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Selected Parameters of Reproduction in Rambouillet and St. Croix Ewes

Ronald Cole Evans
Utah State University

SELECTED PARAMETERS OF REPRODUCTION IN RAMBOUILLET AND ST. CROIX EWES

by

Ronald Cole Evans

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Ronald Cole Evans

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ABSTRACT

Selected Parameters of Reproduction
in Rambouillet and St. Croix Ewes

by

Ronald Cole Evans, Master of Science
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Major Professor: Dr. Warren C. Foote
Department: Animal, Dairy and Veterinary Sciences

Experiments were conducted to determine the genetic reproductive potential of Rambouillet and St. Croix ewes. Ovulation rate (monthly) and estrus (daily) were observed for two years on 10 ewes of each breed to establish seasonal patterns. Both breeds demonstrated seasonal anestrus from May through July. Ovulation rates reached 2.0 or greater for both breeds during September to November, and decreased to 1.25 by March.

Breeding groups for St. Croix and Rambouillet ewes were bred each February and August for five years to establish lambing performance at six month intervals. Age at first lambing was earlier for St. Croix than Rambouillet (89% vs 0.0% lambing at 12 months of age). Both breed and age influenced lambing rate.

Fifty-two of 108 (48%) lambings from mature St. Croix ewes occurred at six month intervals, compared to 1 of 85 for Rambouillet (1.2%). No Rambouillet under 36 months lambed at 6 month interval, while 8 of 61, 12 month St. Croix ewes lambed at a 6 month interval (13.1%).

Mature St. Croix ewes that lambed at six month intervals produced 3.44 lambs per year, compared to 2.03 for ewes that lambed once a year.

Parturition interval was 262 days for mature and 302 days for 24 month and younger St. Croix ewes on a six month lambing schedule. Parturition interval for mature Rambouillets was 355 days.

Blood samples were taken twice weekly and serum progesterone measured by RIA in 17 St. Croix and four Rambouillet ewes that lambed during the normal breeding season, to determine occurrence of postpartum ovulation. Average days to first postpartum ovulation was 35.8 and 35.6 for St. Croix and Rambouillet, respectively. Thirteen of seventeen (76.5%) St. Croix ewes showed estrus with first ovulation, while none of the Rambouillet showed estrus with first or second postpartum ovulation. The shortened postpartum period for St. Croix compared to Rambouillet (40.2 vs > 70 days) was a result

of estrus accompanying the first or second postpartum ovulation.

(48 pages)

INTRODUCTION

Increases in reproductive performance are a primary prerequisite to increasing production of sheep, particularly meat production. Factors contributing to increased reproductive performance include ovulation and lambing rate, and frequency of lambing. These factors are influenced by both genetics and environment of which climate and nutrition play significant roles. The limits of reproduction are established by genetics, but the degree to which the genetic potential is achieved is a result of proper management of the animals, the environment and of understanding environmental limitations.

The reproductive efficiency of a flock of ewes depends primarily on the number of lambs born within a unit of time compared to the number of ewes exposed for breeding. Three separate reproductive traits must be considered. The first is ovulation rate, which is influenced by age, breed, season of year and nutritional level. The second trait is the length of the breeding season. The third trait is the length of the postpartum interval. These last two traits determine the time of year and frequency of lambing. They are two separate phenomena which can occur separately or together and determine the length of the parturition interval. If lambing frequency is to be greater than once a year then

the breeding season must accommodate breeding, lambing and rebreeding and the postpartum interval must be short enough to accommodate rebreeding in the required period of time. The ability of a ewe to exhibit a short postpartum interval and have an extended breeding season is generally considered to be genetically controlled.

The main thrust of this research is to examine the ovulation rate, length of breeding season, the postpartum interval and lamb production from different lambing interval management programs of two widely divergent breeds of sheep, the Rambouillet and the St. Croix. These breeds also provide a model to better define the physiology and endocrinology of events of the postpartum interval.

REVIEW OF LITERATURE

Determining the reproductive capacity is the first step to developing management programs to increase reproductive performance in sheep. Reproductive traits such as ovulation rates, and seasonal and postpartum anestrous periods have been of interest for many years but are inadequately documented for many breeds. Additionally, a great deal of conflicting evidence has been reported concerning the mechanism regulating the postpartum interval.

I. Ovulation rate.

A review of literature shows that there are four main influences on the ovulation rates of ewes: season of year, breed, nutritional level, and age.

A. Season of year. As early as 1937, the effect of breeding season was studied. McKenzie and Terrill found that both Hampshire and grade ewes began breeding in late August and early September (autumn). Ovulation rate increased from 1.50 at the beginning of the breeding season to 1.76 during the period of September 15 to November 15. Ovulation rate then decreased to 1.21 from January 16 to February 15 in the mature Hampshire ewes. Radford (1959) measured the ovulation rate of forty-nine mature Merino ewes at 10-12 week intervals. These ewes,

which were maintained on a constant diet were found to have the highest ovulation rate during the May-June period, which is late autumn in the area of Australia where the study was conducted. The lowest ovulation rate was reported during the spring season, October-December.

Shelton and Morrow (1965) studied the estrous season and ovulation rates of 539 aged Rambouillet ewes in Texas. The ewes were bred March 21, June 21, September 21 and December 21, representing different seasons reflecting photoperiod changes during the year. Although the ewes bred during all four seasons, it was determined by examining the ovaries of a random half of the ewes by laparotomy five days after breeding, that the ovulation rate was highest in the ewes bred during September and December. The highest ovulation rate was in September (1.75) and the lowest in ewes bred in March (1.06). The ovulation rates in December (1.52) and June (1.41) were intermediate. Hulet et al. (1974) reported the incidence of estrus and the incidence and rate of ovulation throughout the year in three hundred and forty Rambouillet ewes. One-half were of Idaho and one-half of Texas origin and ewes from each origin were measured at each location or a total of four groups. The ewes were laparotomized each month following an observed estrus. Laparotomies were performed at the end of the month and the occurrence and rate of ovulation observed for those ewes not showing estrus. At both locations the highest

ovulation rates were September through February, with the lowest rates occurring during March through August.

Hulet, Price and Foote (1968) in an effort to determine the effects of light, month of year and nutritional level on the reproduction of ewes during the breeding season observed the ovulation rates of 378 Rambouillet, Targhee and Columbia ewes at three intervals. Ovulation rates were higher at November 3 - 10 than October 1 or the December 10 - January 7 period for both years studied.

In a study by Dermody, Foote and Hulet (1970), ovulation rates were obtained on 64 mature Columbia, Targhee and Rambouillet ewes by laparotomy, at estrous cycle lengths, through most of the normal breeding season. Their studies, initiated in late August, indicate that ovulation rate was high at that period, and remained high through December 1, varying from 1.80 to 2.18. A rapid decrease in ovulation rate began in early December dropping to 1.14 by February 22. Their conclusions were that the stage of the breeding season had a highly significant effect on ovulation rate.

Irazoqui and Menvielle (1982), using 80 Corriedale ewes found that ovulation rate varied from 1.58 to 0.0 throughout the year. Using a regression equation to predict ovulation rates at various times through the year, they found that the highest ovulation rates were centered from 153 $\pm$ 10 days following the longest day of

the year. Seasonal anestrus was centered on day 336 from the longest day and lasted approximately 49 days, during which estrus did not occur.

B. Breed. The effect of breed on ovulation rate has been documented in studies using various breeds. Bellows et al. (1963) studied the Hampshire and Columbia breeds and found a significantly higher ovulation rate in favor of the Hampshire breed (1.76 vs. 1.53). Goode and Tugman (1976) reported the prolificacy of three year old, second lambing ewes for three genotypes: Dorset 1.4, Dorset X Finnish Landrace 1.8, and Rambouillet X Finnish Landrace 2.3 lambs per ewe. Matthews et al. (1977) compared lambing rates of straightbred Targhee and Suffolk X Targhee ewes under range conditions, with ewes ranging in age from two to nine years of age in both groups. The prolificacy of the Targhee was 1.46, and the Suffolk X Targhee was 1.66. Panter (1978) working with 1-3 year old ewes of the St. Croix breed and Barbado X Rambouillet cross reported prolificacy of 1.63 and 1.37 for the two genotypes, respectively. Chiquette et al. (1984) showed ovulation rates for Finnish Landrace ewe lambs to be 2.7, with 1.9 lambs born. In the same study, Suffolk ewe lambs and Suffolk X Finn ewe lambs had ovulation and prolificacy rates of 1.2 and 1.1 for Suffolk and 1.9 and 1.6 for the crossbreds.

C. Nutrition. The nutritional level of breeding ewes has long been accepted as having an important effect on prolificacy. The practice of increasing nutritional level, or "flushing" for a short period of time before and during breeding has been recommended as a method of increasing the lambing rate by increasing ovulation rate.

Allen and Lamming (1961) suggest that ovulation rate is a function of available nutrients in the diet and/or body reserves of stored energy. Their research showed that with diets leading to loss of weight, the ovulation rate of ewes declined. When body weight loss reached 27.7% of the initial weight of the ewe, ovulation continued, but multiple ovulations were inhibited. Their studies also showed that very little is gained by increasing the nutritional level of ewes already in adequate body condition. However, the poorer the body condition of the ewe, the greater the response in ovulation rate to increased nutritional levels. Lamond et al. (1973) found a reduction of fertility in both under and over nourished ewes. Their data also indicated a lowered ovulation rate in under-nourished ewes. Foote et al. (1959) found that ewes receiving two pounds of grain mixture with hay as a diet had a higher ovulation rates than ewes on a diet of hay only. Ewes receiving grain as a flushing technique for seven days had only a slight increase in ovulation rate in one of the two studies. This gives support to Allen and Lammings findings, that

ewes that are receiving an adequate diet, and are in good body condition, benefit very little from flushing.

Hulet, Price and Foote (1968), using three levels of nutrition, 75%, 100% and 150% of NRC requirements for maintenance, found no significant difference in ovulation rates among the feed levels. The ewes were randomly assigned to one of the three feed levels and an initial ovulation rate obtained with laparotomy. Ewes were fed on the assigned level for 17 days and ovulation rates again observed. This study also seems to support Allen and Lamming (1961) findings that ewes in adequate body condition are not affected by a change of 25% decrease in feed levels.

D. Age. Goode and Tugman (1976) showed a significant increase in prolificacy of three-old ewes at second lambing vs. the same ewes measured at two years of age at first lambing. Matthews et al. (1977) compared prolificacy in ewes ranging from two years to nine years of age, and showed that the highest levels occurred at 4-7 years of age. Gonzalez-Reyna (1977) reported an increased lambing rate of 1.13 vs. 1.22 for first partum ewes averaging 425 days old, and second and later partum ewes, respectively, in the Peliguey sheep of Mexico.

II. Duration of the Breeding Season

The length of breeding season for sheep varies throughout the world, and is defined as the length of time within a year that a ewe demonstrates behavioral estrus accompanied by ovulation. The endocrinology of the ewe has been described for the breeding season, anestrous season, and the two transition periods. Legan and Karch (1979), Karch et al. (1980) and Karch et al. (1976) have defined the patterns of steroids and gonadotrophins and their interactions. The generally accepted explanation of the endocrinology of anestrus in sheep is that with increasing day length there is an increased sensitivity to estrogen at the arcuate nucleus and median eminance portions of the hypothalamus that controls the tonic release of LH. As breeding season ends, estrogen has a negative feedback effect on the hypothalamus resulting in a decrease in tonic LH. With the decrease in tonic LH release, estrogen levels fall. There appears to be an estrogen threshold that must be reached before the pre-ovulatory surge of LH can be released, but with low estrogen there is a negative feedback on the hypothalamus that causes a decrease in GnRH from the pituitary causing an increased rate in the decline of tonic LH, resulting in reduced follicular growth and therefore no ovulation.

With the day-lengths becoming shorter, the sensitivity of the median eminence to estrogen decreases and the negative feedback system of estrogen on that portion of the hypothalamus becomes refractory. The increase in circulating tonic LH causes an increase in ovarian activity which causes estrogen levels to increase and stimulate the pre-ovulatory release of GnRH from the preoptic and anterior portions of the hypothalamus which causes the pre-ovulatory surge of LH from the anterior pituitary. During the breeding season, progesterone acts as an inhibitory regulator for tonic LH secretion.

The changing ratios of hormones also apparently affect the receptor sites in the hypothalamus, anterior pituitary and the ovary, both quantitatively and in the ability of the receptors to bind hormone (Ferris, 1983; Mole, 1984).

It is recognized that breeds of sheep throughout the world north or south of the equatorial zone have a defined breeding or estrous season. The estrous season varies with the breed of sheep and the latitude, but it has been reported that for wool breeds, the finer wooled breeds generally have a shorter anestrous period (Shelton and Morrow, 1965) than courser wooled breeds. Hulet et al. (1974) studied the effect of location on breeding season in the Rambouillet breed, using two locations, one in Idaho and one in Texas. The breeding season extended from September through March, and the anestrous

season from May through July, with transition occurring during April and August in Idaho. In Texas the breeding season was extended further by one month at both the beginning and end.

Gonzalez-Reyna (1977) reported no definite breeding season for the Peliguey hair sheep in the subtropical area of Tamiloupes in Mexico. Hupp and Deller (1983) report an extended breeding season that allows lambing throughout the year for the Virgin Island White hair sheep, which is the founding stock of the St. Croix in the continental United States. This is in agreement with Panter (1978) who reported an extended breeding season for the St. Croix hair sheep in Utah, comparable to the Rambouillet and the Rambouillet X Barbados sheep.

III. Postpartum Events in the Ewe

The postpartum interval (PPI) or period of time from parturition to the first estrus that is accompanied by ovulation has been shown to be affected by season, breed, nutrition and possibly lactation (Novoa, 1984). Since most ewes lamb during the anestrous season, no behavioral estrus is noted until the onset of the next breeding or estrous season, the events of the postpartum interval become confounded with seasonal anestrus. The events of the postpartum interval can be measured only

during the breeding season when they can be observed without the confounding affect of the anestrous season.

Ovarian activity is low for a period of time after parturition. Foote (1971) found that follicles of 2 mm or larger do not appear on the ovaries until after day ten postpartum. This is consistent with work done by Wyck et al. (1972) and Mallampati (1971) who found that at day 20 and 21 respectively, follicles did not exceed 6 mm, but that a significant difference in the size of follicles of suckled and non-suckled ewes exists. Follicles of non-suckled ewes were significantly larger in both instances. Endocrine levels (i.e. progesterone and tonic LH) are also low during early postpartum. LH levels increase leading to the increased ovarian activity culminating in ovulation during the first three weeks following parturition (Novoa, 1985; Villalta, 1986).

Ovulation occurs in the absence of estrus prior to the occurrence of ovulation accompanied by behavioral estrus. Fitzgerald and Cunningham (1981), have reported one to three periods of ovulation before the occurrence of ovulation accompanied by estrus. Conception can occur at these ovulation periods following forced breeding or by artificial insemination (Miller and Wiggins, 1964).

Results of research to determine the effect of lactation on the resumption of ovulation and estrus is inconsistent. Hunter and VanAarde (1975) found that lactation had only an indirect effect on the resumption

of ovarian activity, acting through nutritional stress. They found that the interaction between suckling and nutritional level significantly affected the time of ovulation, but not the time of first estrus following lambing. Restall and Starr (1977) found that nutrition and season of lambing modify the effect of suckling. Lactational anestrus was more pronounced when nutrition was inadequate when lambing was at the end of the breeding season than at the beginning of the breeding season. Evans and Robinson (1980) reported that generally ewes lambing at the middle of their breeding season, have a shorter PPI than ewes lambing at either the beginning or ending of the natural breeding season.

It appears that suckling and the frequency of suckling during the first two weeks after parturition rather than lactation, is correlated with the length of postpartum anestrus (Fletcher, 1971). Shevah et al. (1974) reported that suckling delays the resumption of ovarian activity in adequately fed Finn X Dorset ewes.

Once ovarian activity resumes after parturition, estrus occurs accompanying ovulation after one to four ovulation periods, and it is suggested that these ovarian cycles serve to "prime" or stimulate the neuroendocrine system for the occurrence of estrus, by means of the rise in progesterone, followed by a decline (Fitzgerald and Cunningham, 1981; Gonzales-Reyna, 1983). The occurrence of short luteal phases (7-8 days) following these

postpartum ovulations was reported for the Peliguey sheep by Gonzales-Reyna (1983), who suggested that inadequate luteal function may account for these shorter cycles.

METHODS AND MATERIALS

I. Experiment 1

Twenty mature ewes, ten each from the Rambouillet and St. Croix breeds were exposed continuously to painted vasectomized rams and the ewes were checked daily to determine the occurrence of estrus. Approximately one week after the detection of estrus, the occurrence and ovulation rate was determined by endoscopy as described by Seegar and Klatt (1980). Ewes were denied food for thirty six hours, and water for twenty-four hours prior to observation. Each ewe was given 10 mg Rompun (Xylazine), placed on a laparotomy cradle, sheared mid-ventrally and the surgical site scrubbed prior to endoscopy. Ovarian activity (corpus luteum and follicular development) was observed and recorded. Ovulation rate was defined as the number of Corpus Luteum present on the ovaries. Ovarian activity was observed in all ewes not demonstrating estrus by the 20th of any month. Estrus was checked daily and endoscopy was performed on a monthly basis for two years to measure the occurrence of estrus and the occurrence and rate of ovulation throughout the year (to identify anestrous periods) and to estimate variations between years.

II. Experiment 2

Beginning December 1975, lambing records were kept on a flock of 20 St. Croix ewes imported to Utah State University from the U.S. Virgin Islands. Forty 12 month old Rambouillet ewe lambs were purchased January 1978, and both St. Croix and Rambouillet ewes were exposed for breeding to fertile rams at six month intervals: February 1 and August 1. Each breeding period was 40 days. This twice a year breeding schedule was maintained for 5 years. Breeding and lambing data were analyzed from both breeds for the five year period with the exception of one year when part of the lambing records were accidentally destroyed.

Beginning in November 1983, St. Croix ewes were placed on a 12 month lambing interval and exposed to fertile rams for forty days beginning the first week in November.

III. Experiment 3

A group of ewes consisting of four Rambouillet and 17 St. Croix were treated with exogenous hormones consisting of 40 mg FGA in intravaginal sponges for 14 days, and 800 IU PMSG 24 hours prior to sponge removal. The hormone treatment was initiated during May and June, and the ewes were bred to fertile rams. Lambing occurred in October and November, during the established breeding season, which avoided any confounding affect of seasonal

anestrus, and all lambs were allowed to remain with the ewes. Beginning at the time of parturition, painted vasectomized rams were placed with the ewes to determine the occurrence of estrus. Twice weekly, beginning on the day of parturition, 10 ml blood samples were taken from each ewe until the occurrence of the first postpartum estrus or for 70 days. Blood samples were analyzed for progesterone levels using RIA methods described by Gibori et al. (1977), with modifications described by Novoa (1985). Progesterone levels were used to determine the occurrence of ovulation associated with the first postpartum estrus, and any ovulations prior to the first postpartum estrus.

RESULTS AND DISCUSSION

I. Occurrence of Estrus and Occurrence and Rate of Ovulation.

The occurrence of estrus and ovulation by month for both the St. Croix and Rambouillet breeds are shown in Table 1 for 1982 and Table 2 for 1983. These data indicate that a definite anestrous season occurs in both breeds from May through July, and that it is very similar for the two breeds and years. The transition into the breeding season was in August, where 20% and 50% of the Rambouillet and 70% and 70% of the St. Croix showed estrus for 1982 and 1983, respectively. By September all but one Rambouillet ewe had shown estrus in 1982, and all ewes of both breeds had shown estrus in 1983.

The incidence of estrus remained at or near 100% through February, and by March the transition into the anestrous season had begun. The major transition period was in April with 80 and 30% of the Rambouillets showing estrus and 70 and 78% for the St. Croix, respectively, for 1982 and 1983. Except for the St. Croix in May (10% in 1982), estrus did not occur in either breed or either year during May, June or July. Within the limits of time measured in this experiment the pattern of occurrence of estrus and ovulation were similar throughout the two-year observation period. Where they did differ, the

Table 1. The occurrence of estrus and ovulation and ovulation rate in Rambouillet and St. Croix ewes by month (1982).

	Rambouillet			St. Croix		
Mo.	Estrus (%)	Ovulation (%)	Ovulation rate	Estrus (%)	Ovulation (%)	Ovulation rate
Jan	100	90	1.66	100	100	1.80
Feb	50	100	1.30	90	100	2.00
Mar	60	80	1.37	90	100	1.80
Apr	80	80	1.25	70	70	1.85
May	0	0	0	10	10	1.00
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	20	90	1.33	20	70	1.71
Sep	90	90	1.62	100	100	1.87
Oct	90	100	1.14	90	100	1.85
Nov	100	100	1.66	100	100	2.18
Dec	100	100	1.77	100	100	2.18

occurrence of ovulation was higher (with one exception) than that of estrus indicating that ovulation occurs without estrus at the transition periods into and out of seasonal anestrus.

The incidence of estrus in both the Rambouillet and St. Croix breeds for the two year period are very similar to the results of Hulet *et al.* (1974) in Rambouillet and Irazoqui and Menvielle (1982) using Corriedale, where

anestrus was reported to be centered at the longest day of the year.

Table 2. The occurrence of estrus and ovulation and ovulation rate in Rambouillet and St. Croix ewes by month (1983).

	Rambouillet			St. Croix		
Mo.	Estrus (%)	Ovulation (%)	Ovulation rate	Estrus (%)	Ovulation (%)	Ovulation rate
Jan	100	100	1.75	100	100	1.67
Feb	100	100	1.50	100	100	1.67
Mar	100	100	1.50	90	90	1.25
Apr	30	30	1.33	78	78	1.28
May	0	0	0	0	0	0
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	50	50	1.60	70	70	1.42
Sep	100	100	2.30	100	100	1.33
Oct	100	100	2.20	100	100	2.00
Nov	100	100	2.00	100	100	2.00
Dec	100	100	1.67	100	100	2.00

Ovulation rate was somewhat variable between breeds for the two years measured. The highest ovulation rates in both breeds in 1982 were reached in November and December (1.66 and 1.77 for the Rambouillet and 2.18 and 2.18 for the St. Croix). In 1983 the peak ovulation rate

for the Rambouillet (2.00 to 2.30) occurred in September through November and in the St. Croix (2.00) occurred in October through December.

Table 3. The mean occurrence of estrus and ovulation and ovulation rate in Rambouillet and St. Croix ewes by month (1982 and 1983 combined).

	Rambouillet			St. Croix		
Mo.	Estrus (%)	Ovulation (%)	Ovulation rate	Estrus (%)	Ovulation (%)	Ovulation rate
Jan	100	95	1.70	100	100	1.74
Feb	75	100	1.40	95	100	1.83
Mar	80	90	1.44	95	95	1.52
Apr	55	55	1.29	74	74	1.56
May	0	0	0	5	5	1.00
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	35	70	1.47	45	70	1.56
Sep	95	95	1.96	100	100	1.60
Oct	95	100	1.67	100	100	1.92
Nov	100	100	1.83	100	100	2.09
Dec	100	100	1.72	100	100	2.09

Table 3 shows the mean occurrence of estrus and ovulation and ovulation rate in Rambouillet and St. Croix ewes by month for the combined years of 1982 and 1983.

Table 4 shows the ovulation rates for mature St. Croix and Rambouillet during 1982-1983 (experiment 1) compared to the lambing rates of St. Croix and Rambouillet ewes obtained from 1976 through 1986 during the months available (experiment 3).

Table 4. Ovulation rate and lambing rates of mature ewes 36 months old and older.[1]

	Lambing rate (1976-1986)			Ovulation rate (1982-1983)		
Mo. bred	No. of observations	Lambing rate	S.E.M.	No. of observations	Ovulation rate	S.E.M.
St. Croix						
Nov.	48	2.08	0.300	20	2.09	0.088
Feb.	41	1.90	0.500	20	1.84	0.157
Aug.	51	1.96	0.049	20	1.57	0.196
Rambouillet						
Feb.	10	1.10	0.105	20	1.25	0.121
Aug.	75	1.68	0.055	20	1.46	0.166

[1]Lambing rate was determined by number of live lambs born from breeding during months indicated; ovulation rate was determined by laparoscopy.

Ovulation rate and lambing rates are in close agreement. The observed lambing rate for ewes of both breeds bred in August was higher than the observed ovulation rate and is assumed due to year differences and sampling errors.

The lambing rate of ewes that were exposed for breeding at 6, 12 and 18 months of age that were exposed for breeding at six month intervals is shown in Table 5. Eighty-nine and zero percent of the St. Croix and Rambouillet ewes lambed following exposure for breeding at six months of age, respectively, with the St. Croix producing 1.50 lambs per ewe lambing, demonstrating the earlier sexual development of the St. Croix. Breeding data were not available for Rambouillet ewes bred at six months of age, and was 0% for those bred at 12 months and 75% for those bred at 18 months. None of the Rambouillet ewes under 36 months bred at six month intervals but thirteen percent of the St. Croix ewes bred at six and twelve months of age to complete a six month interval. The mean age at conception for the St. Croix was 180 to 210 days which differs from data reported by Panter (1978) who reported the mean age at puberty in St. Croix ewe lambs to be 230 days, with a range of 193-263 days. With the 40 day breeding season, only 75% of the Rambouillet ewes conceived at 12 months of age. The lambing rate of 12-13 month old St. Croix ewe lambs (1.50) is similar to the mature Rambouillet ewes (1.49) and higher than the 18 and 24 month old Rambouillet ewes (1.33).

Table 5. The percent ewes lambing and lambing rate for St. Croix and Rambouillet ewes bred at 6, 12 and 18 months of age and maintained on a six month lambing interval

Breed	Age at breeding (mo.)	No. of ewes in experiment[3]	Percent ewes lambing[2]	Lambing rate	S.E.M.
St. Croix					
	6 months	68	89[a]	1.50	0.065
	12 months	48	48[b]	1.52	0.108
	18 months	52	90[a]	1.80	0.067
Rambouillet[1]					
	12 months	40	0[d]	0	0
	18 months	40	75[c]	1.33	0.089

[1]Rambouillet ewes were placed in the experiment at 12 months of age.

[2]$P < 0.05$ for means not having the same superscript letters ($P < 0.01$ for a, b, c, vs. d)

[3]The same ewes were represented in more than one age category.

Table 6 shows the increase in lambing rate that occurs from first lambing of both St. Croix and Rambouillet breeds through lambing as mature ewes (36 months old or older).

This increase in lambing rate was consistent with research reported by Goode and Tugman (1976) using Dorset, Dorset x Finn, and Rambouillet x Finn ewes, Matthews *et al*. (1977) using Targhee and Suffolk x

Targhee ewes and Gonzalez-Reyna (1977) using Peliguey ewes that report ewes do not reach maximum production until at least 36 months of age.

Table 6. Effect of age on lambing rate.

Age of Ewe at Lambing	No. of Ewes	No. of Lambs	Lambing Rate	S.E.M.
St. Croix				
12 months	61	92	1.50	0.065
18 months	23	35	1.52	0.108
24 months	47	85	1.80	0.442
30 months	11	20	1.82	0.190
36 months	152	294	1.93	0.037
Rambouillet				
12 months[1]	-	-	-	-
18 months	0	0	0	0
24 months	30	40	1.33	0.089
30 months	3	6	2.00	0.000
36 months	85	127	1.49	0.062

[1]Ewes were placed in study at one year of age.

II. Lambing Intervals

The proportion of ewes lambing at six month intervals is shown in Table 7.

Table 7. Percent of ewes lambing at 6 month intervals.

Breed	Age at lambing	No. of observations	No. ewes lambing at 6 mo. interval	Percent of ewes lambing[1]
St. Croix	12 mo.	61	8	13.1
	Mature[2]	108	52	48.1
Average				35.5
Rambouillet	12 mo.[3]	40	0	0
	Mature	85	1	1.2

[1]Percent of ewes lambing at two consecutive six month intervals of the total six month intervals.

[2]36 months of age and older.

[3]Included ewes placed in study at 12 months of age, and replacement ewes placed in the study at 6 months of age.

These data indicate that St. Croix ewes have the ability to conceive 40 days postpartum and lamb at six month intervals. Forty-eight percent of the 108 mature St. Croix ewes lambed again at the subsequent six month interval compared to only 1.2% of the 85 Rambouillet lambing observations. The percent of St. Croix ewe lambs that lambed at a six month interval (six and twelve months of age) was 13.1. None of the Rambouillet ewes lambed at six month intervals between 12 and 24 months of age.

The lambing rate per parturition for St. Croix ewes that lambed at six-month intervals (1.75 for 1978-1984)

is similar to ewes that lamb at 12 month intervals (1.84 for 1984-1986; Table 8). This resulted in a lambing rate expressed on a yearly basis of 3.50 for ewes lambing at a six month interval compared to 1.84 for ewes lambing at a 12 month interval.

Table 8. Lambing rates of St. Croix ewes on six-month and 12-month lambing schedules.

	Years	No. lambings	Lambing rate	SEM	Lambing rate ewe /years	Partur-ition interval	SEM
A. Six month interval lambing schedule							
Lambing at six month interval							
Mature	1978-84	52	1.75	.072	3.50	191.0	1.667
Immature	1978-84	32	1.60	.089	3.20	188.6	1.643
Lambing at twelve month interval							
Mature	1978-84	56	2.03	.072	2.03	349.7	1.438
Immature	1978-84	28	1.61	.094	1.61	355.0	1.376
B. Twelve month interval lambing schedule							
St. Croix							
Mature	1984-86	102	1.84	.048	1.84	358.2	.766
Immature	1984-86	38	1.60	.080	1.60	361.4	1.778

III. Postpartum Events

Table 9 shows the results of progesterone analysis of blood taken from day of parturition until ewes showed first postpartum estrus, or to 70 days. Table 9 also summarizes the number of ewes ovulating, average days to first and subsequent ovulation periods, and the average days to first estrus.

The average days to first ovulation was 35.8, with a range of 12 to 58 days for the 17 St. Croix ewes, compared to an average of 35.6 days with a range of 33 to 40 days for the three Rambouillet ewes that ovulated. The average days to second ovulation for the four St. Croix ewes that did not show estrus at the first ovulation was 39.6; the average days to first ovulation (without estrus) for these four ewes was only 19.5. It is interesting to note that in ewes showing early ovulation, the ovulations were not accompanied with estrus. It is also important to note that the first postpartum ovulation was accompanied by estrus in 76% of the St. Croix ewes. Three of four Rambouillet ewes demonstrated two ovulation periods unaccompanied by estrus before the study ended at 70 days without any demonstrating estrus and one ewe failed to ovulate or show estrus.

Table 9. Events of the postpartum interval in St. Croix and Rambouillet ewes.[1,2]

	St. Croix	Rambouillet
Number of ewes	17	4
Number of ewes ovulating	17	3
Average days to first ovulation	35.8	35.6
Range	12-58	33-40
S.E.M.	3.13	4.26
Average days to second ovulation	42.3	48.0
Range	30-58	41-61
S.E.M.	5.49	6.51
Ewes showing postpartum estrus	17	0
Average days to first estrus	40.2	>70
Percent showing estrus at first ovulation	76	0

[1]Observations were made to 70 days postpartum.

[2]Information on time of ovulation determined from serum progesterone analysis.

Table 10 provides a comparison of days to conception for St Croix ewes conceiving at the first or second estrus postpartum. The actual days postpartum to conception is very similar (36.1 vs. 38.4) but the ewes that conceived on the second estrus had shown an earlier estrus at an average of 24.0 days. In this particular

study the length of the estrous cycle was 14.4 days, which is slightly shortened, and is consistent with reports that many of the first cycles after parturition are shorter than the normal 16-17 days (Gonzales, 1983).

Another comparison of the ability of St. Croix ewes to rebreed after parturition is shown in Table 11. Group A conceived at an estimated 38 days postpartum which is very similar to the days to conception shown in Table 10.

Table 10. Average days to first and second postpartum estrus in St. Croix ewes.

No. of observations	Average days to first estrus	Range	S.E.M.	Average days to second estrus	Range	S.E.M.
29[1]	36.1	26-57	2.23	-	-	-
18[2]	23.9	18-31	1.99	38.36	33-43	1.61
Total						
47	31.2	18-57	2.04	38.36	33-43	1.61

[1]Ewes that conceived to breeding at first postpartum estrus.

[2]Ewes that conceived to breeding at second postpartum estrus after failing to become pregnant following breeding at first postpartum estrus.

Table 11. St. Croix postpartum estrus and rebreeding results from lambing records.

Group[2]	No.	Days from parturition to conception[1]	Range	S.E.M.
A	19	37.9	18 - 64	2.67
B	26	50.7	13 - 70	2.38
Total	45	46.6	13 - 70	2.50

[1]Calculated as the number of days between two consecutive parturitions - 150days (length of gestation).

[2]Two separate breeding groups.

Group B averaged an estimate of almost 48 days from parturition to conception. These data were calculated by subtracting 150 days (estimated gestation period) from the parturition interval, and do not show whether the ewe conceived on the first or second estrus after parturition.

The effect of the number of lambs nursing on the days postpartum to conception is shown in Table 12. With group A, days to conception was calculated by subtracting 150 days from the total number of days between parturitions since no estrus data were recorded. With group A there appears to be little effect of the number of lambs suckling when ewes with one lamb are compared to ewes nursing multiple lambs. Group B had painted, fertile rams placed with the ewes at the time of parturition, and days to first estrus was obtained. Ewes with one lamb

showed first estrus 10 days earlier than the ewes with multiple lambs (22.3 vs. 32.0). However, there were only 3 ewes without multiple lambs. Ewes with single lambs

Table 12. Days to conception and parturition interval in mature St. Croix ewes with one vs multiple lambs.

	Ewes with one lamb	Ewes with multiple lambs (2 or greater)
Group A[1] (Includes February and August breeding)		
No.	14	12
Parturition interval (mean)	197.07	198.50
Parturition interval (range)	160-217	182-211
Range in days	13-70	35-64
Days to conception	47.07	48.5
Group B[2] (Bred August - lambed January)		
No.	3	11
Days to first estrus	22.3	32.0
Days to conception	32.0	37.6
Total: Group A plus Group B		
No.	17	23
Days to conception	44.4	43.3

[1]Days to conception calculated as parturition interval - 150 days (length of gestation).

[2]Painted rams used to detect breeding dates.

Table 13. Parturition intervals of St. Croix and Rambouillet ewes on a 6 month lambing schedule.

	Number of Observations	Mean Parturition Interval	S.E.M.
Mature St. Croix	72	262[a]	9.0
12-24 month St. Croix	20	302[b]	17.0
Mature Rambouillet	40	355[c]	4.5

[1]$P < 0.05$ for means not bearing the same superscript letters ($P < 0.01$ for mature St. Croix vs. mature Rambouillet).

conceived earlier than ewes with multiple lambs (32.0 - 37.6) but was not significant ($P > 0.05$). The average days to conception for groups A and B combined was 44.4 for ewes with single and 43.3 for ewes with multiple lambs.

Table 13 shows the parturition interval for St. Croix ewes divided by age groups: 12-24 months and those ewes older than 24 months, and mature Rambouillet ewes (those older than 24 months). The ability of the mature St. Croix ewes to rebreed at six month intervals is reflected in the shorter parturition interval (262.0) which is significantly shorter than the younger St. Croix ewes which had a parturition interval of 302 days ($P < 0.05$). Both groups of St. Croix had significantly ($P <$

0.01) shorter parturition interval than the mature Rambouillet ewes (355 days).

SUMMARY

Incidence of estrus and ovulation, ovulation rate, and postpartum events were measured for St. Croix and Rambouillet ewes. The two breeds were similar and showed a definite anestrous season from May through July, with the transition to and from breeding season being August and April. Ovulation rates were highest for both breeds September through December with the St. Croix reaching 2.18 and Rambouillet reaching 2.30.

Blood serum was analyzed for progesterone to determine the time of postpartum ovulation for both breeds. The average days to first postpartum ovulation was 35.8 $\pm$ 3.13 for the St. Croix and 42.3 $\pm$ 5.49 days to the second postpartum ovulation. All St. Croix ewes showed estrus with a second postpartum ovulation. The Rambouillet was very similar with 35.6 $\pm$ 4.26 days to first postpartum ovulation and 48.0 $\pm$ 6.51 days to second postpartum ovulation. None of the Rambouillet ewes, however, demonstrated estrus at their second postpartum ovulation.

Estrus data collected from the St. Croix placed with fertile rams showed average days to first postpartum estrus to be 36.1 $\pm$ 2.23 for ewes that conceived to the first estrus and 23.9 $\pm$ 1.99 for ewes conceiving to second estrus. The second postpartum estrus occurred at 38.36 $\pm$ 1.61 days. Seventy-six percent of St. Croix ewes

demonstrated estrus with the first postpartum ovulation, with 61% of the ewes conceiving to the first postpartum estrus. None of the Rambouillet ewes demonstrated estrus during the 70 day postpartum observation period.

The St. Croix ewes have a shortened postpartum anestrus compared to other breeds of sheep reported. Forty-eight percent of the mature St. Croix ewes lambed at a six month interval, compared to 13.1% for St. Croix ewe lambs and 1.2% and 0.0% for mature Rambouillet and yearling Rambouillet, respectively. The actual parturition interval was 262 $\pm$ 9.0, 302 $\pm$ 16.9 and 355 $\pm$ 4.4 for mature St. Croix, St. Croix 24 months and under, and mature Rambouillet ewes respectively.

The ability of the mature St. Croix ewes to rebreed and conceive at six month intervals was not affected by the number of lambs nursing. Ewes nursing single lambs conceiving in 44.4 days and ewes nursing multiple lambs conceiving in 43.3 days.

Prolificacy of both St. Croix and Rambouillet ewes increased with age. The St. Croix increased from a mean of 1.50 at 12 months to a mean of 1.93 for mature ewes. The Rambouillet increased from a mean 1.33 lambs at 24 months to a mean of 1.49 for mature ewes.

The St. Croix produced their first lamb at a younger age than Rambouillet; 61% of the St. Croix lambed at 12 months of age compared to 0.0 for the Rambouillet ewes to

24 months of age, when the breeding season was limited to two 40-day periods beginning August 1 and February 1.

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