a]															
	1,0		1,1		2,0		2,1		2,2		3,2		3,3		Total	
Year	W[b]	C	W	C	W	C	W	C	W	C	W	C	W	C	W	C
57			3	1		1									3	2
58			4	9					1	3					5	12
59	1	1	19	16			2	1	5	2					27	20
60	3	3	7	2		1			8	2					18	8
61			10	1			1	1	9	4			1		21	6
62	1		7	1			1		10	2					19	3
63		2	3	2	1				1	2				1	5	7
64			2	2			1	1	1	2		1			4	6
65		1		1					3	2					3	4
Total	5	7	55	35	1	2	5	3	38	19		1	1	1	105	68

[a] 1,0 = one lamb born, none reared; 1,1 = one lamb born, one reared, etc.

[b] W = Western ewes; C = Crossbred ewes.

where: Y_{ijkl} = fall-lambing date.

μ = overall mean fall-lambing date.

A_i = a constant for the i^{th} year (i = 57, 58, --, 66).

B_j = a constant for the j^{th} age of dam (j = 1, 2, --, 10).

C_k = a constant for the k^{th} type of ewe parturition (k_1 = one lamb born, k_2 = two lambs born).

e_{ijkl} = failure of the above model to estimate fall-lambing date.

There was only a limited number of Western and crossbred ewes giving birth to triplets and these ewes were eliminated from the lambing date data. Also, since no winter-lambing was permitted during 1966, this eliminated year 1966 and all 10-year-old ewes from the winter-lambing data. Examination of the ewe reproduction data revealed that only one 9-year-old crossbred ewe and no Western ewes represented by the same age of dam classification lambed during the winter. Therefore, this one crossbred ewe was eliminated leaving nine years and eight age of dam classifications for the winter-lambing date data.

Wool Data

Records were available on 806 grease and clean fleece weights for the Western ewes and 780 grease and clean fleece weights for the crossbred ewes collected during the years 1957-1965. The ewes were sold prior to the spring of 1967, at which time the 1966 fleece data would have been collected, since the project was being terminated.

Both the grease and clean fleece data were analyzed separately for each breed group, and each grease and clean fleece weight observation for either the Western or crossbred ewes were considered to be the sum of the effects represented by the following model: $Y_{ijkl} = \mu + \beta_1(X_1-\overline{X}_1) + \beta_2(X_1^2-\overline{X}_1^2) + \beta_3(X_2-\overline{X}_2) + \beta_4(X_2^2-\overline{X}_2^2) + A_i + B_j + C_k + e_{ijkl}$

where: Y_{ijkl} = grease or clean fleece weight.

μ = overall mean grease or clean fleece weight.

β_1 = a regression coefficient for the linear effect of the ewe's body weight at shearing time, X_1, a covariable.

β_2 = a regression coefficient for the quadratic effect of the ewe's body weight at shearing time, X_1, a covariable.

β_3 = a regression coefficient for the linear effect of the ewe's condition score at shearing time, X_2, a covariable.

β_4 = a regression coefficient for the quadratic effect of the ewe's condition score at shearing time, X_2, a covariable.

A_i = a constant for the i^{th} year (i = 57, 58, --, 65).

B_j = a constant for the j^{th} age of dam (j = 1, 2, --, 9).

C_k = a constant for the k^{th} number of lambs born and reared (k_o = no lambs born, none reared;

k_1 = one lamb born, none reared; k_2 = one lamb born, one lamb reared; k_3 = two lambs born, none reared; k_4 = two lambs born, one reared; k_5 = two lambs born, two lambs reared.

e_{ijkl} = failure of the above model to estimate grease or clean fleece weight.

It was assumed that the number of lambs born and reared might have an influence on the annual wool production. Under this assumption, it was possible to combine the wool data from the ewes that lambed and those that did not lamb. Ewes lambing in both the fall and winter seasons were included among those lambing since preliminary analyses indicated season of lambing to have essentially no influence on either grease or clean fleece weights for the two breed groups. Since there were only a liminted number of ewes from both breed groups that had triplets, the records on these ewes were eliminated from the wool data.

The quadratic effect referred to in the models utilized to describe the lamb growth and wool variables is a special kind of quadratic effect rather than the usual expression, $\beta_i\ (X_i - \overline{X}_i)^2$, normally considered as the qudaratic effect.

Percent Advantage

The percent advantage of the crossbred ewes over the Western ewes for the lamb growth, ewe reproduction, lambing date and wool traits was calculated by use of the following formula:

$$\text{Percent Advantage} = \left[\frac{\mu_c - \mu_w}{\mu_w}\right] \times 100$$

where: μ_c = overall mean for crossbred ewe data.

μ_w = overall mean for Western ewe data.

Statistical significance of the percent advantage values was assessed through use of the nonparametric sign test (Siegel, 1956) for the ewe reproduction data and the "t" test (Steel and Torrie, 1960) for the lamb growth, lambing date and wool data to determine if the mean values for the crossbred ewes were significantly different from the mean values for the Western ewes. If the two means being compared were statistically nonsignificant, then the percent advantage value was assumed to be estimating zero or a value too small to be of any importance

RESULTS AND DISCUSSION

The Western and crossbred ewes were compared on the basis of the performance of their lambs across all years, age of dam groups, type of birth and rearing classifications and the two sexes with respect to each of the lamb growth variables studied. In addition to the above comparison, an attempt was made to determine what influence year of birth, age of dam, type of birth and rearing and sex of lamb had on each of the lamb growth variables for the lambs from both breed groups. Although some of these factors were statistically nonsignificant sources of variation influencing the lamb growth variables, they were still discussed because in almost all cases definite trends are apparent.

The reproductive performance of the Western ewes during the fall and winter seasons is compared to that of the crossbreds with respect to the percent ewes lambing, lambing rate and number of lambs reared per 100 ewes in the flock. The date of fall and winter-lambing and the wool production (grease and clean fleece weight) of each breed group were compared in a manner similar to that described for the lamb growth data.

The least squares constants for the lamb growth, lambing date and wool data are presented in tabular form and the least squares means are illustrated through use of figures for both breed groups. In the case of the first four lamb growth variables and the two wool variables, the least squares constants and means are expressed in pounds; whereas, the market age and lambing date variables are expressed in days.

It is well to emphasize that in the comparison of the two breed groups with respect to the lamb growth, lambing date and wool data, that each least squares mean for the Western ewe data was not tested to be significantly different from the respective least squares mean for the crossbred ewe data. For example, the mean birth weight of all lambs born during 1958 from the Western ewes was not tested to see if this value was significantly different from the mean birth weight of all lambs born during the same year from the crossbred ewes. The reasoning behind this procedure was due to the uncertainty of the significance level when each pair of means are tested to be statistically different. Only the difference between the overall means for each trait was tested for statistical significance and the results of these tests are discussed under the percent advantage section for each variable.

In the least squares analysis of each variable where main effects and covariables are included in the statistical model, statistical significance of the main effects is discussed first and this is followed by an individual discussion of each main effect. Thirdly, the covariables (lamb growth and wool data only) are discussed, and this is followed by the discussion of the percent advantage value for the particular variable under consideration.

LAMB GROWTH DATA

Birth Weight

The analysis of variance of birth weight is presented in Table XI for the lambs from the Western and crossbred ewes. Year, age of dam, type of birth and sex of lamb were significant (P<.01) sources of variation influencing the birth weights of lambs from both breed groups. The statistical model utilized to describe the birth weight data accounted for 30 percent of the variation in the birth weight of lambs from the Western ewes and 36 percent of the variation in birth weight of lambs from the crossbred ewes.

TABLE XI

ANALYSIS OF VARIANCE OF BIRTH WEIGHT

Source	Western ewes		Crossbred ewes	
	d.f.	M.S.	d.f.	M.S.
Total	846		1036	
Covariable:				
Birth date	1	76.629**	1	76.965**
Birth date squared	1	9.433	1	8.047
Main effects:				
Year	8	35.353**	8	48.158**
Age of dam	8	11.529**	8	26.803**
Type of birth	1	408.574**	1	741.119**
Sex of lamb	1	88.414**	1	65.685**
Error	826	2.656	1016	2.622
	R^2 = 30%		R^2 = 36%	

**P<.01

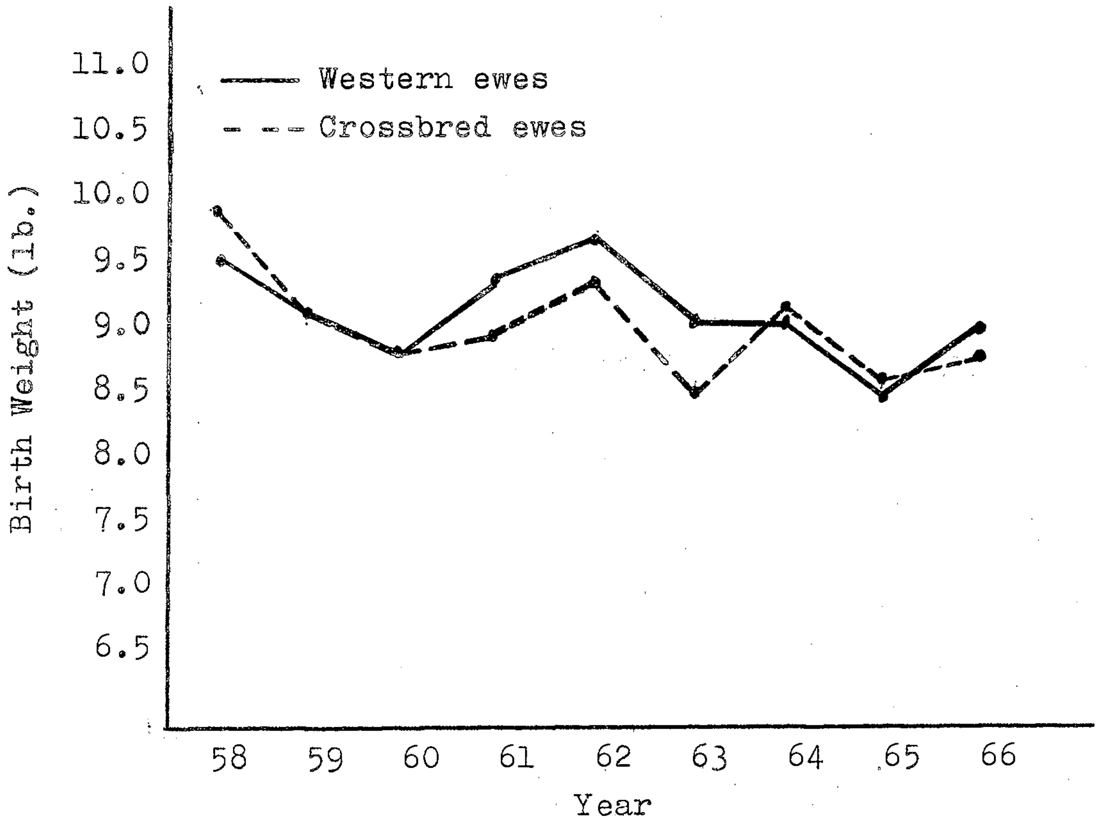

Figure 3. The Effect of Year on Birth Weight of Lambs from the Western and Crossbred Ewes

Year. The least squares constants for all effects are presented in Table XII and the least squares means for each year are plotted in Figure 3. This figure reflects more or less random variation between the two breed groups with respect to the mean yearly birth weights of their lambs. The birth weights of lambs from both breed groups tended to follow a similar pattern each year, i.e., as the average birth weight of lambs from one breed group increased or decreased, so did the birth weights of lambs from the other breed group. The greatest difference between the two breed groups was from 1961 through 1963, when the lambs from the Western ewes were about one-half pound heavier at birth than those from the crossbred ewes.

TABLE XII

LEAST SQUARES CONSTANTS FOR BIRTH WEIGHT

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	847	9.021	0.0604	1037	8.929	0.0581
Birth date		0.192	0.2953		0.439	0.2989
Birth date squared		-0.0003	0.0015		-0.0007	0.0015
Year:						
58	69	0.465	0.3396	62	0.901	0.3089
59	93	0.041	0.2814	127	0.211	0.2391
60	114	-0.340	0.2363	141	-0.211	0.2082
61	93	0.360	0.2162	143	-0.146	0.1846
62	106	0.549	0.2018	133	0.339	0.1784
63	129	-0.127	0.2132	131	-0.507	0.1936
64	114	-0.168	0.2388	107	0.081	0.2184
65	78	-0.604	0.2924	93	-0.416	0.2586
66	51	-0.176	0.3579	100	-0.252	0.3429
Age of dam:						
1	52	-2.107	0.3606	31	-2.925	0.3639
2	106	-0.852	0.2819	136	-1.368	0.2443
3	111	-0.124	0.2420	157	-0.090	0.2074
4	107	-0.239	0.2117	142	0.054	0.1872
5	119	0.158	0.1996	136	0.220	0.1790
6	116	0.266	0.2091	129	0.790	0.1888
7	109	0.638	0.2346	123	0.593	0.2165
8	85	0.980	0.2885	107	1.431	0.2649
9+	42	1.280	0.2468	76	1.295	0.3201
Type of birth:						
Single	473	0.741	0.0602	383	0.902	0.0540
Twin	374	-0.741	0.0602	654	-0.902	0.0540
Sex of lamb:						
Female	431	-0.325	0.0564	511	-0.255	0.0509
Male	416	0.325	0.0564	526	0.255	0.0509

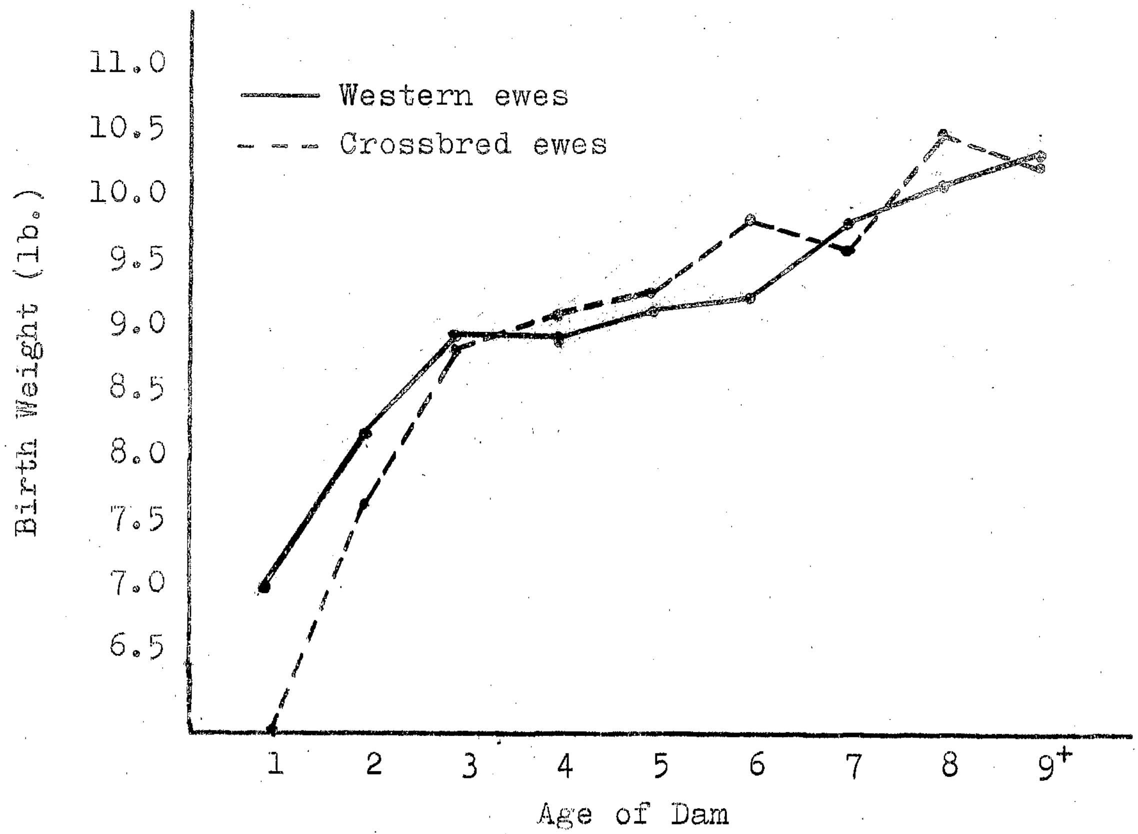

Figure 4. The Effect of Age of Dam on Birth Weight of Lambs from the Western and Crossbred Ewes

Several other workers have also reported that year of birth has a definite influence on lamb birth weight. Bogart et al. (1957) reported year differences in birth weights were apparent in their study. In the study conducted by Harrington (1963), the effects of years and age of dam were completely confounded; however, Harrington stated that this year classification was highly significant in the analysis of birth weight. Butcher et al. (1964) reported that the birth weights of lambs in their study were corrected to a common year before heritability estimates and correlations between birth weight and 140-day weight were calculated.

Age of Dam. The least squares means for each age of dam are plotted in Figure 4 for both breed groups. Lambs from the one-year-old crossbred ewes were about one pound lighter than those from the Western ewes represented by this same age of dam classification. This advantage in birth weight for the lambs from the Western ewes was probably due to the fact that the Western ewes were about seven months older and slightly more mature from the standpoint of body size than were the crossbred ewes. However, this birth weight advantage for the lambs from the Western ewes declined as the crossbred ewes became older and after three years of age, the average birth weight of lambs from both breed groups was quite similar with neither breed group showing any appreciable advantage over the other.

The results from both ewe breed groups reveal that the younger ewes gave birth to lambs having the lightest birth weights, and the birth weights increased almost steadily as the ewes from both breed groups increased in age. These results are similar to those reported by Bennett et al. (1963), which indicate almost no decrease in lamb birth weight as ewes increased in age from two to eight years. The older ewes of both breed groups produced lambs having the heaviest birth weights; however, a more variable response is noted in the birth weight of lambs from the crossbred ewes as these ewes advanced in age. Several workers have reported a decline in birth weight of lambs from very old ewes. Nelson and Venkatachalam (1949), Ragab et al. (1953), Blackwell and Henderson (1955), MacNaughton (1957), Sidwell et al. (1964), Smith and Lidvall (1964), Ray and Smith (1966) and Shelton and Bassett (1967) have all reported that young ewes gave birth to the lightest lambs and birth weights tended to increase as age of dam increased up to a point and declined as the ewes became older.

Type of Birth. The influence of type of birth on birth weight of lambs from the two breed groups is illustrated in Figure 5. This figure illustrates that single lambs from the Western and crossbred ewes had almost identical birth weights. However, twin lambs from the Western ewes were slightly heavier (0.25 lb.) at birth than twin lambs from the crossbred ewes.

The results from both ewe breed groups indicate single lambs were heavier than twins at birth. Single lambs from the Western ewes were 1.48 pounds heavier than the twins; whereas, single lambs from the crossbred ewes were 1.80 pounds heavier than the twins. These results are similar to those reported in the literature by several workers. Blackwell and Henderson (1955), Cassard and Weir (1956), Sidwell et al. (1964), Harrington and Whiteman (1967) and Frederiksen et al. (1967) stated single lambs were heavier than twins at birth. Other workers such as Shelton and Carpenter (1957), Bogart et al. (1957), Bennett et al. (1963), Shelton (1964), Smith and Lidvall (1964) and Shelton and Bassett (1967) have reported advantages ranging from 1.6 to 2.4 pounds for singles over twins at birth.

Sex of Lamb. The influence of sex of lamb on birth weight of lambs from the two breed groups is illustrated in

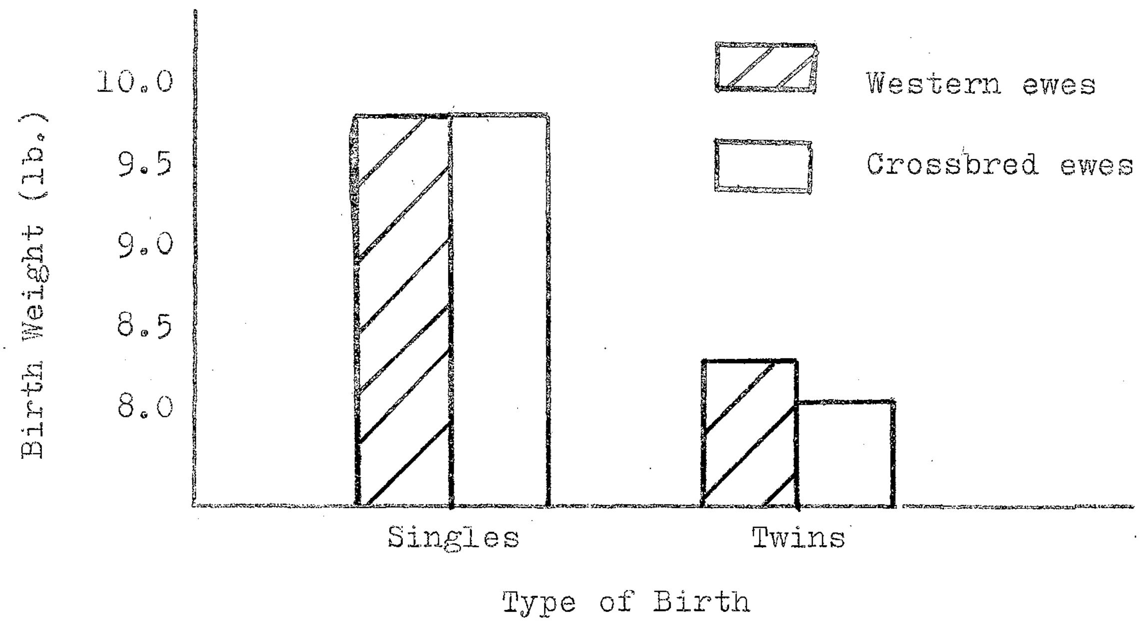

Figure 5. The Effect of Type of Birth on Birth Weight of Lambs from the Western and Crossbred Ewes

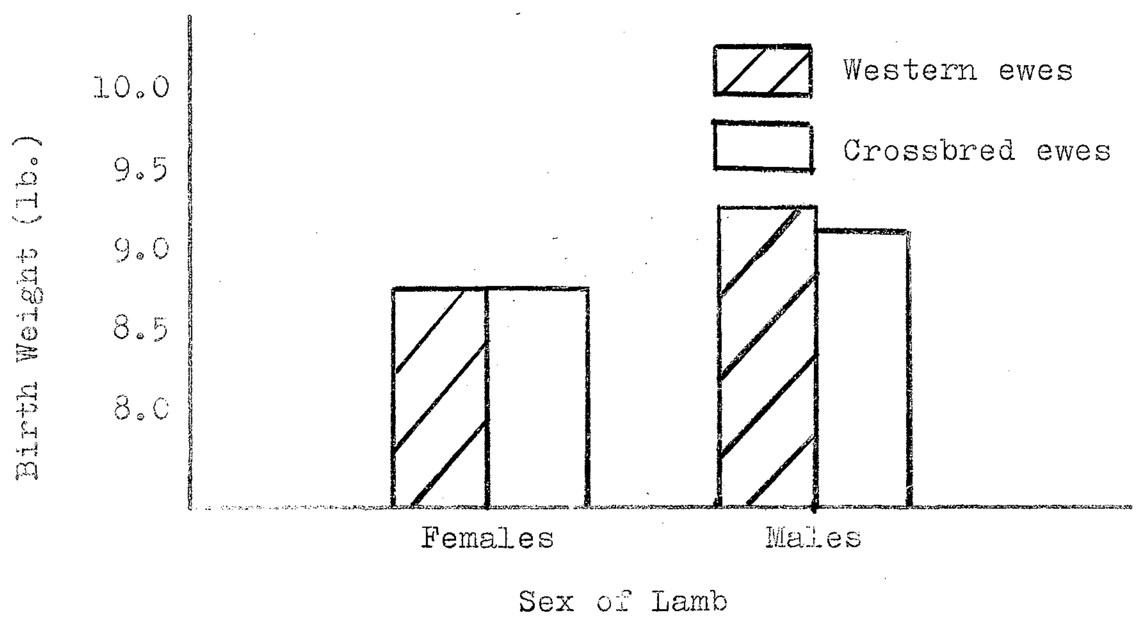

Figure 6. The Effect of Sex of Lamb on Birth Weight of Lambs from the Western and Crossbred Ewes

Figure 6. The birth weights of female lambs from both breed groups were very similar, but male lambs from the Western ewes were slightly heavier (0.16 lb.) than those from the crossbred ewes.

Male lambs from both breed groups were heavier than females at birth. Male lambs from the Western ewes were 0.650 pounds heavier than females and male lambs from the crossbred ewes were 0.510 pounds heavier than the females. Several other workers have also reported males to be heavier than females at birth. Blackwell and Henderson (1955), Bogart et al. (1957), Sidwell et al. (1964) and Frederiksen et al. (1967) have all reported males to be heavier than female lambs at birth. Rempel et al. (1959), Bennett et al. (1963), Smith and Lidvall (1964) and Shelton and Bassett (1967) reported advantages ranging from 0.4 to 3.5 pounds for males over female lambs at birth. Cassard and Weir (1956), Brown et al. (1961) and Matthews et al. (1965) reported that males were heavier than females, but the differences between the two sexes at birth were not statistically significant.

Covariable. The birth date of the lamb was considered as a covariable in the analysis of the birth weight data. Most of the lambs in this study were born between October 15 and November 30, thus there was about 45 days difference between the oldest and the youngest lambs in the flock.

The influence of birth date on birth weight was highly significant ($P<.01$) as a linear function (Table XI), but had practically no quadratic effect on the birth weight of lambs from both breed groups. Harrington (1963) stated the influence of birth date on weight of the lamb at birth was nonsignificant.

The linear effect of birth date on birth weight indicates that the birth weights increased slightly as the lambing season progressed. It was often observed that the first lambs born each lambing season were usually the smallest, and hot weather during late July and August was often suggested as a contributing factor to these low birth weights through its influence on the pregnant ewe. An analysis of birth weights of 1600 lambs by Shelton (1964) indicated that these weights were closely related to date of birth within a fall-lambing program. The observed birth weights ranged from 6.9 pounds in mid-October to 10.2 pounds for the third week in December. It was suggested that a part of this variation in birth weight could possibly be attributed to high environmental temperatures during gestation.

Percent Advantage. The overall birth weight means were 9.021 and 8.929 pounds for the lambs from the Western and crossbred ewes, respectively (Table XII). The difference of 0.092 pounds in favor of the lambs from the Western ewes was nonsignificant and the percent advantage value of -1.02 was assumed to be estimating zero.

Although no other information was found in the literature where percent advantage values as such were calculated, several workers have reported the birth weights of lambs from various types of ewes to be quite similar. Hunt (1935) reported that lambs from finewool ewes weighed 9.4 pounds at birth compared to 8.4 pounds for lambs from ewes produced by the crossing of Dorset rams on grade Merino ewes. Lambs from finewool crossbred ewes were about 0.2 pounds lighter than those from Rambouillet ewes in the study reported by Shelton _et al._ (1966). Kincaid and Carter (1963) reported that lambs produced from a group of crossbred ewes resulting from the crossing of Hampshire rams on grade range ewes were slightly heavier at birth than those from a group of selected native ewes. In a similar study, Carter _et al._ (1957) stated that lambs from Suffolk x Rambouillet ewes weighed 11.0 pounds at birth while those from Rambouillet ewes weighed 10.7 pounds.

Rate of Gain from Birth to 70 Days

The analysis of variance of rate of gain from birth to 70 days is presented in Table XIII for the Western and crossbred ewe data. Year, age of dam, type of birth and rearing and sex of lamb were significant ($P<.01$) sources of variation influencing the rate of gain of lambs from both breed groups. The model utilized to describe the data accounted for 50 and 46 percent of the variation in rate of gain from birth to 70 days for the lambs from the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XIV for the Western and crossbred ewes and the means for each year are plotted in Figure 7. During the early

TABLE XIII

ANALYSIS OF VARIANCE OF RATE OF GAIN FROM BIRTH TO 70 DAYS

Source	Western ewes d.f.	Western ewes M.S.	Crossbred ewes d.f.	Crossbred ewes M.S.
Total	737		871	
Covariables:				
Birth date	1	0.0788**	1	0.0799**
Birth date squared	1	0.0047	1	0.0557**
Birth weight	1	2.2917**	1	3.5535**
Birth weight squared	1	0.0103	1	0.0105
Main effects:				
Year	8	0.0709**	8	0.0306**
Age of dam	8	0.0180**	8	0.0248**
Type of birth and rearing	2	0.5312**	2	0.5561**
Sex of lamb	1	0.0976**	1	0.2145**
Error	714	0.0060	848	0.0077
	$R^2 = 50\%$		$R^2 = 46\%$	

** $P<.01$

years the mean values follow a similar pattern for the lambs from both ewe breed groups, but an interesting situation is noted beginning with the year 1963. At this point, the average yearly rate of gain increased and continued to do so on through 1966. This particular pattern of response is probably a reflection of the previously mentioned change in management resulting from the addition of the soybean oilmeal to the lamb creep-feed ration beginning with the year 1963. It would appear that the addition of this protein supplement to the creep-ration improved the rate of gain considerably for the lambs from both ewe breed groups. Lambs present in the year 1966 had the highest average rate

TABLE XIV

LEAST SQUARES CONSTANTS FOR RATE OF GAIN FROM BIRTH TO 70 DAYS

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	718	0.619	0.0061	872	0.620	0.0059
Birth date		0.009	0.0155		0.050	0.0181
Birth date squared		-0.00002	0.0000		-0.0001	0.0000
Birth weight		0.045	0.0115		0.043	0.0114
Birth weight squared		-0.0013	0.0006		-0.0011	0.0006
Year:						
58	65	0.001	0.0175	56	-0.034	0.0179
59	83	-0.064	0.0146	109	-0.054	0.0139
60	97	-0.028	0.0123	126	-0.037	0.0120
61	86	-0.013	0.0113	125	-0.019	0.0108
62	90	-0.068	0.0107	117	-0.044	0.0104
63	112	-0.009	0.0112	110	-0.009	0.0113
64	90	0.003	0.0127	91	0.021	0.0128
65	60	0.051	0.0157	76	0.061	0.0155
66	35	0.127	0.0210	62	0.115	0.0149
Age of dam:						
1	45	-0.010	0.0194	29	-0.026	0.0217
2	97	0.015	0.0148	116	0.036	0.0146
3	100	0.028	0.0126	137	0.046	0.0120
4	99	0.034	0.0110	127	0.049	0.0110
5	105	0.029	0.0105	121	0.029	0.0104
6	98	0.017	0.0110	113	0.013	0.0110
7	88	0.003	0.0125	94	-0.017	0.0130
8	52	-0.025	0.0162	84	-0.041	0.0159
9+	34	-0.091	0.0228	51	-0.089	0.0173
Type of birth and rearing:[a]						
SS	400	0.021	0.0067	319	0.043	0.0070
TS	23	0.049	0.0112	31	0.005	0.0109
TT	295	-0.070	0.0067	522	-0.048	0.0062
Sex of lamb:						
Female	376	-0.012	0.0090	434	-0.016	0.0030
Male	342	0.012	0.0090	438	0.016	0.0030

[a]SS = Single reared as single; TS = Twin reared as single; TT = Twin reared as twin.

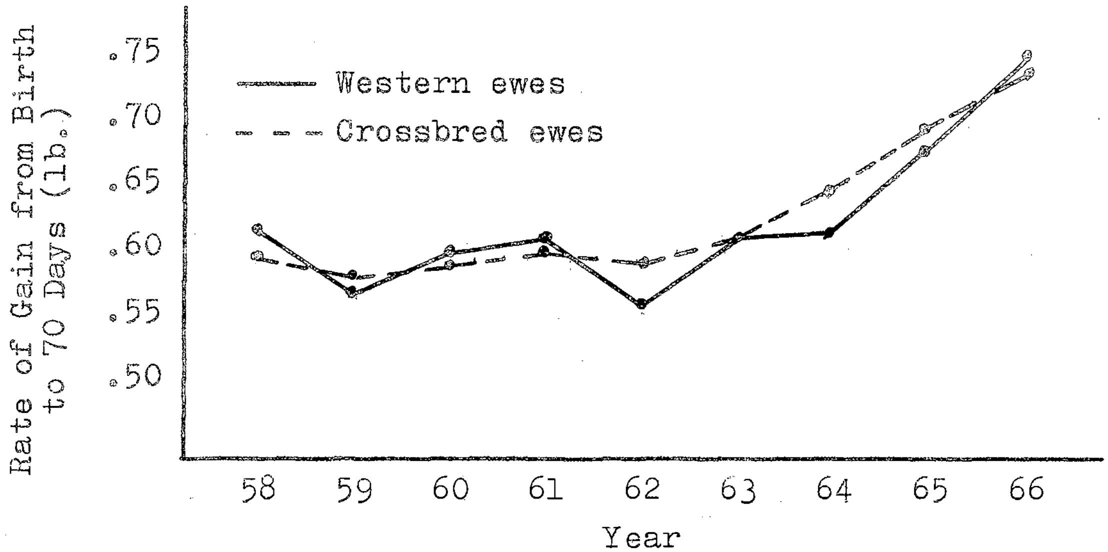

Figure 7. The Effect of Year on Rate of Gain from Birth to 70 Days of Lambs from the Western and Crossbred Ewes

of gain from birth to 70 days of all lambs from the two breed groups. This response was anticipated since these were a rather select group of lambs. All of the "poor-doing" lambs that were born during 1966 to both breed groups had been selected at about four weeks of age and utilized for a nutrition study.

Only limited information has been reported in the literature regarding the influence of year of birth on rate of gain from birth to 70 days. Cassard and Weir (1956) reported that year differences were a nonsignificant source of variation for rate of gain from birth to 70 days in their study.

Age of Dam. The least squares means for each age of dam are plotted in Figure 8 for both ewe breed groups. Lambs from the one-year-old crossbred ewes gained at a slightly slower rate from birth to 70 days than lambs from the Western ewes represented by the same age classification. This is probably due to the fact that the lambs from these cross-

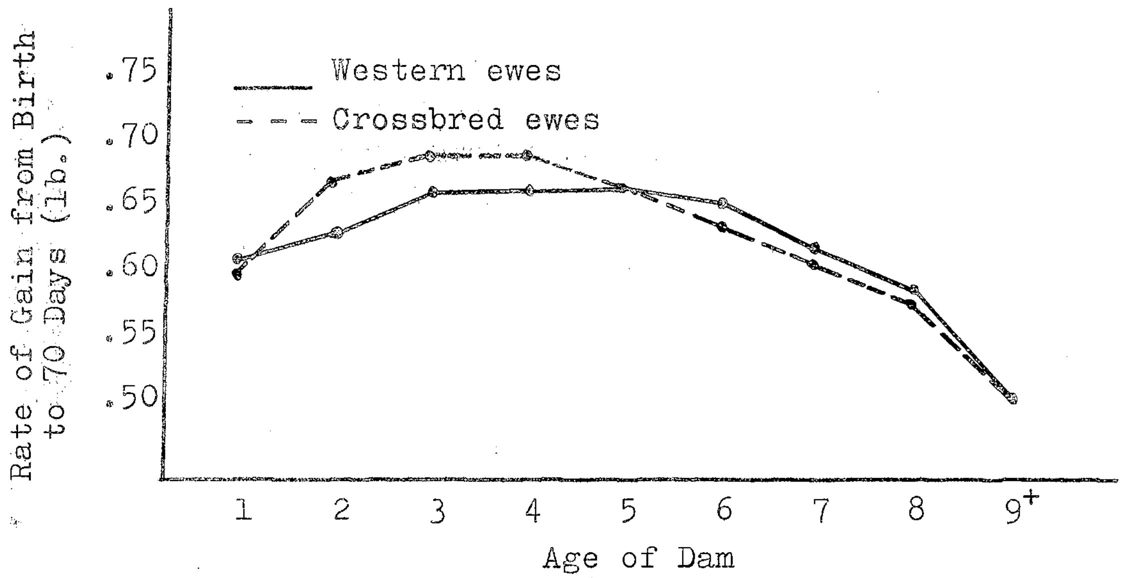

Figure 8. The Effect of Age of Dam on Rate of Gain from Birth to 70 Days of Lambs from the Western and Crossbred Ewes

bred ewes were about one pound lighter than those from the Western ewes at birth (Figure 4). As the crossbred ewes increased in age from one to five years, the average rate of gain of their lambs from birth to 70 days increased beyond that of the lambs from the Western ewes. Beyond this point as the ewes from both breed groups became older, the average rate of gain of lambs from the crossbred ewes dropped slightly below that of the lambs from the Western ewes. It is interesting to note that the average rate of gain of lambs from the crossbred ewes began to decline after these ewes were four years old; whereas, the average rate of gain of lambs from the Western ewes did not decline much until after these ewes were past six years of age.

The younger and older ewes from both breed groups produced lambs having slower rates of gain from birth to 70 days than did the middle-aged ewes. As the ewes from both breed groups advanced in age, the average rate of gain of their lambs increased up to a point and then declined as the ewes became older. Rate of gain was lowest for the lambs from the older ewes of both breed groups.

Only a limited amount of information has been reported in the literature with respect to the influence of age of dam on rate of gain of lambs from birth to 70 days. Cassard and Weir (1956) indicated that age of dam had a curvilinear effect on rate of gain from birth to 70 days. Smith and Lidvall (1964) reported that rate of gain from birth to 120 days tended to increase as age of dam increased through four years of age, declined slightly at five, increased again at six and continued to decline through 10 years of age.

Type of Birth and Rearing. The influence of type of birth and rearing on rate of gain from birth to 70 days is illustrated in Figure 9. This figure illustrates that lambs born and reared as singles from the crossbreds had a slightly faster rate of gain (0.023 lb.) than those born and reared as singles from the Western ewes. Lambs born and reared as twins from the crossbred ewes also had a slightly faster rate of gain (0.023 lb.) than those born and reared as twins from the Western ewes. However, lambs born as twins but reared as singles from the Western ewes gained at a faster rate (0.043 lb.) than those born as twins and reared as singles from the crossbred ewes. It is suggested that any conclusion regarding the response of the lambs born as twins but reared as singles should be made with caution since only

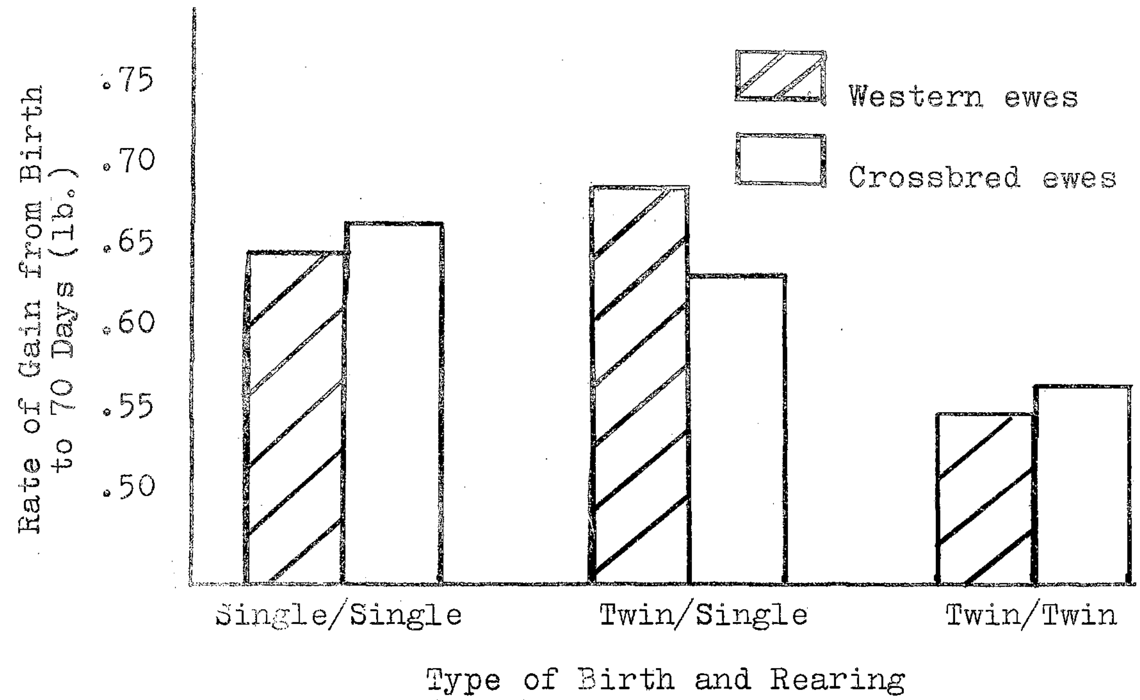

Figure 9. The Effect of Type of Birth and Rearing on Rate of Gain from Birth to 70 Days of Lambs from the Western and Crossbred Ewes

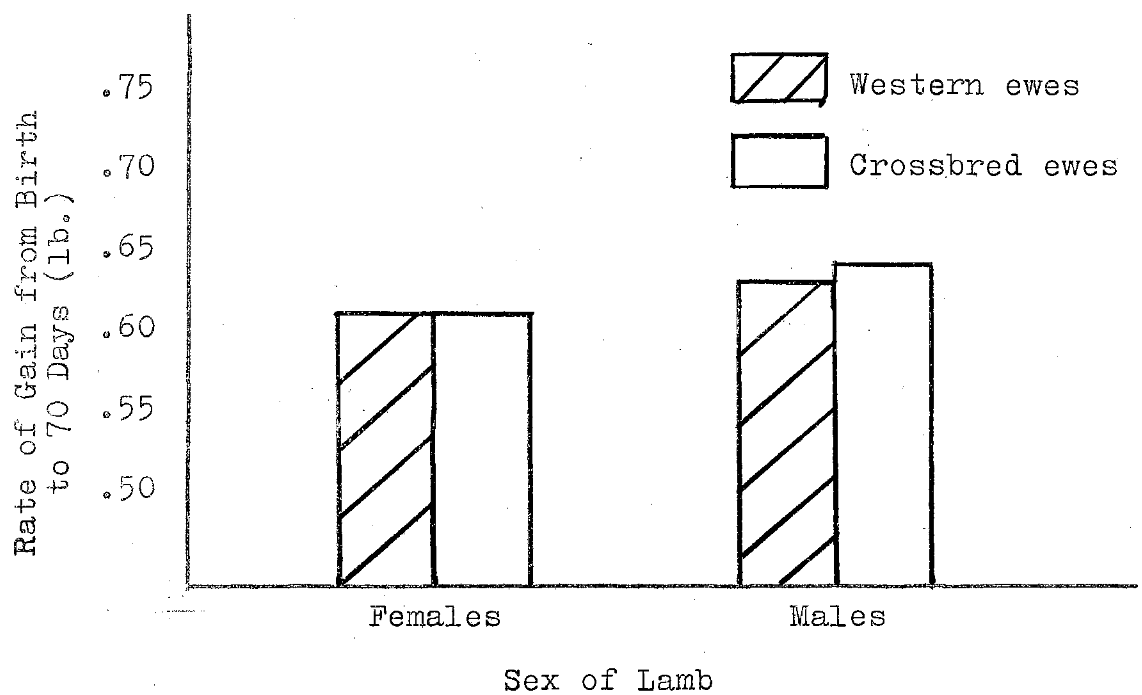

Figure 10. The Effect of Sex of Lamb on Rate of Gain from Birth to 70 Days of Lambs from the Western and Crossbred Ewes

a small number of lambs was present in this particular category (23 lambs for the Western ewes and 31 lambs for the crossbred ewes).

The lambs from both breed groups that were born and reared as singles had a faster rate of gain from birth to 70 days than those born and reared as twins. For the crossbred ewes, lambs born and reared as singles out-gained (0.038 lb.) those born as twins and reared as singles and these in turn out-gained (0.053 lb.) those born and reared as twins. However, lambs from the Western ewes that were born as twins and reared as singles had a faster rate of gain than those born and reared as singles or twins (0.028 and 0.119 pounds faster, respectively, than the singles and twins). Again, it is well to keep in mind that only a small number of lambs from the Western ewes were born as twins and reared as singles.

The limited amount of information available in the literature agrees favorably with these results. Cassard and Weir (1956) reported singles grew at a faster rate from birth to 70 days than twins. Smith and Lidvall (1964) reported that lambs born and reared as singles outgained those born as twins and reared as singles and these in turn gained faster than those born and reared as twins from birth to 120 days. Givens *et al.* (1960) reported single lambs gained 0.077 pounds more per day than twins from birth to 120 days.

Sex of Lamb. The influence of sex of lamb on rate of gain from birth to 70 days is illustrated in Figure 10. Female lambs from both breed groups gained at about the same rate; whereas, male lambs from the crossbred ewes gained slightly faster (0.005 lb.) than male lambs from the Western ewes.

Male lambs from both breed groups gained at a slightly faster rate from birth to 70 days than did the females. These results are similar to those reported by Cassard and Weir (1956). Male lambs from the Western ewes gained 0.024 pounds more per day than the female lambs, and male lambs from the crossbred ewes out-gained the females by 0.032 pounds per day. These values are similar to those reported by other workers where the lambs were weaned at an average age of 120 days. Smith and Lidvall (1964) indicated that males out-gained females by 0.043 pounds per day from birth to 120 days. Similarly, Givens *et al.* (1960) reported that wether lambs gained 0.037 pounds more per day than ewes from birth to 120 days.

Covariables. Birth date and birth weight were considered as covariables in the analysis of the rate of gain from birth to 70 days data. The influence of birth date on rate of gain from birth to 70 days was highly significant ($P<.01$) as a linear function for the lambs from both breed groups (Table XIII). The quadratic effect was nonsignificant for the lambs from the Western ewes, but highly significant ($P<.01$) for the lambs from the crossbred ewes indicating a curvilinear effect. The influence of birth weight on rate of gain from birth to 70 days was highly significant ($P<.01$)

as a linear function but the quadratic effect was nonsignificant for the lambs from both breed groups. No information was found in the literature with respect to the influence of birth date or birth weight on rate of gain of lambs from birth to 70 days.

Percent Advantage. The overall means were 0.619 and 0.620 pounds for rate of gain from birth to 70 days for the lambs from the Western and crossbred ewes, respectively (Table XIV). The mean difference of 0.001 pounds in favor of the lambs from the crossbred ewes was nonsignificant and the percent advantage value of 0.16 was assumed to be estimating zero.

As was mentioned in the birth weight section, no percent advantage values as such were found in the literature; however, a limited amount of information has been reported which suggests a slightly faster rate of gain from birth to weaning for lambs from various types of crossbred ewes when compared to the performance of lambs from high-grade or purebred ewes. Hunt (1935) reported that lambs from Dorset x grade Merino ewes gained 0.53 pounds per day compared to 0.48 pounds per day for lambs from grade Merino ewes. Similarly, Miller (1935) reported that lambs from Romney x Rambouillet ewes gained 0.038 pounds more per day than those from Rambouillet ewes. Kincaid and Carter (1963) stated that a group of ewes produced by the crossing of Hampshire rams on grade range ewes produced lambs that gained 0.52 pounds per day from birth to weaning compared to 0.51 and

0.49 for lambs from selected and commercial natives, respectively. Suffolk x Rambouillet ewes produced lambs that gained 0.60 pounds per day from birth to weaning in a study reported by Carter *et al.* (1957); whereas, lambs from Rambouillet ewes gained 0.56 pounds per day. Matthews *et al.* (1965) reported no significant differences in rate of gain from birth to weaning for lambs from Rambouillet, Columbia, Targhee, Rambouillet x Targhee, Rambouillet x Columbia, Targhee x Columbia and Rambouillet x Targhee x Columbia ewes.

70-Day Weight

The analysis of variance of 70-day weight is presented in Table XV for the Western and crossbred ewe data. Year, age of dam, type of birth and rearing and sex of lamb were all significant ($P<.01$) sources of variation influencing the 70-day weights of lambs from both breed groups. The model utilized to describe the data accounted for 39 and 58 percent of the variation in 70-day weight for lambs from the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XVI and the means for each year are plotted in Figure 11. The 70-day weights of lambs from both breed groups remained relatively constant with only minor fluctuations through 1962. However, the 70-day weights of lambs from both breed groups began to increase during 1963 and continued to do so on through the year 1966. Again, this is probably a reflection of the change in management resulting from

TABLE XV

ANALYSIS OF VARIANCE OF 70-DAY WEIGHT

Source	Western ewes d.f.	Western ewes M.S.	Crossbred ewes d.f.	Crossbred ewes M.S.
Total	737		871	
Covariables:				
Birth date	1	122.388**	1	154.921**
Birth date squared	1	54.746	1	316.658**
Birth weight	1	23889.237**	1	34898.531**
Birth weight squared	1	50.075	1	45.445
Main effects:				
Year	8	348.338**	8	150.021**
Age of dam	8	86.732**	8	117.169**
Type of birth and rearing	2	2622.519**	2	2780.690**
Sex of lamb	1	482.273**	1	985.469**
Error	714	29.511	848	37.320
	$R^2 = 39\%$		$R^2 = 58\%$	

**P<.01

the addition of the soybean oilmeal to the creep-ration. The 70-day weights would be expected to increase, since there was a substantial improvement in the rates of gain from birth to 70 days from the time the oilmeal was first added to the creep-ration. The 1966 lambs from both breed groups had the highest average 70-day weights, but it is well to remember that these were a rather select group of lambs resulting from the previously mentioned culling of the "poor-doing" lambs for a nutrition study.

The results discussed herein on 70-day weights are similar to those reported in the literature by various workers who have studied the influence of year of birth on weaning

TABLE XVI

LEAST SQUARES CONSTANTS FOR 70-DAY WEIGHT

Effect	Western ewes No.	Western ewes Constant	Western ewes S.E.	Crossbred ewes No.	Crossbred ewes Constant	Crossbred ewes S.E.
μ	718	52.511	0.1340	872	52.305	0.1302
Birth date		0.570	0.3423		3.528	0.3986
Birth date squared		-0.001	0.0017		-0.006	0.0020
Birth weight		4.173	0.2552		3.946	0.2516
Birth weight squared		-0.093	0.0135		-0.071	0.0135
Year:						
58	65	0.082	0.3882	56	-2.724	0.3967
59	83	-4.562	0.3201	109	-3.747	0.3070
60	97	-1.969	0.2720	126	-2.566	0.2655
61	86	-0.867	0.2490	125	-1.312	0.2378
62	90	-4.735	0.2370	117	-3.058	0.2302
63	112	-0.646	0.2481	110	-0.538	0.2488
64	90	0.189	0.2821	91	1.522	0.2830
65	60	3.589	0.3481	76	4.316	0.3423
66	35	8.919	0.4639	62	8.107	0.3297
Age of dam:						
1	45	-0.715	0.4289	29	-1.631	0.4786
2	97	1.062	0.3270	116	2.377	0.3216
3	100	1.989	0.2794	137	3.249	0.2659
4	99	2.397	0.2447	127	3.435	0.2417
5	105	2.017	0.2321	121	2.047	0.2304
6	98	1.171	0.2446	113	0.893	0.2440
7	88	0.198	9.2760	94	-1.142	0.2876
8	52	-1.725	0.3576	84	-2.893	0.3512
9+	34	-6.394	0.5055	51	-6.335	0.3819
Type of birth and rearing:[a]						
SS	400	1.445	0.1493	319	3.004	0.1538
TS	23	3.446	0.2488	31	0.372	0.2412
TT	295	-4.891	0.1479	522	-3.376	0.1364
Sex of lamb:						
Female	376	-0.850	0.1996	434	-1.100	0.0677
Male	342	0.850	0.1996	438	1.100	0.0677

[a]SS = Single reared as single; TS = Twin reared as single; TT = Twin reared as twin.

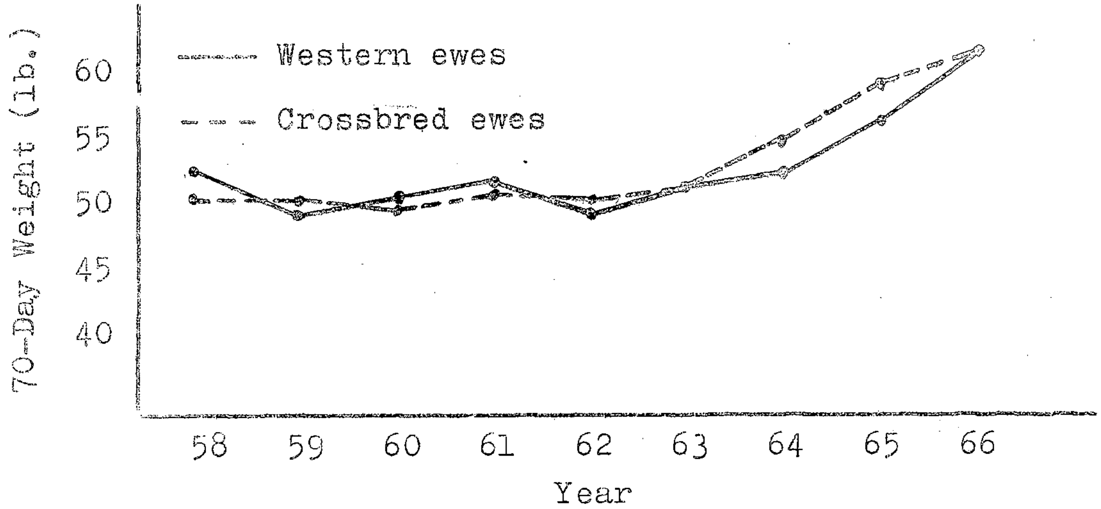

Figure 11. The Effect of Year on 70-Day Weight of Lambs from the Western and Crossbred Ewes

weights (usually 120 days) of lambs. As was previously mentioned for the study conducted by Harrington (1963), the effects of years and age of dam were completely confounded, but Harrington (1963) stated this year classification was highly significant for the analysis of 70-day weights. However, Cassard and Weir (1956) reported that year differences were a nonsignificant source of variation influencing the 70-day weights of lambs in their study. Sidwell and Grandstaff (1949), Blackwell and Henderson (1955) and Warwick and Cartwright (1957) indicated that year of birth had an important effect upon the weaning weights of lambs in their studies. Twombly *et al.* (1961) studied several environmental factors affecting weaning weight of lambs and stated that year of birth had the greatest single influence of the factors studied.

Age of Dam. Least squares means for each age of dam are plotted in Figure 12 for the lambs from both breed groups

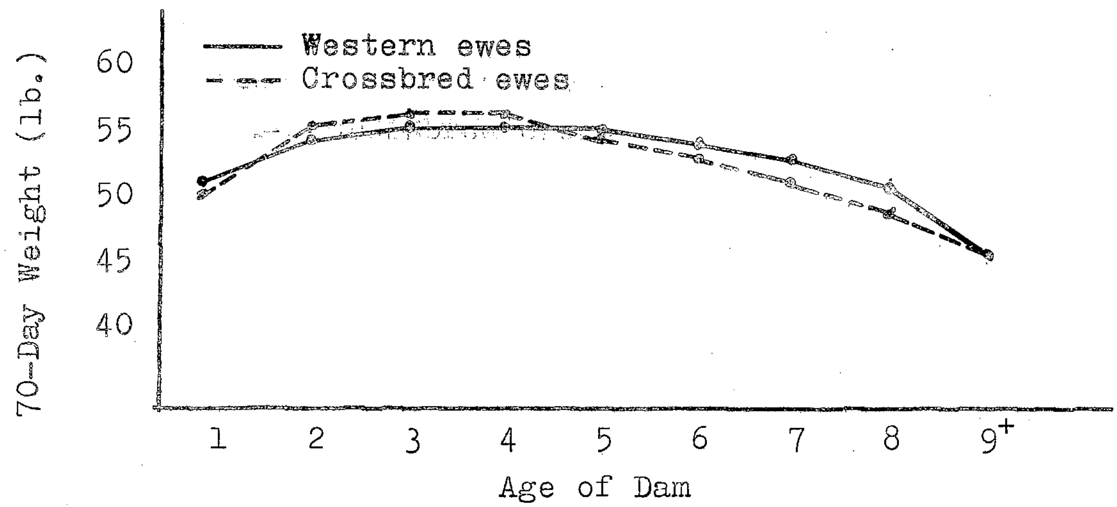

Figure 12. The Effect of Age of Dam on 70-Day Weight of Lambs from the Western and Crossbred Ewes

Two to 4-year-old crossbred ewes produced lambs having 70-day weights slightly heavier than lambs from the corresponding Western ewes. As was evident in the section dealing with rate of gain from birth to 70 days, the average 70-day weights began to decline after the crossbred ewes were four years of age; whereas, the average 70-day weight of lambs from the Western ewes did not decline much until after the ewes were six years old.

The 70-day weights of lambs from both breed groups tended to increase as age of dam increased up to four years of age beyond which there was an almost continuous decline in average weights of the lambs as the ewes became older. The literature contains only a limited amount of information on the influence of age of dam on 70-day weights, but several workers have reported age of dam to be an important source of variation influencing the weaning weights of lambs. Even though years and age of dam were completely confounded in the study reported by Harrington (1963), it was suggested that age of dam probably has a more pronounced effect on 70-day weights rather than year of birth. Hazel and Terrill (1945, 1946), Nelson and Venkatachalam (1949), Sidwell and Grandstaff (1949), Blackwell and Henderson (1955), Felts *et al.* (1957), MacNaughton (1957), Brown *et al.* (1961), Twombly *et al.* (1961), Vesely and Slen (1961), Bailey *et al.* (1961), Shelton and Campbell (1962), Bennett *et al.* (1963), Sidwell *et al.* (1964), Smith and Lidvall (1964) and Ray and Smith (1966) have all reported that age of dam was an important source of variation influencing weaning weights of lambs. Most of the lambs in these studies were weaned at an average age of 120 days.

Type of Birth and Rearing. The influence of type of birth and rearing on 70-day weight is illustrated in Figure 13. This figure illustrates that lambs from the crossbred ewes that were born and reared as singles were slightly heavier (1.353 lb.) at 70 days than the corresponding lambs from the Western ewes. Also, lambs born and reared as twins from the crossbred ewes were heavier (1.309 lb.) than those born and reared as twins from the Western ewes. However, there was about a 3.28 pound advantage at 70 days for lambs from the Western ewes over those from the crossbred ewes that were born as twins but reared as singles.

The results from both breed groups reveal that lambs born and reared as singles were heavier at 70 days than lambs born and reared as twins. Lambs from the crossbred ewes that were born and reared as singles were heavier (2.632 lb.)

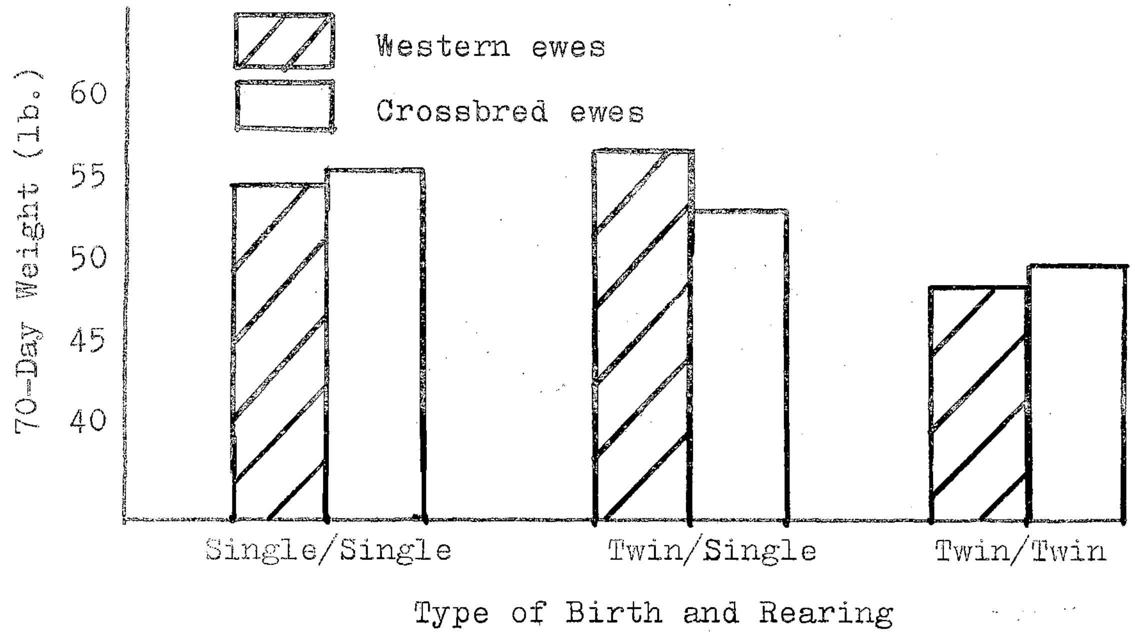

Figure 13. The Effect of Type of Birth and Rearing on 70-Day Weight of Lambs from the Western and Crossbred Ewes

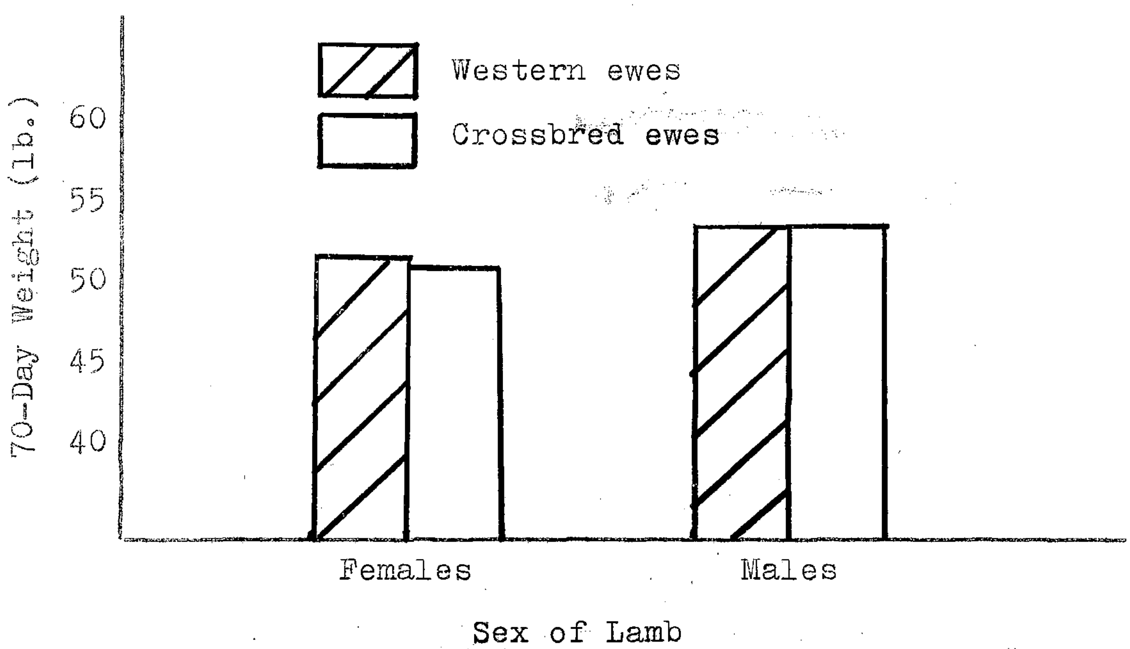

Figure 14. The Effect of Sex of Lamb on 70-Day Weight of Lambs from the Western and Crossbred Ewes

than those born as twins and reared as singles and these in turn were heavier (3.748 lb.) than those born and reared as twins. Several workers have reported results where lambs were weaned at 120 days of age that agrees favorably with those of this study. Sidwell and Grandstaff (1949), Blackwell and Henderson (1955), Bailey *et al.* (1961), Bennett *et al.* (1963), Smith and Lidvall (1964), Sidwell *et al.* (1964) and Shelton and Bassett (1967) have all reported that single lambs were heavier at weaning than lambs born as twins and reared as twins or singles. Lambs from the Western ewes that were born as twins and reared as singles were heavier at 70 days than those born and reared as singles (2.001 lb.) or twins (8.337 lb.). No other results of this nature were found in the literature; however, Botkin *et al.* (1956), MacNaughton (1957) and Brown *et al.* (1961) reported twins reared as singles weighed about the same as single lambs at weaning. Lambs from the Western ewes that were born and reared as singles were heavier (6.336 lb.) at 70 days than those born and reared as twins. deBaca *et al.* (1956), Shelton and Carpenter (1957), Neville *et al.* (1958), Givens *et al.* (1960) and Vesely and Slen (1961) reported single lambs were heavier than twins at weaning. Twombly *et al.* (1961) indicated singles averaged 18.4 pounds heavier than triplets reared as twins, 13.7 pounds heavier than twins and 7.1 pounds heavier than twins reared as singles at weaning time.

Sex of Lamb. The influence of sex of lamb on 70-day weight is illustrated in Figure 14 for the lambs from both breed groups. Female lambs from both breed groups were quite similar in weight at 70 days. Also, the male lambs from the two breed groups had 70-day weights that were almost identical.

Male lambs from both breed groups were heavier than females at 70 days of age. Male lambs from the Western ewes were (1.70 lb.) heavier at 70 days than the females. Similarly, males from the crossbred ewes were 2.20 pounds heavier than the females. These results are similar to those reported by Cassard and Weir (1956) and Harrington (1963), which indicate males to be heavier than females at 70 days of age. Various other workers have studied the influence of sex of lamb on weaning weight of lambs. Blackwell and Henderson (1955), Warwick and Cartwright (1957), Harrington *et al*. (1958), Sidwell *et al*. (1964) and Frederiksen *et al*. (1967) reported males to be heavier than females at weaning. Hazel and Terrill (1945, 1946), Nelson and Venkatachalam (1949), Sidwell and Grandstaff (1949), Botkin *et al*. (1956), Givens *et al*. (1960), Twombly *et al*. (1961), Shelton and Campbell (1962), Bennett *et al*. (1963), Smith and Lidvall (1964) and Shelton and Bassett (1967) have reported weight advantages ranging from 4.4 to 15 pounds for males over females at weaning. Brown *et al*. (1961) reported that differences in weaning weight due to sex were nonsignificant. Some of these studies included ewes, wethers and rams; however, many were concerned only with ewes and wethers.

Covariables. As for the analysis of rate of gain from birth to 70 days, birth date and birth weight were considered as covariables in the analysis of the 70-day weights. The influence of birth date on 70-day weight was highly significant ($P<.01$) as a linear function for the lambs from both breed groups (Table XV). The quadratic effect was nonsignificant for the lambs from the Western ewes, but was highly significant ($P<.01$) for the lambs from the crossbred ewes. These results are in contrast to those reported by Harrington (1963), which indicate the influence of birth date on the weight of lambs at 70 days to be nonsignificant.

The influence of birth weight on 70-day weight was highly significant ($P<.01$) as a linear function but the quadratic effect was nonsignificant for the lambs from both breed groups. Harrington (1963) also reported the effect of birth weight on 70-day weight was highly significant as a linear function but had essentially no curvilinear effect. The literature contains considerable information on the linear relationship between birth weight and subsequent lamb growth but no or very little information is available on any curvilinear relationship between birth weight and subsequent lamb growth. Phillips and Dawson (1937) found that each pound increase in birth weight was associated with 4.3 pounds increased weight at three months of age. deBaca *et al.* (1956) reported an increase of 2.50 to 5.96 pounds at weaning for every pound increase in birth weight. Harrington *et al.* (1958) stated birth weight was a most important source of variation influencing lamb weights at different ages.

Percent Advantage. The overall means for 70-day weights were 52.511 and 52.305 pounds for the lambs from the Western and crossbred ewes, respectively (Table XVI). The mean difference of 0.206 pounds in favor of the lambs from the Western ewes was nonsignificant and the percent advantage value of -0.39 was assumed to be estimating zero.

The limited amount of information reported in the literature reveals quite variable results have been obtained where the weaning weights of lambs from ewes of various breeding have been compared. Hunt (1935) reported that lambs from Dorset x grade Merino ewes were 20 pounds heavier at 70 days of age than those from grade Merino ewes. Grandstaff (1948) stated that lambs produced by Navajo ewes weighed 57.0 pounds at weaning compared to 53.4 pounds for those from Romney x Navajo ewes. Similarly, Shelton et al. (1966) reported a slight increase (0.8 lb.) in 120-day weights of lambs from Rambouillet ewes over those from a group of finewool crossbred ewes.

Rate of Gain from 70 Days to Market

The analysis of variance of rate of gain from 70 days to market is presented in Table XVII for the Western and crossbred ewe data. Year, age of dam, type of birth and rearing and sex of lamb were not all significant sources of variation for the lamb data from the Western ewes as they were for the crossbred ewe data. Age of dam and type of birth and rearing were both unimportant sources of variation

TABLE XVII

ANALYSIS OF VARIANCE OF RATE OF GAIN FROM 70 DAYS TO MARKET

Source	Western ewes		Crossbred ewes	
	d.f.	M.S.	d.f.	M.S.
Total	634		784	
Covariables:				
Birth date	1	0.1056**	1	0.0677**
Birth date squared	1	0.1174**	1	0.0035
Birth weight	1	0.4521**	1	1.0387**
Birth weight squared	1	0.0001	1	0.0010
Main effects:				
Year	8	0.1769**	8	0.2237**
Age of dam	8	0.0121	8	0.0268*
Type of birth and rearing	2	0.0095	2	0.0278*
Sex of lamb	1	0.4168**	1	0.2194**
Error	611	0.0077	761	0.0082
	$R^2 = 36\%$		$R^2 = 35\%$	

* P<.05 **P<.01

influencing the rate of gain of lambs from the Western ewes. The model utilized to describe the data accounted for 36 and 35 percent of the variation in rate of gain from 70 days to market for the lambs from the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XVIII and the means for each year are plotted in Figure 15 for the lambs from both breed groups. During the first two years, lambs from the Western ewes gained faster from 70 days to market than those from the crossbred ewes. However, this rate of gain advantage for the lambs from the Western ewes was no longer evident after 1960. In fact,

TABLE XVIII

LEAST SQUARES CONSTANTS FOR RATE OF GAIN FROM 70 DAYS TO MARKET

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	635	0.539	0.0069	785	0.549	0.0063
Birth date		0.009	0.0183		0.036	0.0200
Birth date squared		-0.00001	0.0000		-0.0001	0.0000
Birth weight		0.024	0.0143		0.026	0.0133
Birth weight squared		-0.0007	0.0008		-0.0004	0.0007
Year:						
58	64	0.020	0.0206	54	-0.038	0.0194
59	66	-0.048	0.0177	80	-0.092	0.0157
60	88	-0.057	0.0145	120	-0.065	0.0128
61	83	-0.095	0.0132	120	-0.097	0.0116
62	80	-0.037	0.0126	114	-0.009	0.0111
63	85	0.085	0.0137	97	0.103	0.0123
64	80	-0.013	0.0152	88	0.009	0.0136
65	56	0.061	0.0184	61	0.071	0.0172
66	33	0.084	0.0254	51	0.118	0.0233
Age of dam:						
1	43	-0.027	0.0227	24	0.046	0.0243
2	90	0.010	0.0176	105	0.066	0.0159
3	82	0.023	0.0149	114	0.045	0.0130
4	90	0.021	0.0130	123	0.019	0.0117
5	88	0.014	0.0125	112	-0.014	0.0113
6	80	0.011	0.0133	107	-0.032	0.0119
7	83	-0.013	0.0146	86	-0.029	0.0140
8	46	0.007	0.0192	73	-0.029	0.0173
9+	33	-0.046	0.0266	41	-0.072	0.0233
Type of birth and rearing:[a]						
SS	377	-0.009	0.0077	304	-0.008	0.0074
TS	22	0.011	0.0129	30	-0.003	0.0116
TT	236	-0.002	0.0078	451	0.011	0.0066
Sex of lamb:						
Female	310	-0.027	0.0036	382	-0.017	0.0033
Male	325	0.027	0.0036	403	0.017	0.0033

[a]SS = Single reared as single; TS = Twin reared as single; TT = Twin reared as twin.

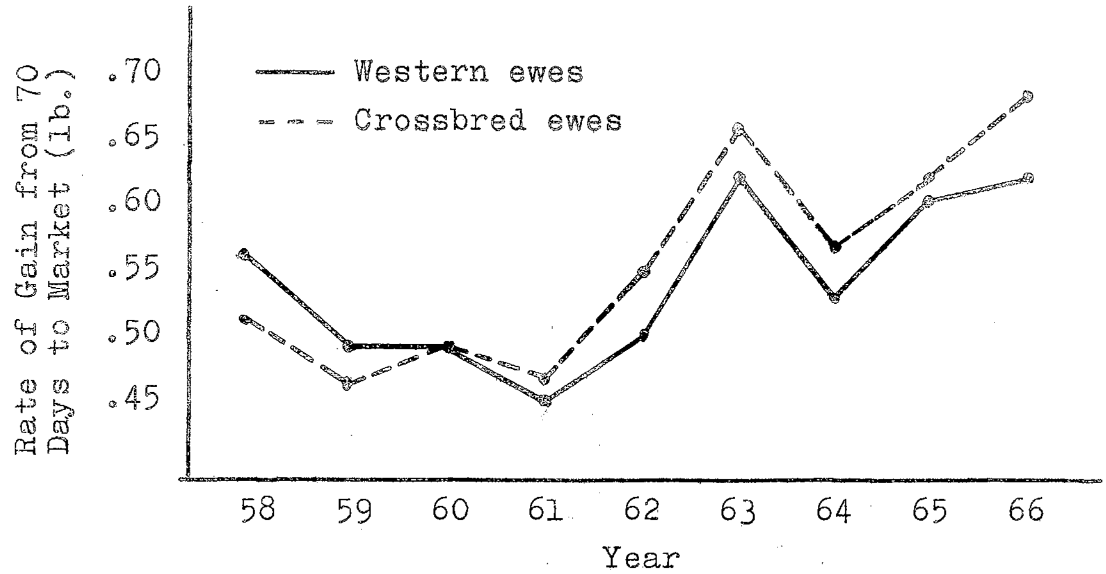

Figure 15. The Effect of Year on Rate of Gain from 70 Days to Market of Lambs from the Western and Crossbred Ewes

lambs from the crossbred ewes gained faster than those from the Western ewes after 1960 and maintained this advantage on through the final year. It is interesting to note that a similar pattern was evident for the growth performance of the lambs from both breed groups, i.e., as the rate of gain of lambs from one breed group increased or decreased, do did the lambs from the other breed group. The select group of 1966 lambs from the crossbred ewes had the highest rate of gain (0.667 lb.) and the select group of 1966 lambs from the Western ewes also had a high rate of gain (0.623 lb.), but the 1963 lambs from this breed group performed similarly to those in 1966. A sharp decline in rate of gain of the lambs from both breed groups is noted during 1964. This is probably due to the fact that immediately after the lambs were weaned during this year, the soybean oilmeal was removed abruptly from the creep-ration and during the later years the

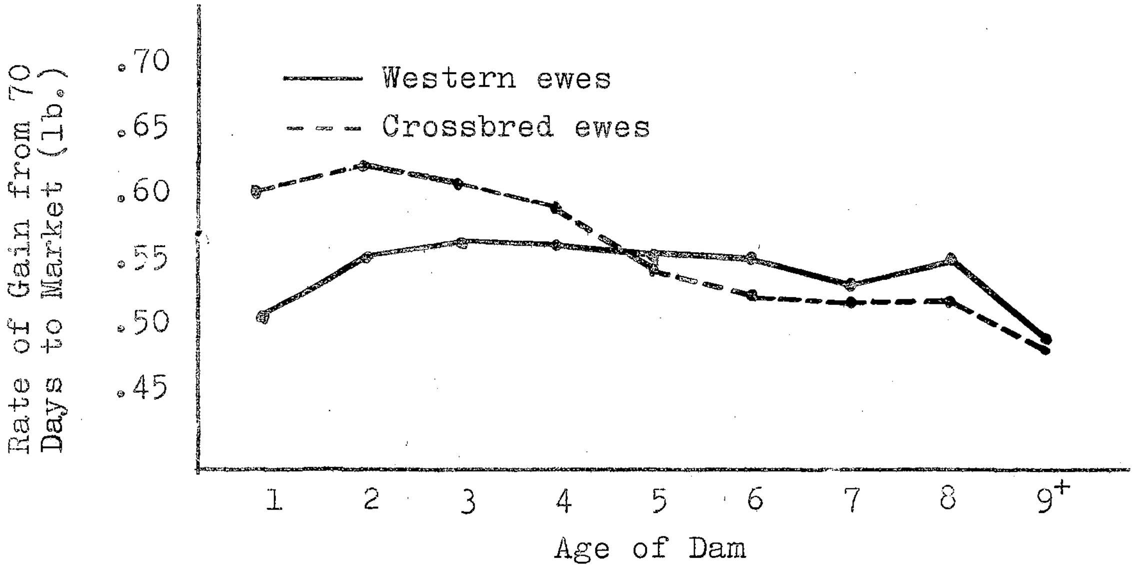

Figure 16. The Effect of Age of Dam on Rate of Gain from 70 Days to Market of Lambs from the Western and Crossbred Ewes

oilmeal was gradually removed from the creep-ration after the lambs were weaned.

The literature contains only limited information on the influence of year of birth on rate of gain past 70 days. Cassard and Weir (1956) reported year of birth to be a non-significant source of variation influencing rate of gain from 70 to 120 days. However, Harrington (1963) reported year of birth to have a highly significant effect on rate of gain from 70 to 140 days.

Age of Dam. The least squres means for each age of dam are plotted in Figure 16 for both ewe breed groups. Up until the ewes of both breed groups reached four years of age, the lambs from the crossbred ewes gained faster than those from the Western ewes. Beyond this age, lambs from the Western ewes gained faster than those from the crossbred ewes as the ewes of each breed group increased in age.

The results from both breed groups reveal that the rate of gain was greater for lambs from the younger crossbred ewes, but the rate of gain remained relatively constant across all age groups for the lambs from the Western ewes, with the exception of those from the youngest and oldest ewes. In the case of the lambs from the crossbred ewes, the rate of gain tended to decline as age of the crossbred ewes increased, and this decrease in gain appeared to be almost linear as the ewes increased in age from two to eight years. Cassard and Weir (1956) indicated age of dam had virtually no influence on lamb rate of gain from 70 to 120 days. Harrington (1963) suggested that the influence of years would probably have a greater effect on rate of gain from 70 to 140 days than age of dam since lamb growth during this period is much more dependent upon the quantity and quality of feed available than the milk supply of the ewe.

Type of Birth and Rearing. The influence of type of birth and rearing on rate of gain from 70 days to market is illustrated in Figure 17. Lambs from the crossbred ewes that were born and reared as singles gained faster (0.011 lb.) than those born and reared as singles from the Western ewes. Also, lambs born and reared as twins from the crossbred ewes gained faster (0.023 lb.) than those born and reared as twins from the Western ewes. Lambs born as twins but reared as singles from both breed groups gained at about the same rate from 70 days to market.

The results from both breed groups suggest that the

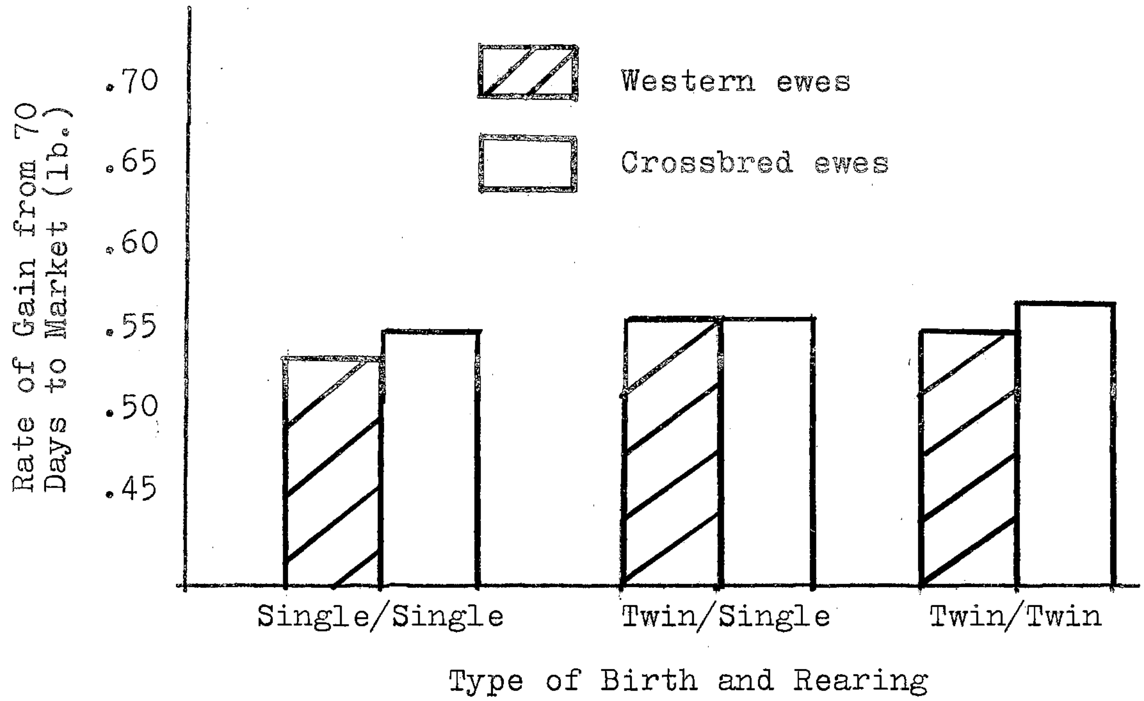

Figure 17. The Effect of Type of Birth and Rearing on Rate of Gain from 70 Days to Market of Lambs from the Western and Crossbred Ewes

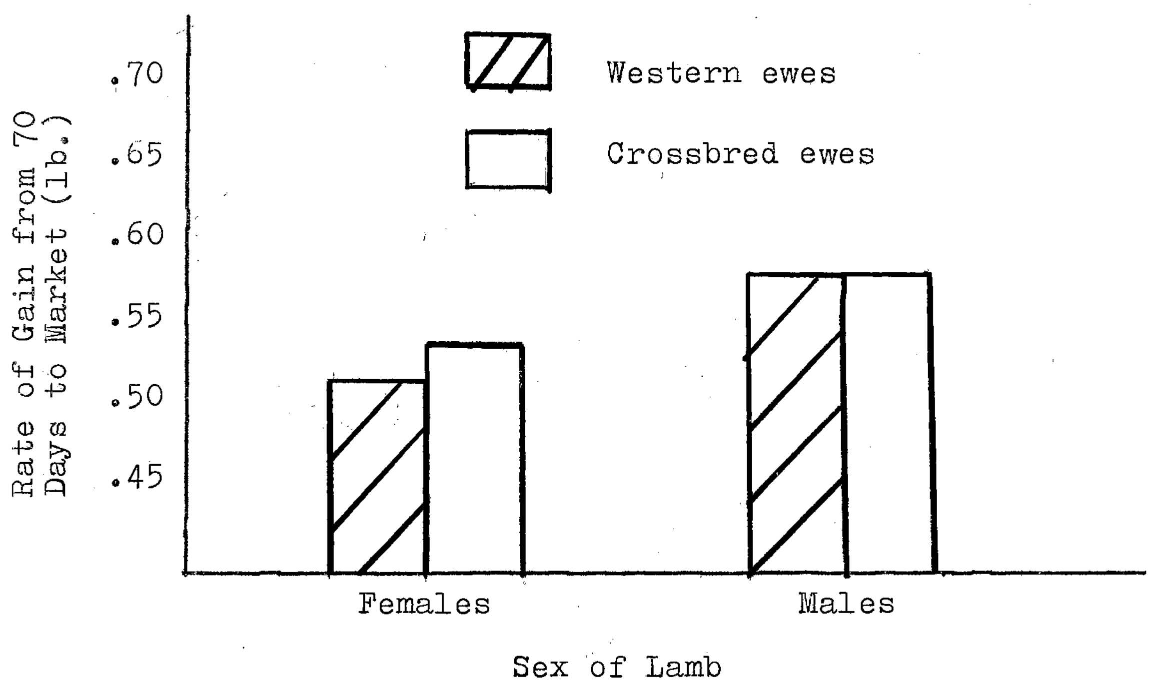

Figure 18. The Effect of Sex of Lamb on Rate of Gain from 70 Days to Market of Lambs from the Western and Crossbred Ewes

lambs born and reared as twins gained at a rate comparable to those born and reared as singles. Lambs from the cross-bred ewes that were born and reared as twins out-gained (0.014 lb.) those born as twins and reared as singles and these in turn gained faster (0.005 lb.) than the lambs born and reared as singles. Lambs born and reared as twins from the Western ewes gained slightly faster (0.007 lb.) than those born and reared as singles, but the lambs born as twins and reared as singles out-gained those born and reared as singles or twins (0.020 and 0.013 pounds faster respectively, than the lambs born and reared as singles and twins).

These results compare favorably with those reported in the literature. Karam *et al*. (1949) reported twin lambs averaged 0.01 pounds higher than singles for daily gain on feed. Similarly, Botkin (1964) stated that the post-weaning performance of twins and singles was essentially the same, on the average, although there were some year-to-year variations. Type of birth and rearing apparently had no influence on the 84-day feedlot performance of lambs in the study reported by Frederiksen *et al*. (1967). In the analysis of rate of gain from 70 to 140 days, Harrington (1963) reported the effect of birth type and rearing was a significant source of variation in some analyses and not in others. Harrington *et al*. (1962), in a study of lamb gain from 50 to 90 pounds, reported that lambs reared as twins tended to gain as fast or faster than lambs reared as singles during this period.

Sex of Lamb. The influence of sex of lamb on rate of gain from 70 days to market is illustrated in Figure 18 for the lambs from both ewe breed groups. Female lambs from the crossbred ewes had a faster rate of gain (0.020 lb.) than females from the Western ewes. However, male lambs from both breed groups were almost identical in rate of gain from 70 days to market.

The results from both breed groups indicate that male lambs gained at a faster rate from 70 days to market than the female lambs. Male lambs from the Western ewes out-gained the females by 0.054 pounds per day; whereas, males from the crossbred ewes out-gained the females by 0.034 pounds per day. These post-weaning results are similar to those reported by other workers. Karam et al. (1949) reported wether lambs averaged 0.01 pounds higher than ewes for daily gain on feed. Ram lambs gained significantly faster than ewe lambs regardless of year, method of feeding or length of feeding period in a study reported by Botkin (1964). Frederiksen et al. (1967) also indicated daily gains of rams were greater than ewes during an 84-day feeding test. Harrington (1963) reported sex of lamb was a highly significant source of variation in rate of gain from 70 to 140 days. Similarly, Brothers and Whiteman (1960) reported sex of lamb was an important source of variation influencing lamb gains from 50 to 90 pounds.

Covariables. The influence of birth date on rate of gain from 70 days to market was highly significant ($P<.01$) as a linear function for the lambs from both breed groups

(Table XVII), and the quadratic effect was nonsignificant for the crossbred ewe data but highly significant ($P<.01$) for the Western ewe data. Harrington (1963) reported that birth date, both linear and quadratic effects, had a highly significant effect on lamb gain from 70 to 140 days.

The influence of birth weight on rate of gain from 70 days to market was highly significant ($P<.01$) as a linear effect but the quadratic effect was nonsignificant for the data from both breed groups. These results are in contrast to those reported by Harrington (1963), which reveal exactly the opposite situation.

Percent Advantage. The overall means were 0.539 and 0.549 pounds for rate of gain from 70 days to market for the lambs from the Western and crossbred ewes, respectively (Table XVIII). The mean difference of 0.10 pounds in favor of the lambs from the crossbred ewes was nonsignificant and the percent advantage value of 1.85 was assumed to be estimating zero. No comparison of any ewes with respect to growth rate of their lambs past 70 days of age was found in the literature.

Market Age

The analysis of variance of market age is presented in Table XIX for the data from both breed groups. Year, type of birth and rearing and sex of lamb were all significant ($P<.01$) sources of variation influencing the market age of lambs from both breed groups. Age of dam was significant

TABLE XIX

ANALYSIS OF VARIANCE OF MARKET AGE

Source	Western ewes d.f.	Western ewes M.S.	Crossbred ewes d.f.	Crossbred ewes M.S.
Total	634		784	
Covariables:				
Birth date	1	570.425	1	928.421
Birth date squared	1	1354.573*	1	683.346
Birth weight	1	102500.770**	1	159105.590**
Birth weight squared	1	1258.638*	1	1031.485
Main effects:				
Year	8	5255.020**	8	2900.852**
Age of dam	8	694.594*	8	851.552**
Type of birth and rearing	2	5590.727**	2	4759.221**
Sex of lamb	1	11800.833**	1	8994.357**
Error	611	306.256	761	326.958
	R^2 = 49%		R^2 = 50%	

*P<.05 **P<.01

(P<.05) for the Western ewe data and highly significant (P<.01) for the crossbred ewe data. The model utilized to describe the data accounted for 49 and 50 percent of the variation in market age for the lambs from the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XX and the means for each year are illustrated in Figure 19. Lambs from the Western ewes went to market about 10 days earlier than those from the crossbred ewes during 1958. However, lambs from the crossbred ewes began to reach market weight sooner than the lambs from the Western ewes during 1959 and maintained this advantage on through 1963. Beyond

TABLE XX

LEAST SQUARES CONSTANTS FOR MARKET AGE

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	635	156.427	1.3837	785	155.502	1.2546
Birth date		-2.065	3.6383		-11.121	4.0004
Birth date squared		0.004	0.0175		0.018	0.0572
Birth weight		-14.569	2.8494		-13.817	2.6621
Birth weight squared		0.450	0.1485		0.364	0.1412
Year:						
58	64	-10.592	4.1067	54	0.221	3.8790
59	66	13.333	3.5340	80	11.212	3.1238
60	88	11.369	2.8878	120	8.433	2.5657
61	83	11.961	2.6140	120	6.014	2.3197
62	80	16.984	2.5135	114	8.606	2.2147
63	85	-9.930	2.7213	97	-8.590	2.4543
64	80	-1.931	3.0287	88	0.878	2.7177
65	56	-11.255	3.6645	61	-8.682	3.4302
66	33	-19.939	5.0538	51	-18.092	4.6531
Age of dam:						
1	43	1.264	4.5158	24	-1.694	4.8445
2	90	-3.844	3.4980	105	-9.331	3.1794
3	82	-8.402	2.9573	114	-9.069	2.5980
4	90	-8.258	2.5859	123	-4.806	2.3306
5	88	-6.728	2.4865	112	1.354	2.2568
6	80	-1.903	2.6548	107	0.175	2.3682
7	83	5.194	2.9077	86	3.395	2.8030
8	46	6.541	3.8315	73	5.592	3.4500
9+	33	16.136	5.2878	41	14.384	4.6531
Type of birth and rearing:[a]						
SS	377	-0.655	1.5538	304	-4.262	1.4771
TS	22	-8.378	2.5638	30	-0.288	2.3144
TT	236	9.033	1.5604	451	4.550	1.3170
Sex of lamb:						
Female	310	4.475	0.7209	382	3.514	0.6700
Male	325	-4.475	0.7209	403	-3.514	0.6700

[a]SS = Single reared as single; TS = Twin reared as single; TT = Twin reared as twin.

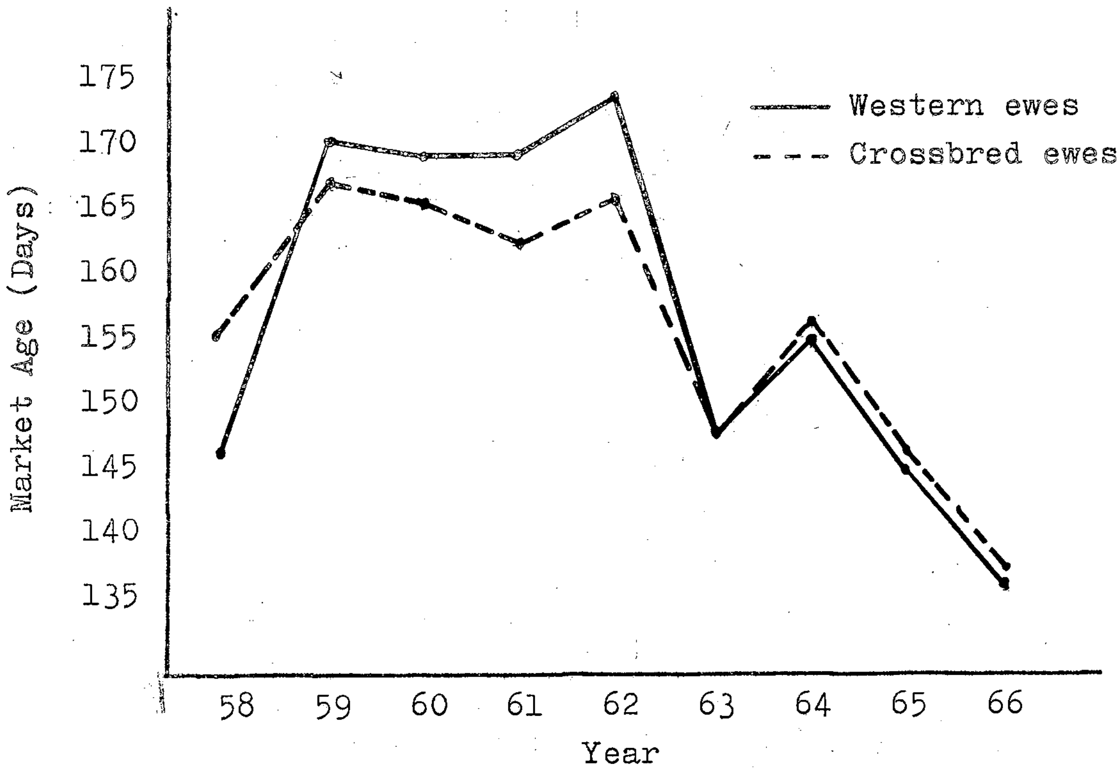

Figure 19. The Effect of Year on Market Age of Lambs from the Western and Crossbred Ewes

this point there was about a one to two day advantage for the lambs from the Western ewes.

Figure 19 illustrates an interesting situation during 1963. Lambs from both breed groups reached market weight considerably sooner than those during the preceeding years with the exception of lambs born to the Western ewes during 1958. This response is no doubt a result of the rapid rate of growth from 70 days to market that was evident during 1963 (Figure 15) for the lambs from both breed groups. Also, the rapid growth rate that was evident during 1958 (Figure 15) tends to serve as an explanation as to why the lambs from both breed groups went to market so soon during 1958. Since the rate of gain from 70 days to market (Figure 15) declined considerably during 1964, then it would be expected

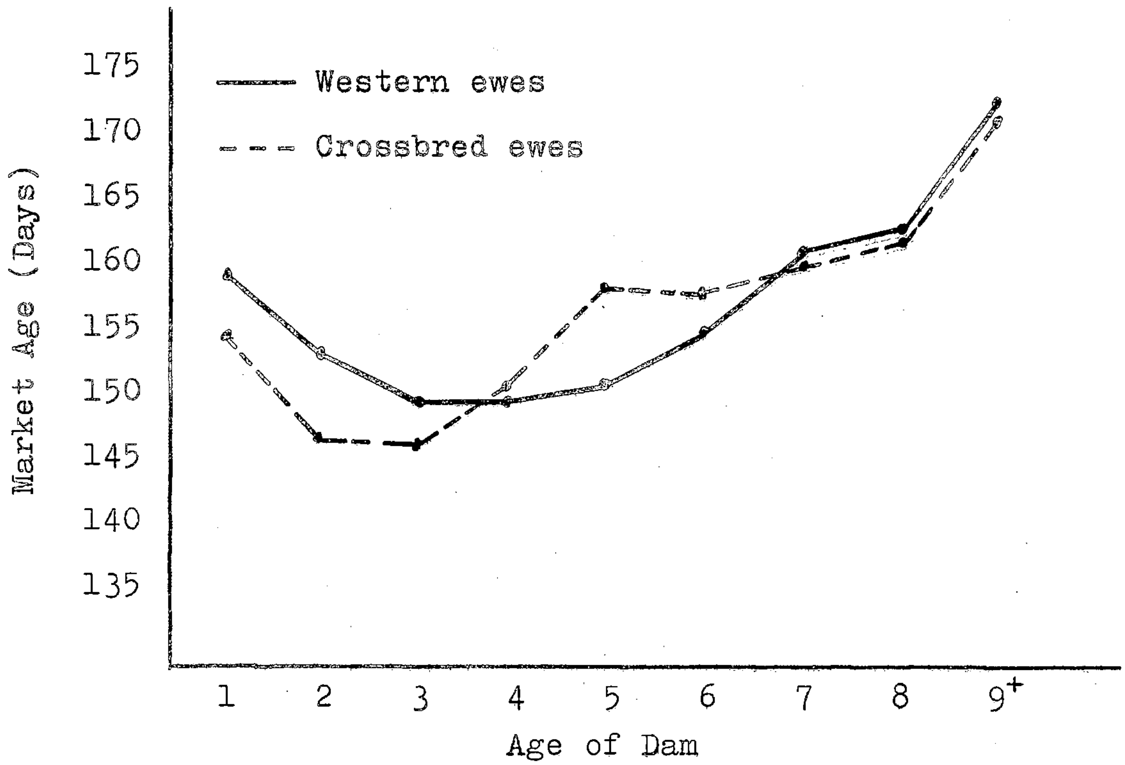

Figure 20. The Effect of Age of Dam on Market Age of Lambs from the Western and Crossbred Ewes

that these lambs would require a longer period of time to reach market weight. Such was the case as is evident from Figure 19. Similarly, the select group of 1966 lambs had a high rate of growth from 70 days to market and Figure 19 reveals that these lambs went to market at an earlier age than those in previous years. No reports on the influence of year of birth on market age of lambs were found in the literature.

Age of Dam. The least squares means for each age of dam are plotted in Figure 20. Lambs from the one to 3-year-old crossbred ewes went to market about three to five days before the lambs from the similar aged Western ewes. However, lambs from the crossbred ewes ranging in age from four to six years required from three to eight days longer to reach market weight than those from the Western ewes. Beyond this age, there was a slight advantage for the lambs from the crossbred ewes as the ewes from both breed groups increased in age.

Figure 16 indicated that the crossbred ewes ranging in age from one to four years produced lambs having a faster rate of growth from 70 days to market than lambs from similar aged Western ewes. These results lead one to expect, as Figure 20 illustrates, that the younger crossbred ewes would produce lambs that reach market weight sooner than the Western ewes of similar age. As the ewes passed four years of age, the rate of gain of their lambs from 70 days to market was quite similar and this gain tended to decline as age of ewe increased. With the exception of ewes that were five years old, the length of time required for the lambs to reach market weight was quite similar for both breed groups and increased as age of dam increased. These results are as one would expect since the growth rate from 70 days to market declined as age of dam increased and the lambs should require a longer period of time to reach market weight.

Results from both breed groups reveal that the lambs from the youngest and oldest ewes required a longer period of time to reach market weight than those from the ewes ranging in age from two through six years. No reports on the influence of age of dam on market age of their lambs were found in the literature.

Type of Birth and Rearing. The influence of type of birth and rearing on market age is illustrated in Figure 21.

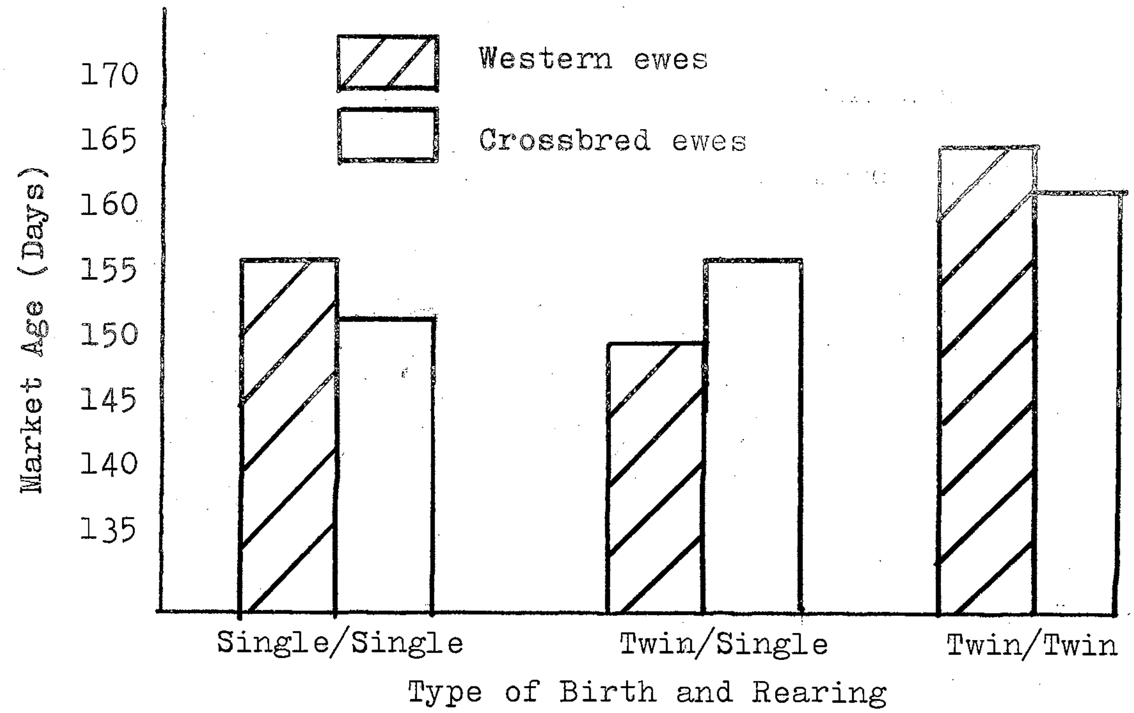

Figure 21. The Effect of Type of Birth and Rearing on Market Age of Lambs from the Western and Crossbred Ewes

Lambs from the crossbred ewes that were born and reared as singles went to market about 4.5 days before those born and reared as singles from the Western ewes. Also, lambs born and reared as twins from the crossbred ewes required a shorter period of time (5.4 days) to reach market weight than lambs born and reared as twins from the Western ewes. These results were to be expected since the singles and twins from the crossbred ewes gained faster from 70 days to market than the singles and twins, respectively, from the Western ewes (Figure 17). Lambs born as twins and reared as singles from the Western ewes reached market age sooner (7.2 days) than those from the crossbred ewes that were born as twins but reared as singles. These results are probably due to the fact that the lambs born as twins and reared as singles from the Western ewes had a faster rate of gain from birth to 70 days and heavier 70-day weights than those from the crossbred ewes (Figures 9 and 13). Lambs represented by this type of birth and rearing classification from both ewe breed groups were similar with respect to growth rate from 70 days to market (Figure 17).

The results from both breed groups indicate that lambs born and reared as twins required a longer period of time to reach market weight than those born and reared as singles. Although the singles and twins from both breed groups had similar rates of gain from 70 days to market, the twins still required a longer period of time to reach market weight due to the superior growth rate of the singles prior to 70 days of age. For the crossbred ewes, lambs born and reared as singles went to market sooner (3.97 days) than those born as twins and reared as singles and these in turn required less time (4.84 days) to reach market weight than those born and reared as twins. Lambs born and reared as singles from the Western ewes went to market sooner (10.69 days) than those born and reared as twins. However, the lambs born as twins but reared as singles went to market in a shorter period of time than those born and reared as singles or twins (7.72 and 17.41 days sooner, respectively, than those lambs born and reared as singles or twins). Again, it is well to remember that only a few (22) lambs are represented in this group compared to the number represented in the other type of birth and rearing classifications. No reports on the in-

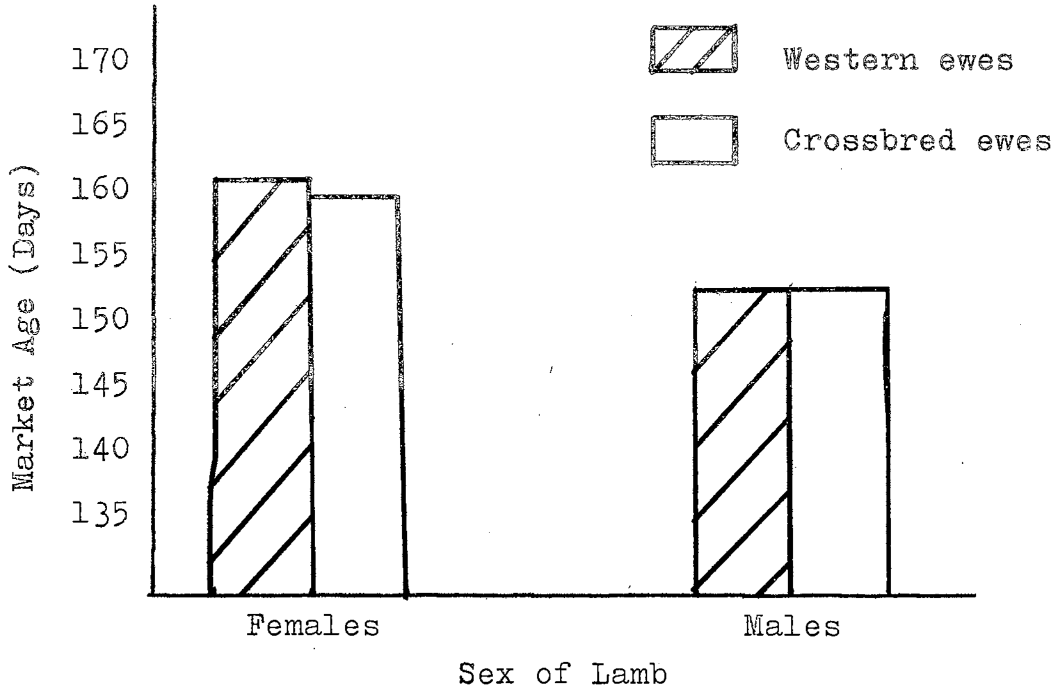

Figure 22. The Effect of Sex of Lamb on Market Age of Lambs from the Western and Crossbred Ewes

fluence of type of birth and rearing on market age were found in the literature.

Sex of Lamb. The influence of sex of lamb on market age is illustrated in Figure 22. Female lambs from the crossbred ewes went to market about 1.89 days ahead of female lambs from the Western ewes. Male lambs from both breed groups required about the same length of time to reach market weight. These results were to be expected since the female lambs from the crossbred ewes had a slightly faster rate of gain from 70 days to market than female lambs from the Western ewes and the males from both breed groups were similar with respect to growth rate during this period (Figure 18).

The males from each ewe breed group reached market weight at an earlier age than the females. Male lambs from the crossbred ewes required 7.03 fewer days to reach market weight than the female lambs. Similarly, male lambs from the Western ewes were shipped to market approximately 8.15 days ahead of the females. No reports on the influence of sex of lamb on market age were found in the literature.

Covariables. The influence of birth date on market age had virtually no linear or quadratic effect for the crossbred ewe data (Table XIX). The quadratic effect was significant ($P<.05$) for the Western ewe data but the linear effect was nonsignificant. The influence of birth weight on market age was highly significant ($P<.01$) as a linear function for the data from both breed groups. The quadratic effect was significant ($P<.05$) for the Western ewe data but nonsignificant for the crossbred ewe data.

Percent Advantage. The average market age of lambs from the Western ewes was 156.427 days compared to 155.502 days for the lambs from the crossbred ewes (Table XX). The mean difference of 0.925 days in favor of the lambs from the crossbred ewes was nonsignificant and the percent advantage value of -0.59 was assumed to be estimating zero. No reports were found in the literature where the market ages of lambs from various ewes were compared.

Conclusions
(Lamb Growth Data)

A comparison of the Western and crossbred ewes with respect to their lamb growth data indicates that both breed groups produced lambs that had similar birth weights, rates of gain from birth to 70 days, 70-day weights, rates of gain from 70 days to market and market ages. The overall means for each of these variables for the lambs from both breed groups were statistically nonsignificant and the percent advantage values of -1.02, 0.16, -0.39, 1.85 and -0.59 for birth weight, rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market and market age, respectively, were assumed to be estimating zero. So, it would appear that from the standpoint of the lamb growth data, neither ewe breed group has any advantage over the other.

Year of birth, age of dam, type of birth and rearing (type of birth for birth weight) and sex of lamb were all significant sources of variation influencing the birth weight, rate of gain from birth to 70 days, 70-day weight and market age of lambs from both breed groups. These factors were also significant sources of variation influencing the rate of gain from 70 days to market of lambs from the crossbred ewes, but only year of birth and sex of lamb were significant for the rate of gain of lambs from the Western ewes.

The performance of all lambs from both ewe breed groups, for each of the variables other than birth weight, was superior during the later years (1963-1966) and this was attributed to the addition of soybean oilmeal to the lamb creep-ration. Performance of the lambs from the middle-aged ewes of both breed groups was superior to that of lambs from the youngest and oldest ewes. Birth weight of lambs from both breed groups, which showed no decline as age of dam increased, and rate of gain from 70 days to market of lambs from the crossbred ewes were the only exceptions to this pattern. In most cases, the performance of the lambs from the crossbred ewes for each of the growth variables was superior to that of the lambs from the Western ewes up until these ewes were four to five years old. Beyond this age, the performance of the lambs from the crossbred ewes dropped below that of the lambs from the Western ewes.

Male and single lambs from both breed groups were heavier at birth, had faster rates of growth after birth and consequently reached market weight sooner than female and twin lambs, respectively. However, the growth rates were similar for singles and twins after 70 days of age. Variable results were observed for the lambs born as twins but reared as singles from the Western ewes, and this was attributed to the small number of lambs represented by this type of birth and rearing classification.

In general the influence of birth date and birth weight on the various lamb growth variables was of more importance as a linear rather than as a quadratic effect; however, the quadratic effect was significant for some of the variables.

Ewe Reproduction Data

The number and percent ewes lambing, number of lambs born and reared, lambs reared per 100 ewes in the flock and lambing rate during the fall and winter of each year are presented in Tables XXI and XXII, respectively, for the Western and crossbred ewes. The number of lambs born and reared is further subdivided according to the number of singles, twins and triplets born and reared by the two breed groups in Tables XXIII and XXIV for the fall and winter seasons, respectively.

Percent Ewes Lambing During the Fall

The values for each year are taken from Table XXI and plotted in Figure 23 for each breed group. About 2.6 percent more of the Western ewes lambed during the fall of 1957 than did the crossbred ewes. This difference in favor of the Western ewes was even greater (18.8%) during 1958, but beyond this point the percentage of the crossbred ewes that lambed was considerably higher than that for the Western ewes except during 1964 when the performance was similar for both breed groups. The higher percentage of Western ewes lambing during 1957 and 1958 is probably due to the age advantage that the Western ewes had over the crossbreds.

The percentage of crossbred ewes that lambed during the fall continued to increase through 1961 and declined thereafter. An almost entirely different pattern is noted for the Western ewes. There was a great deal of fluctuation in the percentage of the Western ewes that lambed during the early years. After 1961, the percentage of these ewes that lambed continued to increase until a maximum of 89.3 percent was reached during 1964. It is interesting to note that

TABLE XXI

NUMBER AND PERCENT EWES LAMBING, NUMBER OF LAMBS BORN AND REARED, LAMBS REARED PER 100 EWES AND LAMBING RATE DURING THE FALL OF EACH YEAR FOR THE WESTERN AND CROSSBRED EWES

Year	Total No. of ewes		No. of ewes lambing		Percent ewes lambing		No. of lambs born		No. of lambs reared		Lambs reared[b]		Lambing rate[c]	
	W[a]	C	W	C	W	C	W	C	W	C	W	C	W	C
57	39	39	11	10	28.2	25.6	11	11	11	8	28.2	20.5	1.00	1.10
58	78	79	64	50	82.1	63.3	69	64	65	61	83.3	77.2	1.08	1.28
59	118	116	79	85	67.0	73.3	97	127	91	116	77.1	100.0	1.23	1.49
60	116	113	87	102	75.0	90.3	114	144	101	135	87.1	119.5	1.31	1.41
61	111	109	79	102	71.2	93.6	93	149	86	136	77.5	124.8	1.18	1.46
62	109	103	85	95	78.0	92.2	106	133	95	118	87.2	114.6	1.25	1.40
63	107	97	95	89	88.8	91.8	128	141	114	120	106.5	123.7	1.35	1.58
64	84	85	75	76	89.3	89.4	120	127	105	120	125.0	141.2	1.60	1.67
65	74	79	61	70	82.4	88.6	90	105	77	90	104.1	113.9	1.48	1.50
66	69	76	44	63	63.8	82.9	51	100	49	84	71.0	110.5	1.16	1.59
Totals and means	905	896	680	742	75.1	82.8	879	1101	794	988	87.7	110.3	1.29	1.48

[a]W = Western ewes; C = Crossbred ewes.
[b]Lambs reared per 100 ewes in the flock.
[c]Lambs born per ewe lambing.

TABLE XXII

NUMBER AND PERCENT EWES LAMBING, NUMBER OF LAMBS BORN AND REARED, LAMBS REARED PER 100 EWES AND LAMBING RATE DURING THE WINTER OF EACH YEAR FOR THE WESTERN AND CROSSBRED EWES

Year	Total No. of ewes		No. of ewes lambing		Percent ewes lambing		No. of lambs born		No. of lambs reared		Lambs reared[b]		Lambing rate[c]	
	W[a]	C	W	C	W	C	W	C	W	C	W	C	W	C
57	39	39	3	2	7.7	5.1	3	3	3	1	7.7	2.6	1.00	1.50
58	78	79	5	12	6.4	15.2	6	15	6	15	7.7	19.0	1.20	1.25
59	118	116	27	20	22.9	17.2	34	23	31	21	26.3	18.1	1.26	1.15
60	116	113	18	8	15.5	7.1	26	11	23	6	19.8	5.3	1.44	1.38
61	111	109	21	6	18.9	5.5	33	11	32	10	28.8	9.2	1.57	1.83
62	109	103	19	3	17.4	2.9	30	5	28	5	25.7	4.9	1.58	1.67
63	107	97	5	7	4.7	7.2	7	11	5	9	4.7	9.3	1.40	1.57
64	84	85	4	6	4.8	7.1	6	11	5	9	6.0	10.6	1.50	1.83
65	74	79	3	4	4.1	5.1	6	6	6	5	8.1	6.3	2.00	1.50
Totals and means	836	820	105	68	12.6	8.3	151	96	139	81	16.6	9.9	1.44	1.41

[a]W = Western ewes; C = Crossbred ewes.

[b]Lambs reared per 100 ewes in the flock.

[c]Lambs born per ewe lambing.

TABLE XXIII

NUMBER OF SINGLES, TWINS AND TRIPLETS BORN AND REARED DURING THE FALL OF EACH YEAR BY THE WESTERN AND CROSSBRED EWES

Year	No. of singles born		No. of singles reared		No. of twins born		No. of twins reared		No. of triplets born		No. of triplets reared	
	W[a]	C	W	C	W	C	W	C	W	C	W	C
57	11	9	11	6		2		2				
58	59	36	57	35	10	28	8	26				
59	62	43	57	41	32	84	32	75	3		2	
60	60	61	55	56	54	80	46	76		3		3
61	65	57	60	50	28	86	26	81		6		5
62	64	57	60	51	42	76	35	67				
63	62	40	57	34	66	92	57	78		9		8
64	32	28	28	25	82	90	71	86	6	9	6	9
65	33	37	27	32	54	62	47	53	3	6	3	5
66	37	26	36	22	14	74	13	62				
Total	485	394	448	352	382	674	335	606	12	33	11	30

[a]W = Western; C = Crossbred ewes.

TABLE XXIV

NUMBER OF SINGLES, TWINS AND TRIPLETS BORN AND REARED DURING THE WINTER OF EACH YEAR BY THE WESTERN AND CROSSBRED EWES

Year	No. of singles born		No. of singles reared		No. of twins born		No. of twins reared		No. of triplets born		No. of triplets reared	
	W[a]	C	W	C	W	C	W	C	W	C	W	C
57	3	1	3	1		2		0				
58	4	9	4	9	2	6	2	6				
59	20	17	19	16	14	6	12	5				
60	10	5	7	2	16	6	16	4				
61	10	1	10	1	20	10	19	9	3		3	
62	8	1	7	1	22	4	21	4				
63	3	4	3	2	4	4	2	4		3		3
64	2	2	2	2	4	6	3	5		3		2
65		2		1	6	4	6	4				
Total	60	42	55	35	88	48	81	41	3	6	3	5

[a]W = Western ewes; C = Crossbred ewes.

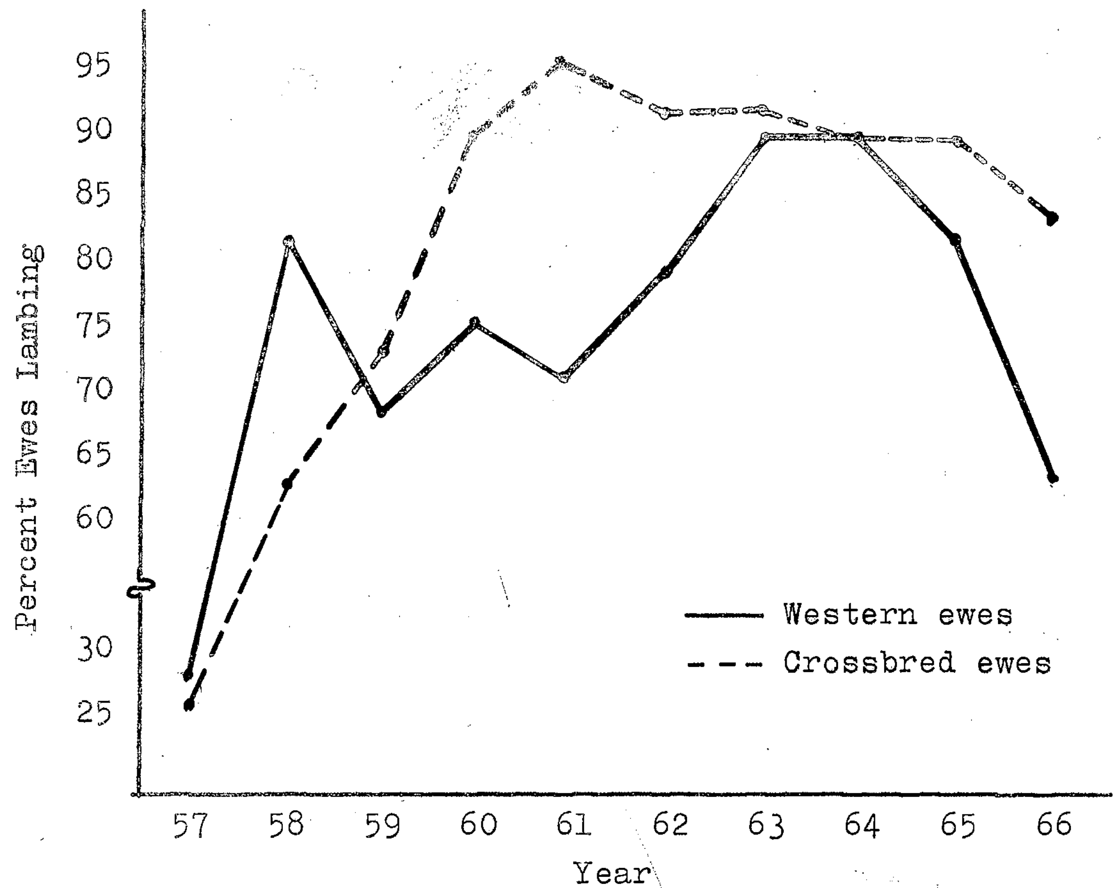

Figure 23. Percent Western and Crossbred Ewes Lambing during the Fall of each Year

during the last two years, the percentage values for the Western ewes declined considerably when compared to those of the crossbred ewes.

Percent Advantage. The values presented in the last row of Table XXI indicate that, on the average, 82.8 percent of the crossbred ewes lambed during the fall of each year compared to 75.1 percent for the Western ewes. This difference of 7.7 percent in favor of the crossbred ewes was significant ($P<.05$) and the percent advantage value of 10.3 suggests a substantial advantage for the crossbred ewes.

The results reported in the literature are quite variable where the lambing percentages of various crossbred ewes have been compared to those of purebred or native ewes. Fox and McArthur (1962) reported that 94 percent of a group of crossbred ewes (Hampshire x Columbia, Hampshire x Targhee) lambed, when bred as lambs, compared to 43 percent for a group of purebreds (Columbia, Targhee). When these same ewes were bred as yearlings, 94 and 100 percent of the crossbred and purebred ewes lambed, respectively. In a similar study, Fox et al. (1964) compared the lambing percent of crossbred (Hampshire x Columbia, Hampshire x Targhee) and purebred (Hampshire, Columbia, Targhee) ewes at the Corvallis and Union Stations in Oregon. Seventy percent of the crossbreds lambed at the Corvallis Station and 61 percent at the Union Station, as contrasted with values of 64 and 53 percent at Corvallis and Union, respectively, for the purebred ewes. The data (Table I) summarized by Shelton et al. (1966) reveal that a higher percentage of the Florida native ewes (91.7%) lambed and these were followed by the Rambouillet (83.2%), finewool crossbred (81.0%) and Southdown (80.8%) ewes.

Lambing Rate During the Fall

The lambing rates during the fall of each year are taken from Table XXI and plotted in Figure 24 for the Western and crossbred ewes. There is virtually no comparison between the two breed groups. The number of lambs born per ewe lambing was consistently in favor of the crossbred ewes across all years with the greatest difference between the two breed groups being during the last year.

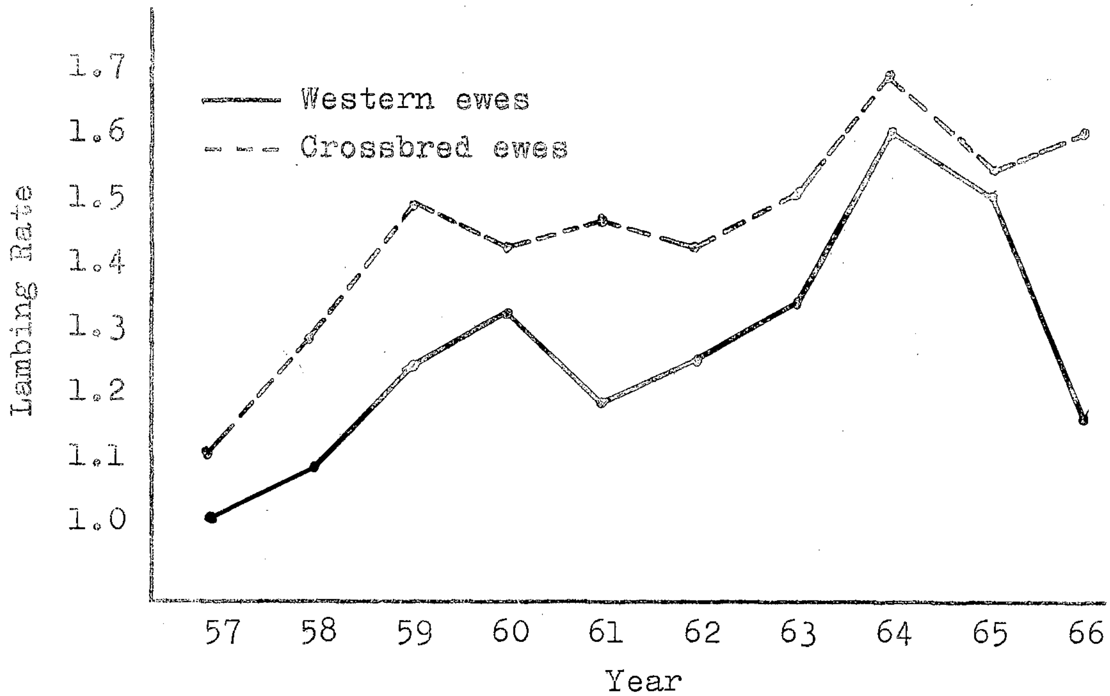

Figure 24. Lambing Rate for the Western and Crossbred Ewes during the Fall of each Year

Percent Advantage. The mean values presented in Table XXI reveal that the average lambing rate was 1.48 for the crossbred ewes compared to 1.29 for the Western ewes. So, on the average, the crossbred ewes gave birth to 0.19 more lambs per ewe lambing during the fall of each year than did the Western ewes. This difference in favor of the crossbred ewes was significant ($P<.001$) and resulted in the percent advantage value of 13.2.

This advantage in lambing rate for the crossbred ewes was due to a large number of multiple births during the fall of each year. The information in Table XXIII reveals that the crossbred ewes gave birth to 292 more twins and 21 more triplets than the Western ewes. Figure 25 shows the percent of the ewes from both breed groups that lambed and produced multiple births during the fall of each year. This figure

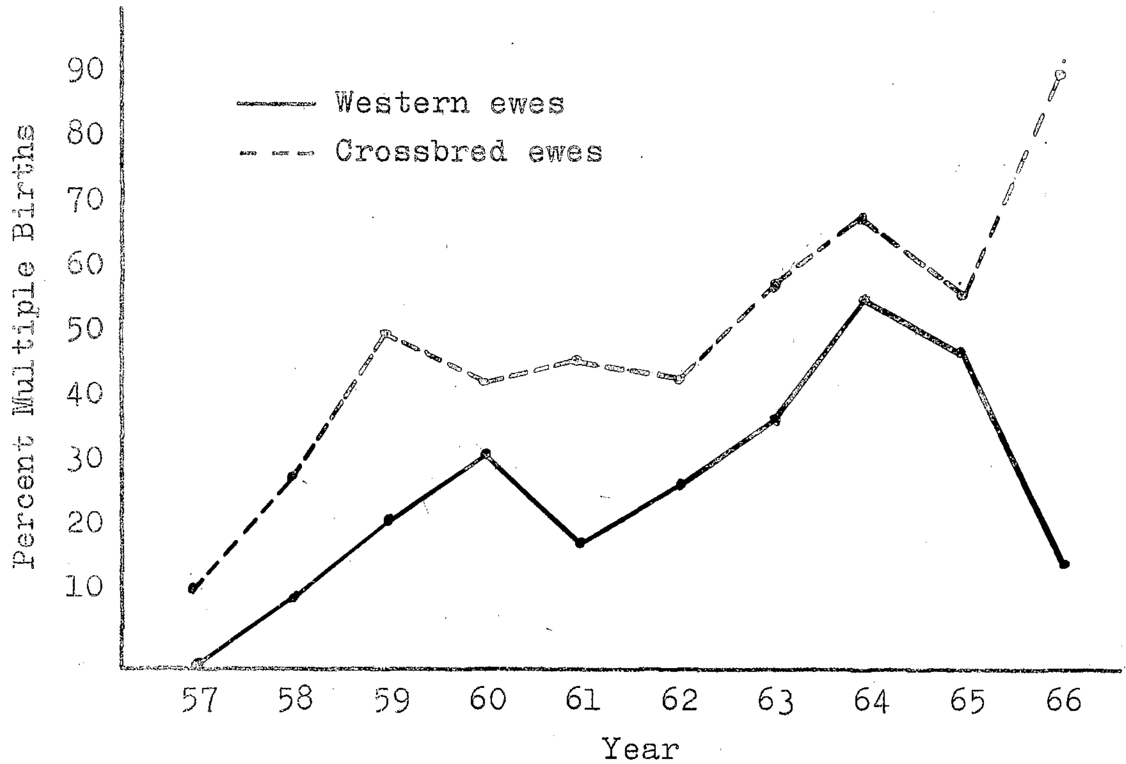

Figure 25. Percent of the Western and Crossbred Ewes that Lambed and Produced Multiple Births during the Fall of each Year

illustrates that a higher percentage of the crossbred ewes consistently produced twins and triplets than did the Western ewes. The percent of Western ewes that produced multiple births ranged from a low of zero during 1957 to a high of 57.3 percent during 1964; whereas, the crossbred ewes ranged from a low of 10 percent in 1957 to a high of 86.1 percent in 1966. These results tend to support the conclusion that the lambing rate advantage for the crossbred ewes was due to their ability to produce more lambs per ewe lambing.

Other workers have also found the lambing performance of various crossbred ewes to be quite good. Gorman *et al.* (1942) reported that Corriedale x Rambouillet, Romney x Rambouillet, Lincoln x Rambouillet and Columbia x Rambouillet ewes produced 121, 112, 109 and 107 lambs, respectively, per 100 ewes in the flock. The percentage lambs born of ewes lambing was 127.3, 138.4 and 128.5 for Navajo, Corriedale x Navajo and Romney x Navajo ewes, respectively, in a study reported by Grandstaff (1948). Fox and McArthur (1962) indicated that, when bred as yearlings, the crossbreds in their study produced 169 percent lambs compared to 125 percent for the purebreds. This advantage for the crossbreds was also evident in a later study by Fox et al. (1964). The results summarized by Shelton et al. (1966) show an advantage in lambing rate for the various purebred ewes over the finewool crossbred ewes (Table I).

Lambs Reared During the Fall

The number of lambs reared per 100 Western and crossbred ewes in the flock during the fall of each year is illustrated in Figure 26. The Western ewes reared a slightly higher number (7) of lambs during 1957 and 1958. However, from 1959 through 1966, the crossbred ewes consistently reared a higher number of lambs than did the Western ewes. The slight advantage for the Western ewes during the first two years is probably due to the age advantage that they had over the crossbreds.

The number of lambs reared by the Western ewes was quite variable during the early years (1957-1961) but increased considerably up through 1964. A different pattern is noted

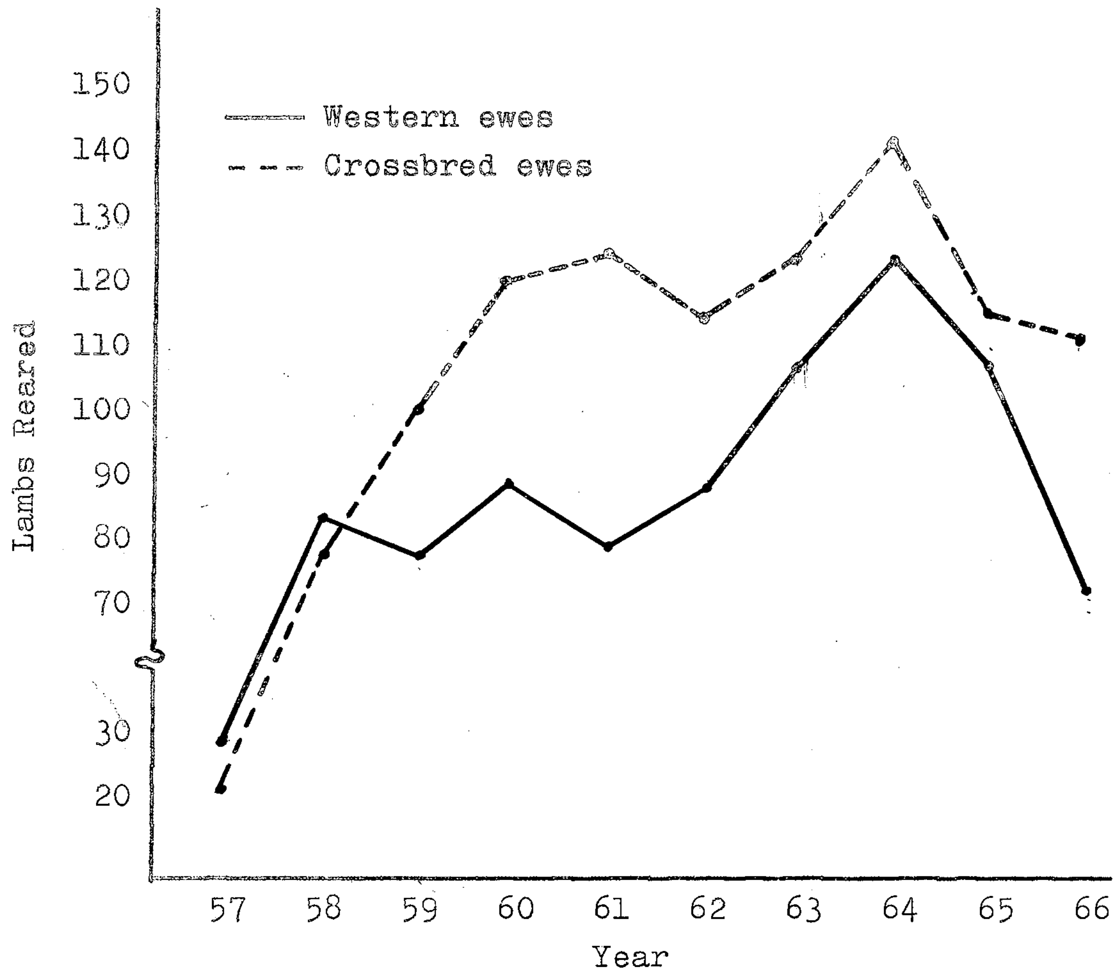

Figure 26. Lambs Reared per 100 Western and Crossbred Ewes in the Flock during the Fall of each Year

for the crossbreds during the early years. The number of lambs reared by these ewes continued to increase through 1964 with a slight decline during 1962. Both breed groups reared the highest number of lambs during 1964, but the number reared by both breed groups declined considerably after 1964. It is interesting to note that the crossbred ewes reared 39.5 more lambs during 1966 than the Western ewes.

Percent Advantage. The information in Table XXI shows that the crossbred ewes, on the average, reared 110.3 lambs per 100 ewes in the flock compared to 87.7 reared by the

Western ewes. This difference of 22.6 lambs in favor of the crossbreds was significant (P<.05) and as would be expected, the percent advantage value of 25.8 suggests a considerable advantage for the crossbred ewes.

No reports were found in the literature where lambs were considered to be reared as they were in this study if alive at two weeks of age. However, some work has been reported where the percentage or number of lambs weaned by various ewes has been compared. Gorman et al. (1942) reported the number of lambs reared per 100 ewes in the flock for four different kinds of crossbred ewes. The results were: Corriedale x Rambouillet, 108; Romney x Rambouillet, 100; Lincoln x Rambouillet, 95; Columbia x Rambouillet, 78. The percentage of lambs weaned of live lambs born in a study reported by Grandstaff (1948) was 99.5 for Navajo ewes, 112.2 for Corriedale x Navajo ewes and 92.4 for Romney x Navajo ewes. Kincaid and Carter (1963) indicated that the number of lambs raised to weaning per ewe bred was highest for a group of selected native ewes (1.02), lowest for a group of commercial native ewes (0.64) and intermediate for a group of ewes produced by the crossing of Hampshire rams on grade range ewes (0.95). In a similar study by Carter et al. (1957), the number of lambs reared to weaning per ewe bred was higher for Suffolk x Rambouillet (1.02), Hampshire x Rambouillet (1.04) and whiteface crossbreds (1.02) than for grade Rambouillet ewes (1.01).

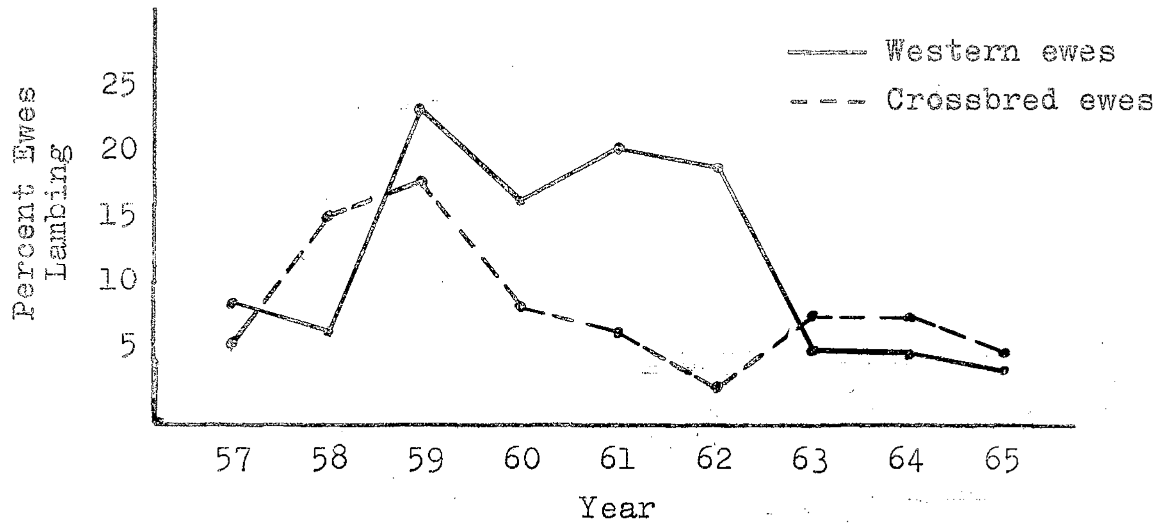

Figure 27. Percent Western and Crossbred Ewes Lambing during the Winter of each Year

Percent Ewes Lambing During the Winter

In a fall-lambing program under Oklahoma conditions, it is desirable to have as many ewes as possible lamb during the fall rather than the winter so maximum utilization can be made of the available wheat pasture and the lambs can be shipped to market before the advent of hot weather. Figure 27 reveals that a higher percentage of the Western ewes lambed during the winters of the more productive years (1959-1962) than did the crossbreds. However, a slightly higher percentage of the crossbred ewes lambed during the winters of 1958, 1963, 1964 and 1965.

The percentage of crossbred ewes lambing during the winter increased from 1957 through 1959 and declined for the next three years. But, the percentage of crossbred ewes lambing during the winter increased by about four percent during 1963 over that for 1962 and failed to decline again by any appreciable amount. A more variable response is noted for the Western ewes.

Percent Advantage. The mean values presented in Table XXII indicate that, on the average, 12.6 percent of the Western ewes lambed during the winter compared to 8.3 percent for the crossbred ewes. The difference of 4.3 percent in favor of the Western ewes was nonsignificant and the percent advantage value of -34.1 was assumed to be estimating zero. It is well to point out that only a small number of ewes from both breed groups lambed during the winter (105 Western and 68 crossbred ewes) compared to the number lambing during the fall (680 Western and 742 crossbred ewes).

Lambing Rate During the Winter

Figure 28 reflects considerable variation in the lambing rate of both breed groups during the winter seasons. The winter-lambing rate of the Western ewes increased almost steadily from 1957 through 1962, declined during 1963 and increased thereafter. The lambing rate for the crossbred ewes was of a more variable nature than that of the Western ewes.

Percent Advantage. The mean winter-lambing rate (Table XXII) was 1.44 and 1.41 for the Western and crossbred ewes, respectively. The difference of 0.03 lambs per ewe lambing in favor of the Western ewes was nonsignificant and the percent advantage value of -2.1 was assumed to be estimating zero. It is well to emphasize that 37 fewer crossbred ewes

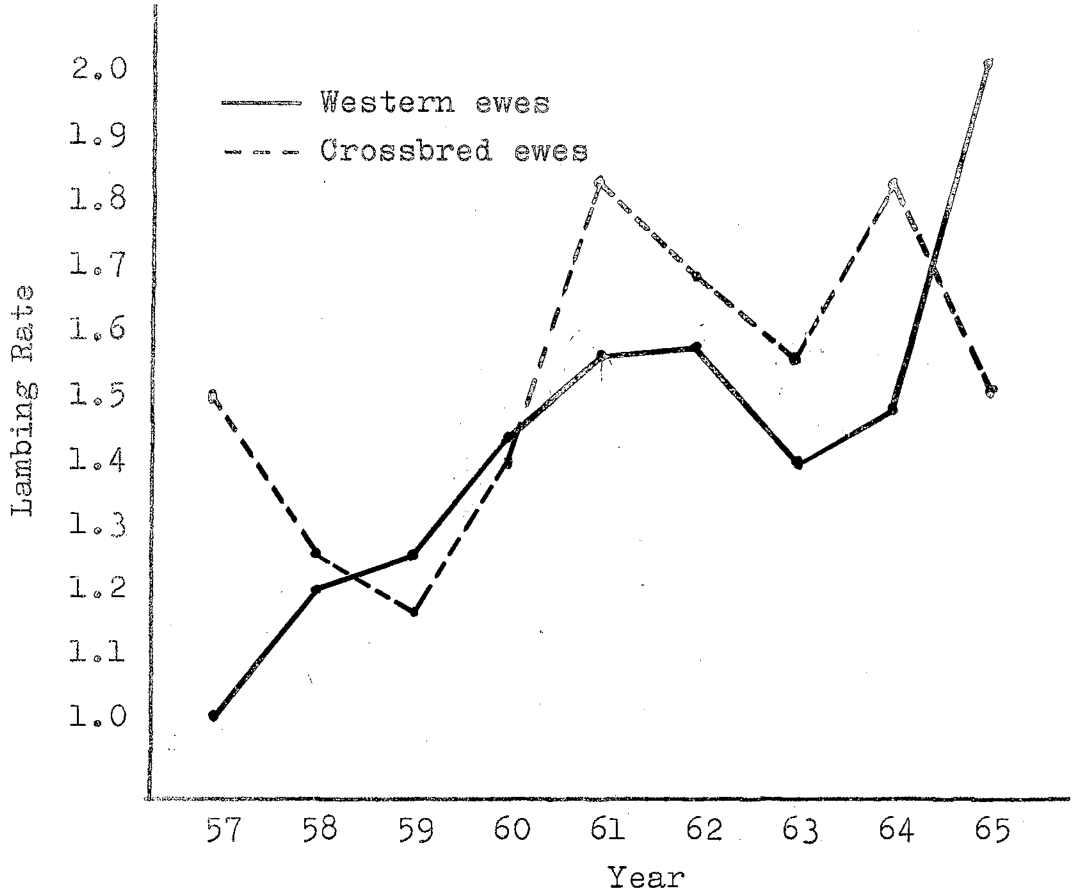

Figure 28. Lambing Rate for the Western and Crossbred Ewes during the Winter of each Year

lambed during the winter (Table XXII) than did the Western ewes; however, the lambing rates were similar for both breed groups. Of the crossbred ewes that lambed during the winter, a higher percentage of these ewes produced multiple births during six of the nine years in which winter-lambing was permitted than did the Western ewes (Figure 29).

Lambs Reared During the Winter

The number of lambs reared per 100 Western and crossbred ewes in the flock during the winter of each year is illustrated in Figure 30. The Western ewes reared a higher number of lambs during five of the nine years.

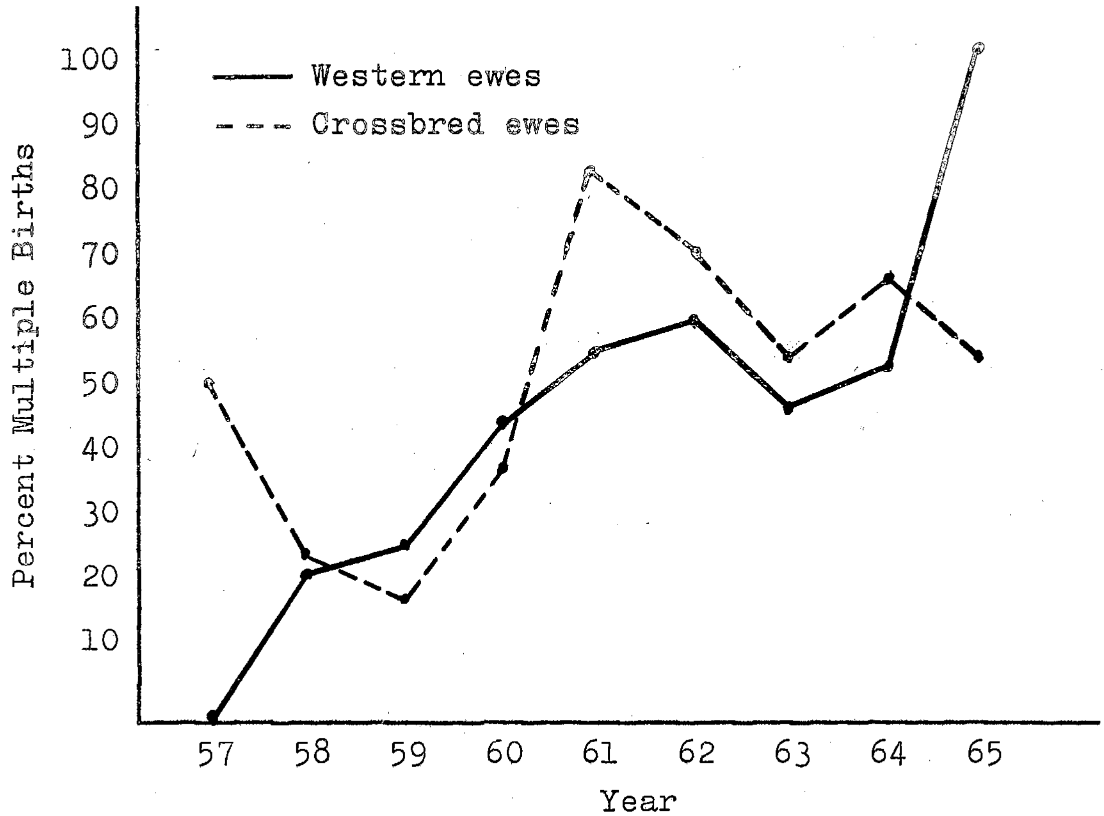

Figure 29. Percent of the Western and Crossbred Ewes that Lambed and Produced Multiple Births during the Winter of each Year

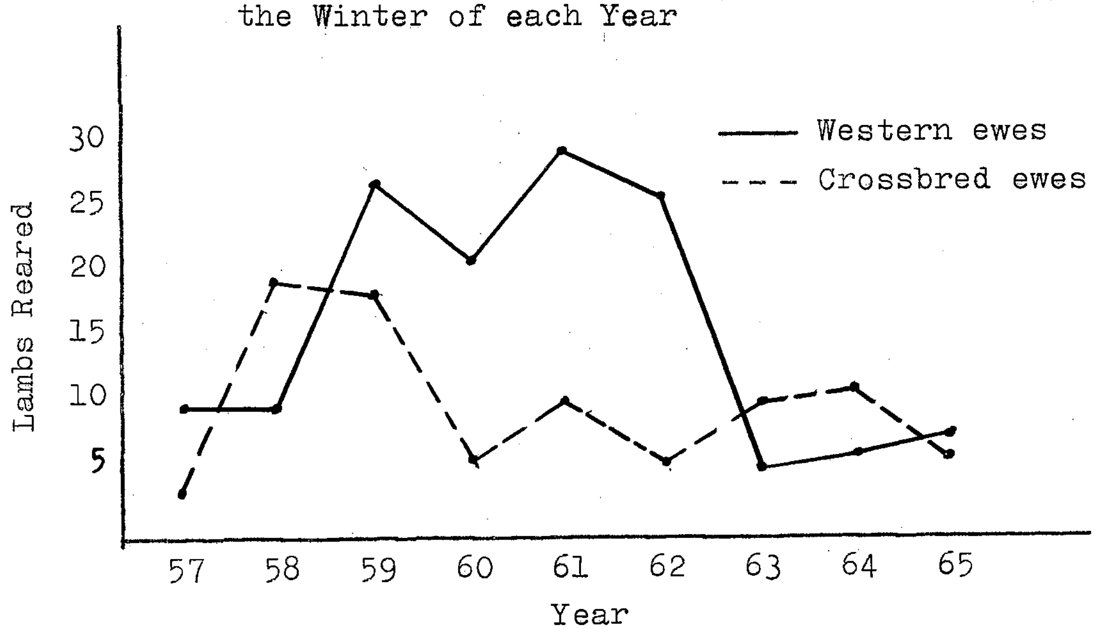

Figure 30. Lambs Reared per 100 Western and Crossbred Ewes in the Flock during the Winter of each Year

Percent Advantage. The mean values presented in Table XXII indicate that, on the average, the Western ewes reared 6.7 more lambs during the winter than the crossbred ewes. This difference was nonsignificant and the percent advantage value of -40.4 was assumed to be estimating zero.

Conclusions
(Ewe Reproduction Data)

In a fall-lambing program it is desirable to have as many ewes as possible lamb during the fall rather than the winter. A higher percentage (7.7 %, P<.05) of the crossbred ewes lambed during the fall than did the Western ewes. This greater percentage of the crossbred ewes lambing each fall resulted in a percent advantage value of 10.3. During the fall of the first two years of this study, a higher percentage of the Western ewes lambed, but this advantage for the Western ewes was no longer evident after the third year of production. This early performance can probably be attributed to the age advantage that the Western ewes had over the crossbreds. The winter-lambing results reveal that 4.3 percent more of the Western ewes lambed during the winter than did the crossbred ewes, but this difference in favor of the Western ewes was nonsignificant and the percent advantage value of -34.1 was assumed to be estimating zero.

On the average, the crossbreds gave birth to 0.19 more lambs per ewe lambing than did the Western ewes during the fall of each year. This difference in favor of the crossbred ewes was significant (P<.001) and resulted in the percent advantage value of 13.2. During the winter, 4.3 percent fewer crossbred ewes lambed than did the Western ewes, but the lambing rate was similar for both breed groups (1.44 and 1.41 for the Western and crossbred ewes, respectively; non-significant). This high lambing rate for the crossbred ewes during the fall and winter was due to a greater number of multiple births.

During the fall of the first two years of this study, the Western ewes reared a slightly higher number (7) of lambs per 100 ewes than did the crossbred ewes. This can also be attributed to the age advantage that the Western ewes had over the crossbreds. However, from an overall standpoint, the crossbreds not only produced more lambs during the fall but they also reared a greater number (22.6, $P<.05$) of lambs than did the Western ewes. Since the crossbred ewes reared such a higher number of lambs, the percent advantage value of 25.8 seems entirely reasonable. Random variation appeared to be the most logical explanation for the number of lambs reared during the winter of each year.

LAMBING DATE DATA

Fall-Lambing Date

The analysis of variance of fall-lambing date is presented in Table XXV for the Western and crossbred ewes. Year and age of dam were significant sources of variation for both breed groups; however, type of ewe parturition was significant ($P<.05$) only for the crossbred ewes. The model

TABLE XXV

ANALYSIS OF VARIANCE OF FALL-LAMBING DATE

Source	Western ewes d.f.	Western ewes M.S.	Crossbred ewes d.f.	Crossbred ewes M.S.
Total	675		730	
Year	9	2411.731**	9	2194.767**
Age of dam	9	165.125*	9	286.781**
Type of ewe parturition	1	45.656	1	438.541*
Error	656	74.404	711	72.012
	$R^2 = 32\%$		$R^2 = 31\%$	

*P<.05 **P<.01

utilized to describe the data accounted for 32 and 31 percent of the variation in fall-lambing date for the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XXVI and the means for each year are illustrated in Figure 31. This figure illustrates a more or less random pattern across all years; however, a certain degree of similarity is noted for both breed groups, i.e., if the Western ewes tended to lamb earlier or later each year, so did the crossbred ewes. An advantage, greater in some years than in others, is noted for the crossbreds over the Western ewes.

The Western ewes lambed the latest during 1957 and the average lambing date decreased through 1959 and gradually became later until 1963 when the ewes lambed the earliest during the 10 year period. From 1963 on through 1966, the average lambing date tended to become later each year. As was mentioned previously, the crossbreds followed a pattern

TABLE XXVI

LEAST SQUARES CONSTANTS FOR FALL-LAMBING DATE

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	676	306.046	0.6267	731	303.471	0.5392
Year:						
57	11	6.231	3.0031	10	3.355	3.1898
58	64	1.250	1.8238	50	-1.918	1.7715
59	78	-0.588	1.5479	85	1.026	1.4276
60	87	3.136	1.3472	101	3.923	1.2611
61	79	2.329	1.2812	100	4.445	1.1773
62	85	4.695	1.2555	95	5.030	1.1851
63	95	-8.422	1.3438	86	-7.937	1.2930
64	73	-5.902	1.5889	73	-4.608	1.5035
65	60	-5.059	1.8986	68	-3.781	1.7726
66	44	2.330	2.3712	63	0.465	1.9634
Age of dam:						
1	61	6.143	2.1738	35	9.327	2.3037
2	89	1.341	1.8165	104	2.804	1.6414
3	87	0.793	1.5836	105	-0.146	1.4378
4	90	-0.680	1.3842	99	-2.672	1.2858
5	86	-3.197	1.2915	93	-4.009	1.2026
6	85	-1.446	1.2905	86	-1.861	1.2170
7	79	-0.767	1.3867	81	1.862	1.3274
8	63	-2.234	1.6592	73	-1.400	1.5508
9	26	1.369	2.2313	41	1.372	1.9155
10	10	-1.322	3.2144	14	-1.553	2.7472
Type of ewe parturition:						
One lamb born	485	0.308	0.3928	394	0.808	0.3275
Two lambs born	191	-0.308	0.3928	337	-0.808	0.3275

similar to that of the Western ewes. They lambed late during 1957, but the average lambing date was about five days earlier during 1958. Beyond this point, the average yearly fall-lambing date became later and the crossbred ewes lambed the latest during 1962. However, the following year they lambed the earliest, and on through 1966 the average lambing date became slightly later each year. It should be emphasized that the average fall-lambing date for both breed groups would be expected to be later during 1957 because the

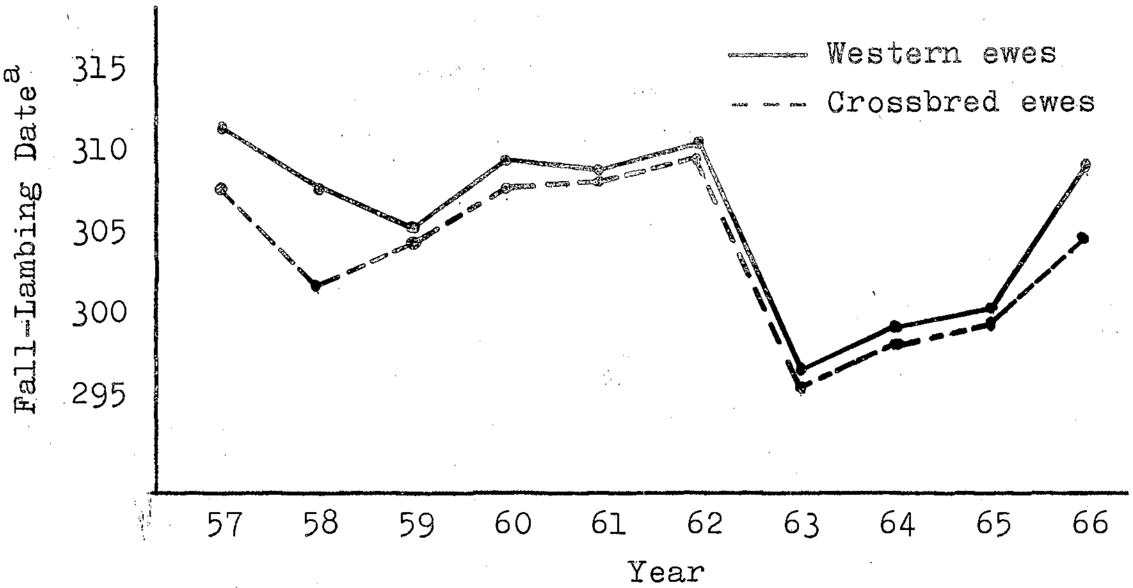

Figure 31. The Effect of Year on Fall-Lambing Date of the Western and Crossbred Ewes. [a]295 = Oct. 22; etc.

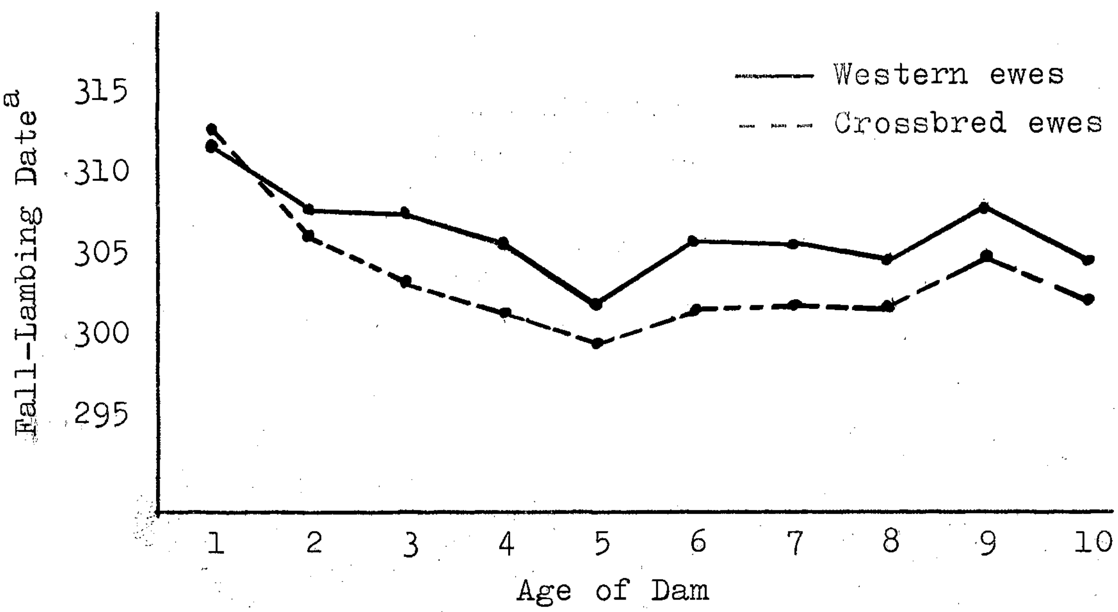

Figure 32. The Effect of Age of Dam on Fall-Lambing Date of the Western and Crossbred Ewes. [a]295 = Oct. 22; etc.

breeding season was not started until the first of June; whereas, the breeding seasons for the remaining years were started about 10 days earlier (Table V).

Age of Dam. The least squares means for each age of dam are plotted in Figure 32. Except for the one-year-old ewes, the crossbreds consistently lambed earlier than the Western ewes across all age groups.

The younger ewes from both breed groups lambed later than all other age groups. This may partly be a reflection of the previously mentioned fact that the 1957 breeding season was initiated about 10 days later than the other breeding seasons (Table V). As the Western ewes became older, they lambed earlier during the fall and the average lambing date tended to increase slightly as the ewes increased in age past eight years. A similar pattern is evident for the crossbred ewes as they increased in age.

Type of Ewe Parturition. The association of type of ewe parturition with fall-lambing date, although nonsignificant for the Western ewes, is illustrated in Figure 33 for both breed groups. The Western and crossbred ewes that gave birth to singles lambed at about the same time during the fall. However, the crossbred ewes that gave birth to twin lambs did so about three days earlier than the Western ewes that produced twins at birth.

It was anticipated that type of ewe parturition would have a greater influence on the fall-lambing dates of the crossbreds rather than those of the Western ewes since a

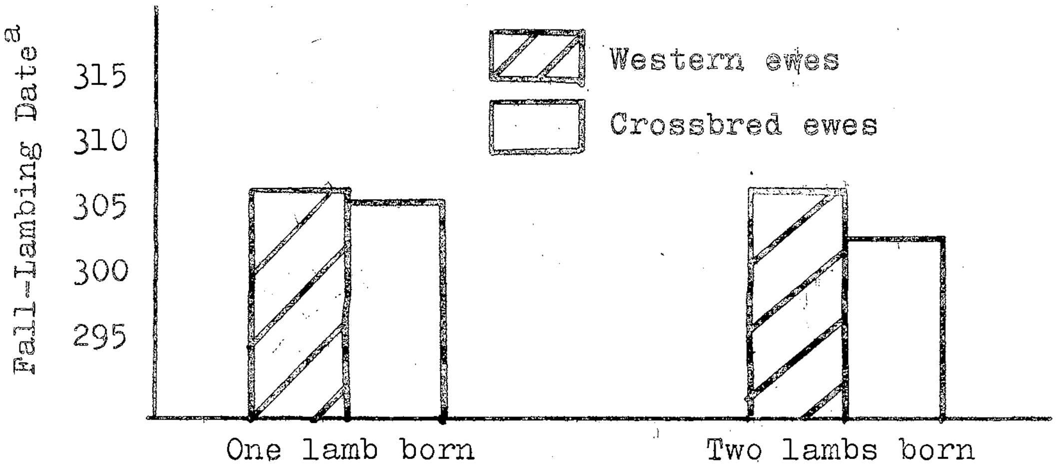

Figure 33. The Association of Type of Ewe Parturition with Fall-Lambing Date of the Western and Crossbred Ewes. [a]295 = Oct. 22; etc.

larger number of the crossbred ewes produced twin lambs during the fall (Table XXIII). Figure 33 tends to support this line of reasoning for the crossbred ewes that gave birth to twins lambed an average of two days earlier than those giving birth to singles; whereas, the Western ewes, whether giving birth to one or two lambs, lambed at about the same time during the fall. No reports on the association of type of ewe parturition with fall-lambing dates were found in the literature.

Percent Advantage. The mean fall-lambing date for the Western ewes was on the 306.046 (Nov. 2) day of the year compared to the 303.471 (Oct. 30) day of the year for the crossbred ewes (Table XXVI). The mean difference of 2.575 days in favor of the crossbred ewes was significant ($P<.01$) and the percent advantage value of -0.84 suggests a slight advantage for the crossbred ewes.

Any attempted explanation of this advantage for the crossbred ewes would be a matter of speculation; however, some discussion appears to be justified. One reason for this advantage may be that the crossbred ewes have over the years consistently bred and conceived earlier during the breeding season than the Western ewes. Consequently, if an equal or similar gestation length is assumed for both breed groups, then the crossbred ewes would be expected to lamb earlier than the Western ewes. As was mentioned before, this type of reasoning may be entirely speculation, but the consistency with which the crossbred ewes have either equalled or excelled the Western ewes with respect to earliness of fall-lambing seems to suggest and support a conclusion of this nature. No information was found in the literature regarding the fall-lambing dates of any ewes.

Winter-Lambing Date

The analysis of variance of winter-lambing date is presented in Table XXVII for the Western and crossbred ewes.

TABLE XXVII

ANALYSIS OF VARIANCE OF WINTER-LAMBING DATE

Source	Western ewes		Crossbred ewes	
	d.f.	M.S.	d.f.	M.S.
Total	103		64	
Year	8	528.095**	8	264.756**
Age of dam	7	51.612	7	25.349
Type of ewe parturition	1	15.640	1	42.950
Error	87	58.487	48	78.489
	R^2 = 48%		R^2 = 38%	

**P<.01

It is suggested that extreme caution should be utilized when inferences are drawn from the winter-lambing data due to the limited number of observations for each breed group. Year was the only significant ($P<.01$) source of variation influencing the winter-lambing dates of both breed groups. The model utilized to describe the data accounted for 48 and 38 percent of the variation in winter-lambing dates for the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XXVIII and the means for each year are plotted in Fig-

TABLE XXVIII

LEAST SQUARES CONSTANTS FOR WINTER-LAMBING DATE

	Western ewes			Crossbred ewes		
Effect	No.	Constant	S.E.	No.	Constant	S.E.
μ	104	391.630	1.1755	65	389.420	2.6361
Year:						
57	3	-19.738	5.1853	2	-17.280	9.4727
58	5	-9.552	4.2264	12	-11.040	6.9451
59	27	6.121	3.1240	20	-1.112	7.6498
60	18	9.558	2.9531	8	2.277	5.9218
61	20	7.515	2.8523	6	0.530	6.3441
62	19	10.759	3.0234	3	12.444	6.1989
63	5	-3.208	5.1254	6	-1.420	9.0149
64	4	1.189	5.2744	5	6.759	9.5312
65	3	-2.644	6.2962	3	8.842	10.3590
Age of dam:						
1	21	-1.781	3.5890	29	5.859	9.5966
2	17	-4.165	3.1258	9	1.029	8.0698
3	19	0.597	2.6687	6	3.858	7.3608
4	13	-1.235	2.7059	6	1.636	6.4109
5	15	-1.201	2.5958	1	-5.047	10.4540
6	9	-5.042	3.1942	5	0.182	6.4686
7	7	5.883	5.3762	5	-3.297	8.0550
8	3	6.944	6.3273	4	-4.220	9.1308
Type of ewe parturition:						
One lamb born	60	-0.445	0.8611	41	1.046	1.4142
Two lambs born	44	0.445	0.8611	24	-1.046	1.4142

ure 34. Ewes from both breed groups lambed the earliest during the 1957 winter season. This response was to be expected since the overall breeding performance was rather poor during the 1957 spring breeding season and a large number of the ewes did not breed or did not conceive if they mated. If for any reason the ewes did not conceive during the spring breeding period, they were allowed to mate during the August "cleanup" breeding period. It would appear that a few of the ewes from both breed groups mated and conceived early during the 1957 "cleanup" period and consequently they lambed early during the 1957 winter-lambing period. These results are also probably due to the fact that the "cleanup" breeding began about 20 days earlier during 1957 (Table V).

From 1957 on through 1962, the average winter-lambing date tended to be later each year for both breed groups with the crossbreds showing an advantage over the Western ewes for earliness of winter-lambing. Both groups lambed about the same time during 1963 and beyond this point the Western ewes lambed earlier than the crossbreds.

Age of Dam. Figure 35 illustrates a similar pattern for both breed groups through four years of age with the Western ewes lambing slightly earlier than the crossbreds. Beyond this point, random variation appears to be the most logical explanation for the observed pattern. Table XXVIII reveals that the number of observations for the aged ewes was rather small and this is probably responsible for the extreme variation noted as the ewes increased in age.

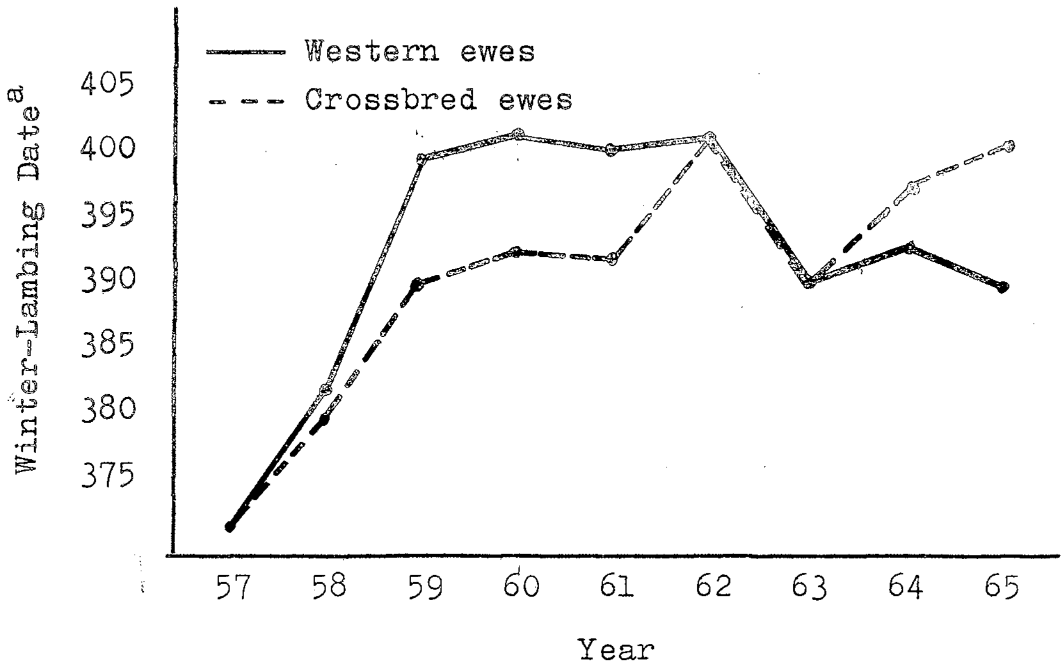

Figure 34. The Effect of Year on Winter-Lambing Date of the Western and Crossbred Ewes. [a]375 = Jan. 10; etc.

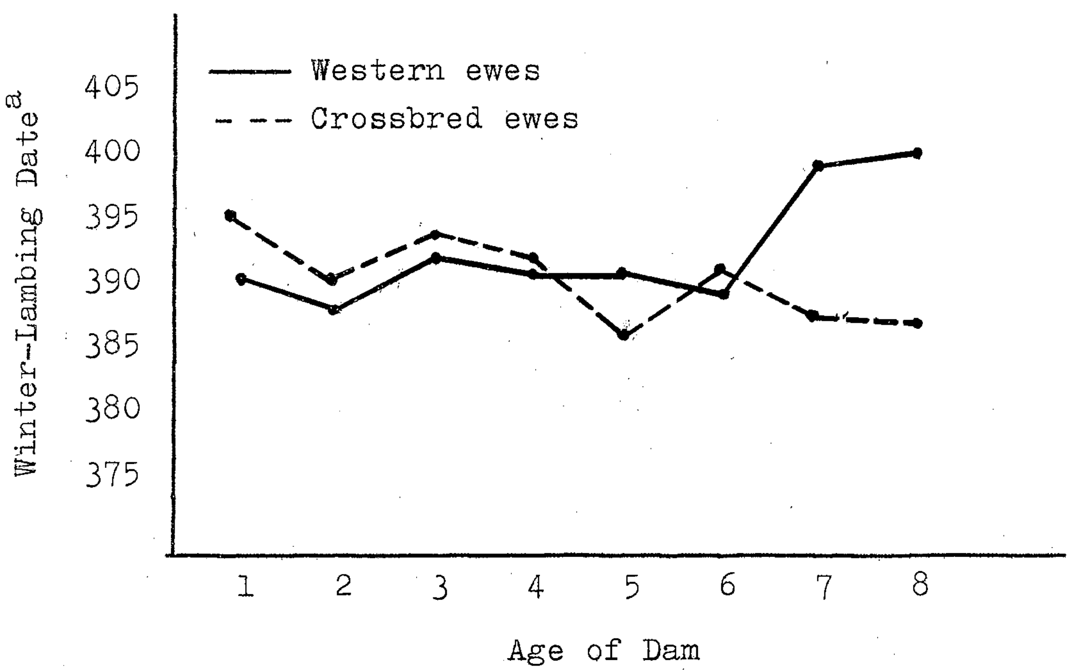

Figure 35. The Effect of Age of Dam on Winter-Lambing Date of the Western and Crossbred Ewes. [a]375 = Jan. 10; etc.

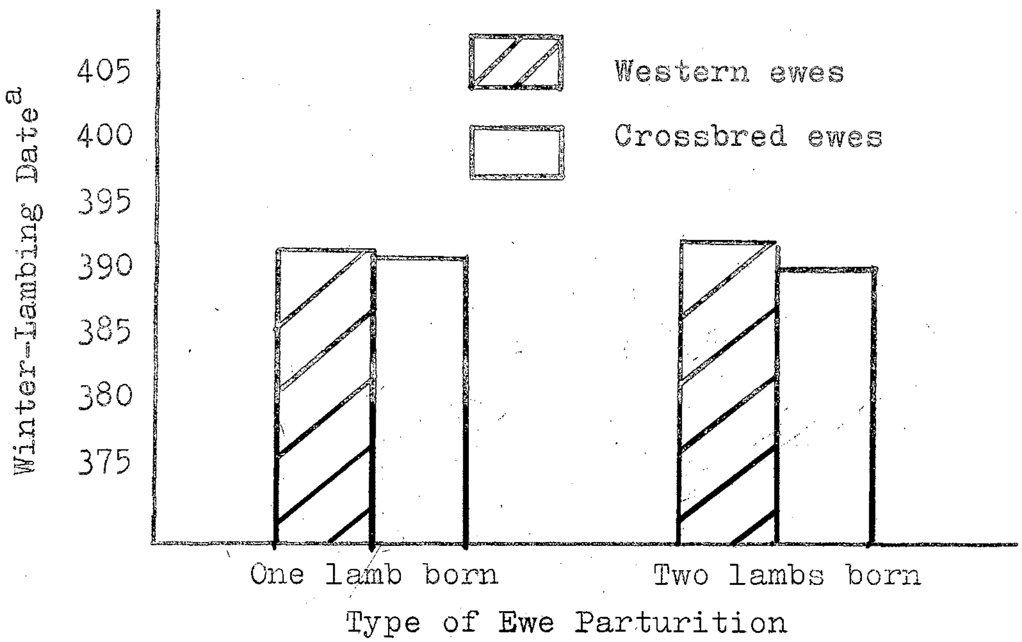

Figure 36. The Association of Type of Ewe Parturition with Winter-Lambing Date of the Western and Crossbred Ewes. [a]375 = Jan. 10; etc.

Type of Ewe Parturition. The association of type of ewe parturition with winter-lambing date is illustrated in Figure 36, and these results are similar to those observed for the fall-lambing dates. The Western and crossbred ewes that gave birth to singles lambed at about the same time during the winter, but the crossbred ewes that gave birth to twins lambed about three days prior to the Western ewes that gave birth to twins. The Western ewes that produced one lamb lambed about 0.89 days earlier than those that produced twins. However, the crossbred ewes that gave birth to twins lambed about two days earlier than those giving birth to singles.

Percent Advantage. The mean winter-lambing date for the Western ewes was on January 26 (391.630) compared to January 24 (389.420) for the crossbred ewes (Table XXVIII).

The mean difference of 2.21 days in favor of the crossbred ewes was nonsignificant and the percent advantage value of -0.56 was assumed to be estimating zero.

A few workers have compared the average fall-breeding and spring-lambing dates for various crossbred and parental ewes. Miller (1935) stated the average breeding date for Rambouillet ewes was August 1 compared to August 21 for a group of Romney x Rambouillet ewes. Suffolk x Rambouillet ewes had the earliest average lambing date (Feb. 1) followed by Hampshire x Rambouillet and Rambouillet (each averaging Feb. 3) in a study reported by Carter et al. (1957). Fox and McArthur (1962) indicated the average lambing date for the purebred ewes in their study, when bred as lambs, was March 1 compared to February 13 for the crossbred ewes. When bred as yearlings, the average lambing date was January 21 for the purebreds compared to January 23 for the crossbred ewes. In a similar study, Fox et al. (1964) reported March 1 and March 4 as the average lambing dates for the purebred and crossbred ewes, respectively.

Conclusions
(Lambing Date Data)

The crossbred ewes consistently lambed as early and in most cases earlier than the Western ewes during the fall of each year. The overall means reveal that, on the average, the crossbred ewes lambed three days earlier ($P<.01$) than the Western ewes during the fall. This earlier lambing by the crossbred ewes resulted in a percent advantage value of

-0.84.

Any conclusions regarding the winter-lambing date data should be made with caution, since each breed group was represented by a small number of observations. As was evident for the fall-lambing dates, the crossbred ewes lambed about two days earlier than the Western ewes during the winter. This difference in favor of the crossbred ewes was non-significant and the percent advantage value of -0.56 was assumed to be estimating zero.

Year of lambing and age of dam were significant sources of variation influencing the fall-lambing dates of both breed groups. Type of ewe parturition was significant ($P<.05$) only for the crossbred ewes. In general the younger and older ewes lambed later than did the middle-aged ewes of both breed groups. The crossbred ewes that gave birth to twins lambed earlier than those that gave birth to singles; whereas, the Western ewes that gave birth to one lamb did so about the same time as those that gave birth to twins. Year of lambing was the only significant source of variation that influenced the winter-lambing dates of both breed groups.

WOOL DATA

Grease Fleece Weight

The analysis of variance of grease fleece weight is presented in Table XXIX for the Western and crossbred ewes. Year ($P<.01$) and age of dam ($P<.05$) were significant sources of variation influencing the grease fleece weights for both

TABLE XXIX

ANALYSIS OF VARIANCE OF GREASE FLEECE WEIGHT

Source	Western ewes d.f.	Western ewes M.S.	Crossbred ewes d.f.	Crossbred ewes M.S.
Total	805		779	
Covariables:				
Ewe weight	1	126.739**	1	261.934**
Ewe weight squared	1	11.268	1	3.148
Ewe score	1	0.007	1	2.640
Ewe score squared	1	0.810	1	0.038
Main effects:				
Year	8	80.989**	8	32.418**
Age of dam	8	7.837*	8	5.305*
No. of lambs born and reared	5	24.073**	5	3.481
Error	780	3.411	754	2.359
	R^2 = 27%		R^2 = 25%	

*P<.05 **P<.01

breed groups. The number of lambs born and reared was significant (P<.01) for the Western ewes but nonsignificant for the crossbreds. The model utilized to describe the data accounted for 27 and 25 percent of the variation in grease fleece weight for the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XXX and the means for each year are plotted in Figure 37. This figure illustrates virtually no comparison between the two ewe breed groups with respect to their grease fleece weights. The Western ewes were superior across all years. These results were to be expected since the Western ewes are noted for their ability to shear heavy fleeces. The general

TABLE XXX

LEAST SQUARES CONSTANTS FOR GREASE FLEECE WEIGHT

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	806	10.824	0.1590	780	8.705	0.1232
Ewe weight		0.029	0.0504		0.083	0.0397
Ewe weight squared		0.0001	0.0005		-0.0002	0.0000
Ewe score		0.403	0.3302		0.401	0.3990
Ewe score squared		-0.055	0.0295		-0.034	0.0309
Year:						
57	39	1.287	0.4572	39	0.031	0.3884
58	78	-0.124	0.3338	79	-0.030	0.2878
59	116	-0.727	0.2680	113	-0.391	0.2380
60	113	-1.368	0.2345	110	-1.057	0.2045
61	110	0.092	0.2274	103	0.070	0.1939
62	108	-1.202	0.2404	100	-0.339	0.2024
63	97	0.088	0.2809	87	0.095	0.2392
64	73	1.687	0.3433	76	1.492	0.3010
65	72	0.267	0.4212	73	0.129	0.4183
Age of dam:						
1	117	1.003	0.4046	116	1.089	0.3427
2	114	0.756	0.3238	113	1.005	0.2692
3	113	0.578	0.2763	110	0.497	0.2357
4	112	0.122	0.2456	104	-0.059	0.2118
5	106	-0.193	0.2381	95	-0.209	0.2014
6	96	-0.732	0.2531	92	-0.484	0.2105
7	85	-0.725	0.2868	82	-0.590	0.2455
8	47	-1.045	0.3833	47	-0.678	0.3197
9	16	0.236	0.5473	21	-0.571	0.4534
No. of lambs born and reared:[a]						
0,0	95	0.591	0.2247	74	0.089	0.2190
1,0	38	0.999	0.2819	40	-0.386	0.2246
1,1	457	0.375	0.1576	357	0.241	0.1239
2,0	10	-1.085	0.5041	13	-0.349	0.3646
2,1	24	-0.499	0.3402	32	0.210	0.2475
2,2	182	-0.381	0.1811	264	0.195	0.1387

[a]0,0 = No lambs born, none reared; etc.

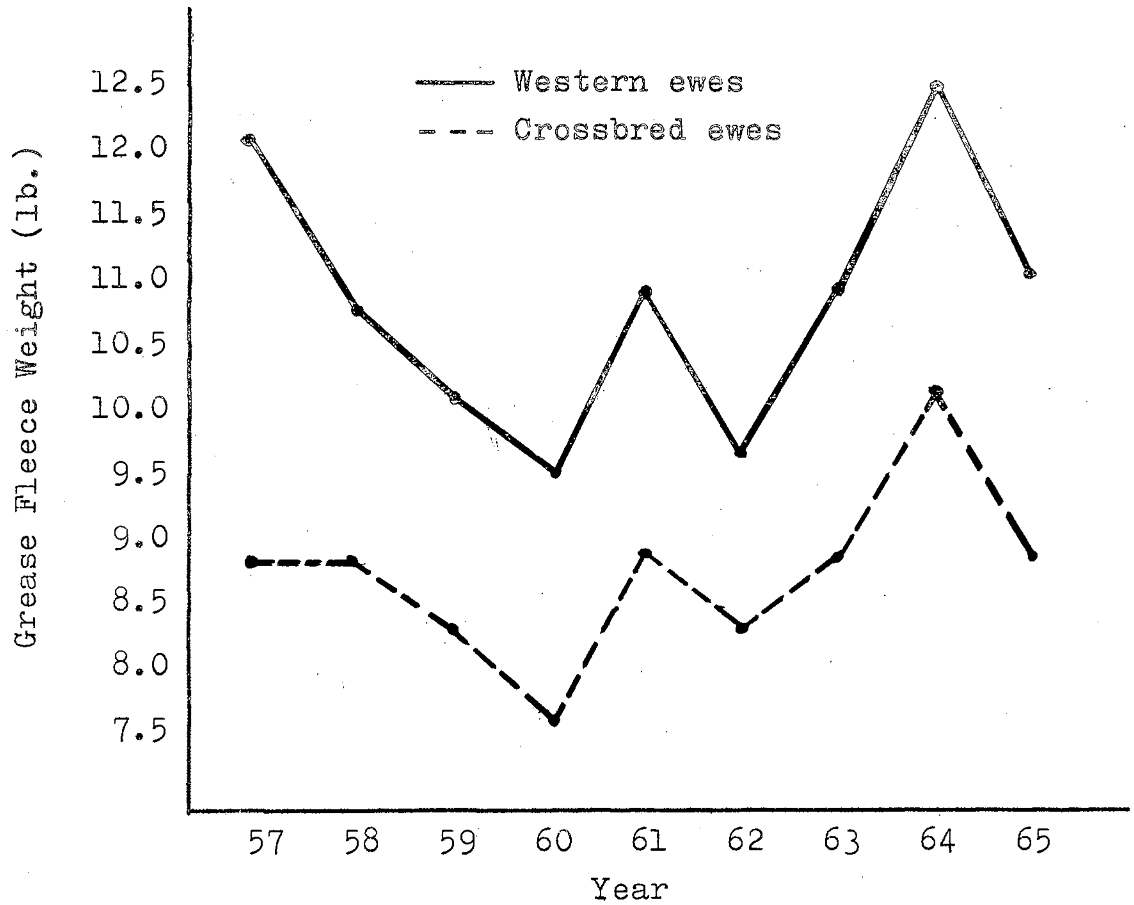

Figure 37. The Effect of Year on Grease Fleece Weight of the Western and Crossbred Ewes

pattern across all years was very similar for both breed groups although the yearly means were widely different in most cases.

The greatest difference between the two breed groups appears to be during 1957. This is probably due to the fact that some of the Western ewes had been shorn in the spring prior to their purchase and they were not reshorn before being placed in the breeding flock as were the raised crossbred ewes. Consequently, the 1957 grease fleece weights would represent slightly more than one year's growth for some of the Western ewes. This would also be true to a certain extent for the 1958 and 1959 weights from the Western

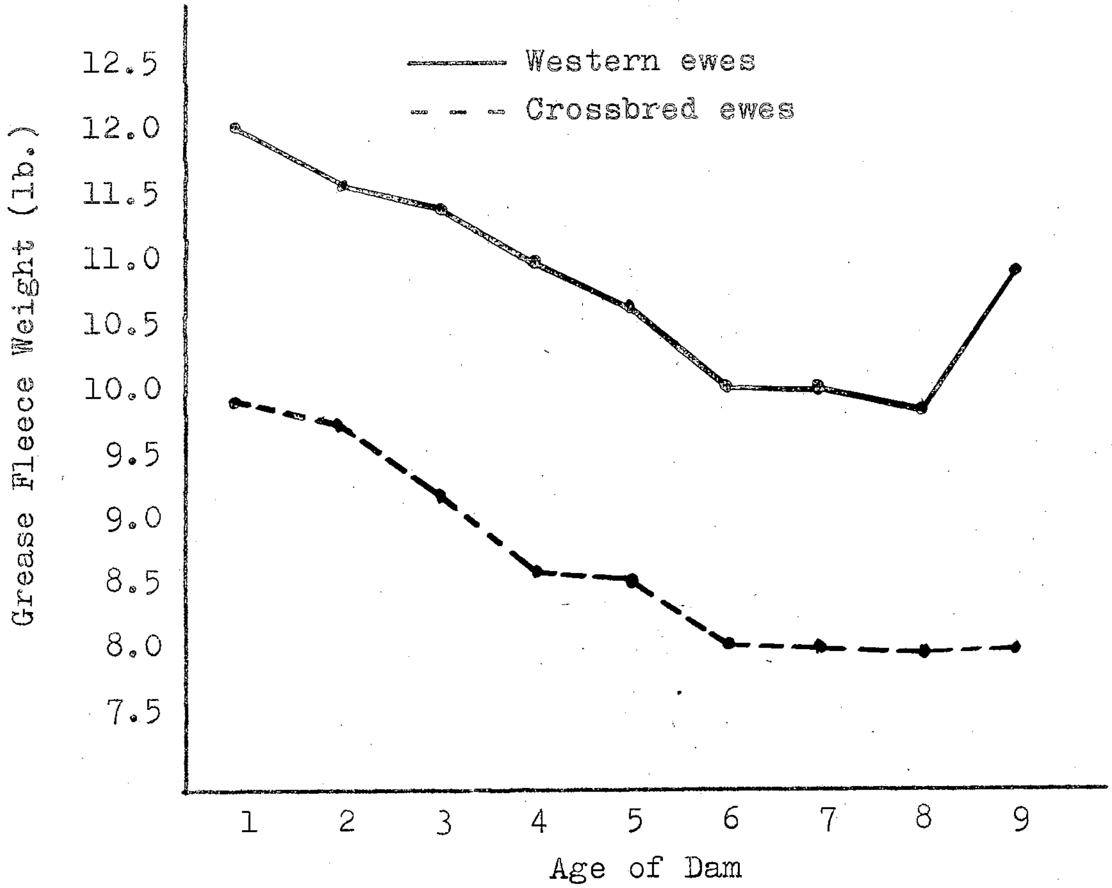

Figure 38. The Effect of Age of Dam on Grease Fleece Weight of the Western and Crossbred Ewes

ewes, but the difference between the two breed groups is less pronounced for these two years. No reports on the influence of years on grease fleece weights were found in the literature.

Age of Dam. The least squares means for each age of dam are plotted in Figure 38. As was previously mentioned, there is virtually no comparison between the two breed groups with respect to grease fleece weight; however, a high degree of similarity is noted as the ewes from both groups increased in age. The youngest ewes from both breed groups produced the heaviest grease fleece weights and the production continued to decline as the ewes increased in age, except for the Western ewes represented by the last age classification. The Western ewes in this particular age group did not produce very many lambs and their wool production would be expected to increase, since the number of lambs born and reared was an important source of variation influencing the grease fleece weights of these ewes.

The results from both breed groups are similar to those reported in the literature by various workers. Rambouillet and Corriedale ewes produced the heaviest fleeces at two years of age in a study reported by Lush and Jones (1923). Bennett _et al_. (1963) indicated age of dam had a pronounced effect upon wool production. Two-year-old ewes produced the heaviest clip of wool and production decreased with each additional year. Four-year-old ewes produced the maximum amount of unscoured wool in a study reported by Jones _et al_. (1944). After the fourth year, there was a slight but consistent decline in fleece weight at each subsequent age year. Gorman _et al_. (1942), in a study representing Columbia, Corriedale, Lincoln and Romney breeds crossed with medium-fine Rambouillet ewes, reported heaviest fleece weights for Columbia-cross 2-year-old ewes (12.39 lb.) followed by Lincoln-cross (12.03 lb.), Corriedale-cross (10.84 lb.) and Romney-cross (10.74 lb.).

Number of Lambs Born and Reared. The influence of number of lambs born and reared on grease fleece weight is illustrated in Figure 39. It is well to mention again that the number of lambs born and reared was a significant ($P<.01$)

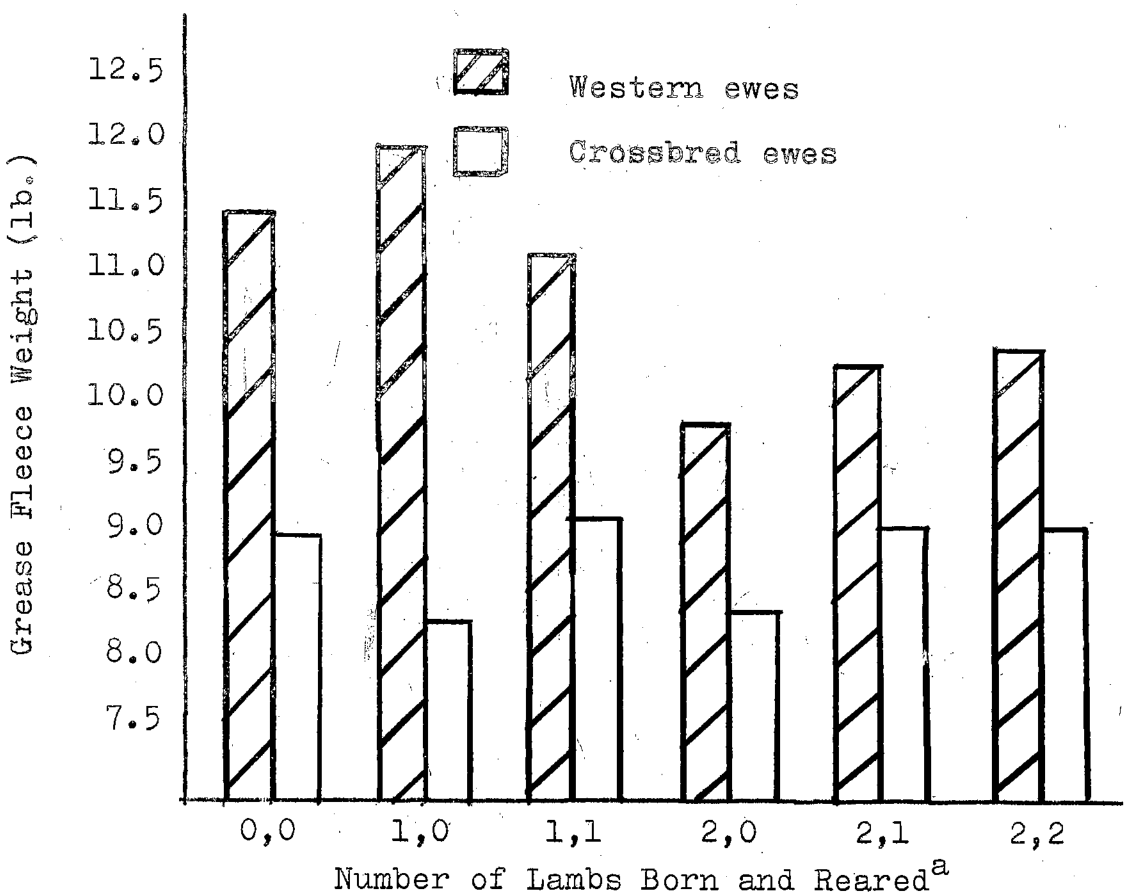

Figure 39. The Effect of Number of Lambs Born and Reared on Grease Fleece Weight of the Western and Crossbred Ewes. [a]0,0 = No lambs born, none reared; etc.

source of variation influencing the grease fleece weights of the Western ewes but was nonsignificant for the Crossbreds. These results are about as one would expect since all ewes were fed after lambing according to the number of lambs reared. As was mentioned in the MATERIALS AND METHODS section, the ewes that reared twins were separated from those that reared one lamb and their average daily feed intake was increased until their lambs were weaned to help compensate for their increased level of productivity. The data presented in the ewe reproduction section revealed that the crossbred ewes consistently reared a greater number of twins than the Western ewes. Consequently, more of the crossbreds received additional feed after lambing than did the Western ewes. It seems reasonable to assume that this increased feed intake would have a tendency to offset some of the adverse effects that the number of lambs born and reared may have on the annual grease fleece production by the crossbred ewes. Since most of the Western ewes that lambed consistently gave birth to single lambs each year (Tables XXIII and XXIV), their feed intake was not increased as for the ewes that produced twins, and for this reason it may be possible that the number of lambs born and reared could have had a greater influence on their annual grease fleece production.

Figure 39 illustrates that regardless of the number of lambs born and reared by either breed group, the grease fleece weights of the Western ewes were consistently heavier than the fleece weights from the crossbred ewes. The grease fleece weights of the Western ewes that failed to lamb or gave birth to one lamb were considerably higher than those that gave birth to twins. The ewes that gave birth to one lamb but failed to rear this lamb produced the heaviest grease fleece weights. The Western ewes that failed to lamb were next in order and these in turn produced fleece weights that were heavier than those that gave birth and reared one lamb. Of the Western ewes that gave birth to twins, those from which both lambs died produced the lightest grease fleece weights. This group of ewes was placed on dry grass pasture immediately after their lambs died and received hay as the only supplemental feed. The Western ewes that gave birth to and reared both twins produced the heaviest fleeces of those giving birth to twin lambs. The average fleece weights for the Western ewes that gave birth to twins but reared only one lamb were intermediate between those that reared both lambs and those from which both lambs died.

An entirely different pattern is noted for the crossbred ewes. Ewes that failed to lamb, those that gave birth and reared one lamb, those that gave birth to two lambs and reared one lamb and those that gave birth and reared twins all had fleece weights that were very similar. The ewes that lost their lambs, regardless of whether one or two lambs were born, had grease fleece weights considerably lower than the ewes that reared their lambs or those that failed to lamb.

Most of the information reported in the literature suggests that wool production declines as lamb production increases. Jones et al. (1935) stated that a group of sterile Rambouillet ewes had a grease fleece weight advantage of 0.41 pounds over a group of fertile Rambouillet ewes. Bell et al. (1936) reported that pregnancy did not influence the rate of growth of wool produced by well-fed Merino sheep. However, these authors stated that lambing and starting of milk flow had a pronounced retarding influence on the rate of growth of wool fiber. Jones et al. (1944) stated that the unscoured fleeces of Rambouillet ewes that dropped lambs during a given year were 0.57 pounds per head less than fleeces produced by ewes that did not lamb during the year. Shelton and Carpenter (1957) indicated that ewes giving birth to and nursing twins produced 0.5 pounds less wool than those with singles. Ray and Sidwell (1964) reported that ewes which gave birth to twins, singles or no lambs produced 6.55, 7.04 and 7.77 pounds of grease wool, respectively. When the records were classified according to type of lactation only, ewes nursing twins, ewes nursing singles and dry ewes produced 6.50, 6.99 and 7.38 pounds of grease wool, respectively.

Some of the differences in reduction of wool growth reported to be due to lactation and pregnancy by the various workers can probably be attributed to differences in plane of nutrition. This would be especially true for the studies that were conducted in the range area.

Covariables. Ewe weight and condition score were considered as covariables in the analysis of the grease fleece data. The influence of ewe weight on grease fleece weight was highly significant ($P<.01$) as a linear effect but the quadratic effect was nonsignificant for both breed groups (Table XXIX). The linear and quadratic effects for ewe condition score were nonsignificant for both breed groups.

Only a limited amount of information was found in the literature regarding the influence of ewe weight and condition on grease fleece weight. Nichols and Whiteman (1966) concluded from their study that fleece weight appears to be associated with ewe weight only as ewe weight is a measure of size, with degree of condition having little influence on fleece weight.

Percent Advantage. The overall mean grease fleece weight was 10.824 pounds for the Western ewes compared to 8.705 pounds for the crossbred ewes (Table XXX). The difference of 2.119 pounds in favor of the Western ewes was highly significant ($P<.001$) and as would be expected, the percent advantage value of -19.58 is quite large and negative.

Several workers have reported variable results regarding the wool production of some breeds of sheep and their crosses. Miller (1935), Hunt (1935), Whitehurst *et al.* (1947), Woehling and Henning (1949), Livesay and Cunningham (1957) and Botkin and Paules (1965) have all indicated that at least one of the parental breeds involved in their studies produced more grease wool than crossbred ewes resulting from the mating of the parental breeds among themselves or to some other breed. Miller (1942) reported that Rambouillet and a group of ewes produced by crossing Hampshire rams on grade range ewes were about equal in wool production. Similarly, Neumann *et al.* (1951) stated that the fleeces from Western, high-grade Hampshires and Suffolk ewes were of about equal value, and from the standpoint of wool production no one type had an advantage over the other. Madsen *et al.* (1965) noted very little difference in grease fleece weight for yearling Rambouillet, Columbia, Targhee and the two-way and three-way-cross ewes of these breeds. A few workers have reported an advantage in wool production for certain crossbred ewes produced by the crossing of various parental breeds. Goode et al. (1952) compared the wool production of Hampshires and Hampshire x Rambouillet ewes and reported the crossbreds sheared heavier fleeces than the Hampshires. Carter et al. (1957) stated that ewes produced by crossing Columbia, Corriedale or Lincoln rams on range ewes sheared heavier fleeces than Rambouillets. Similarly, Navajo crossbred ewes produced more grease wool than Navajo ewes in a study reported by Price et al. (1953).

Clean Fleece Weight

The analysis of variance of clean fleece weight is presented in Table XXXI for the Western and crossbred ewes.

TABLE XXXI

ANALYSIS OF VARIANCE OF CLEAN FLEECE WEIGHT

Source	Western ewes d.f.	Western ewes M.S.	Crossbred ewes d.f.	Crossbred ewes M.S.
Total	805		779	
Covariables:				
Ewe weight	1	64.849**	1	36.297**
Ewe weight squared	1	15.496**	1	19.047**
Ewe score	1	33.547**	1	22.632**
Ewe score squared	1	14.148**	1	0.173
Main effects:				
Year	8	24.757**	8	17.316**
Age of dam	8	1.960**	8	1.075
No. of lambs born and reared	5	3.448**	5	0.924
Error	780	0.641	754	0.656
	R^2 = 42%		R^2 = 32%	

**P<.01

With respect to the main effects, year, age of dam and number of lambs born and reared were all significant ($P<.01$) sources of variation for the Western ewes only. Year was the only significant ($P<.01$) source of variation for the crossbred ewes. The model utilized to describe the clean fleece data accounted for 42 and 32 percent of the variation in clean fleece weight for the Western and crossbred ewes, respectively.

Year. The least squares constants are presented in Table XXXII and the means for each year are plotted in Figure 40. Except for 1957, a similar pattern is noted in clean wool yield for both breed groups across all years. The advantage in clean wool yield for the Western ewes during 1957 is probably a reflection of the previously mentioned fact that some of the Western ewes were not reshorn prior to the 1957 breeding season. From 1958 through 1962, the yield of clean wool from the crossbred ewes was greater than that of the Western ewes. However, from 1963 through 1965, the clean wool yield for the Western ewes was superior to that of the crossbred ewes. From 1960 through 1962, the clean fleece weights were at a minimum for both breed groups being slightly less for the Western than the crossbred ewes. This was at a time when most of the ewes were reaching their maximum level of production from the standpoint of number of lambs born and reared, and this increased productivity could have brought about the observed decline in clean fleece weights during this three-year period. This would probably

TABLE XXXII

LEAST SQUARES CONSTANTS FOR CLEAN FLEECE WEIGHT

Effect	Western ewes			Crossbred ewes		
	No.	Constant	S.E.	No.	Constant	S.E.
μ	806	4.896	0.0689	780	4.779	0.0650
Ewe weight		0.013	0.0219		0.014	0.0209
Ewe weight squared		0.00004	0.0000		0.00002	0.0000
Ewe score		-0.348	0.1432		0.168	0.2103
Ewe score squared		0.034	0.0128		-0.014	0.0163
Year:						
57	39	0.489	0.1982	39	0.055	0.2048
58	78	0.279	0.1448	79	0.711	0.1517
59	116	-0.181	0.1162	113	0.100	0.1255
60	113	-0.670	0.1017	110	-0.266	0.1078
61	110	-0.791	0.0986	103	-0.530	0.1023
62	108	-0.678	0.1043	100	-0.479	0.1067
63	97	-0.070	0.1218	87	-0.202	0.1262
64	73	0.297	9.1489	76	-0.230	0.1587
65	72	1.325	0.1827	73	0.841	0.2206
Age of dam:						
1	117	0.445	0.1754	116	0.165	0.1807
2	114	0.540	0.1404	113	0.410	0.1419
3	113	0.495	0.1198	110	0.272	0.1243
4	112	0.248	0.1065	104	0.111	0.1116
5	106	0.126	0.1033	95	0.028	0.1062
6	96	-0.272	0.1098	92	-0.284	0.1110
7	85	-0.388	0.1244	82	-0.169	0.1294
8	47	-0.780	0.1662	47	-0.177	0.1686
9	16	-0.414	0.2373	21	-0.356	0.2390
No. of lambs born and reared:[a]						
0,0	95	0.247	0.0974	74	0.193	0.1155
1,0	38	0.270	0.1222	40	-0.091	0.1184
1,1	457	-0.006	0.0683	357	0.029	0.0653
2,0	10	-0.018	0.2186	13	-0.270	0.1922
2,1	24	-0.236	0.1475	32	0.189	0.1305
2,2	182	-0.257	0.0785	264	-0.050	0.0732

[a]0,0 = No lambs born, none reared; etc.

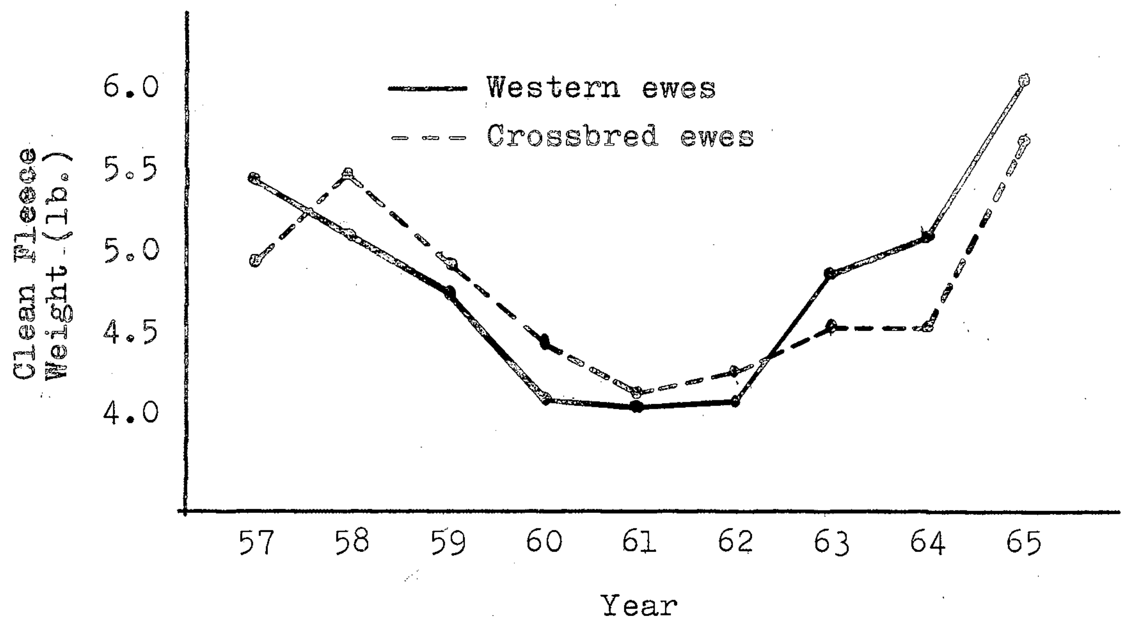

Figure 40. The Effect of Year on Clean Fleece Weight of the Western and Crossbred Ewes

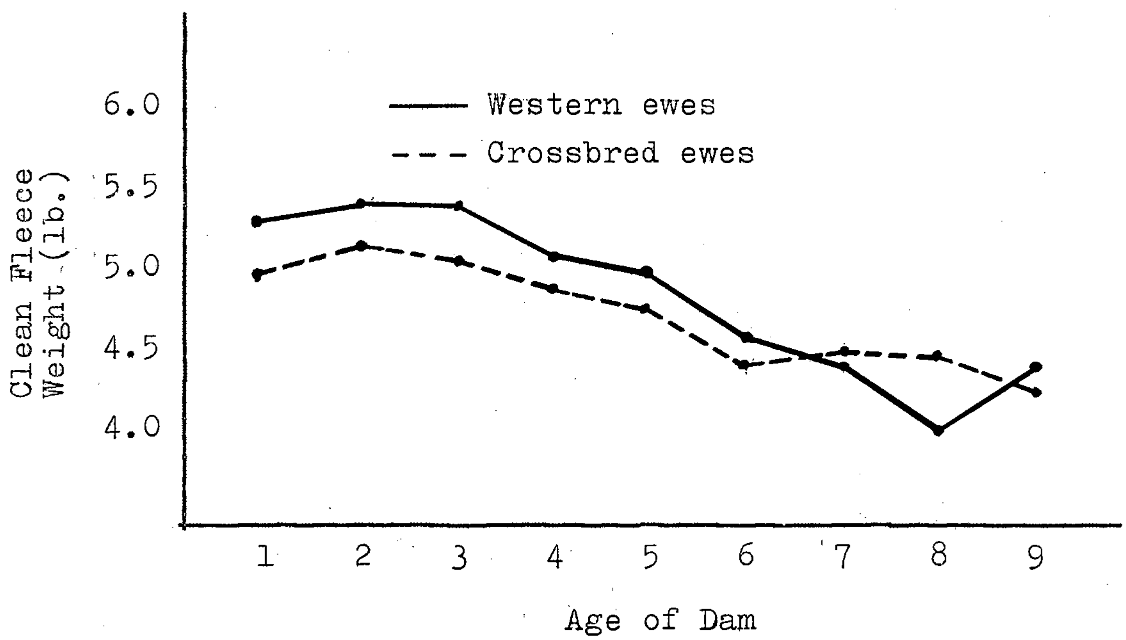

Figure 41. The Effect of Age of Dam on Clean Fleece Weight of the Western and Crossbred Ewes

be more true for the Western than the crossbred ewes.

Age of Dam. The least squares means are plotted in Figure 41 for both breed groups. The clean fleece weights increased slightly as the ewes from both breed groups increased in age from one to two years. Beyond this point, there was an almost continuous decline in clean fleece weights as the ewes increased in age. The Western ewes maintained an advantage over the crossbred ewes across most of the age groups.

Most workers have studied grease rather than clean fleece weights and the literature contains only a limited amount of information on the influence of age of dam on clean fleece weights. Jones et al. (1944) reported maximum production of scoured wool was made by two groups of Rambouillet ewes that were four years of age. After the fourth year, there was a slight but consistent decline in fleece weight on a scoured basis at each subsequent age year.

Number of Lambs Born and Reared. The influence of number of lambs born and reared on clean fleece weight is illustrated in Figure 42. As was mentioned previously, the number of lambs born and reared was a significant ($P<.01$) source of variation influencing the clean fleece weights of the Western ewes but was nonsignificant for the crossbred ewe data. The grease fleece discussion pertaining to how the ewes were fed after lambing according to the number of lambs reared would also apply to the clean fleece data.

The Western ewes that failed to lamb, those that gave

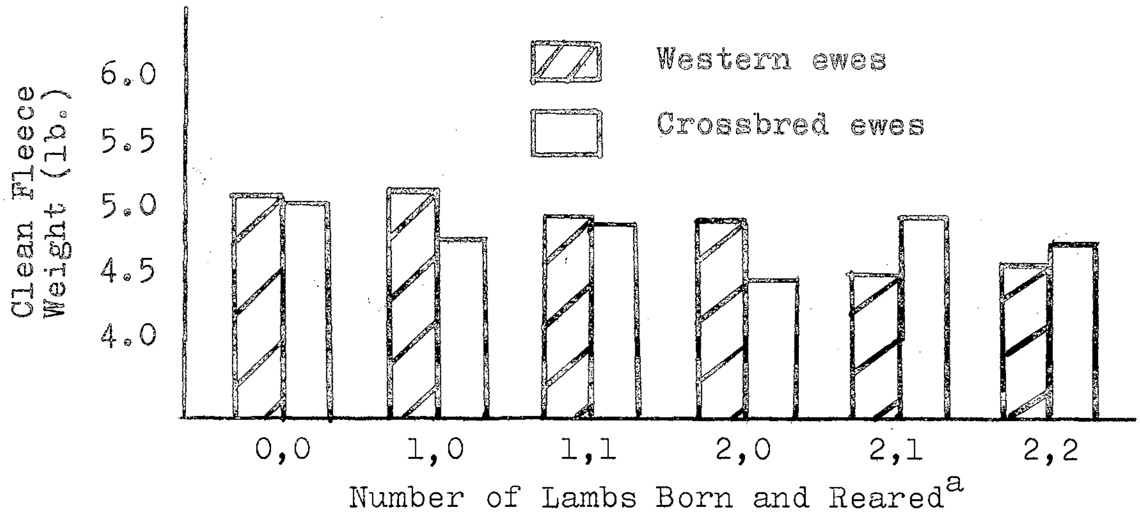

Figure 42. The Effect of Number of Lambs Born and Reared on Clean Fleece Weight of the Western and Crossbred Ewes. [a]0,0 = No lambs born, none reared; etc.

birth to one lamb regardless of whether the lamb was reared and those that gave birth to twins but failed to rear their lambs produced clean fleece weights ranging from one to five tenths of a pound above the respective crossbred ewes. However, the crossbred ewes that gave birth to twins and reared either one or both lambs produced clean fleece weights slightly heavier than the Western ewes that gave birth to twins.

As was mentioned previously, only a limited amount of work has been reported on the factors that influence clean fleece weights. Ray and Sidwell (1964) reported that ewes which gave birth to twins, singles or no lambs produced 3.36, 3.52 and 3.92 pounds of clean wool, respectively. When the records were classified according to type of lactation only, ewes nursing twins, ewes nursing singles and dry ewes produced 3.35, 3.51 and 3.69 pounds of clean wool, respectively. Jones _et al_. (1944) reported that scoured fleeces produced by fertile Rambouillet ewes averaged 0.27 pound per fleece below the production of Rambouillet ewes that failed to lamb.

Covariables. Table XXXI shows that the influence of ewe weights was significant (P<.01) as a linear and quadratic effect for both breed groups. Using the coefficients (Table XXXII) obtained from the data and plotting the relation between clean fleece weight and ewe weight, it was observed that the clean fleece weights of both breed groups tended to increase as ewe weight increased.

Ewe condition score was significant (P<.01) as a linear and quadratic effect for the Western ewes, but only the linear effect was significant (P<.01) for the crossbred ewes. By plotting the relation between clean fleece weight and ewe score, it was observed that the clean fleece weights of the Western ewes declined as ewe score increased from one to three, remained relatively constant for the scores of four, five and six and increased for the remaining scores of seven, eight and nine. A different pattern was noted for the crossbred ewes. The clean fleece weights of these ewes increased as ewe score increased from one to five and remained relatively constant thereafter with a slight decline for the two higher scores.

Percent Advantage. The overall mean clean fleece weight was 4.896 pounds for the Western ewes compared to 4.779 pounds for the crossbreds (Table XXXII). The mean difference of 0.117 pounds in favor of the Western ewes was nonsignificant and the percent advantage value of -2.39 was assumed to be estimating zero.

Several workers have reported that the clean fleece weights are very similar for Rambouillet and various crossbred ewes due to the greater scouring loss of the Rambouillet wool. Miller (1935) reported that on a scoured basis, the wool production of Rambouillet and Romney x Rambouillet ewes was quite similar. Similarly, Miller (1942) indicated that wool from Rambouillet ewes had a greater scouring loss than the wool of ewes produced by the crossing of Hampshire rams on range ewes. Corriedale x Navajo ewes sheared heavier fleeces which yielded more clean wool, although they had a greater shrinkage than fleeces of Romney x Navajo ewes in a study reported by Grandstaff (1948). Madsen _et al_. (1965) noted very little difference in clean fleece weights of Columbia, Rambouillet, Targhee and crossbreds of these three breeds. However, Price _et al_. (1953) reported that the Navajo crossbred ewes in their study produced clean fleece weights superior to that of Navajo ewes. Burns and Johnston (1950) studied the production of fine, medium and coarse-wooled ewes and reported that the coarse-wooled ewes produced the highest amount of clean wool, followed by the medium and then the fine-wooled ewes. Neumann _et al_. (1951) reported fleeces from Western ewes to be heavier in grease than those from Hampshire or Suffolk ewes but lighter when scoured. Cooper and Stoehr (1934) reported there was little difference in grease fleece weight between Columbia and Rambouillet ewes, but the clean fleece weights of Rambouillets averged about one pound lower than the Columbias because of lower yield. Bennett *et al.* (1963) reported Columbia ewes produced 0.30 pounds more clean wool than Rambouillets and 0.27 pounds more than Targhees.

Conclusions
(Wool Data)

There is virtually no comparison between the two breed groups with respect to grease fleece weight. The Western ewes were superior and this was to be expected since these ewes are noted for their ability to shear heavy fleeces. On the average, the Western ewes sheared about two pounds ($P < .001$) more grease wool per year per ewe than did the crossbred ewes. As would be expected, the percent advantage value was quite large and negative (-19.53). Results of the clean fleece data reveal that the two breed groups produced fleece weights that were quite similar. The mean difference of 0.117 pounds in favor of the Western ewes was nonsignificant and the percent advantage value of -2.39 was assumed to be estimating zero.

Year and age of dam were significant sources of variation influencing the grease and clean fleece weights of the Western ewes. Year was a significant source of variation influencing the grease and clean fleece weights of the crossbred ewes, but age of dam was significant only for the grease fleece data of these ewes. The number of lambs born and reared was a significant source of variation influencing the grease and clean fleece weights of the Western ewes, but was essentially of no importance as a source of variation influencing either the grease or clean fleece weights of the crossbred ewes.

A high degree of similarity was noted for the grease and clean fleece weights of both breed groups during most years. In the case of the grease fleece data, the fleeces from the Western ewes were always heavier than those from the crossbreds, but as the grease fleece weights of the Western ewes tended to increase or decrease so did those from the crossbred ewes. In general the younger ewes produced heavier grease and clean fleeces and the fleece weights continued to decline with few exceptions as age of dam increased. Although age of dam was a nonsignificant source of variation influencing the clean fleece weights of the crossbred ewes, there was an indication that the fleece weights declined as ewe age increased. The crossbred ewes produced about the same amount of grease and clean wool each year regardless of the number of lambs born and reared. The only exception to this was the lower grease and clean fleece weights of the ewes that gave birth to but failed to rear their lambs. In the case of the Western ewes, those that did not lamb or those that gave birth to one lamb produced grease fleece weights considerably above those that gave birth to twins regardless of the number of lambs reared. In general as the level of productivity increased for the Western ewes, the yield of clean wool declined slightly.

The influence of ewe weight on grease and clean fleece weight was significant ($P<.01$) as a linear function but the quadratic effect was significant only for the clean fleece data of both breed groups. The linear and quadratic effects for ewe condition score were nonsignificant for the grease fleece data of both breed groups, but both effects were significant ($P<.01$) for the clean fleece data of the Western ewes; whereas, only the linear effect was significant ($P<.01$) for the crossbred ewes.

SUMMARY

A comparison was made between the lifetime performance of two ewe breed groups involved in a fall-lambing program. The two breed groups compared were Western ewes [Panama, 3/4 Rambouillet x 1/4 Merino, Rambouillet, 3/4 Rambouillet x 1/4 Columbia and "Whiteface Market" (part Columbia, Panama or Corriedale mixed with Rambouillet)] and Dorset x Western crossbred ewes [Dorset x Rambouillet and Dorset x (3/4 Rambouillet x 1/4 Panama)]. These two breed groups (120 ewes each) were compared from the standpoint of the growth rate of their lambs, reproductive performance and wool production. Percent advantage values for the Dorset x Western ewes over the Western ewes were calculated for the variables studied. The regular breeding season for these ewes usually began on May 20 and continued for 40 days. A "cleanup" breeding period was permitted from August 20 to September 20 for those ewes failing to conceive during the regular breeding season. This breeding procedure resulted in fall (Oct. 15-Nov. 25) and winter (Jan. 15-Feb. 15) lambing.

The lamb growth variables were: birth weight, rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market and market age. The overall means for each of these variables for the lambs from both breed groups were nonsignificant and the percent advantage values of

-1.02, 0.16, -0.39, 1.85 and -0.59 for birth weight, rate of gain from birth to 70 days, 70-day weight, rate of gain from 70 days to market and market age, respectively, were assumed to be estimating zero or a value too small to be of much importance.

Year of birth, age of dam, type of birth and rearing (type of birth for birth weight) and sex of lamb were all significant sources of variation influencing the birth weight, rate of gain from birth to 70 days, 70-day weight and market age of lambs from both breed groups. These factors were also significant sources of variation influencing the rate of gain from 70 days to market of lambs from the Dorset x Western ewes, but only year of birth and sex of lamb were significant for the rate of gain of lambs from the Western ewes. In general the influence of birth date and birth weight on the lamb growth variables was of more importance as a linear rather than as a quadratic effect.

The reproductive traits were: percent ewes lambing, lambing rate, lambs reared per 100 ewes in the flock and date of lambing. During the fall, a higher percentage of the Dorset x Western ewes lambed, they had a higher lambing rate, reared more lambs per 100 ewes in the flock and consistently lambed about three days earlier than the Western ewes. The percent advantage values were 10.3 ($P<.05$), 13.2 ($P<.001$), 25.8 ($P<.05$) and -0.84 ($P<.01$) for percent ewes lambing, lambing rate, lambs reared per 100 ewes in the flock and date of lambing, respectively. During the winter, 4.3 percent fewer Dorset x Western ewes lambed than the Western ewes but the lambing rate was similar for both breed groups (1.44 and 1.41 for the Western and Dorset x Western ewes, respectively). The high lambing rate of the Dorset x Western ewes was due to a large number of multiple births. During the two seasons, the Dorset x Western ewes gave birth to 722 twins and 39 triplets; whereas, the Western ewes gave birth to 470 twins and 15 triplets. On the average, the Dorset x Western ewes that lambed during the winter did so about two days earlier than the Western ewes that lambed during the winter.

Year of lambing and age of dam were significant sources of variation influencing the fall-lambing dates of both breed groups; however, type of ewe parturition was significant only for the Dorset x Western ewes. Year of lambing was the only significant source of variation that influenced the winter lambing dates of both breed groups.

The wool traits were: grease and clean fleece weights. There was virtually no comparison between the two breed groups with respect to grease fleece weight. The Western ewes were superior; however, the two breed groups produced clean fleece weights that were quite similar. The percent advantage values were -19.58 (P<.001) and -2.39 (nonsignificant) for grease and clean fleece weights, respectively.

Year and age of dam were significant sources of variation influencing the grease and clean fleece data of the Western ewes. Year was a significant source of variation influencing the grease and clean fleece data of the Dorset x Western ewes, but age of dam was significant only for the grease fleece data of these ewes. The number of lambs born and reared was a significant source of variation influencing the grease and clean fleece data of the Western ewes, but was nonsignificant for the grease and clean fleece data of the Dorset x Western ewes. Only the linear effect of ewe weight was significant for the grease fleece data, but both the linear and quadratic effects were significant for the clean fleece data of both breed groups. The influence of ewe score was nonsignificant for the grease fleece data of both breed groups; however, the linear and quadratic effects were significant for the clean fleece data of the Western ewes but only the linear effect was significant for the Dorset x Western ewes.

On the basis of the results obtained in this study, the answer to the question originally proposed as to whether Oklahoma sheepmen can raise a more productive ewe for fall-lamb production than they can purchase appears to be an emphatic - Yes! On the average, a higher percentage of the Dorset x Western ewes lambed during the fall, they had a higher lambing rate, reared more lambs per 100 ewes in the flock and lambed about three days earlier than the Western ewes. Also, the growth performance of their lambs and their clean wool yield were similar to that of the Western ewes.

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VITA

Frederick A. Thrift

Candidate for the Degree of

Doctor of Philosophy

Thesis: WESTERN VS. DORSET X WESTERN CROSSBRED EWES FOR FALL LAMB PRODUCTION IN OKLAHOMA

Major Field: Animal Breeding

Biographical:

Personal Data: Born in St. George, Georgia, October 6, 1940, the son of Alfred and Irene Thrift. Married Barbara Jean Brewer August 12, 1967.

Education: Received the Bachelor of Science degree from the University of Florida with a major in Animal Husbandry in June, 1962; received the Master of Science degree from the University of Georgia with a major in Animal Science in June, 1965.

Experience: Raised on a farm in southeastern Georgia; Graduate Assistant in Animal Science at the University of Georgia, 1963-64; Graduate Assistant in Animal Science at Oklahoma State University, 1964-67.

Member: American Society of Animal Science, Alpha Zeta, Gamma Sigma Delta, Phi Kappa Phi, Sigma Xi, Block and Bridle.

Date of Degree: May, 1968.