AN EVALUATION OF THE POST-PARTUM REPRODUCTIVE PERFORMANCE OF EWES INVOLVED IN A TWICE-YEARLY LAMBING PROGRAM

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CHAPTER I

INTRODUCTION

Currently sheepmen in Oklahoma with limited capital, land and other resources are searching for management practices whereby they can intensify their production programs. Since the present practice is to produce one lamb crop within a one-year period, two general methods may be employed to increase production: (1) Increase the number of lambs born at each lambing or (2) increase the frequency of lambing. Since a ewe's ability is limited in the number of lambs she can bear and rear at one time, the latter practice would appear more feasible.

Several procedures may be used to increase the frequency of lambing. A producer may lamb every eight months, thus producing three lamb crops within a two-year period, or lamb each six months to produce two crops within one year. In 1963 a program was initiated at the Fort Reno Livestock Research Station, El Reno, Oklahoma, to evaluate the problems associated with twice-a-year lambing regimes.

In order to sustain a continuous program of twice-yearly lambing a ewe must lamb, rebreed and conceive within 35 days. With a gestation period of 147 days, the production of two lamb crops requires the ewe to carry lambs about 294 days of the year. The remaining 71 days is the total length of time within which the ewe must lamb, rebreed and conceive twice. Therefore, the pivotal question arising from a proposed twice-yearly lambing scheme is: Will the ewe lamb then rebreed and conceive rapidly enough to continue the program year after year?

The purpose of this study was to evaluate the post-partum reproductive performance of three breeds of sheep, Dorset, Dorset X Rambouillet and Rambouillet ewes, involved in a twice-yearly lambing program.

CHAPTER II

LITERATURE REVIEW

The following literature review deals primarily with the reproductive performance of ewes subsequent to parturition. Several of the observations presented are incidental to the study reported; thus, the data pertain to one lambing period with no further efforts undertaken to evaluate a multiple frequency lambing program. The review includes data relative to lambing rates, factors associated with the interval from lambing to first estrus and the post-partum interval to conception.

Shelton and Huston (1968) reported the results of some multiple lambing schemes conducted at McGregor, Texas. The control flock of 1,139 mature, fine-wool ewes produced an average of 0.99 lambs per head. Under a program of twice-yearly lambing, 30 yearling ewes reared an average of 1.40 lambs while 24 aged ewes produced 1.33 lambs. Twenty mature ewes of similar breeding were lambed continuously throughout the year and yielded 1.56 lambs per head. On a flock basis, ewes managed under multiple lambing schemes produced an average of 0.43 lambs more per ewe in the flock than the normal lambing procedure of one crop per year.

Bigotte (1963) presented results from a pilot study involving Ile-de-France ewes at Ronquerolles, Oise, conducted over a one-year period. Spring breeding extended for 45 days from April 15 to May 31 while fall breeding occurred six months later from October 15 through November 30. The post-partum conceptions increased the production to 2.1 lambs per ewe within a one-year period as compared to the normal flock average of 1.5 lambs. The author did not present other information pertaining to the post-partum reproductive performance of the ewes.

In order to sustain a program of twice-yearly lambing through the spring breeding season, normally a period of anestrus in Russia, Kirillov (1944) placed intact rams with 200 Precose ewes within ten days post-partum. Eighty ewes were mated but only fifty percent of these conceived and produced lambs. Moreover, ewes exposed to a ram more than ten days post-partum failed to come into estrus. The author attempted to repeat these results the following year but none of the ewes returned to heat after lambing. The author attributed this to the poor condition that the ewes were in at lambing time.

At Blacksburg, Virginia, Copenhaver and Carter (1964) mated 26 blackfaced northwestern ewes for maximum lambing frequency. Upon lambing the ewes and lambs were confined to slotted floor pens (described by Watson, 1962) until weaning time at approximately one month of age; thereafter, the ewes were released onto pasture where they were allowed to rebreed to Hampshire rams. Mean lambing dates for three consecutive crops were January 31, August 22 and

March 11; thus, intervals between lambings were 203 and 205 days, respectively. The authors did not report the number of ewes lambing in consecutive seasons or the intervals from lambing to estrus and/or conception; however, it was reported that 96, 95 and 100 percent of the ewes lambed in each respective period.

Hulet and Foote (1967) attempted to repeat the results of the Virginia study with 50 aged white-faced ewes at Dubois, Idaho. Lambing extended for 20 days from January 1 to January 20 and all lambs were weaned on February 20, 30 to 50 days of age. Only nine ewes had shown estrus by March 19 (60 to 80 days post-partum) and only four of these conceived to lambing the following fall. The authors felt that the difference in housing, nutrition, altitude, temperature, humidity, breed of ewe and season of the year all contributed to the failure of the experiment to repeat the results found at Virginia.

Working with Romanov ewes on collective farms in Yaroslave Province, U.S.S.R., Usakava and Fudelj (1941) reported results of a frequent lambing regime conducted over a two-year period. Ewes lambing only once were bred in August or September; whereas, ewes lambing twice were mated from July to August and January to February. The author did not indicate how many of the ewes lambed four times in the two years; however, the post-partum anestrus interval lasted from 10 to 65 days. No values of post-partum intervals within season were presented but the reported percentages of ewes failing to conceive indicated a season difference. Of the 945 ewes observed in 1937, 2.2 percent failed to conceive in the fall while 31.4 percent of 287 ewes failed to conceive in the January through February mating. Corresponding values for the 1938 season were 2.6 percent of 869 and 21.6 percent of 162 ewes failing to conceive following parturition.

Relative to the noted seasonal effects in multiple lambing regimes, observations were taken on a flock of 788 Precose ewes of which 32.8 percent lambed twice during 1937 (Udoljskii _et al._, 1940). A period of general sexual inactivity occurred from January to July, during which time a limited number of ewes exhibited estrus 21 to 22 days post-partum. However, the majority of ewes remated after July 15, within a range of 91 to 128 days following parturition.

Shelton and Morrow (1965) utilized 539 aged Rambouillet ewes to evaluate season differences relative to estrus occurrance over a two-year period. The ewes were randomly assigned to one of four mating periods of six weeks duration, beginning on March 21, June 21, September 21 and December 21; thus, the periods included the longest and the shortest days of the year (measured in hours of daylight) and the days intermediate at three month intervals. A nonsignificant difference between periods was observed in the number of ewes showing estrus, 84.5, 96.4, 97.2 and 99.1 percent, respectively; however, a season difference ($P<.01$) was reported in ovulation rates. Similarly, conception performance showed nonsignificant seasonal differences relative to number of ewes lambing, but indicated significant ($P<.01$) season differences in the number of lambs produced.

Incidental to the main objective of a study at Clemson, South Carolina, Godly et al. (1966) observed 20 Rambouillet ewes for the occurrence of estrus throughout a three-year period. Although a significant year difference ($P<.05$) was denoted, a general trend in estrual activity was detected. Little sexual activity occurred from February 1 through May 30; however, a limited number of ewes showed estrus periodically throughout this period except during the months of April and May.

Watson (1953), Dun et al. (1960) and Watson and Radford (1966) reported on the seasonal variation of Merino ewes in Australia. The results indicated that Merinos are primarily fall breeding ewes in that 11 percent more ewes exhibited estrus in the fall season than in the spring. Also, the ewes were more fertile (10 percent more conceived) in the fall period. This work was supported by Roux (1936) in South Africa, in that he observed that the optimum breeding period extended from February to August, the fall and winter months in this area.

Sayed et al. (1952) working with a limited number of Dorset, Hampshire, Rambouillet X Dorset, Shropshire, Southdown and Suffolk yearling ewes in Michigan indicated that all breeds underwent one or more periods of sexual inactivity from late winter to early summer. The Dorset and Rambouillet by Dorset crossbred ewes returned to estrus three weeks prior to Hampshire ewes which recycled six to seven weeks earlier than the other ewes studied. Data reported by Cole and Miller (1935) and McKenzie and Terrill (1937) also indicated that Dorset and Rambouillet ewes or crosses involving these breeds resumed estrus at an earlier date than those of other breeds, i.e. Hampshire, Southdown, Shropshire or Romney ewes found within the continental United States. Since estrus was terminated by pregnancy, the authors did not report either the date of termination or the length of anestrus within each breed.

Asdell (1964) indicated that, excluding the termination of estrus by pregnancy, fine-wool breeds cycle continuously the year round; whereas, coarse-wool breeds are seasonal breeders with their estrual activity beginning in September and continuing well through the winter months. One noticeable exception to this generalization would be the Dorset ewe which, because of its possible origin from the fine-wooled Merino, could be expected to exhibit estrus the year round. Shelton (1968) classified ewes according to estrual activity as summarized in Table I. Rambouillet, Merino, Dorset and Tunis ewes could be expected to mate at any time of the year or start cycling by June; thus, these breeds would be useful in multiple lambing schemes where at least one breeding period falls during the spring season, normally a season of anestrus under present production procedures.

TABLE I

SUMMARY OF BREED PERFORMANCE RELATIVE TO YEARLY ESTRUAL ACTIVITY (SHELTON, 1968)

Class	Breed of Ewe
Breeds likely to mate year round	Rambouillet Merino Dorset Tunis and others developed in equatorial regions
Breeds restricted to little activity in advance of September	Southdown Cheviot Shropshire Long wool breeds developed in Scotland or England
Breeds intermediate to the extremes	Suffolk Hampshire Columbia Corriedale Crosses from Dorset or fine wools

In a three year study at Kansas State University, Gardner et al. (1955) continuously checked Southwest whiteface and Northwest whiteface and blackface ewes for estrual activity. Outside of a period from January 15 to March 31 a high degree of estrus was reported. Relative to post-partum performance, a small percentage of the spring-lambing ewes were receptive to the ram within 48 hours post-partum; however, anestrus appeared to last five to seven weeks with the occurrence of regular estrual activity two weeks after weaning.

Torell et al. (1956) at Davis, California reported on the rebreeding performance of ewes lambing during the fall, mid-winter and spring. The ewes were grouped into three classes according to lambing dates: Lambed between (a) October 12 and November 13, (b) December 14 and January 14 and (c) April 14 through June 20. Average intervals reported were (a) 55 days, (b) 163 days and (c) 77 days post-partum to estrual activity. These results indicated that parturition during mid-winter tended to increase the expected interval from lambing to estrus.

Barker and Wiggins (1964b) reported on the estrual activity of lactating Dorset, Rambouillet and crossbred ewes at Auburn, Alabama. Ewes were checked for estrus within 15 hours after parturition with observations taken twice daily using vasectomized rams until the beginning of the next breeding season. Lactation lasted for a minimum of 120 and a maximum of 217 days post-partum. The average intervals from lambing to the establishment of a regular estrus cycle for each breed of ewe are presented in Table II. Intervals within the respective years 1957 and 1958 were 73.0 and 96.1 days post parturition for Rambouillet ewes and 38.8 and 66.0 days post-partum for Dorset ewes. Thus, the data tended to indicate that Dorsets remated sooner than Rambouillet ewes; nonetheless, the available data was inadequate to establish this as a definite trend. This observation may be due entirely to the small number of Dorsets involved in that all the ewes remated within 103 days, whereas only 90 percent of the Rambouillet ewes remated within 120 days post-partum.

TABLE II

LENGTH OF INTERVAL FROM LAMBING TO SUBSEQUENT ESTRUS IN FIVE BREEDS OF EWES (BARKER AND WIGGINS, 1964b)

Breed	1957-1958			1958-1959		
	No.	Average Interval	Range	No.	Average Interval	Range
Rambouillet	244	73.0	12-293	262	86.1	8-253
Dorset	5	38.8	14-77	7	66.0	28-103
Columbia x Rambouillet				9	112.0	37-242
Dorset x Rambouillet				8	53.3	21-77
Hampshire x Rambouillet				2	- -	- -

Observations were also presented on 244 Rambouillet ewes and their response to lactation stress. In both years nonsuckled ewes returned to estrus sooner than suckled ewes. Nonlactating ewes established estrual activity in 57.7 days and 54.9 days during 1957 and 1958, respectively. Corresponding values of 80 and 88 days post-partum was reported for lactating ewes.

Smith (1964) worked with Merino ewes in Australia to study the effect of time of lambing relative to the lambing period and levels of nutrition upon the duration of anestrus. A summary of his results are presented in

Table III. Ewes lambing at the beginning or the end of the lambing season required more time to return to estrus than those lambing intermediately, 89.8, 44.9 and 188.6 days post-partum, respectively. Within each time period, a significant difference (P<.01) was reported for the length of intervals for lactating and nonlactating ewes with the latter rebreeding sooner.

TABLE III

DURATION OF POST-PARTUM ANESTRUS FOLLOWING EARLY WEANING (SMITH, 1964)

Lambing Time	No. of Ewes		Range	Mean
Nov. 1-15	28	lactating **	73-129	97.4
	25	nonlactating	58-136	81.3
March 10-28	43	lactating **	30- 67	46.1
	9	nonlactating	23- 58	39.3
July 10-Aug. 23	37	lactating **	171-224	194.9
	19	nonlactating	137-208	176.4

** P< .01

An Illinois study by Williams et al. (1956) evaluated the occurrence of estrus during pregnancy. Secondarily, the authors evaluated the response of 24 of the 103 western crossbred ewes to weaning shortly after parturition (no specific weaning date or age of lamb at weaning was reported). All ewes which weaned lambs returned to estrual activity within 61 days with a mean of 24 days following parturition. No attempt was made to check ovulation or conception in these ewes.

Observations taken on 30 spring-lambing ewes at Davis, California (Torell *et al.*, 1956) indicated that stress from lactation will reduce the frequency of ewes showing estrus. These results, presented in Table IV, indicated that there was no significant difference in the length of post-partum anestrus between lactating and nonlactating ewes. All ewes from which lambs were weaned at one day of age returned to estrus in an average of 50.3 days; however, only 60 percent of the lactating ewes returned with a mean interval of 55.4 days post-partum.

TABLE IV

EFFECT OF LACTATION ON INCIDENCE AND INTERVALS OF POST-PARTUM RETURN TO ESTRUS (TORELL *ET AL.*, 1959)

Class	No. of Ewes	No. Showing Estrus	Interval	S.D.
Weaned	15	15	50.3	8.5
Lactating	15	9	55.4	6.5

Hafez (1952) mated 18 Suffolk ewes with fertile rams the year round for two years. Post-partum estrual activity was observed in 56 percent of the ewes lambing from

January 9 to February 20. The associated interval ranged from two to 60 days with a mean of 35 days. Only 50 percent of the ewes mated actually conceived post-partum and no intervals from lambing to conception were reported.

Gordon (1958b) studied the mating and lambing performance of fall-lambing ewes in Great Britain where the fall lamb crop was induced with the aid of progesterone treatments. Hormones were not administered in the fall to induce estrus in 66 ewes of various breeds and ages. Forty-three ewes were exposed to rams at the time of lambing and 23 were exposed one month after lambing. Forty-two of the first group returned to estrus in approximately 45 days (range of 17 to 75 days after lambing) while all 23 ewes in the second group remated somewhat later (range of 41 to 88 days). The highest incidence of estrual activity was reported to have occurred from 31 to 60 days post-partum. Sixty-one of these ewes were observed through the subsequent lambing period when five ewes or 8.2 percent failed to lamb denoting failure to conceive. Of the 46 lambing ewes, 75.4 percent conceived to first mating and ten to later services. Conception performance between the two groups previously discussed was not compared.

Granger (1947) reported on the post-partum conception performance of 83 Merino ewes at Haddon Rig, Australia. The ewes lambed from March 15 through April 12 and were exposed to intact rams on April 14. No ewe conceived until at least eight or nine days after exposure to the ram and ewes lambing earlier in the period tended to conceive sooner than those lambing later. In general, the interval from lambing to conception ranged from 29 to 61 days with a mean of 41 days.

Sixty-seven of the 262 Rambouillet ewes used in the study by Barker and Wiggins (1964b) were inadvertantly bred by ram lambs following the 1957 lambing period. The average interval from lambing to first heat for the ewes was 67 days. Prior to conception, the ewes had undergone an average of five estrual cycles; thus, a rather long interval of 116 days from lambing to conception was reported.

The literature indicated that the interval from lambing to conception is somewhat longer than that to estrual activity. In order to evaluate the occurrence of ovulation relative to estrual resumption, Hunter and Lishman (1967) of South Africa reported results of post-partum ovulation and estrus of 24 German Merino ewes lambing in the spring. The ewes were teased with vas-ectomized rams beginning three days after lambing. The day of first ovulation was determined by laparotomies performed on the ewes at 20-day intervals subsequent to lambing. The ewes ovulated 18 to 45 days (mean 32.1) after lambing; however, visual manifestation of estrus was not observed until an average of 57.1 days. Thus, there appears to be a "silent" heat present during the first estrual cycle as has been reported by Hafez (1952) and Hulet and Foote (1967).

Barker and Wiggins (1964a) presented data relative to the occurrence of estrus immediately after parturition. During 1957, 240 grade Rambouillet and six Dorset ewes were observed for estrus twice daily beginning immediately after lambing. During the 1958-59 lambing season, 274 Rambouillet, eight Dorset X Rambouillet, nine Columbia X Rambouillet and eight Dorset ewes were similarly checked. A ewe was considered to be in heat when she would stand and accept a vasectomized ram. Twenty-two or nine percent of the Rambouillet ewes in the 1957 season exhibited estrus between 15 and 27 hours following lambing. In 1958 a similar seven percent of the 274 Rambouillet ewes had a post-partum estrus immediately after parturition. Although the number of Dorset ewes observed was small, a significantly ($P<.05$) higher frequency exhibited post-partum heat than did Rambouillet ewes in both years. Since only three of the nine Columbia X Rambouillet ewes were observed in heat, no conclusions were drawn regarding the crossbred groups.

Two Rambouillet ewes which displayed estrus within 15 hours post-partum in October of the second season were slaughtered and their ovaries examined approximately 12 hours after the termination of estrus. The ovaries were smaller than normal and only a slight indication of follicular development was noted. Also, the corpora lutea were small and degenerate and appeared nonfunctional; thus, this post-partum heat would not appear to be accompanied by ovulation. These results are similar to those reported in swine by Warnick et al. (1950) and Baker et al. (1953).

An interesting observation presented relative to this heat was that ewes experiencing this type of estrual activity tended to return to regular breeding behavior more rapidly than did those ewes not having this post-partum estrus. The intervals from lambing to establishment of regular estrual activity reported were 61.0 and 73.0 days for the respective groups in 1957 and 62.8 versus 86.1 days in 1958.

This literature review indicates that some ewes will resume estrual activity and conceive following parturition. The reviewed results concerning post-partum reproduction were variable with incidence and intervals being influenced by locality, breed of ewe, season of lambing and lactation. A summary of various post-partum reproductive performance studies is presented in Table V.

TABLE V

SUMMARY OF POST-PARTUM INTERVALS TO ESTRUS AND CONCEPTION

Breed	Locality	Time of Lambing	Post-partum Interval Range	Post-partum Interval Mean	Reference
Dorset	Alabama	June to January	14-103	52	Barker and Wiggins (1964a)
Karakul	Maryland	March	61-159	102	Phillips *et al.* (1947)
Merino	Ermelo, S. Africa Karoo, S. Africa	July-September " "	62-234 12- 60	- - - -	Roux (1936) " "
Merino	Pretoria, S. Africa	April-June	51-264 19- 54[a]	103 34	Ravenscrift (1941)
Persian	Pretoria, S. Africa	March-April	33- 98	60	" "
Persian	Pretoria, S. Africa	March-April	8-283	90	Opperman (1949)
Romanov	U.S.S.R.	December	10- 65	35-40	Usakova and Fudelj (1941)
Rambouillet	Alabama	June-January	8-293	79	Barker and Wiggins (1964b)
Rambouillet	Alabama	June-January	12-212	73	" " "
Suffolk	Cambridge	January-February	2- 60	35	Hafez (1952)

TABLE V (Continued)

Breed	Locality	Time of Lambing	Post-partum Interval		Reference
			Range	Mean	
Fur milch x Karakul	U.S.S.R.	December	5- 79[b,c]	28	Baronov (1941)
Merino	Australia	March-April	29- 54[b]	41	Granger (1947)
Precose	U.S.S.R.	February	21-128[b]	110	Udoljskii *et al.* (1940)

[a]nonlactating ewes

[b]interval to conception

[c]these ewes received hormone treatments

CHAPTER III

MATERIALS AND METHODS

Managerial Procedures

The breeding flock consisted of 182 ewes of which 60 were of Dorset breeding, 60 from the Rambouillet breed and 62 from the cross of the two breeds, Dorset X Rambouillet, hereafter referred to as crossbred ewes. Ten of the crossbreds were obtained from the existing flock (project S-908) at the Fort Reno Livestock Research Station near El Reno, Oklahoma. The remaining 52 crossbreds and the 60 Dorset ewes were purchased from several other flocks in Oklahoma while the 60 Rambouillet ewes were procured from various flocks in Texas. The normal lambing procedure in these source flocks was to lamb in both the fall and spring seasons, but a ewe lambed only once per year.

In an effort to evaluate the effect on performance of initiating the program in the fall or the spring season, three duplicate purchases were made. Figure 1 illustrates that with the exception of the 22 crossbred ewes obtained in the fall of 1963, 20 ewes of each breed group were purchased at six-month intervals. Sixty-two 1963 spring-born ewes were obtained in the fall of 1963, 60 fall-born ewes were purchased in the spring of 1964 and

60 spring-born ewes were purchased in the fall of 1964 to complete the flock. All ewes were first bred when approximately one year of age, thus part of each breed group was bred first in the fall and the remainder during the spring season.

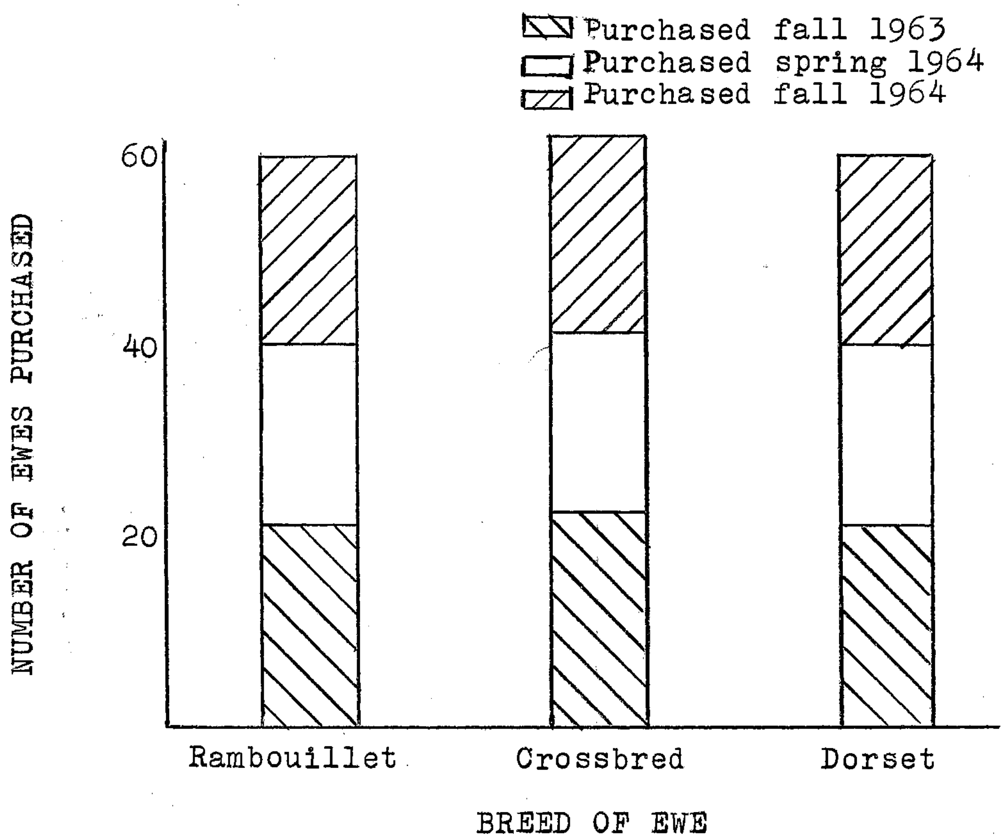

Figure 1. Acquisition of the Ewe Flock Involved in the Twice-yearly Lambing Program

As the ewes were purchased, they were combined into one flock and were handled as such. Following each breeding season the ewes were maintained on wheat pasture in the fall and bermuda grass in the spring season. Approximately one month prior to the lambing period, ewes that had recorded matings the previous season were separated from those that did not and were supplemented with about one-third of a pound of ground milo per head per day. This amount was gradually increased to one pound by the start of the lambing period. Until weaning time, the ewes received this level of supplement plus two pounds of alfalfa hay which was increased or doubled during periods of inclement weather conditions. As the lambs were weaned the ewes were transferred to the flock of dry ewes and remained on pasture until the next production cycle began. Fall lambing ewes were allowed to graze on wheat pasture with their lambs; however, in an effort to reduce internal parasite infestation in the lambs, ewes lambing in the spring were separated twice daily from their lambs for two-hour periods and allowed to graze on a bermuda grass pasture or wheat pasture when available while the lambs were retained in dry lot.

Figure 2 illustrates the breeding and subsequent lambing periods associated with the program. Fall mating extended for a 60-day period which began on October 20 and ended December 19; thus spring lambing occurred from approximately March 15 until May 15. Similarly, spring breeding extended for 60 days from April 20 through June 19 and, as a result, fall lambing began about September 15 and ended about November 15.

In an effort to reduce the sire effect on the ewes'

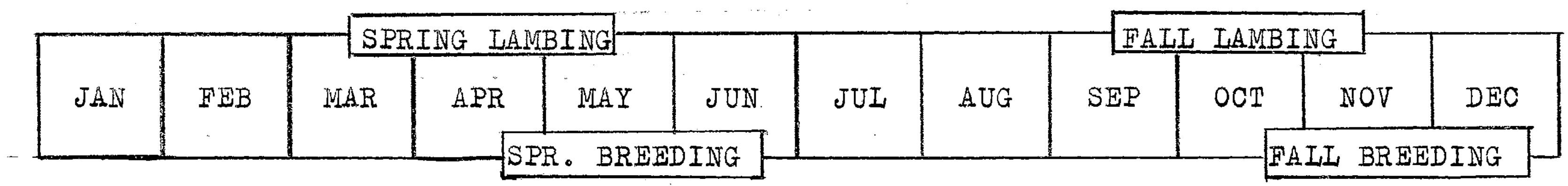

Figure 2. Breeding and Subsequent Lambing Periods Associated with the Twice-Yearly Lambing Program

post-partum reproductive performance, a gross microscopic examination of semen from all rams was made prior to each breeding season and any ram with questionable semen was not used during that season. The ewes were mated at random to Dorset, Hampshire or Suffolk rams which were rotated daily in the described time periods.

Ewes in heat were detected with the aid of both sire marking harnesses and visual observations throughout the breeding seasons. Mating data collected in this manner were not entirely accurate--a few ewes were mated, yet no mark was recorded, and others were marked but not actually mated. Ewes lambing more than ten days prior to the breeding season were exposed daily to a vasectomized ram to detect estrus until the breeding season began after which they were mated to fertile rams. Later lambing ewes were exposed to a fertile ram approximately ten days post-partum. Upon lambing the ewe and her lamb(s) were confined to an individual pen in the central lambing barn. When the lamb had gained enough strength to follow its dam (approximately three days post-partum) they were transferred to a larger area with about 10 other ewes and their lambs. Here the lambs were docked and retained for about a week, after which time the group was released into the breeding areas. When the oldest lambs reached 45 days of age, a biweekly weighing regime was initiated. To facilitate the ewe's recovery for her next parturition, the lambs were weaned when they attained a minimum age of 66 days and weight of 50 pounds.

In an effort to record the ewe's condition relative to fatness, each ewe was weighed and scored (for fat covering) prior to each lambing period and after each breeding season. The condition score was a numerical value of 1 through 9 where a score of 1 represented a very thin, emaciated ewe, and a score of 9 indicated a very fat ewe, while the intermediate scores represented ewes of relative fatness between these extremes.

Data Studied

Reproductive performance was evaluated relative to post-partum remating and subsequent conceptions. Mating data of primary importance was the first post-partum mating date and the interval from lambing to the first estrus cycle. All dates were manipulated by transforming the date to its corresponding day of the year; for example April 6 would become the 96th day or in a leap year the 97th day of the year. Mating data was collected as previously outlined; however, if a ewe lambed but had not recorded a mating date an estimated date was computed by subtracting an average gestation interval of 147 days from the lambing date. The interval from parturition to first estrus was simply the difference between the first mating and lambing dates.

Conception dates were computed from the amassed lambing and mating data where the measure of conception utilized was whether or not the ewe lambed in the ensuing lambing period. This system was not entirely accurate because a ewe may have conceived and yet produced no lambs. She may have reabsorbed the embryo or aborted it when it was too small to observe; thus, conception was undetected. However, in any program such as this the final objective was to obtain marketable products; thus, relative to this study, lambs produced were of primary importance.

An estimated conception date was computed by subtracting 147 days from the ensuing lambing date. If the ewe had recorded a mating within three days of this calculated date, that mating date was used as the actual conception date; otherwise, the estimated date was used. Then the previous lambing date was subtracted from the conception date to yield the interval from lambing to conception.

Other observations taken included type of birth, type of rearing and group of ewe. Type of birth referred to the number of lambs born as single or multiple births. Triplets were classified with twins as multiples because of the lack of numbers. Type of rearing referred to the number raised past two weeks of age and was similar to type of birth except that a class for zero raised was added. Type of rearing was not statistically analysed because of low numbers and missing cells in the classifications. Group of ewe referred to the time when the ewe was started on the program as previously outlined in Figure 1, but is also confounded with age of ewe.

Statistical Analysis

To facilitate the analysis involving unequal subclass numbers, the data were analyzed by use of the least squares method of fitting constants as outlined by Harvey (1960). The normal equations used can be delineated by the equation:

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

where X was the observation matrix, X' was the transpose of the observation matrix, $\hat{\beta}$ was the vector of least squares constants, and Y was the vector of observations. Since the normal equations were not independent, the restriction that the sum of the least squares constants for each effect equaled zero was imposed so that a unique solution could be obtained. Thus, the least squares constants for each effect was expressed as a deviation from zero. The procedure involved in constructing $[X]$, the observation matrix, was presented in detail by Cundiff (1966), Cunningham (1967) and Cunnnngham (1968).

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

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

from which estimates of least squares constants were derived.

Sums of squares for the analysis of variance were computed by:

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

or when simply considering one least squares constant:

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

Where $\hat{\beta}_i$ and $\hat{\beta}_j$ were the appropriate least squares constants, C_{ii} and C_{jj} were the corresponding diagonal inverse elements and C_{ij} was the off-diagonal inverse element. The sum of squares calculated in this manner was the difference of the reduction in the sum of squares due to fitting all constants in the model except the set being considered. Thus, all sums of squares in the analysis of variance were adjusted for all other sources of variation in the model.

Standard errors of the individual least squares estimates were obtained by:

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

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

Similarly, the standard error of the sum of two estimates was obtained from:

$$S_{(\hat{\beta}_i + \hat{\beta}_j)} = \sqrt{(C_{ii} + C_{jj} + 2C_{ij})\hat{\sigma}^2}$$

where C_{ii} and C_{jj} were the diagonal elements corresponding to the least squares constants $\hat{\beta}_i$ and $\hat{\beta}_j$, C_{ij} was the off-diagonal element from the inverse matrix and $\hat{\sigma}^2$ was the appropriate residual mean square. Likewise, test for significance in differences between two constants was given by:

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

where the denominator was also the standard error of the difference.

The model utilized for this study was:

$$Y_{ijkl} = u + A_i + B_j + C_k + (BC)_{jk} + e_{ijkl}$$

where,

Y_{ijkl} is an individual observation of conception date, interval lambing to conception, first remating date or interval to first estrus.

u is an effect common to all observations, the overall mean.

A_i is the effect for the i^{th} group of ewe. $i = 1,2,3$.

B_j is the effect for the j^{th} type of birth. $j = 1,2$.

C_k is the effect for the k^{th} breed of dam. $k = 1,2,3$.

$(BC)_{jk}$ is the effect of the interaction of the j^{th} type of birth and the k^{th} breed of dam.

e_{ijkl} is the random error for each observation.

The data were sorted such that the analysis of variance was done within season and within year then pooled over years. Since all groups of ewes were not represented in the 1964 fall and 1965 spring seasons, these were omitted from the statistical analysis.

Under this type of analysis, the assumption was made that the failure of the model to estimate the observations exactly was strictly a function of the errors of the individual observations. To test the validity of this assumption a measure of error other than that of the residual mean square was extracted from a hierarchal or nested analysis of variance such that the error mean square became a within cell variance estimate. This error mean square was used to test the effects in the model and the lack of fit as described by Ostle (1963). The difference between the residual sum of squares and this error sum of squares then became the sum of squares for lack of fit with the associated degrees of freedom. As an example, Table VI presents a typical analysis of variance used in this study.

TABLE VI

ANALYSIS OF VARIANCE FOR POST-PARTUM REPRODUCTIVE DATA WITHIN SEASON AND YEAR

Source	D.F.[a]	Sum of Squares
Total	N-1	SS
Group of ewe	2	SS_A
Type of birth	1	SS_B
Breed of ewe	2	SS_C
Birth type x breed	2	SS_{BC}
Residual	N-8	[b] SS_R
Lack of fit	$(N-8)-n_i$	SS_R-SS_E
Error	n_i	[c] SS_E

[a] N was the total number of observations and n_i was the number of observations contained within a cell

[b] $SS_R = SS - SS_A - SS_B - SS_C - SS_{BC}$

[c] SS_E was the within cell variance taken from the hierarchal analysis of variance

CHAPTER IV

RESULTS AND DISCUSSION

Lamb Production

The principal objective of post-partum reproduction was to increase the number of lambs born by increasing the frequency of lambing. A summary of the lamb production data collected over the duration of this study is presented in Table VII. Two ewe seasons in the total represented one ewe's record over a one-year period; thus, the flock average for 564 ewes was 1.86 lambs born per ewe in the flock. Statistics from U.S.D.A. publications indicated that each ewe in Oklahoma reared 1.03 lambs per year; therefore, with the addition of 12 percent to account for death losses (Nichols and Whiteman, 1966), an expected flock average would be approximately 1.15 lambs born per ewe under a normal once-a-year lambing program. Thus, comparisons showed an advantage of 0.71 lambs produced per ewe per year under the twice-yearly lambing program in this study. This was a larger advantage than that reported by either Bigotte (1963) or Shelton and Huston (1968) when they indicated an advantage of 0.60 and 0.41 lambs, respectively. These discrepancies could be associated with the length of time and number of

TABLE VII

LAMB PRODUCTION UNDER A TWICE-YEARLY LAMBING SCHEME

	Fall	Spring	Total
Ewe seasons[a]	537	591	1,128
Ewes lambing	188	495	683
Percent ewes lambing	35.0	83.7	60.5[c]
Lambs born	254	795	1,049
Lambs per ewe lambing	1.36	1.60	1.53[c]
Lambs born excluding first lamb crop	160	738	898
Lambs conceived post-partum[b]	116	210	326
Percent conceived post-partum	72	28	36.3[c]

a Number of records available

b Indicates number conceived following parturition in previous season

c Values calculated using total numbers

animals involved in the various studies. The present study was conducted over a four-year period with 180 ewes, whereas the other two studies were conducted for one-year periods with 30 or less ewes.

Since the first lamb(s) produced by a ewe could not be produced post-partum, these numbers were removed from the total lambs and a percent of those conceived post-partum were calculated. Thirty-six percent of 898 lambs were born from post-partum conceptions with 72 percent of the fall-born lambs and 28 percent of those born in the spring resulting from conceptions following parturition. Since 83.7 percent of the ewes lambed in the spring season, only a limited number of open ewes were available for breeding; thus, a larger proportion of the ewes that conceived in the spring had to conceive post-partum than those conceiving in the fall season. The literature yielded no observations relative to this type of data; however, these data do illustrate the need for an in depth study of the post-partum performance within each season.

Post-Partum Estrual Activity

Observations on post-partum performance of ewes relative to estrual activity are presented in Table VIII. Of the 188 ewes lambing in the fall, 159 (85 percent) mated following parturition whereas only 50 percent of the 495 ewes mated subsequent to lambing in the spring. This spring percentage was similar to that reported by

Kirillov (1944) but higher than the 18 percent reported by Hulet and Foote (1967). This discrepancy could be associated with the observation that the ewes involved in the latter study were aged range ewes. Torell et al. (1956) reported that 80 percent of the spring lambing ewes exhibited post-partum estrus; however, one half (15 ewes) were weaned within one day of lambing and of the lactating ewes remaining only 66 percent showed estrus which agrees with the data from the present study. The 85 percent of the fall lambing ewes returning to estrus agrees with results found by Gordan (1958), yet was somewhat higher than the 56 percent reported by Hafez (1952) involving 18 Suffolk ewes.

TABLE VIII

POST-PARTUM ESTRUAL ACTIVITY IN EWES

Item	Fall 1964-1967	Spring 1965-1968
No. ewes lambing	188	495
Avg. lambing date	Oct. 12	Apr. 4
No. ewes mating	159	248
Percent ewes mating	85	50
Avg. lambing date[a]	Oct. 14	Apr. 6
Avg. remating date	Nov. 6	May 23
Avg. interval to first estrus, days[a]	32	59

[a] Of ewes that remated following lambing

The resumption of estrual activity occurred approximately 27 days later in the spring breeding period than in the fall breeding interval. Similar results were previously reported by Torell et al. (1956) and Smith (1964). The length of the post-partum interval was longer in the latter study because the ewes were observed until estrual activity was noted in all ewes. Although reports specifically comparing spring and fall performance of ewes were not available in the literature, a study of the post-partum intervals to estrus and conception reported by other workers and presented in Table V reveals that spring lambing ewes tend to exhibit longer periods of anestrus than do fall lambing ewes.

Date of First Estrual Activity

Values of F and error mean squares obtained in the analyses of variance for the date of estrual resumption within the spring and fall seasons are presented in Tables IX and X. Two seasons (fall 1964 and spring 1965) were omitted from the analysis because observations pertaining to group 2 and 3 ewes were not present. The test for lack of fit as discussed by Ostle (1963) indicated that the linear model used adequately described the data. If the source of variation truly did not exist, the expected F ratio should equal 1.0; however, by chance an equal proportion of the values obtained would fall below and above this expected ratio. The data indicated that the sources of variation studied in the fall season did not contribute

TABLE IX

ERROR MEAN SQUARES AND F VALUES FOR DATE OF FIRST ESTRUS IN THE SPRING SEASON

Source	1966	1967	1968	Pooled
Group of ewe	0.598	0.906	0.190	0.654
Type of birth	0.399	2.052	0.028	1.038
Breed of ewe	0.487	3.881*	6.807**	4.652**
Interaction (BxC)	0.044	0.296	1.161	0.612
Lack of fit	1.180	0.542	0.565	0.792
Lack of fit (d.f.)[a]	(12)	(14)	(9)	(35)
E.M.S.	140.722	252.617	216.095	180.587
E.M.S. (d.f.)[a]	(61)	(17)	(34)	(112)

[a] Degrees of freedom for the corresponding source of variation

* $P < .05$

** $P < .01$

TABLE X

ERROR MEAN SQUARES AND F VALUES FOR DATE OF FIRST ESTRUS IN THE FALL SEASON

Source	1965	1966	1967	Pooled
Group of ewe	0.891	1.598	0.247	0.878
Type of birth	0.085	2.112	0.412	0.767
Breed of ewe	1.116	0.749	3.548	1.324
Interaction (BxC)	0.671	1.057	0.311	0.640
Lack of fit	0.485	1.061	2.580	0.897
Lack of fit (d.f.)[a]	(7)	(8)	(3)	(18)
E.M.S.	302.419	250.458	152.428	268.307
E.M.S. (d.f.)[a]	(40)	(31)	(7)	(78)

[a] Degrees of freedom for the corresponding source of variation

significantly to the variation of the population. Thus, the variance was apparently an individual or a within cell variance component.

In the spring season, breed of ewe source of variation was significant in 1967 ($P<.05$), 1968 ($P<.01$) and for the pooled estimate ($P<.01$). The least squares constants for all effects studied for the first post-partum estrual date in the spring season are presented in Appendix Table XXI and the least squares means for breed of ewe are illustrated in Figure 3. In the three years studied Dorset ewes tended to resume estrual activity at an earlier date than the other two breeds studied. Although not significant, the Dorset ewes returned two days earlier in 1966. In 1967 the date was 11 days earlier ($P<.05$) and nine days ($P<.01$) sooner in 1968. Crossbred and Rambouillet ewes returned approximately the same day until 1968 when Rambouillet ewes returned 13 days ($P<.01$) after the crossbred ewes had resumed cycling. These results agreed with the trend observed by Barker and Wiggins (1964b).

Figure 4 presents the plotted least squares means for the dates of resumption of estrual activity following parturition as are found in Appendix Tables XXI and XXII. The data indicated that over the years the date of resumption became later in the breeding season. Also, the dates for first estrus following parturition tended to occur later in the spring breeding interval than during the fall. From these dates it appeared that the ewes possibly were not remating soon enough following

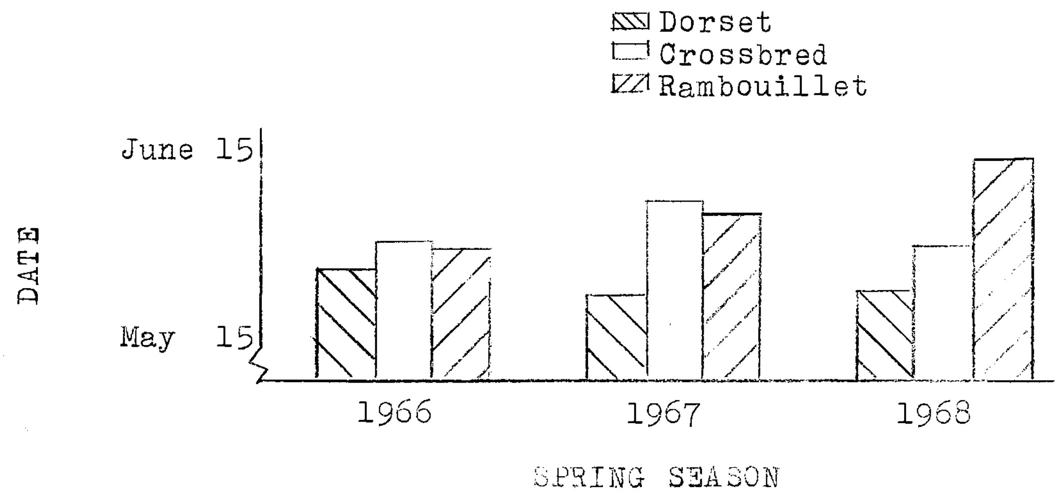

Figure 3. The Effect of Breed of Ewe on Date of First Estrus in the Spring

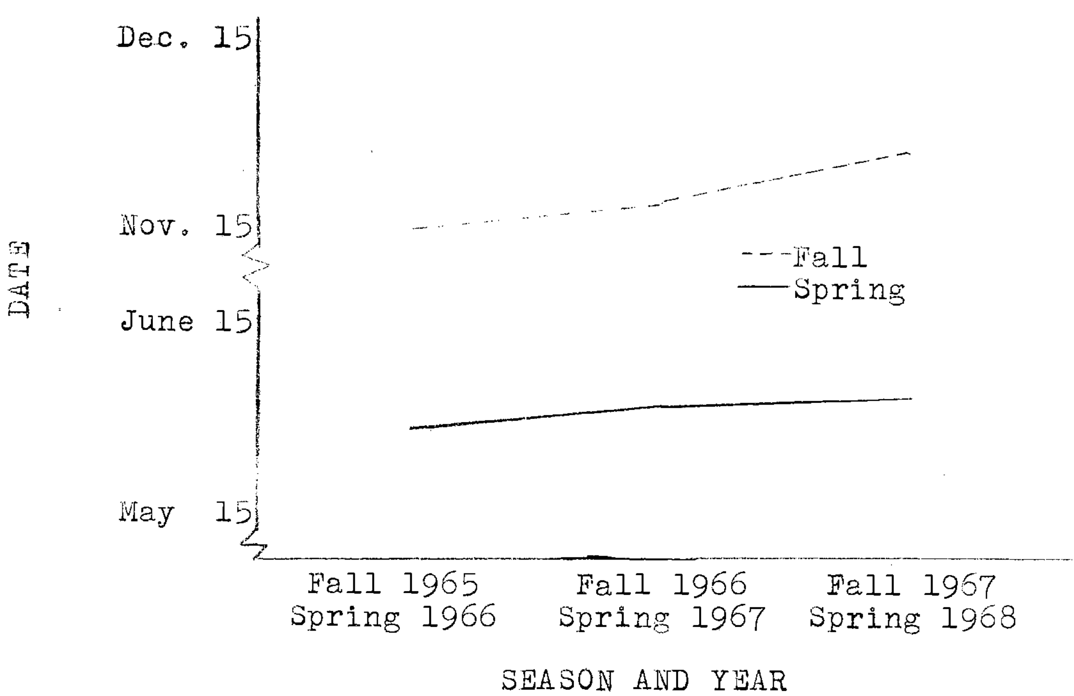

Figure 4. Mean Dates for Resumption of Estrual Activity Following Parturition

parturition to maintain the necessary time schedule for lambing every six months as was previously discussed and a closer evaluation of the interval from parturition to first estrus was necessary.

Interval From Lambing to First Estrus

Figure 5 presents the plotted least squares means of the interval from parturition to estrual activity taken from Appendix Tables XXIII and XXIV. These data indicated that a longer period of time was required for a ewe to rebreed following parturition in the spring than in the fall; thus, illustrating why the remating date was later in the spring mating period. Torell et al. (1956) and Smith (1964) reported similar results. Smith obtained somewhat longer intervals in his study since he observed the ewe flock until all ewes had remated; nonetheless, spring-lambing ewes tended to exhibit a longer period of post-partum anestrus.

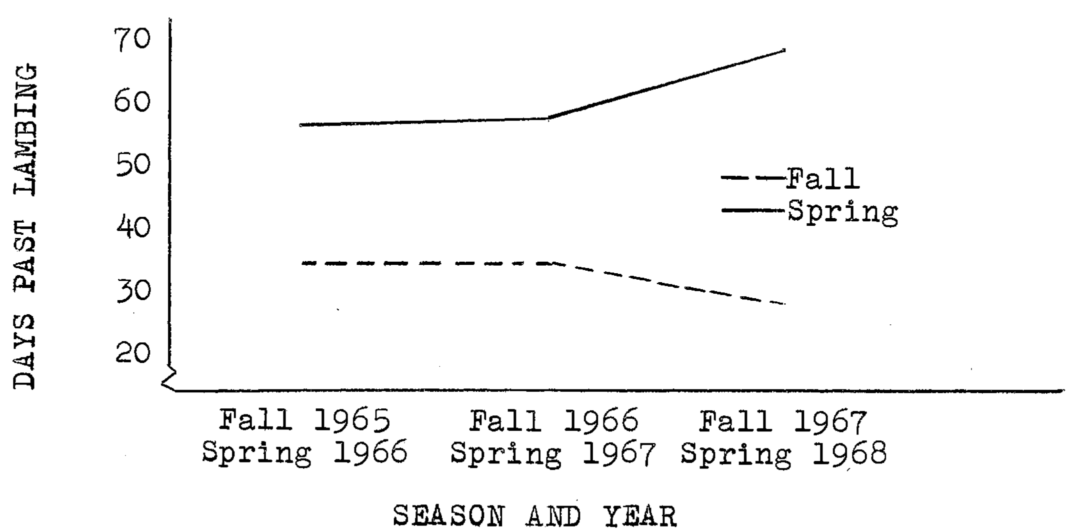

Figure 5. Means for the Interval from Lambing to First Estrus

Values of F and error mean squares obtained from the analyses of variance within three spring and three fall seasons for the interval from lambing to first estrus are presented in Tables XI and XII. The test for lack of fit indicated that the linear model adequately described the data for the interval from lambing to first estrus.

These data indicated that group of ewe was a significant source of variation ($P < .05$) in the fall of 1965. Least squares means for the groups in this one season are illustrated in Figure 6. Ewes in group one returned to estrus in a mean of 34 days which was eight days longer than group two ewes ($P < .05$). Group three ewes required 41 days to return to estrus following parturition which was significantly ($P < .05$) longer than the other two groups of ewes studied. Since the trend of group two ewes exhibiting a shorter post-partum anestrus period was not apparent in subsequent years, the results in 1965 were probably associated with the age of ewe rather than when the ewes were first started on the lambing regime. Barker and Wiggins (1964b) indicated 2-, 3- and 4-year-old ewes reacted similarly relative to the post-partum interval to remating; yet, an unexplained interaction was reported between age of ewe and year.

The breed of ewe was a significant ($P < .01$) source of variation in the spring season. The least squares means for breed of ewe in the three spring seasons are illustrated in Figure 7. Again, as in the date of first estrus data, the Dorset ewes tended to establish estrual cycles

TABLE XI

ERROR MEAN SQUARES AND F VALUES FOR INTERVAL FROM LAMBING TO FIRST ESTRUS IN THE SPRING SEASON

Source	1966	1967	1968	Pooled
Group of ewe	1.296	0.733	0.238	0.827
Type of birth	0.375	1.330	0.931	0.930
Breed of ewe	1.077	6.921**	7.326**	5.238**
Interaction (BxC)	0.143	0.694	0.736	0.538
Lack of fit	1.086	1.270	0.644	1.171
Lack of fit (d.f.)[a]	(12)	(14)	(9)	(35)
E.M.S.	284.414	349.720	211.929	272.324
E.M.S. (d.f.)[a]	(61)	(17)	(34)	(112)

[a] Degrees of freedom associated with corresponding source of variation

** $P < .01$

TABLE XII

ERROR MEAN SQUARES AND F VALUES FOR INTERVAL FROM LAMBING TO FIRST ESTRUS IN THE FALL SEASON

Source	1965	1966	1967	Pooled
Group of ewe	4.433*	1.082	0.179	1.786
Type of birth	0.722	0.182	0.120	0.290
Breed of ewe	0.213	0.499	1.785	0.581
Interaction (BxC)	0.426	1.167	0.673	0.732
Lack of fit	0.611	0.836	1.595	0.815
Lack of fit (d.f.)[a]	(7)	(8)	(3)	(18)
E.M.S.	208.629	298.540	123.071	237.068
E.M.S. (d.f.)[a]	(40)	(31)	(7)	(78)

[a] Degrees of freedom associated with the corresponding source of variation

* $P < .05$

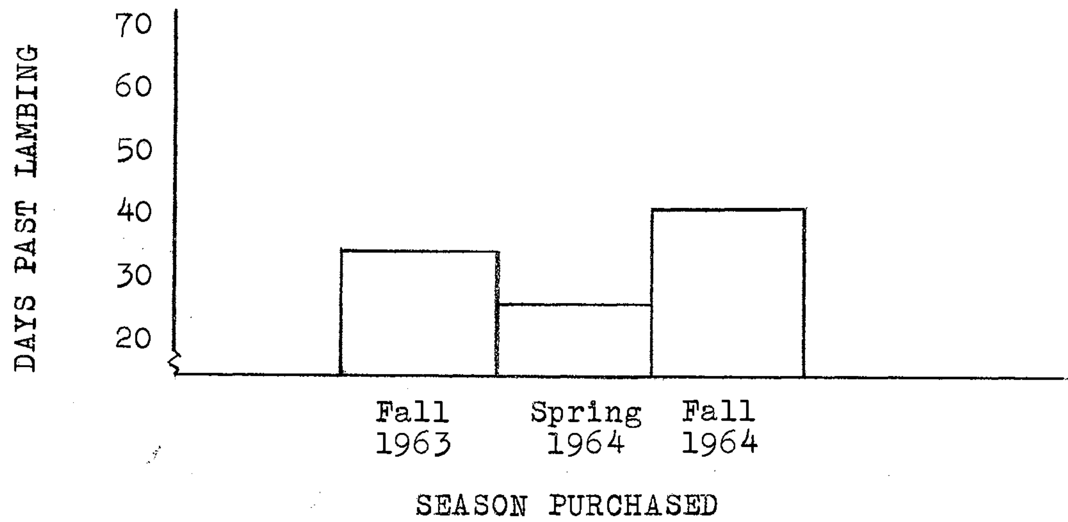

Figure 6. Effect of Group of Ewe on the Interval From Lambing to First Estrus for the Fall of 1965

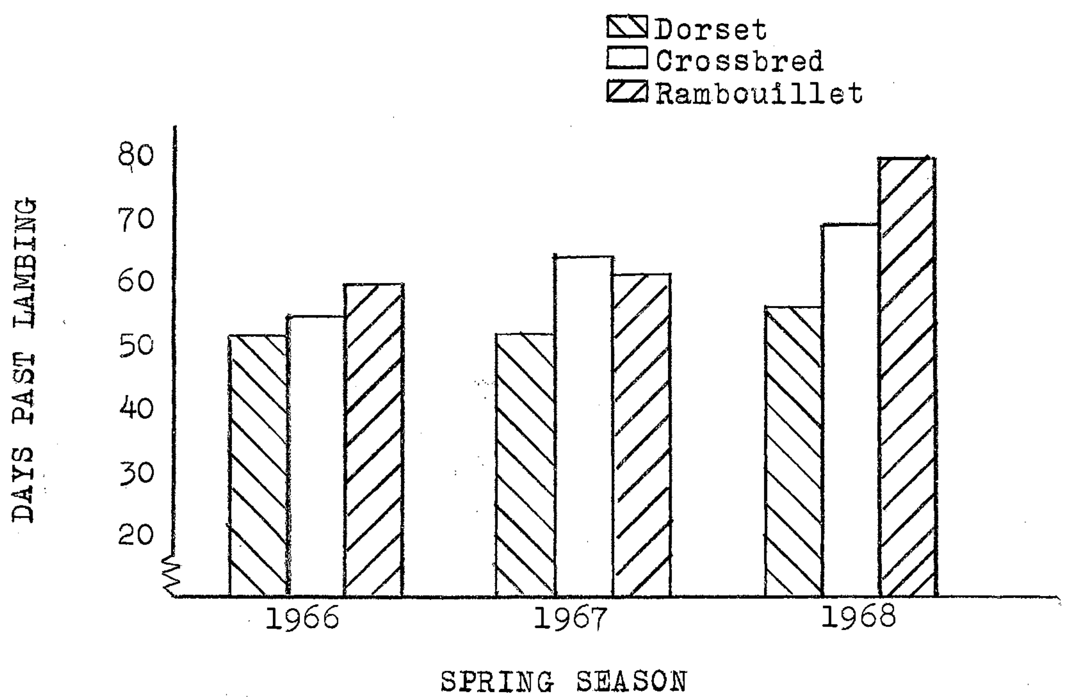

Figure 7. The Effect of Breed of Ewe on Interval From Lambing to First Estrus in the Spring Season

more rapidly following lambing than did the other two breeds studied. Although the intervals were not significantly different in 1966, the Dorset ewes remated three days before the Rambouillet ewes and six days before the Crossbreds. In 1967 Dorsets returned 8 and 10 days ($P < .01$) sooner than the Rambouillet and Crossbred ewes, respectively; furthermore, Dorsets remated 11 days sooner than the Crossbreds which in turn remated 11 days before the Rambouillet ewes ($P < .01$) in 1968. These results agreed with those reported by Barker and Wiggins (1964a) when Dorset ewes involved in the study tended to return to estrus following parturition more rapidly than did the Rambouillet and Crossbred ewes involved.

<u>Conclusions on Post-Partum Estrus</u>

An evaluation of ewe post-partum estrual activity indicated that a season difference did exist. Spring-lambing ewes were less likely to return to estrus following parturition and those ewes that did return, exhibited a longer period of anestrus than ewes lambing in the fall. These results were similar to the seasonal trends noted in the literature. The group of ewe was a significant source of variation in the fall of 1965 which was probably associated with the age of ewe involved in the study. Furthermore, within the spring season breed of ewe was a source of variation with Dorset ewes returning to estrual activity sooner than the Rambouillet and Crossbred ewes.

The magnitude of the error mean squares may have indicated that some unidentified source of variation was involved. However, since the data collected did not show what this source may be, it was assumed that the error term was associated with the individual ewe variation. This large individual variation was reported by Barker and Wiggins (1964a,b), Hulet and Foote (1967), Hunter and Lishman (1967) and Williams et al. (1956) in that establishment of estrual activity was not repeatable from year to year.

Post-Partum Conception

Post-partum conception data for ewes involved in the twice-yearly lambing program are presented in Table XIII. Of the 188 fall-lambing ewes, 71 percent conceived after parturition whereas only 23 percent of the 495 spring-lambing ewes conceived post-partum. Furthermore, 84 percent of the ewes that remated in the fall conceived while 45 percent of those remating in the spring conceived following parturition.

Conflicting results relative to post-partum conception performance were reported in the literature. Kirillov (1944) reported results similar to those under the present study while Udoljskii et al. (1940), Usakava and Fudelj (1941) and Gordon (1958b) reported percentages that exceeded those in this study. Furthermore, Hafez (1952) and Hulet and Foote (1967) reported lower values of 8 and 28 percent conceiving post-partum, respectively. These discrepancies were probably associated with breed of ewe, location, length of post-partum breeding season, and in one case, Gordon (1958b), previous treatments imposed on the animals.

TABLE XIII

POST-PARTUM CONCEPTION PERFORMANCE OF EWES

	Fall	Spring
No. lambing	188	495
Avg. lambing date[a]	Oct. 16	Mar. 27
No. mating	159	248
No. conceiving	134	113
Percent conceiving	71	23
No. conceiving to first mating	75	94
Percent conceiving to first mating	47	38
Avg. interval to conception	44	66
Avg. conception date[a]	Nov. 29	June 1

[a] Refers to ewes that lambed, rebred and conceived

Other season differences observed in the post-partum estrual activity data were detected in the conception data. The ewes required 22 more days to conceive during the spring than during the fall breeding period. The literature lacked information relative to post-partum conception performance; however, based on trends previously reported together with those observed in this study, it appears that on the average ewes conceived later than the mean remating date. This would be expected because not all ewes will conceive to the first mating. In the fall season 47 percent of the ewes settled to the first post-partum mating while 38 percent conceived to first estrus in the spring. Furthermore, since a ewe might mate only once in the spring breeding season because of the long post-partum interval, a larger percent of those conceiving settled to the first mating than in the fall (83 versus 56 percent, respectively). The percent reported in the fall-lambing ewes was lower than the 75 percent reported by Gordon (1958b). His difference may be associated with a "carry-over" effect of hormone treatments administered during the previous spring season. The data indicated that the ewes were more sexually active and fertile in the fall breeding season. Observations of this type may be expected because this period is the normal period of estrus.

Conception Date Following Parturition

The error mean squares and F values obtained from the analyses of variance for spring and fall conception dates following lambing are found in Tables XIV and XV, respectively. The tests for lack of fit were nonsignificant in each season. Group of ewe was a significant ($P < .05$) source of variation in the fall of 1965 but not in ensuing

TABLE XIV

ERROR MEAN SQUARES AND F VALUES FOR DATE OF POST-PARTUM CONCEPTION IN THE SPRING SEASON

Source	1966	1967	1968	Pooled
Group of ewe	1.667	0.830	0.197	0.633
Type of birth	2.517	0.013	0.020	0.602
Breed of ewe	7.108**	0.234	3.740*	3.435**
Interaction (BxC)	1.201	0.071	2.632	1.509
Lack of fit	0.345	0.882	0.722	0.645
Lack of fit (d.f.)[a]	(7)	(4)	(7)	(18)
E.M.S.	58.267	45.055	119.517	82.766
E.M.S. (d.f.)[a]	(20)	(3)	(19)	(42)

[a] Degrees of freedom for the appropriate source of variation

* $P < .05$

** $P < .01$

TABLE XV

ERROR MEAN SQUARES AND F VALUES FOR DATE OF POST-PARTUM CONCEPTION IN THE FALL SEASON

Source	1965	1966	1967	Pooled
Group of ewe	4.651*	0.383	0.761	1.791
Type of birth	0.114	0.445	0.384	0.280
Breed of ewe	0.883	0.223	1.034	0.533
Interaction (BxC)	0.215	0.660	0.786	0.473
Lack of fit	1.400	0.563	0.909	0.934
Lack of fit (d.f.)[a]	(7)	(8)	(1)	(16)
E.M.S.	249.756	280.815	169.000	260.172
E.M.S. (d.f.)[a]	(36)	(27)	(2)	(65)

[a] Degrees of freedom for the appropriate source of variation

* $P < .05$

seasons. Figure 8 illustrates the least squares means for group of ewe in 1965 as taken from Appendix Tables XXV and XXVI. Group 3 ewes conceived 9 days earlier within the breeding period than group 1 ewes and 17 days earlier than group 2 ewes (P< .05). This response was expected because group 3 ewes, lambing for the first time, lambed an average of 15 days earlier than did the other two groups involved.

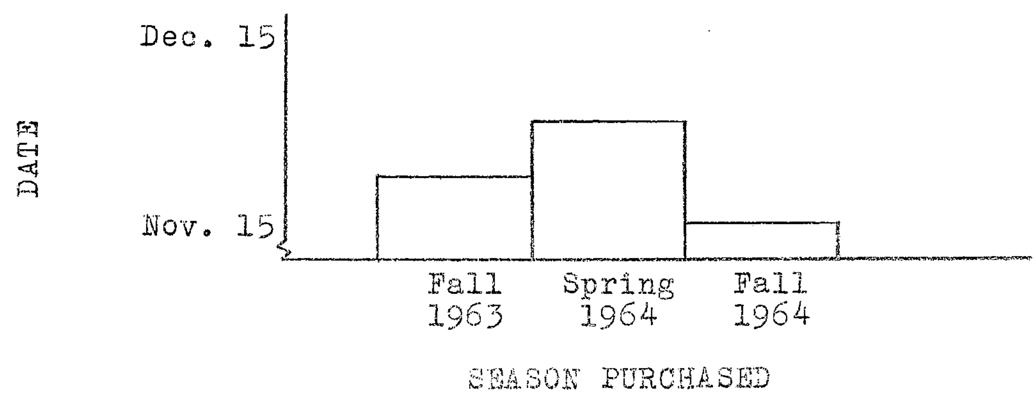

Figure 8. The Effect of Group of Ewe on Conception Date Following Parturition in the Fall of 1965

Within the spring season, breed of ewe was a significant source of variation in 1966 (P< .01), 1968 (P< .05) and in the pooled estimate (P < .01). The least squares means for the effect of breed of dam in the spring are illustrated in Figure 9. In 1966 Rambouillet ewes conceived 10 and 14 (P< .01) days earlier than the Dorset or Crossbred ewes, respectively. However, just the opposite trend was observed in the spring of 1968 when Dorset and

Crossbred ewes conceived approximately eight days earlier in the breeding season than Rambouillet ewes. A trend similar to that in 1968 was observed in 1967 although the differences were not significant possibly because of the low number of observations (16) on ewes conceiving post-partum in that season. Although Dorset ewes established estrual activity earlier in the breeding season, the three breeds of ewes exhibited no definite trends relative to the order in which they may be expected to conceive following parturition. These data may suggest that the first estrual cycle in Dorset ewes was not accompanied in all instances by ovulation similar to the estrual activity immediately post-partum reported by Barker and Wiggins (1964a). These authors reported that a significantly higher frequency of Dorset ewes exhibited this type of heat than the Rambouillet or Crossbred ewes involved. However, this assumption would be contrary to the results of Hunter and Lishman (1967) when they utilized laparotomy techniques and detected ovulation approximately 25 days prior to the visual manifestations of estrus in Merino ewes. No attempt was made in the present study to detect whether or not ovulation occurred at first estrus.

The least squares means for the spring and fall conception dates are plotted in Figure 10. The mean post-partum conception dates occurred after two-thirds of the breeding cycle had elapsed and in the 1967 spring season the mean was only nine days prior to the termination of breeding. Thus, apparently the conception date following

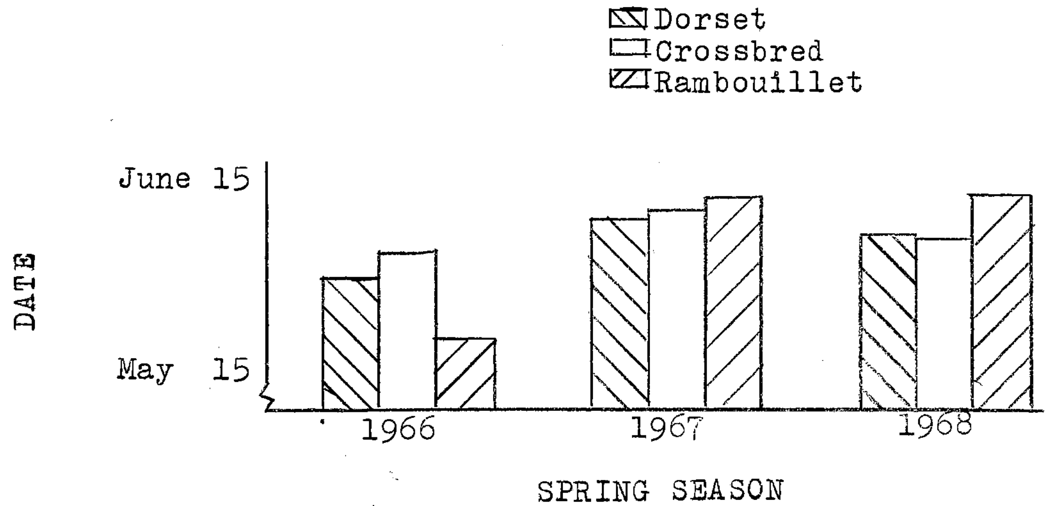

Figure 9. The Effect of Breed of Ewe on the Spring Conception Date Following Lambing

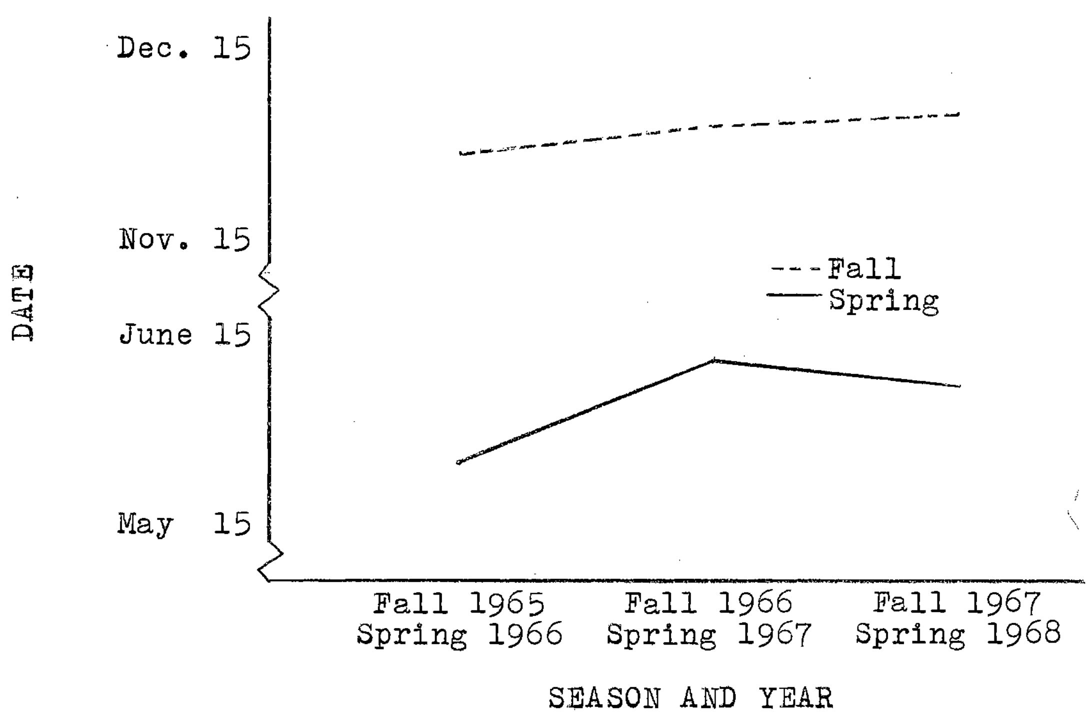

Figure 10. Means for Conception Date Following Parturition

parturition occurred too late in the breeding cycles to effectively sustain a program of twice-yearly lambing over a period of time. An evaluation of the interval from lambing to conception was necessary to support the preceding observations.

Interval From Lambing to Conception

The least squares means taken from Appendix Tables XXVII and XXVIII for the interval to conception in the spring and fall seasons are plotted in Figure 11. The spring intervals of 55.1, 62.9 and 74.5 days over the three years data analyzed were longer than those of 41.4, 45.3 and 39.5 days observed in the fall. These intervals were longer than the minimum necessary to effectively produce lambs every six months; however, ewes could be expected to produce three lamb crops in a two-year period. The literature lacked reports relative to the post-partum conception interval in the spring season. The fall interval agreed with the 41 days reported by Granger (1947); however, Udoljskii et al. (1940) reported an interval of 110 days post-partum. Evidence was not presented why the interval was this long in the Precose ewes of Russia.

Error mean squares and values of F are presented in Tables XVI and XVII for the spring and fall intervals from lambing to conception. Lack of fit was again nonsignificant. Breed of ewe was a significant ($P < .01$) source of variation in the spring season. Least squares means as

TABLE XVI

ERROR MEAN SQUARES AND F VALUES FOR THE POST-PARTUM INTERVAL TO CONCEPTION IN THE SPRING SEASON

Source	1966	1967	1968	Pooled
Group of ewe	1.877	7.347	0.011	1.322
Type of birth	3.972	4.473	0.002	1.955
Breed of ewe	11.956**	9.657*	3.037	6.498**
Interaction (BxC)	1.991	2.167	2.251	1.642
Lack of fit	2.112	1.578	0.397	1.220
Lack of fit (d.f.)[a]	(7)	(4)	(7)	(18)
E.M.S.	141.427	26.233	103.010	115.827
E.M.S. (d.f.)[a]	(20)	(3)	(19)	(42)

[a] Degrees of freedom for the indicated source of variation

* P< .05

* P< .01

TABLE XVII

ERROR MEAN SQUARES AND F VALUES FOR THE POST-PARTUM INTERVAL TO CONCEPTION IN THE FALL SEASON

Source	1965	1966	1967	Pooled
Group of ewe	1.580	0.104	1.190	0.658
Type of birth	1.002	1.669	0.535	0.924
Breed of ewe	0.381	0.526	8.331	0.743
Interaction (BxC)	0.088	0.284	1.860	0.221
Lack of fit	0.656	1.343	2.103	0.980
Lack of fit (d.f.)[a]	(7)	(8)	(1)	(16)
E.M.S.	194.082	176.626	28.597	181.739
E.M.S. (d.f.)[a]	(36)	(27)	(2)	(65)

[a] Degrees of freedom for the indicated source of variation

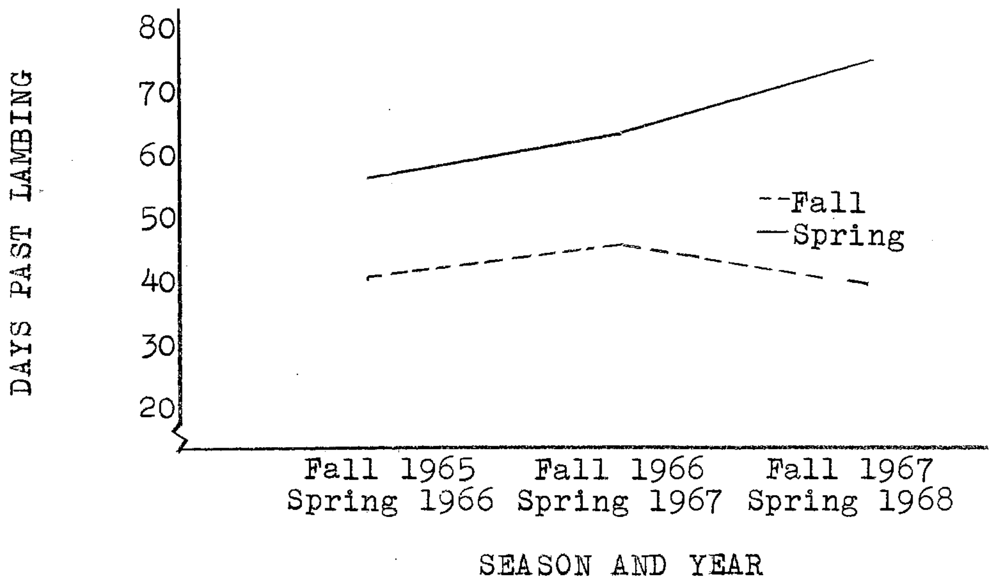

Figure 11. Means for the Interval From Lambing to Conception

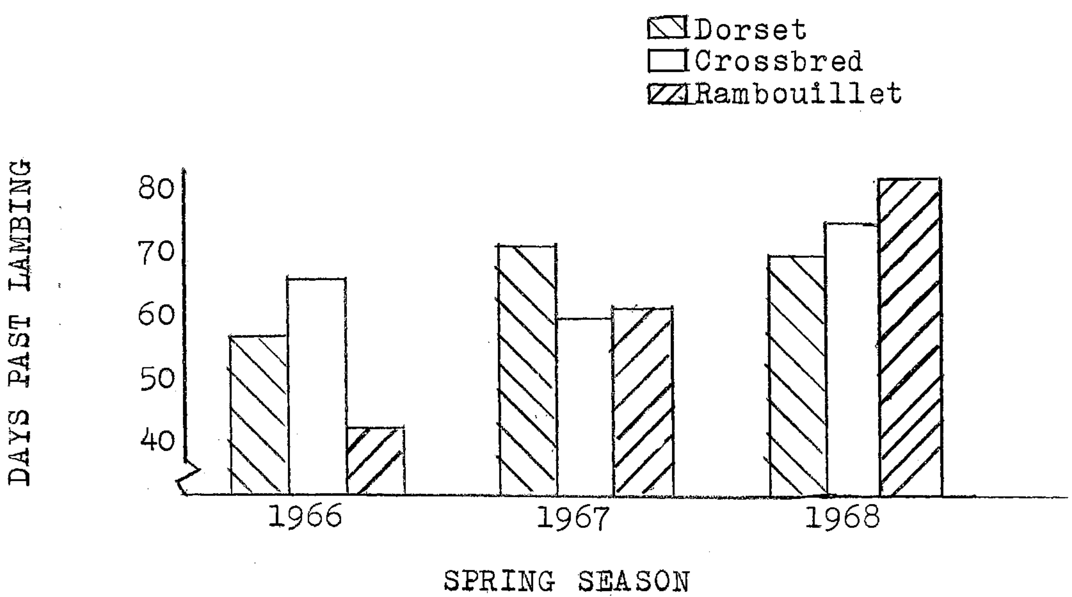

Figure 12. The Effect of Breed of Ewe on the Spring Interval From Lambing to Conception

illustrated in Figure 12 revealed that in 1966 Dorset ewes conceived nine days earlier than Crossbreds and 15 days later ($P < .01$) than Rambouillet ewes; however, Rambouillet and Crossbred ewes in 1967 conceived 12 days sooner ($P < .05$) than did the Dorset ewes. Although the differences were not significant in 1968, Dorset ewes conceived 6 and 12 days earlier than Crossbred or Rambouillet ewes, respectively. Thus, although breed of ewe significantly affected the interval from lambing to conception, an interaction was apparent between breed and year such that no definite trend was established relative to which breed could be expected to conceive more quickly. The literature did not contain breed comparisons for postpartum conception and, since these results conflicted with the trend observed in the estrual activity data, mating and conception responses were not compared.

The nonsignificant F values obtained in 1967 spring and fall were associated with a limited number of degrees of freedom in the error term (3 and 2, respectively); therefore, little emphasis can be placed on these values. The rather large but nonsignificant ($P < .05$) F value reported for type of birth in the spring of 1966 could possibly be attributed to chance when only 15 ewes gave birth to multiple lambs. However, since ewes with multiple births tended to return nine days earlier than those with single births, this response could be associated with the fertility of the ewes involved.

Conclusions on Post-Partum Conception

Several trends in the conception data were similar to those previously described in the estrus data. Spring-lambing ewes conceived approximately 22 days later post-partum than did fall-lambing ewes; furthermore, a larger proportion of ewes conceived post-partum in the fall indicating that ewes were more fertile in this season. Similarly, other than the individual or within cell variation, breed of ewe was apparently the major source of variation in both conception date and post-partum conception interval in the spring. A definite trend relative to breed performance was not established in the interval data.

Miscellaneous Observations

This section presents observations on data that lacked sufficient numbers to run a meaningful statistical analysis. The frequencies of individual ewe breeds exhibiting estrus and conception following parturition are presented. Data is presented on the effect of lactation as noted by Hafez (1952), Williams *et al*. (1956) and Torell *et al*. (1956). The performance of open ewes is compared in groups according to their previous season's post-partum estrual activity.

Breed Frequencies

Table XVIII presents a summary of the post-partum performance of the three breeds of ewes involved in the twice-yearly lambing program. A lower percentage of the Dorset ewes (80 percent) mated following fall lambing than did either Crossbreds (87 percent) or Rambouillets (85 percent). The Dorsets appeared less fertile in that 71 percent conceived to post-partum matings compared to 86 and 96 percent reported for the Crossbred and Rambouillet ewes, respectively. Thus, these data and the frequency of ewes that lambed, rebred and conceived in the fall, indicated that Rambouillet ewes were more likely to produce post-partum conceived lambs than the Dorset or Crossbred ewes.

The reverse trend was observed in spring-lambing ewes. Thirty-seven percent of the Rambouillet ewes mated post-partum whereas 62 and 53 percent of the Dorset and Cross-bred ewes mated. Furthermore, only 16 percent of the Rambouillet ewes lambed, rebred and conceived compared to 26 and 25 percent for the other two breeds involved. Thus, these data indicated that the three breeds of ewes were primarily fall-breeding ewes but several ewes bred in either season and while one breed performed more desirably in one season, its post-partum performance was lowest in the next season.

Effect of Lactation

Table XIX presents observations relative to the performance of lactating and nonlactating ewes. Nonlactating ewe data were collected from the small number of ewes that

TABLE XVIII

PERFORMANCE OF DORSET, RAMBOUILLET AND DORSET BY RAMBOUILLET EWES FOLLOWING PARTURITION

	Fall			Spring		
	D	DxR	R	D	DxR	R
No. lambing	60	74	54	132	178	185
No. mating[a]	48	65	46	82	96	70
Percent mating	80	87	85	62	53	37
No. conceiving[a]	34	56	44	36	46	31
Conception rate	71	86	96	44	48	44
Percent lamb., rebred, conc.	56	77	81	26	25	16

[a] Refers to ewes mating post-partum

TABLE XIX

OBSERVATIONS ON THE ASSOCIATION BETWEEN LACTATION AND POST-PARTUM REPRODUCTIVE PERFORMANCE

	Fall		Spring	
	Nonlact.	Lact.	Nonlact.	Lact.
No. of records	29	159	16	479
No. remating	28	131	13	240
Percent remating	96	82	81	50
Avg. int. to first estrus	33	32	37	58
No. conceiving post-partum	21	113	8	108
Percent conceiving[a]	75	86	62	45
Avg. int. to concep.	43	44	57	65

[a] Refers to those remating following parturition

lost their lambs within two weeks following birth. The fall data indicated that stress from lactation tended to reduce the frequency of ewes remating following parturition. Ninety-six percent of the nonlactating ewes exhibited estrus whereas only 82 percent remated while lactating. Lactation did not appear to reduce the fertility of ewes remating in that 86 percent conceived as compared to 75 percent in the nonlactating ewes. Furthermore, the intervals from lambing to estrus and conception did not appear to be affected by lactation.

In the spring a ewe was more likely to rebreed and conceive subsequent to lambing if she was not lactating. A higher percentage of the nonlactating ewes returned to estrus and a larger proportion of these ewes conceived than ewes that were raising lambs. Also, the nonlactating ewes remated in a mean of 47 days and conceived in an average of 57 days post-partum compared to the means of 58 and 65 days, respectively, for lactating ewes.

The literature revealed quite variable results with respect to lactation stress. Hafez (1952) found that lactation would completely suppress estrus. Torell et al. (1956) found that some ewes would not return to estrus while lactating but the interval from lambing to estrus for those returning was similar to nonlactating ewe performance. Smith (1964) reported that lactation significantly increased the interval from parturition to estrus at any time of the year. Ravenscrift (1941) reported that lactation in the fall season increased the interval by 69 days post-partum. Similarly, Barker and Wiggens (1964b) reported that lactation increased the interval by 22 and 33 days in 1957 and 1958, respectively. The increases were somewhat larger than the differences reported in this study; however, since the intervals were shorter, a smaller increase would be exptected.

Comparisons Involving Open Ewes

Data involving open ewes indicated that they were more sexually active in the fall when 88 percent mated than in the spring with 82 percent mating. Furthermore, the ewes were more fertile in that 98 percent of the ewes conceived to fall mates and 82 percent conceived in the spring. These results agreed with the values of 97 and 84 percent reported by Shelton and Morrow (1965). Usakava and Fudelj (1941) reported similar results of a 98 and 79 percent conception rate in Romanov ewes. In work with Merino ewes by Watson (1953), Dun *et al*. (1960) and Watson and Radford (1966), 11 percent more ewes exhibited estrus and ten percent more conceived in the fall than the spring season.

Observations relative to open ewe performance when compared in groups based on the previous season's post-partum estrual activity are presented in Table XX. Although the number of observed instances in the spring season was low, ewes which did not exhibit estrus following parturition in the fall tended to be more sexually active and fertile than those showing estrus. Of the ewes showing estrus, 76 percent mated in the spring and 77 percent conceived whereas 84 percent mated and 87 percent of these conceived from the ewes not showing estrus in the fall. These observations may be a function of the numbers involved; however, the same general trend was observed in the fall when larger numbers were involved. Comparisons between groups of ewes exhibiting post-partum estrus and those not showing estrus indicated 83 and 91 percent of the respective groups mated and 97 and 98 percent conceived in the ensuing fall season. Evidence was not found in the literature that either substantiated or explained this trend, nor did the literature indicate the reasons for this trend.

TABLE XX

BREEDING PERFORMANCE OF OPEN EWES RELATIVE TO THEIR PREVIOUS SEASON'S POST-PARTUM ACTIVITY

Sexual Activity[a]	Fall		Spring	
	Estrus	No Estrus	Estrus	No Estrus
No. of open ewes	108	169	17	19
No. mating	90	154	13	16
Percent mating	83	91	76	84
No. conceiving	88	152	10	14
Conception rate[b]	97	98	77	87
Avg. prior season's lambing date	Oct. 17	Oct. 20	Apr. 4	Apr. 8
Avg. conception date	Nov. 2	Oct. 30	May 9	Apr. 25

[a] Refers to ewes post-partum activity in previous season
[b] Based on those that mated

CHAPTER V

SUMMARY

The post-partum reproductive performance of 182 ewes involved in a twice-yearly lambing regime was evaluated from records covering a four-year period from 1964 through 1968. Approximately equal numbers of Dorset, Rambouillet and Dorset X Rambouillet ewes were exposed to intact rams for 60 days twice each year. With spring and fall breeding beginning on April 20 and October 20, respectively, the lambing periods were from September 15 through November 15 and March 15 through May 15. Performance subsequent to lambing was evaluated from the standpoint of frequency of ewes showing estrus and conception, first estrus date, conception date and the intervals from lambing to first estrus and conception. The analyses were conducted on a within season basis.

The data indicated an advantage of 0.71 lambs produced under this program per ewe per year above the normal flock average in Oklahoma. Of the lambs born in the fall, 72 percent were conceived post-partum and 28 percent of the lambs born in the spring were conceived following parturition in the fall. Fifty percent of the spring-lambing ewes exhibited estrus whereas 85 percent were observed in heat following parturition in the fall. These results were associated with the fact that 71 percent of those remating in the fall conceived but only 23 percent remated and conceived in the spring. Also, spring-lambing ewes required 27 more days to mate post-partum and required 22 more days from lambing to conception than did fall-lambing ewes.

The source of variation denoting when a ewe was purchased (group of ewe) was significant in the fall of 1965 for the variables of interval from lambing to first estrus and conception date. The effect of group on the interval was probably associated with age where the younger ewes required a longer period to resume estrual activity. The effect on post-partum conception date was associated with the lambing date in that ewes lambing for the first time lambed at an earlier date than the other two groups involved. Since the data from the fall of 1964 and spring of 1965 were deleted from the analyses, further evidence was not available to support these observations.

Breed of ewe was a significant source of variation for all four of the variables studied within the spring seasons. Dorset ewes tended to return to estrual activity at an earlier date post-partum than did the Rambouillet or Crossbred ewes; however, no definite trend was established relative to which breed would be expected to conceive most rapidly following parturition in the spring season. The post-partum reproductive performance was low for all three breeds of ewes especially in the spring season. The percent of ewes that lambed, rebred and conceived in the fall was highest for Rambouillet ewes and lowest for Dorset ewes while just the reverse trend was observed in the spring season.

These data indicated that, although the intervals from lambing to conception were longer than the range necessary to sustain a continuous program of multiple frequency lambing, an intensified production scheme involving post-partum conceptions is feasible. Further research is required to reduce this interval especially in the spring season. Areas of possible research include discovery of artificial techniques such as control of environmental conditions and hormonal therapy to induce estrus and ovulation.

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APPENDIX

TABLE XXI

LEAST SQUARES CONSTANTS FOR SPRING REMATING DATE

Effect	Spring 1966			Spring 1967			Spring 1968		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	81	148.0	±1.4	39	150.9	±2.6	51	152.1	±2.1
Group of ewe									
1	23	2.0	±2.0	13	-3.6	±3.2	16	1.7	±2.9
2	28	-1.5	±1.9	11	-0.8	±3.5	16	-1.5	±3.0
3	30	-0.5	±1.9	15	4.4	±3.2	19	-0.2	±2.7
Type of birth									
Single	44	0.9	±1.4	15	-5.2	±2.6	21	-0.3	±2.1
Multiple	37	-0.9	±1.4	24	5.2	±2.6	30	0.3	±2.1
Breed of ewe									
Rambouillet	28	0.5	±2.1	6	3.8	±4.5	13	11.8	±2.9
Dorset	27	-1.8	±2.0	17	-8.8	±3.5	12	-10.3	±3.2
Corssbred	26	1.3	±2.0	16	5.0	±3.3	26	-1.5	±2.7
Interaction									
Single x Ramb.	22	0.5	±2.1	2	-2.2	±4.4	5	1.5	±3.2
Single x Dorset	10	-0.4	±2.0	6	-0.6	±3.4	7	2.8	±3.2
Single x Crossbred	12	-0.1	±2.0	7	2.8	±3.3	9	-4.3	±2.7
Mult. x Ramb.	6	-0.5	±2.1	4	2.2	±4.4	8	-1.5	±3.2
Mult. x Dorset	17	0.4	±2.0	11	0.6	±3.4	5	-2.8	±3.2
Mult. x Crossbred	14	0.1	±2.0	9	-2.8	±3.3	17	4.3	±2.7

TABLE XXII

LEAST SQUARES CONSTANTS FOR FALL REMATING DATE

Effect	Fall 1965			Fall 1966			Fall 1967		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	55	317.3	±3.0	47	322.2	±2.8	18	329.0	±4.4
Group of ewe									
1	11	0.9	±3.9	14	-4.6	±3.7	6	4.1	±7.4
2	18	4.1	±3.5	19	-1.4	±3.5	4	-2.8	±6.5
3	26	-5.0	±3.3	14	6.0	±3.4	8	-1.3	±5.8
Type of birth									
Single	45	-0.9	±3.0	20	4.1	±2.8	13	-2.3	±4.5
Multiple	10	0.9	±3.0	27	-4.1	±2.8	5	2.3	±4.5
Breed of ewe									
Rambouillet	19	5.8	±4.3	14	3.5	±3.8	4	-0.5	±7.2
Dorset	13	-0.5	±4.4	12	-3.7	±4.1	8	-12.8	±6.0
Crossbred	23	-5.3	±4.1	21	0.2	±3.5	6	13.3	±6.5
Interaction									
Single x Ramb.	16	4.5	±4.5	10	-1.2	±4.0	2	-0.2	±6.5
Single x Dorset	10	-4.9	±4.4	3	-3.6	±4.1	6	5.1	±6.2
Single x Crossbred	19	0.4	±4.0	7	4.8	±3.4	5	-4.9	±7.5
Mult. x Ramb.	3	-4.5	±4.5	4	1.2	±4.0	2	0.2	±6.5
Mult. x Dorset	3	4.9	±4.4	9	3.6	±4.1	2	-5.1	±6.2
Mult. x Crossbred	5	-0.4	±4.0	14	-4.8	±3.4	1	4.9	±7.5

TABLE XXIII

LEAST SQUARES CONSTANTS FOR SPRING INTERVAL TO FIRST ESTRUS

Effect	Spring 1966			Spring 1967			Spring 1968		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	81	55.0	±2.0	39	58.4	±3.7	51	68.2	±2.1
Group of ewe									
1	23	4.3	±2.8	13	-4.9	±4.6	16	2.1	±2.9
2	28	-2.9	±2.7	11	1.6	±4.9	16	-1.8	±3.0
3	30	-1.4	±2.7	15	3.3	±4.5	19	-0.3	±2.7
Type of birth									
Single	44	1.2	±2.1	15	-9.2	±3.7	21	-2.2	±2.1
Multiple	37	-1.2	±2.1	24	9.2	±3.7	30	2.2	±2.1
Breed of ewe									
Rambouillet	28	-0.3	±3.0	6	2.3	±6.3	13	11.2	±3.1
Dorset	27	-3.3	±2.8	17	-6.2	±4.9	12	-11.9	±3.2
Crossbred	26	3.6	±2.8	16	3.9	±4.6	26	0.7	±2.7
Interaction									
Single x Ramb.	22	1.0	±3.0	2	-6.7	±6.1	5	-0.5	±3.2
Single x Dorset	10	-1.5	±2.9	6	2.7	±4.7	7	3.4	±3.2
Single x Crossbred	12	0.5	±2.8	7	4.0	±4.7	9	-2.9	±2.7
Mult. x Ramb.	6	-1.0	±3.0	4	6.7	±6.1	8	0.5	±3.2
Mult. x Dorset	17	1.5	±2.9	11	-2.7	±4.7	5	-3.4	±3.2
Mult. x Crossbred	14	-0.5	±2.8	9	-4.0	±4.7	17	2.9	±2.7

TABLE XXIV

LEAST SQUARES CONSTANTS FOR FALL INTERVAL TO FIRST ESTRUS

Effect	Fall 1965			Fall 1966			Fall 1967		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	55	33.7	±2.6	47	33.2	±3.0	18	28.7	±3.5
Group of ewe									
1	11	0.3	±3.3	14	-3.5	±3.6	6	-0.4	±5.9
2	18	-7.3	±2.9	19	-2.0	±3.7	4	1.9	±5.2
3	26	7.0	±2.7	14	5.5	±3.7	8	-1.5	±4.6
Type of birth									
Single	45	-2.2	±2.5	20	1.3	±3.0	13	-0.3	±3.6
Multiple	10	2.2	±2.5	27	-1.3	±3.0	5	0.3	±3.6
Breed of ewe									
Rambouillet	19	-0.3	±3.6	14	4.7	±4.1	4	-0.5	±5.8
Dorset	13	2.2	±3.7	12	-3.6	±4.4	8	-6.9	±4.8
Crossbred	23	-1.9	±3.4	21	-1.1	±3.7	6	7.4	±5.2
Interaction									
Single x Ramb.	16	3.2	±3.7	10	3.5	±4.2	2	-0.2	±5.2
Single x Dorset	10	-3.1	±3.7	3	-6.8	±4.4	6	5.1	±4.9
Single x Crossbred	19	-0.1	±3.4	7	3.3	±3.6	5	-4.9	±6.0
Mult. x Ramb.	3	-3.2	±3.7	4	-3.5	±4.2	2	0.2	±5.2
Mult. x Dorset	3	3.1	±3.7	9	6.8	±4.4	2	-5.1	±4.9
Mult. x Crossbred	5	0.1	±3.4	14	-3.3	±3.6	1	4.9	±6.0

TABLE XXV

LEAST SQUARES CONSTANTS FOR SPRING CONCEPTION DATE

Effect	Spring 1966			Spring 1967			Spring 1968		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	35	146.3	±1.3	15	161.1	±2.0	34	157.2	±2.3
Group of ewe									
1	13	-2.9	±2.1	6	2.5	±2.3	11	-1.4	±2.8
2	15	-2.0	±1.6	2	-4.6	±3.1	10	-0.1	±2.7
3	7	4.9	±2.4	7	2.1	±2.2	13	1.5	±2.4
Type of birth									
Single	20	2.3	±1.3	6	-0.2	±1.8	14	0.3	±2.3
Multiple	15	-2.3	±1.3	9	0.2	±1.8	20	-0.3	±2.3
Breed of ewe									
Rambouillet	10	-8.4	±2.2	3	1.9	±2.9	10	5.4	±3.1
Dorset	11	2.6	±2.0	9	-1.3	±2.0	6	-2.9	±4.1
Crossbred	14	5.8	±1.7	3	-0.6	±2.9	18	-2.5	±2.8
Interaction									
Single x Ramb.	8	3.4	±2.1	1	2.6	±2.9	4	0.2	±3.3
Single x Dorset	5	-2.5	±1.8	3	1.4	±3.6	5	6.5	±4.2
Single x Crossbred	7	-0.9	±1.9	2	-4.0	±5.6	5	-6.7	±2.8
Mult. x Ramb.	2	-3.4	±2.1	2	-2.6	±2.9	6	-0.2	±3.3
Mult. x Dorset	6	2.5	±1.8	6	-1.4	±3.6	1	-6.5	±4.2
Mult. x Crossbred	7	0.9	±1.9	1	4.0	±5.6	13	6.7	±2.8

TABLE XXVI

LEAST SQUARES CONSTANTS FOR FALL CONCEPTION DATE

Effect	Fall 1965			Fall 1966			Fall 1967		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	51	327.0	±3.1	43	333.2	±3.0	11	336.1	±3.4
Group of ewe									
1	11	0.2	±3.8	13	-3.5	±3.8	3	2.7	±5.7
2	15	8.7	±3.7	17	1.6	±3.7	3	4.1	±4.6
3	25	-8.9	±3.3	23	1.9	±3.6	5	-6.8	±4.9
Type of birth									
Single	42	-1.0	±3.1	19	-2.1	±3.0	8	0.9	±5.0
Multiple	9	1.0	±3.1	24	2.1	±3.0	3	-0.9	±5.0
Breed of ewe									
Rambouillet	18	2.8	±4.3	14	3.3	±4.0	3	3.8	±6.8
Dorset	13	-3.8	±4.4	10	-3.5	±4.8	4	-19.8	±6.3
Crossbred	20	1.0	±4.4	19	0.2	±3.7	4	16.0	±4.2
Interaction									
Single x Ramb.	15	2.0	±4.5	10	-2.2	±4.1	1	-3.5	±4.6
Single x Dorset	10	-2.7	±4.4	2	-2.1	±4.7	3	-0.4	±5.1
Single x Crossbred	17	0.7	±4.2	7	4.3	±3.6	3	3.9	±4.9
Mult. x Ramb.	3	-2.0	±4.5	4	2.2	±4.1	2	3.5	±4.6
Mult. x Dorset	3	2.7	±4.4	8	2.1	±4.7	1	0.4	±5.1
Mult. x Crossbred	3	-0.7	±4.2	12	-4.3	±3.6	1	-3.9	±4.9

TABLE XXVII

LEAST SQUARES CONSTANTS FOR SPRING INTERVAL TO CONCEPTION

Effect	Spring 1966			Spring 1967			Spring 1968		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	35	55.1	±2.6	15	62.9	±3.5	34	74.5	±2.1
Group of ewe									
1	13	-2.7	±4.0	6	3.5	±4.0	11	-0.4	±2.5
2	15	-4.7	±3.2	2	-19.5	±5.1	10	0.3	±2.4
3	7	7.4	±4.7	7	16.0	±4.5	13	0.1	±2.2
Type of birth									
Single	20	4.5	±2.5	6	3.5	±2.9	14	0.1	±2.1
Multiple	15	-4.5	±2.5	9	-3.5	±2.9	20	-0.1	±2.1
Breed of ewe									
Rambouillet	10	-13.5	±4.3	3	-3.7	±4.6	10	6.4	±2.8
Dorset	11	2.1	±3.8	9	7.9	±3.1	6	-5.6	±3.7
Crossbred	14	11.4	±3.3	3	-4.2	±4.4	18	-0.8	±2.5
Interaction									
Single x Ramb.	8	7.3	±4.2	1	-0.9	±4.2	4	-1.9	±3.0
Single x Dorset	5	-3.8	±3.5	3	-3.7	±3.3	5	7.4	±3.8
Single x Crossbred	7	-3.5	±3.8	2	4.6	±5.8	5	-5.5	±2.5
Mult. x Ramb.	2	-7.3	±4.2	2	0.9	±4.2	6	1.9	±3.0
Mult. x Dorset	6	3.8	±3.5	6	3.7	±3.3	1	-7.4	±3.8
Mult. x Crossbred	7	3.5	±3.8	1	-4.6	±4.6	13	5.5	±2.5

TABLE XXVIII

LEAST SQUARES CONSTANTS FOR FALL INTERVAL TO CONCEPTION

Effect	Fall 1965			Fall 1966			Fall 1967		
	No.	Const.	S.E.	No.	Const.	S.E.	No.	Const.	S.E.
Mean	51	41.4	±2.5	43	45.3	±2.6	11	39.5	±1.6
Group of ewe									
1	11	-0.6	±3.2	13	-1.3	±3.3	3	4.3	±2.7
2	15	-4.1	±3.1	17	0.1	±3.2	3	-0.8	±2.2
3	25	4.7	±2.8	23	1.2	±3.1	5	-3.5	±2.4
Type of birth									
Single	42	-2.6	±2.5	19	-3.3	±2.6	8	6.1	±2.4
Multiple	9	2.6	±2.5	24	3.3	±2.6	3	-6.1	±2.4
Breed of ewe									
Rambouillet	18	-2.5	±3.5	14	3.5	±3.5	3	12.2	±3.3
Dorset	13	-0.5	±3.6	10	-0.6	±4.1	4	-13.7	±3.0
Crossbred	20	3.0	±3.6	19	-2.9	±3.2	4	1.5	±2.0
Interaction									
Single x Ramb.	15	-1.4	±3.7	10	0.5	±3.6	1	0.8	±4.5
Single x Dorset	10	1.2	±3.6	2	-2.5	±4.1	3	-2.4	±3.8
Single x Crossbred	17	0.2	±3.5	7	2.0	±3.1	3	1.6	±5.9
Mult. x Ramb.	3	1.4	±3.7	4	-0.5	±3.6	2	-0.8	±4.5
Mult. x Dorset	3	-1.2	±3.5	8	2.5	±4.1	1	2.4	±3.8
Mult. x Crossbred	3	-0.2	±3.5	12	-2.0	±3.1	1	-1.6	±5.9

VITA

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