BREED GROUP EFFECTS ON PREGNANCY RATE AND EWE PERFORMANCE IN DIFFERENT SEASONS OF THE YEAR

by

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(ABSTRACT)

Thirty-one Dorset (D), 24 Finnish Landrace (F), 35 Barbados Blackbelly x Dorset (BD), 10 Dorset x Finn (F), 24 Finn x Dorset (FD) and 35 grade Rambouillet (R) ewes were exposed to rams in various seasons. Ewes were born in 1979 or 1980; no R ewes were born in 1980. Ewes were bred in April, 1980 (APR80); November, 1980 (NOV80); August, 1981 (AUG81); May, 1982 (MAY82); and April, 1983 (APR83). Ewes born in 1980 entered the study in NOV80. The analytical model used to describe ewe performance included effects of ewe birth year (EBY), breed/EBY, season/EBY, breed x season/EBY and ewe (random). The model used to describe lamb performance included effects of EBY, ewe breed/EBY, season/EBY, sex of lamb, ewe breed x season/EBY, and sex x season/EBY. For 1979-born ewes, pregnancy rates were highest for NOV80 (89.1%), AUG81 (93.4%) and APR83 (88.1%) and lowest for APR80 (57.3%). Finn (88.1%), BD (89.3%) and DF (93.4%) had higher mean pregnancy rates than ewes of other breed groups.

For 1980-born ewes, pregnancy rates for D (91.1%), F (92.0%) and BD (99.8%) were highest; season effects were not significant. Prolificacy tended to be higher for ewes mated in MAY82 (2.11 and 1.92 for 1979- and 1980-born ewes, respectively) and lower for ewes mated in APR80 (1.41). Mean litter sizes over all seasons were greatest for F and FD ewes whereas number reared was highest for BD. Birth weights were heaviest for lambs out of BD (4.42 kg for 1979-born and 4.32 kg for 1980-born) and lightest for F (2.49 and 3.18 kg, respectively).

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INTRODUCTION

Out-of-season breeding and accelerated lambing programs have been given a considerable amount of attention over the past 50 yr. Recent economic conditions have forced the sheep industry and the producer to take a more serious look at reproductive performance. Since the profitability of any sheep operation is a direct reflection of the level of lamb production, an accelerated lambing program utilizing out-of-season breeding could prove to be economically beneficial. Such a program could be advantageous to both the producer and the industry by making it possible to market a greater number of lambs per ewe annually. The gestation length of the ewe is 5 mo, and, within the normal breeding season, ewes have been shown to rebreed within 1 to 2 mo after lambing. Thus, immediate rebreeding of ewes would eliminate the 5- to 6-mo period during which ewes are normally non-productive.

The seasonal reproductive pattern of the ewe not only limits the intensity of lamb production, but imposes limitations on the flexibility of the production system as well. Sheep are often included in many farming operations to utilize pasture and roughage sources that otherwise could not be used efficiently. Thus, the capability of controlling the breeding season would be beneficial to producers in areas where the availability of pasture is limited on a seasonal basis. In the South, conditions for maximum growth of forages occur primarily during periods of cool weather. Controlling the time of lambing would make it possible to take advantage of this more efficient period of growth.

The seasonal breeding pattern of the ewe also places major constraints upon the lamb marketing system. Lambs generally require 4 to 7 mo from birth to reach market weight. Thus, lambs from ewes bred during the normal breeding season (August to December) reach slaughter weight between May and December. Consequently, few lambs come to market between the months of December and May. Thus, the seasonal reproductive pattern of the ewe leads to considerable seasonal variation in lamb supply and therefore in lamb price. By controlling the time of lambing, the traditional seasonal fluctuation of the lamb market could be reduced thereby stabilizing market prices for slaughter lambs.

In order to investigate the practicality of out-of-season breeding programs, a study involving Dorset, Finnish Landrace, Barbados Blackbelly x Dorset, Dorset x Finnish Landrace, Finnish Landrace x Dorset, and Rambouillet ewes was conducted. The objectives of this study were:

1. to compare the breed groups for pregnancy rate and prolificacy when given the opportunity to lamb during different seasons of the year;

2. to study longevity traits for the breed groups; and,

3. to examine preweaning lamb performance traits for lambs born during the study.

LITERATURE REVIEW

Mechanisms Controlling Seasonal Breeding in the Sheep

The annual reproductive cycle of the ewe consists of a breeding and a non-breeding (or anestrous) season. In most breeds of sheep the breeding season begins in late summer and is recognized by successive 16-d estrous cycles (Hafez, 1952). Each cycle consists of both a 12 to 13 d luteal phase and a 3 to 4 d preovulatory, follicular phase (Legan and Karsch, 1979). The anestrous season commences in late winter and is characterized by the absence of normal estrous behavior (Hafez, 1952).

The changes in the hypothalamo-pituitary-gonadal system which control the transition from the breeding to the anestrous season in the ewe have been outlined by Legan et al. (1977), Legan and Karsch (1979), Karsch et al. (1980) and Legan and Karsch (1980). During the luteal phase, progesterone levels are elevated (3 to 5 ng/ml) and exert an inhibition on tonic luteinizing hormone (LH) secretion. However, at the time of regression of the corpus luteum (CL), circulating progesterone levels begin to fall from a high of 3 to 5 ng/ml in mid-luteal phase to a minimum of 0 to .2 ng/ml, as a result of luteolysis. This decrease in circulating progesterone removes the inhibition on LH secretion and allows an increase in the frequency of pulsatile release of LH which leads to a corresponding rise in mean serum LH concentrations to levels of about 3 to 5 ng/ml (Karsch et al., 1979). In turn, during the normal estrous cycle, the sustained increase in serum LH concentrations, which spans a period of 48 to 60 hr, is accompanied by a five-fold increase in ovarian estradiol secretion to levels of 1 ng/ml. The sustained nature of the LH increase provides the stimulus necessary to drive circulating estradiol to reach the threshold necessary to trigger the LH surge which in turn leads to ovulation. The LH surge and ovulation are likewise accompanied by behavioral estrus, which occurs approximately 24 hr prior to ovulation (Hauger et al., 1977) in response to the increased estrogen level. Ovulation then occurs, and a new CL is formed. Progesterone secreted by the new CL once again inhibits tonic LH secretion. When the CL begins to regress, progesterone declines to baseline levels (0 to .2 ng/ml), removing the inhibition of LH secretion. Thus, LH levels start to increase and a new cycle begins.

The estrous cycle may be viewed as a progression of events, each of which must occur for the successful completion of each cycle as well as for the progression from one cycle to another. During seasonal anestrus in the ewe, this sequence of events is interrupted, and the functional capacity of the hypothalamo-pituitary-gonadal system becomes impaired. This interruption in the normal sequence of events leading to ovulation seems to be mediated by an increase in sensitivity of the hypothalamo-pituitary-gonadal system to the negative feedback effects of estradiol on LH secretion (Legan and Karsch, 1979).

When the last CL of the breeding season begins to regress, the withdrawal of progesterone removes the negative feedback control on pituitary LH secretion, thus stimulating the expected increases in pituitary LH secretion and in subsequent ovarian estradiol secretion. However, at the transition to anestrus, the estradiol secreted by a growing crop of follicles is now sufficient to inhibit the progressive rise in tonic LH secretion. Thus, follicular development terminates and estradiol secretion decreases before attaining the threshold for triggering the preovulatory LH surge. Estrous cycles cease and a classical negative feedback loop between LH and estradiol is established. Anestrus begins and continues as long as estradiol remains a potent inhibitor of tonic LH secretion. When responsiveness to estradiol negative feedback diminishes at the end of anestrus, sustained increases in LH and estradiol are once again possible, thus enabling estradiol to reach the threshold for triggering the LH surge. Estrous cyclicity is re-established and a new breeding season begins.

Under natural environmental conditions, a dramatic seasonal variation in the negative feedback action of estradiol on LH secretion in the ewe has been shown to exist by Legan et al., (1977). Ovariectomized ewes were treated with estradiol-17β to maintain constant serum estradiol concentrations at mid-luteal levels (3 to 5 pg/ml). Throughout anestrus, LH levels remained undetectable (<.5 ng/ml). However, at the onset of the breeding season, LH concentrations increased considerably. Mean LH concentrations remained high (16 to 19 ng/ml) until the next anestrous season, when once again they decreased to undetectable levels and remained undetectable until the next breeding season (no change in LH concentrations was observed for ovariectomized ewes without estradiol-17β treatment). These changes in the negative feedback action coincided with the transition between the breeding and non-breeding seasons in the intact ewe. During anestrus, estradiol inhibits LH secretion, whereas in the breeding season the negative feedback sensitivity of the hypothalamo-pituitary-gonadal system to estradiol is low.

The inhibitory effect of estradiol appears to act at the level of the hypothalmus to inhibit either the production or release of gonadotropin-releasing hormone (GnRH). Studies conducted by McLeod et al. (1982) and McNatty et al. (1982) showed that exogenous administration of small amounts of GnRH at frequent intervals during anestrus was sufficient to cause resumption of the normal sequence of events leading to ovulation. Clarke et al. (1981) demonstrated that although no seasonal variation in the number of cytoplasmic estrogen receptors existed in the pineal, pituitary and cerebral cortex, the total cytoplasmic estrogen receptor levels in the hypothalmus were nearly two-fold higher in anestrous ewes than in cyclic ewes.

In the ram, seasonal variation in sexual activity has been shown to be accompanied by changes in serum LH, follicle stimulating hormone (FSH), testosterone, melatonin and prolactin levels (Schanbacher and Lunstra, 1976; Lincoln et al. 1977; Lincoln and Peet, 1977; Schanbacher and Ford, 1979; Almeida and Lincoln, 1982). Lincoln (1979) observed a circadian rhythm in the plasma levels of FSH, LH and testosterone, which was related to increased gonadotrophin release during the dark phase of the 24 hr cycle. Gonadotrophin levels were lowest in the late morning, and highest during periods of darkness. Under long daylengths when FSH and LH levels were decreased, a 20% regression in testes size was observed in Soay rams. However, under the influence of short daylengths, plasma FSH and LH levels increased and stimulated testes growth.

The fundamental role of photoperiod in mediating endocrine changes that lead to the seasonal variation in reproductive performance has been documented (Yeates, 1949; Hafez, 1952; Lincoln et al. 1977; Turek and Campbell, 1979; Karsch and Foster, 1980). For photoperiodic changes to be effective in inducing estrus, sheep must vary in their response to the effects of photoperiod at different stages of the reproductive cycle (Yeates, 1949; Yeates, 1956). Before changes in photoperiod can alter the breeding season, light must be perceived and daylength must be assessed through a type of "time measuring system." Information from this system must be transmitted to the hypothalmic-pituitary axis which will directly affect gonadal function. Finally, a change in hypothalmic-hypophyseal-gonadal activity must occur (Turek and Campbell, 1979).

Although the mechanisms by which changes in daylength are converted to neuroendocrine responses remain poorly understood, one of the most commonly accepted hypotheses for photoperiodic regulation of the breeding season involves an endogenous circadian clock that can become synchronized to changes in daylength (Rollag et al. 1978; Turek and Campbell, 1979). Photoperiodic fluctuation is thought to trigger neuroendocrine changes which can ultimately induce changes in reproductive status. In support of the hypothesis that external factors are involved in seasonal breeding is a study conducted by Legan and Karsch (1980). In this study ewes were exposed to 90-d alterations of artificial long-day and short-day photoperiods. The transition between estrous and anestrous seasons occurred at 90-d intervals, resulting in two breeding and two anestrous seasons per year. However, Radford et al. (1961) examined the effect of continuous light on sexual activity in the ewe and found that ewes maintained under constant photoperiod exhibited seasonal variation in sexual activity similar to those observed under normal seasonal light changes. In a similar study, Howles et al. (1982) showed that rams kept under constant photoperiod for 3 yr eventually began to show fluctuation in testicular volume and prolactin levels similar to changes observed under natural daylength fluctuations.

The role of the pineal gland and the importance of the hormone, melatonin, in the perception of daylength changes have been documented (Rollag and Niswender, 1976; Rollag et al., 1978; Almeida and Lincoln, 1982; Kennaway et al., 1982). Rollag et al. (1978) reported that the magnitude of changes in peripheral melatonin concentration due to photoperiodic fluctuation were not significantly different at different stages of the reproductive cycle in the ewe. During periods of light, secretion of melatonin from the pineal gland becomes impaired. However, peripheral melatonin concentrations were shown to be greatly elevated during darkness, accurately reflecting the duration of the dark period. Consequently, during the fall and winter months when days are shorter, elevated melatonin concentrations persist for a longer period of time than during the spring and summer months.

The target tissue for melatonin is thought to be the hypothalamo-hypophyseal axis (Turek et al., 1975). Both a circadian and a circannual rhythm are thought to mediate the response of the hypothalamo-hypophyseal axis to melatonin stimulation. As a result of the circadian rhythm it is necessary that elevated melatonin concentrations persist in the late afternoon for normal estrous cycles to occur. Therefore, it is not the duration of the elevated melatonin concentrations but the time of day during which concentrations are elevated, which bring about this photoperiodic response (Rollag et al., 1978). Thus, it seems reasonable that under the decreasing daylength conditions of the fall and winter months, elevated melatonin concentrations overlap the critical period of the circadian rhythm, whereas, during the summer months they do not. Therefore, photoperiodic control of reproductive performance is dependent upon two endogenous rhythms, a circadian rhythm of sensitivity to daylength and a circannual rhythm entrained to changes in photoperiod.

A circannual pattern of prolactin concentrations has been observed in both ewes and rams (Walton et al., 1977; Walton et al., 1980; Munro et al., 1980; Almeida and Lincoln, 1982). Changes in the plasma concentrations of prolactin can be related to changes in reproductive status and have been shown to be associated with changes in photoperiod (Walton et al., 1977). Prolactin levels are high when ewes are in an anestrous state and the days are long, but levels fall considerably when daylength begins to decrease and normal estrous behavior occurs (Walton et al., 1980). These fluctuations in prolactin release, parallel the changing sensitivity of the hypothalmus to the negative feedback action of estradiol. Several researchers have speculated that prolactin may play a role in the seasonal nature of reproductive performance in the sheep.

Kann and Martinet (1975) demonstrated that elevated levels of prolactin during lactation in the ewe are responsible for the persistence of lactational anestrus. Elevated prolactin levels have also been shown to reduce the release of LH in response to estradiol in the ewe. Furthermore, suppression of prolactin to levels occurring during normal estrous cycles results in cyclicity in lactating ewe (Kann et al., 1976). Therefore, they concluded that high levels of prolactin during anestrus may have exerted an antigonadal effect.

In contrast, Land et al. (1980) examined the effects of pharmacological reduction of the high plasma prolactin levels typical of seasonal anestrus. Prolactin concentrations were reduced (from 64 ± 10 ng/ml to < 4 ng/ml) with twice daily treatments of bromocriptine. This treatment had no effect on the proportion of ewes secreting LH in response to estradiol benzoate or the proportion of the ewes which ovulated.

Variation in the underlying endocrine changes associated with seasonal anestrus has been shown among breeds (Land et al., 1976; Wheeler and Land, 1977; Land et al., 1979). Land et al. (1976) administered estradiol benzoate to ovariectomized ewes during anestrus and observed an increase in LH secretion similar to that observed during the normal estrous cycle. This response was observed more frequently in Scottish Blackface ewes than in Finnish Landrace ewes although no difference in the response was noted during the breeding season. Therefore, it was concluded that Scottish Blackface ewes were more sensitive to the positive feedback effects of estradiol during anestrus than were Finnish Landrace ewes.

Factors that Modify the Transition from Estrus to Anestrus

Methods of increasing lambing rate by inducing cyclicity in the anestrous ewe or by extending the breeding season have been given considerable attention. Although photoperiod appears to be the primary factor controlling seasonal breeding in sheep, other factors have been shown to be involved. Other methods of estrus induction most commonly investigated include the use of exogenous hormone therapy, introduction of rams and the use of existing genetic variation.

The use of exogenous hormone therapy to induce estrous activity in the anestrus ewe has been successful and is commonly used in Europe (Mauleon, 1979). However, the level of fertility resulting from hormonal induction of out-of-season breeding is considerably lower than fertility levels during the natural breeding season (Lees, 1971). Furthermore, the drugs necessary for estrus induction have not yet gained approval from the necessary regulatory agencies for use in the United States.

The introduction of rams into anestrous ewe flocks has long been recognized as a method of stimulating estrous activity (Schinckel, 1954). If preconditioned by a period of isolation from rams (34 d seems to be sufficient) during the non-breeding season, ewes respond to reintroduction of rams (teasing) by exhibiting a relatively synchronized estrus (Oldham, 1980). However, the response to the introduction of rams has been shown to vary depending upon the stage of the reproductive cycle, breed of ewe and ram, and period of isolation from the ram (Oldham, 1980).

The precise mechanism by which rams stimulate estrous behavior in the anestrous ewe remains poorly understood. Watson and Radford (1960) found that the combination of odor and sound was capable of hastening the onset of estrous activity in the anestrous ewe. Fletcher and Lindsay (1968) reported diminished expression of estrus in ewes with combined olfactory ablation and auditory canal occlusion. However, the estrous response of ewes with either the impairment of sight or hearing singly was not different from that of normal animals. More recently, studies conducted by Knight and Lynch (1980 a,b) showed that pheromones present in the wool and (or) wax from certain sebaceous glands of Dorset rams were able to stimulate ovulation in Romney ewes early in the breeding season. Although results from the same study demonstrated small amounts of pheromonal activity in the urine of rams, the urine was not considered to be a major source of the pheromone.

Introduction of rams into seasonally anestrous ewe flocks has been shown to produce increases in the frequency of pulsatile LH secretion in the ewe within 10 to 12 min (Martin et al., 1980 a,b; McNatty et al., 1981). In many cases the increase was so great that individual pulses were difficult to distinguish (Poindron et al., 1980). Following the initial response of LH, a preovulatory surge (or partial surge) of LH takes place within 24 to 30 hr (Oldham et al., 1978; Knight et al., 1978). The first induced ovulation usually occurs within 30 to 72 hr after the introduction of the ram (Oldham et al., 1978; Knight et al., 1978). Although the first induced ovulation usually takes place within 3 to 4 d, it is not generally accompanied by behavioral estrus (Oldham, 1980). However, a fertile estrus accompanied by ovulation usually occurs within 18 to 24 d after introduction of the rams.

Ewes which are induced to ovulate by the introduction of rams often exhibit abbreviated estrous cycles caused by premature regression of the CL (Cognie et al., 1982). These short cycles, however, can be overcome with single 20 mg injections of progesterone just prior to the introduction of the ram. Conversely, long-term progesterone treatment ("progesterone priming") administered by intravaginal sponges (for 12 d prior to the introduction of the rams) in combination with the introduction of the ram resulted in estrous activity in a majority of the ewes.

During the non-breeding season the ewe exhibits an increased sensitivity to the negative feedback action of estradiol on tonic LH secretion, and estradiol is no longer capable of reaching threshold levels to trigger the LH surge (Karsch et al., 1980). Introduction of the ram may reverse the mechanism controlling the negative feedback of estradiol upon LH. Conversely, the ram-induced preovulatory surge of LH may be independent of estradiol (Martin, 1984).

The proportion of ewes which ovulate after the introduction of the ram has been observed to vary greatly (Martin et al., 1980a). For example, Romney Marsh ewes will respond to teasing for only a short time before the beginning of the normal breeding season (Edgar and Bilkey, 1963), whereas Merino ewes respond at almost any time during anestrus. Similarly, rams can stimulate the release of LH in Border Leicester x Scottish Blackface ewes only at the end of anestrus although this release does not appear to be accompanied by ovulation (Chesworth and Tait, 1974). Tervit and Peterson (1978) reported that Dorset rams were more effective in inducing estrus in Romney ewes than were Romney rams.

The use of existing genetic variation offers still another method of extending the breeding season. The vast diversity which exists in both the duration and timing of the breeding season (generally defined as the period of time during which at least 50% of the flock is active) offers a potential for permanent changes in the seasonal pattern of reproduction of the ewe. Genetic variation between breeds and breed crosses in the ability to mate and conceive at different times during the year have been demonstrated. Although the results of selection for extended or year-round breeding have been variable, within-breed variation has also been shown to exist.

In Quebec, Canada, Dufour (1974) characterized the breeding season of Dorset, Leicester and Suffolk ewes (all of which are of British origin) and of a crossbred line developed from these three breeds (DLS). The crossbred ewes were obtained from a genetic study designed to develop a line of sheep with the capability to breed at any time during the year. DLS and Dorset ewes began estrous activity sooner (July 28 and August 8, respectively) than did Leicester (September 13) or Suffolk (September 16) ewes and continued cycling for a longer period of time. Estrous activity of DLS ewes was maintained for an additional 20 d in relation to Dorset ewes and for an additional 70 and 115 days, respectively, in relation to Leicester and Suffolk ewes. The duration of the breeding season was estimated at 227 d for DLS, 206 d for Dorset, 157 d for Leicester and 132 d for Suffolks. Although Leicester and Suffolk ewes began to exhibit estrous cycles at essentially the same time, it was apparent that the Leicester ewes required a longer period of increasing daylength for anestrus to commence.

Wheeler and Land (1977) also found breed differences in the timing and duration of the breeding season among prolific Finnish Landrace, fine-wooled Tasmanian Merino and native Scottish Blackface ewes in Scotland. Finnish Landrace ewes exhibited the longest breeding season of the three breeds (215 d); breeding began October 9 and continued until May 10 (just 28 d prior to the longest day). The shortest breeding season was observed in the native Scottish Blackface ewes (141 d) with an average date of first estrus of October 9 and continuing estrous activity until February 28. Although Merino ewes began cycling over 1 mo earlier (September 5) than either Finnish Landrace or Scottish Blackface ewes, the cycling ended earlier (February 14) and the duration of the breeding season was intermediate to the other two breeds (162 d).

In a French study, Land et al. (1973) examined seasonal variation in the incidence of ovulation for the prolific

Romanov (a breed originating in the U.S.S.R.) and the native Solognote breeds. The duration of the breeding season was greater in Romanov (174 d) than in Solognote (116 d) ewes. Although both Romanov and Solognote ewes have a similar median date of onset of estrous activity (August 28 and August 30, respectively), the mean ending date was considerably different (February 18 and December 24, respectively). Thus, the difference in the duration of the breeding season between these two breeds is primarily due to differences in the time at which anestrus begins rather than to the time at which the breeding season starts. In a similar study, Lamberson and Thomas (1982) examined seasonal variation in the incidence of estrus for crossbred ewes. Finnish Landrace x Suffolk ewes were slower to enter anestrus and had a longer breeding season than Cheviot x Suffolk, Dorset x Suffolk or Rambouillet x Suffolk ewes. Cheviot x Suffolk ewes had the longest anestrus and there was a tendency for them to leave anestrus later than all other breed groups.

Results from studies concerning within-breed genetic variation and selection for an extended breeding season have been variable. Wiggins et al. (1970) conducted a 4-yr study examining estrous activity in open Rambouillet ewes throughout the year in Alabama. The percentage of theoretically possible heat periods actually exhibited by individual ewes ranged from 14.3% to 100%. In 3 of the 4 years, the same ewe had the lowest percentage of potential estrous activity and two ewes exhibited regular cyclic activity throughout the 4-yr period. These results imply that estrous behavior within ewes may be repeatable from one year to another and suggest the possibility of extending the breeding season by selection. In this same study, three distinct annual patterns of estrous behavior were observed. Ewes either cycled continuously all year, exhibited a well-defined period of estrous activity followed by a period of anestrus or exhibited two distinct estrous periods each year. The type of estrual activity exhibited by individual ewes was reported to be highly repeatable among years. Williams et al. (1956), however, found no tendency for individual Western ewes (progeny of finewool ewes mated to blackfaced meat-type rams such as Hampshires, Shropshires or Suffolks) to be consistantly early or late in the onsets of their individual breeding seasons or in the length of the breeding seasons in a 3-yr study conducted in Illinois. They concluded that the length and date of onset of the breeding season were primarily controlled by non-genetic factors; thus, indicating that no progress could be made through selection in sheep of that genetic background.

Repeatability estimates for reproductive traits in the ewe have been quite low (Turner, 1969). Lees (1966) reported repeatabilities for date of onset of the breeding season in Clun Forest ewes ranging from 0 to .45 (pooled value of .22). Dyrmundsson (1978) estimated that the repeatability of date of onset of the breeding season was .12 in Icelandic ewes.

Some studies have attempted to extend the breeding season through selection. Although the results of these studies have been variable, within-breed variation has been shown to exist. Thrift et al. (1971) selected for early lambing in Southdown ewes in Kentucky exposed to rams beginning August 1. The estimated total phenotypic change in date of birth for the 14-yr study was -13.2 d (-.943 d/yr). The heritability estimate for lambing date was reported to be .24 ± .16. In Beltsville, Maryland, Lindahl and Terrill (1975) selected a line of ewes (Morlam) for year-round breeding and were successful in achieving a nearly uniform distribution of ewes lambing in each month. However, when ewes from this flock were compared to Finnish Landrace crossbred ewes in Nebraska (Jenkins and Ford, 1982), the crossbred ewes had a breeding season 58 d longer than ewes of the selected line.

Bernard and Fahmy (1974) reported the results of a 5-yr study conducted in Quebec designed to develop a population of sheep with year-round breeding capabilities. Ewes were 1/2-Dorset, 1/4-Leicester and 1/4-Suffolk, and were exposed to fertile rams from June through September. The selection criteria was early lambing. The number of ewes lambing prior to December 31 increased by 6% over the 5 yr study. During June and July, 32 and 42% of the selected ewes exhibited estrous behavior. Fifteen and 40%, respectively, of the Dorset ewes were cycling during these same two months. Estrous behavior was not observed for Suffolk and Leicester ewes during the same period. Ninety percent or more of the selected ewes exhibited estrous cycles for 7 mo, from August through March. A comparable proportion of Dorset ewes were cycling during 5 mo and of Leicester and of Suffolk ewes during 4 mo. Dufour (1974) compared the seasonal cyclic behavior of a sample of the selected ewes to that of the parental breeds. Ewes from the selected line had a breeding season of 227 d, began estrous activity earlier and ended later than any of the three parental breeds.

Conception Rate

Differences among breeds and breed crosses in ability to breed and conceive outside the normal breeding season have been observed. Fogarty et al. (1984 a,b) compared conception rates (percentage of ewes lambing of ewes exposed) of Finnish Landrace, Rambouillet, Dorset and Finnish Landrace crossbred ewes mated in April, August and December. Ewes were exposed to rams for 32 to 43 d in single sire groups. Conception rates for August were lower in the purebred Finnish Landrace (52.0%) than in any other breed group. In December, conception rates were higher for Finnish Landrace (83.7%) and Finnish Landrace crossbred ewes (average of 90.4% for 8 different crossbred types) than for either Rambouillet (70.6%) or Dorset (73.3%) ewes. Conception rates for April were sharply lower for all breed groups. However, Finnish Landrace x Dorset (42.5%), 7/8-Finnish Landrace (32.1%) and Finnish Landrace (27.0%) ewes had the highest conception rates for April whereas the Dorset (10.4%), 1/2-Finnish Landrace, 1/4-Rambouillet, 1/4-Dorset (9.1%), and Finnish Landrace x Rambouillet (3.3%) ewes had the lowest conception rates.

In a similar study in Virginia, Notter and Copenhaver (1980) evaluated the reproductive performance of 1/2 Finnish Landrace, 1/2-Rambouillet (1/2-Finn) ewes; 1/4-Finnish Landrace, 3/4-Rambouillet (1/4-Finn) ewes, and 1/2-Suffolk, 1/2-Rambouillet (SR) ewes in a system in which all ewes were given the opportunity to lamb three times every 2 yr over a 5-yr period. Ewes were exposed to Suffolk rams for approximately 45 d beginning in early August, early November or early April. Overall conception rates were 90% for August, 70% for November and 53% for April matings. Breed groups did not differ significantly in conception rates in August or November. However, in April, conception rates were higher for 1/2-Finn ewes (60%) than for either 1/4-Finn (45%) or SR (38%) ewes.

In an Oklahoma study, Dzakuma et al. (1982) compared conception rates for crossbred ewes representing five combinations of Finnish Landrace, Dorset and Rambouillet breeding. Ewes were exposed to rams during winter (January and February), fall (September and October) and late spring (May and June). During the winter and fall breeding seasons, conception rates were high (91.8% and 90.6%, respectively) and no differences in conception rate were observed among breed groups. In spring, when overall conception rates were low (47.8%), 1/2-Dorset 1/2-Rambouillet ewes had higher conception rates (67.0%) than 1/4-Dorset, 3/4-Rambouillet (46.0%) or any of the Finnish Landrace crossbred (48.5%) ewes. In a similar study in Oklahoma, Thomas and Whiteman

(1979 a,b) evaluated the main effects of increasing Dorset and Finnish Landrace breeding by one-quarter at the expense of Rambouillet breeding on ewe productivity in crossbred ewes for fall (August to December) and spring (May and June) matings. No differences in conception rates were observed among breed groups in fall matings, but in May and June, the Finnish Landrace crossbred ewes conceived less readily than the Rambouillet x Dorset ewes. When Finnish Landrace breeding was increased by one-quarter, a 19.4% reduction in conception rate for spring mating occurred. Results from these studies are in contrast with the improved performance of various Finnish Landrace crosses by Fogarty et al. (1984 a,b), and Notter and Copenhaver (1980) in March and April, respectively. This may reflect a difference in the timing of onset of anestrus and could suggest that by May and June, Finnish Landrace crossbred ewes are beginning to enter the non-breeding season. Goot and Maijala (1977) indicated that the frequency of estrus among Finnish Landrace ewes was near maximum in April, but declined considerably in late spring (May to July). However, studies conducted Hulet et al. (1974) indicated that estrous behavior of Rambouillet ewes was minimal in May and early June, but increased substantially in late June and July.

In other studies, Whiteman et al. (1972) observed conception rates for Dorset, Dorset x Rambouillet and Rambouillet ewes in a twice-yearly lambing program. Conception rates for fall matings (October to December) were higher for Dorset x Rambouillet (89%) and Rambouillet (85%) ewes than for Dorsets (74%). However, conception rates for spring matings (April to June) were higher for Dorset x Rambouillet (39%) and Dorset (37%) ewes than for Rambouillets (29%). Cedillo et al. (1977) reported that the conception rate for August mating of Finnish Landrace-sired ewe lambs was 72% whereas Dorset-, Cheviot-, and Romney-sired ewe lambs had conception rates of 42%, 38% and 31%, respectively. The high August conception rate for the Finnish Landrace-sired ewes may reflect a more rapid rate of sexual maturity in the Finn-cross ewe lambs.

Speedy and FitzSimons (1977) in Scotland compared the reproductive performance of Finnish Landrace x Dorset ewes with that of Border Leicester x Scottish Blackface ewes mating three times in 2 years. Finnish Landrace x Dorset ewes had higher conception rates than Border Leicester x Scottish Blackface ewes in August (82% vs 55%, respectively) and February (73% vs 26%) but not in November (88 vs 96%). Thus, during the natural breeding season conception rates were highest for Border Leicester x Scottish Blackface ewes whereas conception rates for matings occurring closer to either the estrus-anestrus or anestrus-estrus transitions favored Finnish Landrace x Dorset ewes.

Postpartum Interval

The success of a twice yearly lambing program depends upon the ability of the ewe to rebreed within 30 d postpartum. Otherwise, a three-time-in-2-yr lambing schedule may be more practical, especially if artificial rearing is not practiced. After lambing, normal cyclic behavior in the ewe can be interrupted due to postpartum and (or) lactational anestrus (Hulet and Foote, 1967). Postpartum anestrus has been defined as the period during which the ewe is making the necessary adjustments after lambing to re-establish regular and functional estrous cycles, whereas, lactational anestrus is the interruption of normal cyclic behavior as a direct result of suckling lambs (Lees, 1971).

A study designed to allow 1/2-Finnish Landrace, 1/2-Dorset ewes to lamb four times in 2 yr found that the proportion of ewes lambing was reduced from 93 to 32% by the occurrence of lambing 6 mo previously (Land and McClelland, 1971). Fogarty et al. (1984a) compared Finnish Landrace, Rambouillet, Dorset, Targhee and Suffolk ewes lambing three times in 2 yr (January, May and September) or annually in

April. An 8 mo versus 12 mo lambing interval significantly depressed fertility (52 vs 65%, respectively) for Finnish Landrace and 7/8-Finnish Landrace ewes, indicating that these more prolific ewes needed a longer time to fully recover from lambing. Conversely, Land (1971) found that following spring lambing, a larger proportion of Finnish Landrace ewes displayed estrus between 3 and 56 d after lambing (100%) than did Dorset (68%) or Finnish Landrace x Dorset (59%) ewes.

When exposed to rams in August or November (in season), 1/4- and 1/2-Finnish Landrace ewes that lambed 2 to 4 mo before exposure had conception rates 3 to 5% lower than ewes that had not lambed for at least 7 mo before exposure (Notter and Copenhaver, 1980). In April, ewes that lambed 2 to 4 mo before breeding had a 23% higher conception rate than ewes that lambed at least 7 mo before breeding.

In Wales, Clun Forest ewes lambing from June until the end of the year had an average interval of 6 to 7 wk before ewes conceived (Lees, 1971). In January, some ewes did not conceive again because lactational anestrus carried them out of the breeding season, thus preventing a twice yearly lambing program. Whether this occurs will depend upon individual variation in the length of the breeding season.

Crossbred ewes selected for fall lambing have been shown to have a longer breeding season than nonselected ewes (Dufour, 1974). If the breeding season is extended, this should increase the potential for ewes to rebreed after lambing, making a twice yearly lambing program possible. Dufour (1975) compared the length of the postpartum interval for these selected crossbred ewes (1/2-Dorset, 1/4-Leicester, 1/4-Suffolk) lambing in the fall and in the spring. The average fall lambing date was November 8, and weaning occurred 14 d later. The interval between weaning and first estrus was 18 d. However, following an average spring lambing date of May 14, the postweaning interval to first estrus was 87.1 d. Of the ewes bred, 76.7% lambed after fall lambing whereas 89.1% lambed after spring lambing.

Whiteman et al. (1972) found that for Dorset, Rambouillet and Dorset x Rambouillet ewes that lambed during the fall, 85% mated following lambing and the average interval to the first mating was 32 d. For spring lambing ewes, only 50% mated and the average interval to first mating was 59 d. Thus, the ewes resumed normal cyclic behavior sooner in the fall than in the spring.

Length of lactational anestrus in the sheep has been shown to be related to the degree of mammary stimulation in

Prealpes du Sud ewes (Kann and Martinet, 1975). When ewes were milked by hand two times per day or "dried off" immediately after parturition, the first estrus occurred 30 to 40 d postpartum. However, if the ewe was allowed to nurse her lambs (suckling 10 to 12 times per day) lactational anestrus lasted for 60 to 80 d.

In a similar study, the average interval from lambing to first estrus for Dorset, grade Rambouillet and Rambouillet crossbred ewes was 56 d for nonsuckled ewes. This compared to 80 d for ewes that nursed single lambs and 87 d for ewes that nursed twins (Barker and Wiggins, 1964). Gould and Whiteman (1973) found that for Dorset, Dorset x Rambouillet and Rambouillet ewes, resumption of estrual activity occur at an average of 58 d postpartum for early-weaned, spring-lambing ewes (lambs weaned at 30 d) and 66 d postpartum for late-weaned, spring-lambing ewes (lambs weaned at 70 d).

Whiteman et al. (1972) studied the length of the postpartum interval for Dorset, Rambouillet and Dorset x Rambouillet ewes lambing two times annually. The postpartum interval to first estrus (about 32 d) was essentially the same for lactating and nonlactating ewes during the fall. Spring lambing ewes that did not rear lambs had an average postpartum interval to first estrus of 37 d as compared to

58 d for lactating ewes. Conversely, Ford (1979) found the interval from parturition to estrus for Finnish Landrace crossbred ewes that lambed in the fall to be longer for lactating ewes (45.5 d) than for nonlactating ewes (26.8 d).

Litter Size

Differences in prolificacy (number of lambs born per ewe lambing) have been reported not only between breeds and breed crosses but also between different seasons of the year. Notter and Copenhaver (1980) observed significantly different litter sizes for ewes lambing in January (2.21), April (2.46) and September (1.84). Finnish Landrace x Rambouillet ewes averaged .48 more lambs per litter than did 1/4-Finnish Landrace, 3/4-Rambouillet ewes and .50 more lambs per litter than did Suffolk x Rambouillet ewes. Similar results were reported by workers in Oklahoma (Dzakuma et al. 1982) for crossbred ewes representing five combinations of Finnish Landrace, Dorset and Rambouillet breeding. Prolificacy for ewes lambing in March and April (1.80) was greater than for ewes lambing in July and August (1.67) or in November and December (1.35). Litter size was larger for 1/4-Finnish Landrace crosses (1.66) than for 1/2-Dorset, 1/2-Rambouillet ewes (1.56) and 1/4-Dorset, 3/4-Rambouillet ewes (1.50). Fogarty et al. (1984a) reported litter sizes of 1.8 in January, 1.7 in May and 1.4 in September for Finnish Landrace, Rambouillet, Dorset, Targhee, Suffolk and Finnish Landrace crossbred ewes.

In Scotland, workers compared litter sizes for Finnish Landrace and Tasmanian Merino ewes and for their recriprocal crosses (Land et al., 1973). Litter size of the Finnish Landrace ewes (2.9) was significantly greater than that of the Tasmanian Merinos (1.0) whereas Finnish Landrace x Merino (1.70) and Merino x Finnish Landrace ewes (1.70) were intermediate. Cedillo et al. (1977) observed considerably larger litter sizes for Finnish Landrace crossbred ewes (1.62) than for all other breed crosses (1.18). Similarly, Speedy and FitzSimons (1977) reported litter sizes of 2.34 for Finnish Landrace x Dorset ewes and 2.15 in Border Leicester x Scottish Blackface ewes.

Bradford et al. (1971) observed a higher ovulation rate in Finnish Landrace ewes than in either Welsh Mountain or Border Leicester ewes. Furthermore, a higher percentage of Finnish Landrace ewes had ovulations on both ovaries, partly due to the higher ovulation rate, but also as a result of a more even distribution of multiple ovulations between the ovaries. Similarly, comparisons between Finnish Landrace x Targhee and purebred Targhee ewes revealed significantly higher ovulation rates for the crossbred ewes (Meyer and

Bradford, 1973). Ovulation rates were 30% higher for crossbred ewes than for the purebred Targhee. Maijala and Osterberg (1977) reported that Finnish Landrace ewes had ovulation rates ranging from 2.96 to 3.8.

Finnish Landrace crossbred ewes have been observed to have a longer heat period (52.45 hr) than either Scottish Blackface (42.90 hr) or Merino x Scottish Blackface (28.16 hr) ewes (Land, 1970 a). A significant positive relationship between duration of heat period and prolificacy was observed. Litter size was increased .011 lamb for every 1 hr increase in the length of the heat period. Donald and Read (1967) reported that purebred Finnish Landrace ewes in Britain exhibited a heat period of 48 hr or longer.

In addition to breed and season differences, studies have also reported differences in litter size for ewes of various ages. Notter and Copenhaver (1980) observed that among Finnish Landrace x Rambouillet ewes, litter size increased with increasing age. In Britain, purebred Finnish Landrace ewe lambs averaged 2.0 lambs in their first litter. Average litter size increased to 3.0, 3.3, 3.4 and 3.4 for 2-, 3-, 4- and 5-yr-old ewes, respectively (Donald and Read, 1967).

Maijala and Osterberg (1977) reviewed productivity of Finnish Landrace ewes in 13 countries. Mean litter sizes for 1- and 2-year old, and aged ewes (ewes ranging in age from 3 to 9 years) were 1.84, 2.45 and 2.82, respectively. Conversely, Goot and Maijala (1977) observed that individual litter size was not affected by age of ewes. However, the average litter sizes at first lambing were 1.6, 1.9 and 2.6 for ewes with average ages of 324, 384 and 534 days, respectively.

Birth and Preweaning Traits

The potential for reducing the cost of lamb production is greatest through increased reproductive rate. Larger litter sizes and a greater number of lambs produced per ewe per year can increase individual ewe productivity as well as the productivity of the entire flock. However the advantage of increased reproductive rate is not realized if lambs are dead at birth, have extremely low birth weights, die prior to weaning, have poor growth rates, or have low weaning weights.

Birth weight has been found to be affected by season of birth, birth type and sex of lamb as well as by breed and age of dam. Stritzke and Whiteman (1982) compared birth weights for crossbred ewes lambing in fall (October and November), winter (January to March) and summer (June and July). Winter-born lambs (4.78 kg) were heavier at birth than summer-born lambs (4.45 kg) and heavier than fall-born lambs (3.50 kg). This result was comparable to the observations of Gould and Whiteman (1971) who reported that spring-born lambs (from Dorset, Rambouillet and Dorset x Rambouillet ewes) were .94 kg heavier at birth than fall-born lambs. Single lambs were .99 kg heavier at birth than twins and 1.60 kg heavier than triplets; ram lambs were .21 kg heavier at birth than ewe lambs (Stritzke and Whiteman, 1982). Lambs from 3/4-Rambouillet ewes were heavier at birth than those from 1/4- or 1/2-Rambouillet dams.

Minnesota workers (Oltenacu and Boylan, 1981b) reported that litter size had the greatest influence on birth weight, observing a difference of over 2 kg between birth weights of single and quintuplet lambs. Birth weight declined as litter size increased, with the largest decrease occurring between singles and twins. Male lambs averaged .28 kg heavier than females at birth. The heaviest lambs at birth were purebred Targhee (3.93 kg) and Suffolk (3.90 kg) lambs, and the lightest were Finnish Landrace lambs (2.60 kg). Birth weight was observed to increase as the age of the dam increased. Large differences were reported between lambs of 1- and 2-yr-old ewes (+.43 kg) and between lambs of 2- and 3-yr-old ewes (+.42 kg).

Similarly, Magid et al. (1981) reported that lambs born as twins or triplets had lower birth weights (-.9 kg and -1.7 kg, respectively) than lambs born as singles. Lambs from Hampshire ewes were heaviest at birth (4.1 kg), and lambs from 1/2-Finnish Landrace and Rambouillet ewes were lightest (3.6 kg and 3.7 kg, respectively). Birth weight was observed to increase significantly with age of dam.

Many of the same factors which affect birth weight are also responsible for differences in survival to weaning, growth rate and weaning weight. Fogarty et al., 1984a reported that lamb survival was lowest in January (86.5%) when litter size was largest and highest in September (93.4%) when litters were smallest. Dickerson et al. (1975) found that lambs born as twins were less viable at birth (-1.5%), at 4 wk (-9.8%) and when weaned at 10 wk of age (12.4%) than comparable single-born lambs. Triplet lambs had markedly lower survival rates than singles. Ram lambs were observed to be 3% less viable prior to weaning than ewe lambs. Little difference in percentage of lambs born alive or surviving to weaning was observed between straightbred and crossbred lambs.

Magid et al. (1981) reported that lambs born as triplets or twins had poorer survival to weaning (approximately 5 wk of age) than lambs born as singles (40% and 62%, vs

78%, respectively). Survival (adjusted for type of birth and rearing) was highest for lambs of 1/2-Finnish Landrace ewes (67%), followed by those of Rambouillet (62%), Targhee (58%) and Hampshire (54%) ewes. Similarly, Oltenacu and Boylan (1981a) reported higher survival to weaning for Finnish Landrace lambs born alive (97.5%) than for Targhee (85.2%) and Suffolk (76.8%) lambs. Survival rates of lambs of Finnish crossbred ewes were nearly as high as those of lambs of Dorset-cross ewes when ewes lambed at 1 to 3 yr of age (Donald et al., 1968). Cedillo et al. (1977) reported that Finnish Landrace-sired ewes weaned more lambs per ewe bred (.77 lamb) than Dorset- (.42 lamb), Cheviot- (.38 lamb), and Romney- (.27 lamb) cross ewes.

Fogarty et al. (1984a) reported that mean lamb weights at weaning (5 to 10 wk) were lower in May (10.9 kg) than in January (11.5 kg) and September (11.5 kg). Oklahoma workers (Stritzke and Whiteman, 1982) reported that winter-born lambs weighed more (28.55 kg) than either fall-born (25.62 kg) or summer-born (24.76) lambs at 70 d of age. Similarly, Gould and Whiteman (1971) reported that spring-born lambs were 2.54 kg heavier at 70 d of age than were fall-born lambs.

At 70 d of age, the difference between single-born, single-reared and twin-born, single-reared lambs was .75 kg and the difference between single-born, single-reared and twin-born, twin-reared lambs was 5.48 kg (Stritżke and Whiteman, 1982). Ram lambs were 2.15 kg heavier at 70 d than were ewe lambs.

An increase in age of dam also had a positive effect on weaning weight at 70 d (Oltenacu and Boylan, 1981 b). The greatest differences were observed between 1- and 2-yr-old dams (+3.40 kg) and between 2- and 3-yr olds (+1.93 kg).

Ewe Weight

Ewe weight prior to mating can influence reproductive performance in many ways. In particular, ewe weight may potentially influence fertility, ovulation rate, litter size, litter birth weight and individual ewe feed costs.

Adalsteinsson (1979) examined the effects of live weight and body condition on fertility and productivity of Icelandic ewes. Fertility increased linearly with live weight at 8 wk prior to mating and was also influenced by body condition score and weight change. Ovulation rate varied with ewe weight prior to breeding; heavier ewes tended to have larger litters.

Ewes with live weights greater than the mean had significantly higher ovulation rates than ewes with live weights below the mean (Cumming, 1972). Heavier ewes also had a higher incidence of multiple births (46%) than lighter weight ewes (30%). In Australian breeds, a 2.5 to 3.0% increase in ovulation rate for each 1 kg increase in ewe weight was observed (Cumming, 1977).

Edey (1968) investigated the relationship between breeding weight at the time of ovulation and ovulation rate for Merino ewes in Australia. Below 35 to 37.5 kg, ovulation rate was approximately 105% and did not vary significantly with ewe weight. However, above this level, for each 2.5 kg increment in breeding weight, there was at least a 5% increase in ovulation rate (up to a weight of 53 kg) and at least a 10% increase per 2.5 kg within the weight range of 40.4 to 48.4 kg.

In contrast, Geisler and Fenlon (1979) found no significant relationship between lambing performance and ewe weight for several commercial flocks in the U.K. In an attempt to explain this apparent contradiction to the existing literature, they defined "threshold" body conditions around which the ovulation rate would increase from zero to one and again from one to two. Thus, if a study involved ewes at two different body conditions which were clearly on different sides of a threshold level, an effect of ewe weight on ovulation would be observed. However, if ewes were similar in weight and body condition, no effect on ovulation would be seen.

Spedding et al. (1972) observed an increase in litter birth weight for a given number of lambs with increased ewe weight. Thus, heavier ewes required more feed in proportion to the greater fetal weight.

Geisler and Jones (1979) reported that total energy requirements for lighter ewes were considerably lower than for ewes at heavier weights. The energy requirements of the ewe was dependent on total fetal weight and not on litter size.

Longevity and Lifetime Productivity

In a study conducted by Notter and Copenhaver (1980), the higher productivity of 1/2-Finnish Landrace ewes in accelerated lambing was shown to have no effect on longevity through 5 or 6 yr of age when litters were reduced to two lambs at birth. The 1/2-Finnish Landrace ewes were superior to 1/4-Finnish Landrace and Suffolk x Rambouillet ewes in total number of lambs born and weaned, and kilograms of lamb weaned. Even when litters were reduced to two lambs at birth, the 1/2-Finnish Landrace ewes weaned an average of 12% more kilograms of lamb than 1/4-Finnish Landrace ewes and 17% more kilograms of lamb than the Suffolk x Rambouillets. Similarly, Goot and Maijala (1977) examined the cumulative effect of a continuous twice-yearly lambing program on reproductive performance of Finnish Landrace ewes in Finland. No decline in reproductive performance due to years spent in the system could be detected through 5-1/2 yr of age.

Finnish Landrace crossbred ewes were equal in longevity (measured as a ewe's age in months when she died or was culled from the study or, for surviving ewes, her age when the study was terminated) to Dorset and Romney crosses, while Cheviot-cross ewes had shorter life spans (Hohenboken and Clarke, 1981). Longevity was greater under the management system in which productivity was greater. When nutrition and environment were poor, Finnish Landrace cross ewes had shorter life spans than any of the other breed groups.

Seasonal Variation in Ram Performance

Fertility in the domestic ram undergoes continual seasonal changes. Although semen is produced and rams are usually capable of siring offspring throughout the year, a period of reduced fertility exists for several months during the late spring and early summer.

Mickelsen et al. (1981) reported marked seasonal variation in scrotal circumference and sperm morphology for both Suffolk and Lincoln rams. Mean scrotal circumferences were highest in October, 36 and 37 cm, respectively, for Suffolk and Lincoln rams. Percentage of morphologically normal sperm was highest in October (92.8%) for both breeds and lowest for February (56.1% and 58.8%, respectively, for Suffolk and Lincoln rams).

Seasonal variation in testis diameter and sperm output was studied in Finnish Landrace, Merino and Finnish Landrace x Merino rams throughout the year (Islam and Land, 1977). All breed groups showed significant seasonal fluctuations in testes diameter, exhibiting minimal values in late spring (April through July) and maximal values in winter (November through December). Regression in testes diameter was shown to take place earlier in the year for Merino rams and was essentially complete by March.

Seasonal variation in semen production and sperm quality have been reported to exist between breeds. Ile-de-France and Prealpes du Sud rams showed greater seasonal variation in sperm production than did rams of two other French breeds (Dacheux et al., 1981). Furthermore, Ile-de-France rams showed the greatest variation in sperm concentration between the breeding and non-breeding season. Similarly, Barrell and Lapwood (1979) observed an increased tendency of Romney and Merino rams to exhibit seasonal fluctuations in ejaculate volume, spermatozoal numbers and seminal fructose when compared to Dorset rams.

Land (1970 b) observed no differences in seasonal changes in semen quality between Finnish Landrace and Merino rams, but reported that the libido of 1-yr-old Finnish Landrace rams was greater during the spring and summer months than that of Scottish Blackface rams at the same age. Differences in libido between the two breeds seemed to disappear at 2 yr of age. Schanbacher and Lunstra (1976) monitored sexual activity in Finnish Landrace and Suffolk rams over a 12 mo period. Mating activity was highest during the peak breeding season (October) and declined by 50% by late spring and early summer. Libido scores (a measure of sexual aggressiveness) were highest for Finnish Landrace rams throughout the year.

In Soay rams (a breed recognized for being extremely seasonal) exposed to long days, plasma levels of gonadotrophins became very low and testicles regressed to approximately 20% of their maximum size (Lincoln et al., 1977). Plasma levels of LH and FSH as well as testosterone begin to rise between days 6 and 12 of short days, and rose progressively until day 33 to 54 before declining again. Testicular growth began on days 19 to 26 and continued throughout the short day period (Lincoln and Peet, 1977).

MATERIALS AND METHODS

Collection of the Data

Animals

The data for this study were collected at the Virginia Polytechnic Institute and State University (VPI&SU) Sheep Center in Blacksburg, Virginia. To derive the ewes for this study, 30 Finnish Landrace (Finn) ewes from the US Meat Animal Research Center, Clay Center, Nebraska, 82 Dorset ewes chosen at random from the VPI&SU purebred Dorset flock, and 57 3/4-Rambouillet, 1/4-Finn ewes from the VPI&SU research flock were mated to one of 6 Finn rams from Cornell University (representing two sire lines), 4 Dorset rams from the VPI&SU flock, 2 Barbados Blackbelly rams from Mississippi State University or 2 Rambouillet rams originating from a Texas flock to derive the ewes for this study. Thirty-four grade Rambouillet (7/8-Rambouillet, 1/8-Finn), 30 Dorset, 21 Finn, 10 Dorset x Finn, 23 Finn x Dorset, and 34 Barbados Blackbelly x Dorset ewes resulting from these matings were used. As indicated in Table 1, ewes were born in 1979 or 1980 with the exception that no Rambouillet ewes were born in 1980. Ewes remained in the study for five matings (with

TABLE 1. NUMBER OF EWES ENTERING THE STUDY

Ewe breed	Ewe birth year		
	1979	1980	Total
Dorset	21	9	30
Finn	10	11	21
Blackbelly x Dorset	13	21	34
Dorset x Finn	6	4	10
Finn x Dorset	15	8	23
Rambouillet	34		34
Total	99	53	152

the exception of 1980-born ewes which were present for four matings) or until they died or were culled for physical defects rendering the ewe non-functional (i.e., mastitis, prolapse, etc.). Numbers of potential matings by ewe birth year, ewe breed and mating season are given in Table 2.

Management

Ewes born in 1979 were bred in April, 1980; November, 1980; August, 1981; May, 1982; and April, 1983. The 1980-born ewes entered the study at the November, 1980 mating. For the first and third matings (April, 1980 and August, 1981, respectively), ewes were bred to Suffolk rams. For the second mating, both Hampshire and Suffolk rams were used. Suffolk and Dorset sires were used for the May, 1982 mating to avoid any limiting effects the sire breed may have imposed on conception rate. Over 75% of the lambs born as a result of the May, 1982 mating were sired by Dorset rams. Only Dorset rams were used for the April, 1983 mating due to the high percentage of white-faced lambs resulting from the May, 1982 mating.

Spring and winter lambings (November, 1980 and August, 1981 matings) took place inside a barn or shelter, whereas fall lambings (April, 1980; May, 1982 and April, 1983 matings) took place outside. Third and fourth lambs from mul-

TABLE 2. NUMBER OF EWES EXPOSED BY BIRTH YEAR, BREED AND MATING SEASON

Ewe birth year	Ewe breed	Breeding date					Total
		April 80	November 80	August 81	May 82	April 83	
1979	Dorset	21	20	17	10	9	77
	Finn	10	10	10	10	10	50
	Blackbelly x Dorset	13	13	13	11	9	59
	Dorset x Finn	6	6	5	5	5	27
	Finn x Dorset	15	15	13	11	10	64
	Rambouillet	34	34	33	30	29	160
1980	Dorset		9	8	6	5	28
	Finn		11	11	9	9	40
	Blackbelly x Dorset		21	20	17	17	75
	Dorset x Finn		4	4	4	4	16
	Finn x Dorset		8	6	6	6	26
Total		99	151	140	119	113	622

tiple births were cross-fostered or sold at 1 to 3 d of age if the ewe was unable to nurse them successfully. Ewes were credited with only lambs they raised, and the ewes nursing cross-fostered lambs were not credited with having raised those additional lambs. Ram lambs were castrated (with the exception of those born as a result of the April 1983 mating) and all lambs were docked at 10 to 14 d of age.

Ewes were maintained on pasture during the grazing season and on alfalfa hay during the winter. Grain was fed during late gestation beginning 30 d prior to parturition and continuing through early lactation. Ewes and lambs were moved to a barn with expanded metal floors at 3 d postpartum at which time creep feeding began for the lambs. Lambs were weaned at an average age of 40 to 50 d.

Records

Information recorded for each ewe each year included lambing date, number of lambs born and number of lambs reared (alive at 2 wk). Ewes weights were also taken for each ewe on April 1, 1980; August 5, 1981; May 7, 1982; April 7, 1983 and November 11, 1983. Information recorded for each lamb included date of birth, birth weight, sex, type of birth, type of rearing (to 2 wk of age), weaning date, weaning weight and sire breed. In addition, average daily gain to weaning (ADG) was calculated for each lamb as (weaning weight-birth weight)/age at weaning.

Statistical Analyses

Two analyses were conducted, one for ewe performance and another for lamb performance. Variables included in the ewe analysis were conception rate (fertility), litter size (per ewe lambing and per ewe exposed), number reared (per ewe lambing and per ewe exposed), lambing date, ewe body weight, and longevity traits (days in the study and percentage of ewes completing the study).

Variables included in the analysis of the lamb data were birth weight, percentage dead at birth or shortly after (within 3 d), percentage surviving to weaning, weaning weight, and average daily gain from birth to weaning (ADG).

Ewe performance

The analytical model used to describe ewe performance was:

$$X_{ijkl} = \mu + Y_i + B_{ij} + S_{ik} + (BS)_{ijk} + E_{ijl} + e_{ijkl}$$

where X_{ijkl} was the performance of the l^{th} ewe of the j^{th} breed (j = 1, 2, 3, 4, 5, 6 for 1979-born ewes and j = 1, 2, 3, 4, 5 for 1980-born ewes) and the i^{th} birth year (i = 1,

2) mated in the k^{th} season (k = 1, 2, 3, 4, 5 for 1979-born ewes and k = 1, 2, 3, 4 for 1980-born ewes). The overall mean was μ and was common to all observations; e_{ijkl} was the random error associated with each observation. Random ewe effects (E) were nested within ewe breed and ewe birth year.

The effects of ewe birth year and ewe breed nested within ewe birth year were tested using the between-ewe mean square. Season effects were tested with the error mean square. Ewe effects (E_{ijl}) and error (e_{ijkl}) were considered to be independently and randomly distributed with mean zero and variances σ_E^2 and σ_e^2, respectively; all other effects were considered fixed.

This model was used to analyze all ewe traits except body weight and ewe longevity traits. Both of these traits were analyzed in a model including only effects of ewe birth year and ewe breed nested within ewe birth year.

Sums of squares were calculated by procedures outlined by Harvey (1970). The sum of squares for the ewe effect was calculated from the reductions (R) in sums of squares using two models as $R(\mu,E,F) - R(\mu,F)$ which is the difference in the total sum of squares between a model including the mean and a model including (μ), random ewe effects (E) and all fixed effects in the model (F) and a model including μ and F.

Lamb performance

The model used to describe lamb performance was:

$$Z_{ijklm} = \mu + Y_i + B_{ij} + S_{ik} + (BS)_{ijk} + L_l + (SL)_{ikl} + e_{ijklm}$$

where Z_{ijklm} was the performance of the m^{th} lamb from the j^{th} breed of ewe and the i^{th} ewe birth year conceived in the k^{th} season; μ, Y_i, B_{ij}, S_{ik}, $(BS)_{ijk}$, and e_{ijklm} were the same as the effects described previously for the ewe performance model. The L_l was the effect due to the l^{th} sex of the lamb ($l = 1,2$). All effects included in the lamb performance model were considered to be fixed.

In a supplemental analysis, sire breed was included in the analysis to determine the effect of sire breed on birth weight and ADG for seasons in which more than one breed of ram was used. In November, 1980 (when both Hampshire and Suffolk rams were used) Suffolk-sired lambs had an advantage in ADG of .02 kg, whereas no breed difference was detected in birth weight. In May, 1982 (when both Dorset and Suffolk rams were used) Dorset-sired lambs were .09 kg heavier at birth than the Suffolk-sired lambs and showed no difference in ADG. Birth weights of Dorset-sired lambs in May, 1982 and ADG's of Hampshire-sired lambs in November, 1980, were subsequently additively adjusted to a Suffolk-sired base before fitting the final lamb performance model. Thus, all lamb data is expressed in terms of Suffolk sires except for results from April, 1983 at which time only Dorset sires were used.

RESULTS AND DISCUSSION

Ewe Performance

Analysis of variance per ewe exposed

Mean squares for ewe performance (per ewe exposed) are presented in table 3.

Pregnancy rate. Pregnancy rate (number of ewes lambing per number of ewes exposed) differed ($p < .01$) among breed groups for 1979-born ewes and tended to differ ($p < .01$) for 1980-born ewes. Season effect and ewe breed by season interaction were significant for 1979-born ewes only. The random ewe effect was also highly significant. However, ewe birth year was not a significant source of variation. When Rambouillet ewes were excluded from the analysis (table 4), the random ewe and season effects remained significant, the ewe breed effect only tended toward significance and the ewe breed by season interaction was no longer significant. Thus, the interaction effects were apparently attributable primarily to the Rambouillet ewes.

Least squares means for pregnancy rate for both 1979- and 1980-born ewes are presented in table 5. For 1979-born ewes, mean pregnancy rates tended to be highest for matings

TABLE 3. LEAST-SQUARES ANALYSIS OF VARIANCE FOR EWE PERFORMANCE (PER EXPOSURE)

Source of variation	Degrees of freedom	Mean squares: Pregnancy rate[a]	Number born	Number reared[b]
Ewe birth year	1	.325	.018	.621
Ewe breed/ewe birth year				
Ewe breed/1979	5	.887**	6.363***	2.469*
Ewe breed/1980	4	.464†	3.502**	2.993**
Ewe/ewe breed/ewe birth year[c]	141	.215***	1.062***	.802***
Season/ewe birth year				
Season/1979	4	1.505***	12.656***	10.170***
Season/1980	3	.007	.325	.230
Ewe breed x season/ewe birth year				
Ewe breed x season/1979	20	.302***	.974*	1.223***
Ewe breed x season/1980	12	.021	.440	.628
Error	431	.094	.552	.500

†$p < .1$.

*$p < .05$.

**$p < .01$.

***$p < .001$.

[a]Number of ewes lambing per number of ewes exposed.

[b]Alive at 2 wk.

[c]Ewe birth year and ewe breed/ewe birth year were tested against the ewe mean square.

TABLE 4. LEAST-SQUARES ANALYSIS OF VARIANCE FOR PERFORMANCE OF 1979-BORN EWES EXCLUDING RAMBOUILLETS (PER EXPOSURE)

Source of variation	Degrees of freedom	Mean squares: Pregnancy rate[a]	Number born	Number reared[b]
Ewe breed	4	.440[†]	3.947*	2.386*
Ewe/ewe breed	60	.204**	1.323***	.707
Season	4	.671***	7.738***	5.962***
Ewe breed x season	16	.129	.692	1.088*
Error	192	.120	.679	.606

[†] $p < .1$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

[a] Number of ewes lambing per number of ewes exposed.

[b] Alive at 2 wk.

TABLE 5. LEAST-SQUARES MEANS FOR PREGNANCY RATES (%) FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	45.4± 8.5	89.4± 8.6	89.3± 9.2	71.7±12.1	77.2±12.8	72.8± 5.8
	Finn	90.1±11.9	90.1±11.9	100.1±11.9	60.1±11.9	100.1±11.9	88.1± 7.0
	Blackbelly x Dorset	61.5±10.5	84.5±10.5	99.9±10.5	100.2±11.4	100.4±12.8	89.3± 6.4
	Dorset x Finn	70.7±15.6	104.1±15.6	97.4±16.9	97.4±16.9	97.4±16.9	93.4± 9.5
	Finn x Dorset	64.5± 9.8	84.5± 9.8	86.1±10.5	57.2±11.4	80.6±12.1	74.6± 6.1
	Rambouillet	11.7± 6.5	91.1± 6.5	87.7± 6.6	63.5± 6.9	72.9± 7.0	65.4± 3.9
	Mean	57.3± 4.5	89.1± 4.5	93.4± 4.6	75.0± 4.9	88.1± 5.1	
1980	Dorset		84.9± 9.6	97.4± 9.9	91.1±11.3	91.1±12.5	91.1± 8.4
	Finn		99.3± 8.5	90.2± 8.5	89.2± 9.4	89.2± 9.4	92.0± 7.1
	Blackbelly x Dorset		99.8± 6.2	99.8± 6.2	99.8± 6.8	99.8± 6.8	99.8± 5.2
	Dorset x Finn		74.8±14.1	74.8±14.1	74.8±14.1	74.8±14.1	74.8±11.4
	Finn x Dorset		68.6±10.7	68.6±11.4	85.2±11.4	68.6±11.4	72.7± 8.8
	Mean		85.5± 4.6	86.2± 4.7	88.0± 4.8	84.7± 4.8	

occurring during the normal breeding season (November, 1980 and August, 1981) and lowest for matings that were clearly out-of-season (April, 1980 and May, 1982) with the exception of April, 1983 mating at which time pregnancy rates equalled those recorded during the normal breeding season. The lowest mean pregnancy rate (57.3%) was recorded in April 1980, primarily due to the particularly poor performance of the Rambouillet (11.7%) and Dorset (45.4%) ewes. No meaningful differences in average pregnancy rate among seasons were observed for 1980-born ewes. Results for overall pregnancy rates during the breeding season were in general agreement with those reported by Notter and Copenhaver (1980) (90% for August and 70% for November) and by Dzakuma et al. (1982) (91.8% for winter and 90.6% for fall). Although results from this study showed a decline in overall pregnancy rates for April, 1980, and May, 1982, they were not as low as those suggested by Notter and Copenhaver (1980) (53% for April) or by Dzakuma et al. (1982) (47.2% for spring).

For 1979-born ewes, Dorset x Finn ewes tended to have the highest mean pregnancy rate (93.4%) followed closely by Barbados Blackbelly x Dorset (Blackbelly x Dorset) (89.3%) and Finn (88.1%) ewes. Finn x Dorset, Dorset, and Rambouillet ewes had the lowest mean pregnancy rates (74.6%, 72.8% and 65.4%, respectively). However, mean pregnancy rates for

1980-born ewes were highest for Blackbelly x Dorset (99.8%) followed closely by Finn (92.0%) and Dorset (91.1%) ewes. Pregnancy rates for these breed groups were considerably higher than those of Dorset x Finn (74.8%) and Finn x Dorset (72.7%) ewes. Mean pregnancy rates for 1979-born ewes tended to be somewhat lower than for 1980-born ewes, primarily due to the generally poor pregnancy rates in April, 1980 (1980-born ewes were not present for this mating). This may also explain the considerably higher mean pregnancy rates for 1980-born versus 1979-born Dorset ewes (1980-born ewes were not present for the April, 1980 mating, during which time the performance of the 1979-born Dorset ewes was extremely poor).

Although pregnancy rates for 1979-born ewes were lowest for April, 1980, they showed considerable improvement for the April, 1983 mating. Therefore, it seems reasonable that the poor performance of 1979-born ewes in April, 1980 could be attributable to effects of maturity as well as to effects of season. The extremely high pregnancy rate for the Finn ewes in April, 1980 suggest that limiting effects of maturity were less severe for Finn ewes than for ewes of other breed groups. Ram breed effects may have also contributed to this large difference in pregnancy rates between the April matings; Suffolks were used for the April, 1980 breeding and Dorsets were used for the April, 1983 breeding. For the May, 1982 mating, when both Suffolk and Dorset rams were used, over 75% of the lambs born were sired by Dorset rams. Thus, pregnancy rates resulting from the April, 1980 and April, 1983 matings may have been due to differential fertility for the rams of these breed groups.

During the normal breeding season (November, 1980 and August, 1981) pregnancy rates were high for all breed groups for 1979-born ewes. However, for 1980-born ewes, Finn and Blackbelly x Dorsets tended to have the highest pregnancy rates and Dorset x Finn and Finn x Dorset ewes tended to be lowest. The high August pregnancy rates for Finn ewes in this study agreed with the findings of Cedillo et al. (1977) and Speedy and FitzSimons (1977) but were in contrast to results reported by Fogarty et al. (1984a,b) who observed that pregnancy rates for August were lower for purebred Finn ewes (52.0%) than for Rambouillet, Dorset or Finn-cross ewes.

For the last two out-of-season matings (May, 1982 and April, 1983), pregnancy rates were highest for Blackbelly x Dorsets and Dorset x Finns among 1979-born ewes, and highest for Blackbelly x Dorsets among 1980-born ewes.

Although 1979-born Finn ewes showed extremely high pregnancy rates for April, 1980 and April, 1983 (90.1 and

100.1%, respectively), pregnancy rates were considerably lower in May, 1982 (60.1%). This suggests that although a considerable number of Finn ewes exhibited estrous activity in April, there was a sharp decline in May (as indicated by pregnancy rates) suggesting that the Finn ewes may have been entering a period of anestrus. The high pregnancy rates for Finn ewes in April, and fairly poor pregnancy rates in May were in general agreement with those reported in the literature. The sharp decline in pregnancy rates for 1979-born ewes in May, 1982 strongly supported findings by Goot and Maijala (1977) indicating that the frequency of estrus among Finn ewes was near maximum in April, but declined considerably in late spring (May to July).

For 1979-born ewes, Finn x Dorsets appeared to be much more Finn-like in nature than did Dorset x Finn ewes for ewe performance traits. Like the Finn ewes in this study, the mean pregnancy rate for Finn x Dorset ewes in May, 1982 (57.2%) was quite low, whereas, the pregnancy rates averaged over all seasons were higher for Dorset x Finn (93.4%) than for Finn x Dorset (74.6%) ewes. This difference between recriprocal crosses could be attributable to either the source of Finn germ plasm or to maternal breed effects on subsequent ewe performance. For 1980-born ewes, pregnancy rates in May, 1982 for the reciprocal crosses were similar

(68.6% for Finn x Dorset and 74.8% for Dorset x Finn ewes). Unlike mean pregnancy rates averaged over all seasons for 1979-born ewes, mean pregnancy rates averaged over all seasons for 1980-born ewes were similar for Finn x Dorset (72.7%) and Dorset x Finns (74.8%).

Number of lambs born and reared. Both number of lambs born and number reared (alive at 2 wk) per ewe exposed (table 3) were affected by ewe breed ($p < .001$ and $p < .05$, respectively for 1979-born ewes and $p < .01$ for 1980-born ewes), season within the 1979 birth year ($p < .001$), ewe breed by season interaction within the 1979 birth year ($p < .05$ and $p < .001$, respectively) and random ewe effects ($p < .001$). The least squares analysis of variance for performance of only 1979-born ewes, excluding Rambouillets (table 4) showed that ewe breed and season effects remained significant for both number born and number reared. However, while the ewe breed by season interaction was still significant for number reared it was no longer significant for number of lambs born. Also, random ewe effects remained significant for number of lambs born but was no longer significant for number of lambs reared.

Least squares means for number born and number reared (for both 1979- and 1980-born ewes) are presented in tables 6 and 7, respectively. Litter size per ewe exposed for

TABLE 6. LEAST-SQUARES MEANS FOR NUMBER OF LAMBS BORN PER EWE EXPOSED FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	.72±.19	1.12±.20	1.65±.21	1.43±.27	1.06±.29	1.19±.13
	Finn	1.30±.27	2.40±.27	2.10±.27	1.50±.27	2.20±.27	1.90±.16
	Blackbelly x Dorset	.77±.24	1.54±.24	2.00±.24	2.01±.26	1.88±.29	1.63±.14
	Dorset x Finn	.75±.35	1.75±.35	1.95±.38	2.15±.38	1.75±.38	1.64±.15
	Finn x Dorset	1.13±.22	1.87±.22	2.00±.24	1.48±.26	1.67±.27	1.67±.22
	Rambouillet	.13±.15	1.66±.15	1.66±.15	1.05±.16	1.36±.16	1.17±.09
	Mean	.80±.10	1.72±.10	1.89±.11	1.60±.11	1.65±.11	
1980	Dorset		1.01±.26	1.39±.27	1.37±.31	1.66±.34	1.36±.17
	Finn		2.24±.23	1.97±.23	2.05±.25	1.94±.25	2.05±.15
	Blackbelly x Dorset		1.23±.17	1.88±.17	1.88±.18	1.59±.18	1.65±.11
	Dorset x Finn		1.25±.37	1.25±.37	1.00±.37	1.25±.37	1.18±.23
	Finn x Dorset		1.18±.29	1.52±.30	1.52±.30	1.18±.30	1.35±.18
	Mean		1.38±.12	1.60±.12	1.56±.13	1.52±.13	

TABLE 7. LEAST-SQUARES MEANS FOR NUMBER OF LAMBS REARED[a] PER EWE EXPOSED FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	.34±.17	.94±.18	1.30±.19	1.16±.25	1.10±.26	.97±.11
	Finn	1.00±.24	1.80±.24	1.90±.24	.90±.24	1.00±.24	1.32±.13
	Blackbelly x Dorset	.69±.21	1.54±.21	1.77±.21	1.63±.23	1.91±.26	1.51±.12
	Dorset x Finn	.20±.32	1.37±.32	.98±.34	1.98±.34	1.58±.34	1.22±.18
	Finn x Dorset	1.01±.20	1.34±.20	1.56±.21	.91±.23	1.18±.25	1.20±.11
	Rambouillet	.08±.13	1.46±.13	1.54±.13	.95±.14	1.29±.14	1.06±.07
	Mean	.55±.09	1.41±.09	1.51±.09	1.26±.10	1.34±.10	
1980	Dorset		.66±.26	.91±.27	.78±.31	1.58±.34	.98±.18
	Finn		1.13±.23	1.67±.23	1.40±.30	1.07±.25	1.32±.15
	Blackbelly x Dorset		1.09±.17	1.69±.17	1.71±.18	1.59±.18	1.52±.11
	Dorset x Finn		1.25±.37	.75±.37	1.00±.37	.50±.37	.87±.23
	Finn x Dorset		1.00±.28	1.00±.30	1.00±.30	.83±.30	.95±.18
	Mean		1.02±.12	1.20±.12	1.18±.13	1.11±.13	

[a]Number alive at 2 wk

1979-born ewes was lowest in April, 1980 and highest for ewes mated in August, 1981 (accurately reflecting differences in pregnancy rate for these seasons). Similarly, number of lambs born per ewe exposed tended to be highest for ewes mated in August, 1981 among 1980-born ewes. However, number of lambs born per ewe exposed for 1980-born ewes was lowest for the November, 1980 mating. The poor November, 1980 pregnancy rate may have been due to effects of maturity at mating as well as season effects. Season differences in number of lambs born per ewe exposed were primarily a function of differences in litter size than of differences for 1980-born ewes; pregnancy rates differed little among seasons for these ewes. rate for 1980-born ewes. These season differences were also reflected in number of lambs reared per ewe exposed.

Breed means for number of lambs born per ewe exposed were highest for Finn ewes of both ewe birth years primarily due to the large mean litter sizes of the Finn ewes. However, both 1979- and 1980-born Finn ewes were second to Blackbelly x Dorset ewes for number reared per ewe exposed. This implies that survival for lambs of Blackbelly x Dorset ewes was superior to that for lambs of Finn ewes. Also, number reared per ewe exposed for Finn ewes was extremely low in May, 1982, and led to a significant breed x season interaction. This effect largely reflects the poor pregnancy rate of the Finn ewes in this season.

Among 1979-born ewes, Dorsets and Rambouillets had the lowest mean number of lambs born and reared, primarily due to the particularly low litter sizes and poor pregnancy rates for the April, 1980 mating for these breed groups.

Analysis of variance per ewe lambing

Mean squares for ewe performance (per ewe lambing) are presented in table 8.

Lambing date. Ewe birth year ($p < .001$), ewe breed for 1979- and 1980-born ewes ($p < .001$ and $p < .01$, respectively), season for 1979- and 1980-born ewes ($p < .001$ for both birth years), ewe breed by season interaction within the 1979 birth year ($p < .001$) and random ewe effects ($p < .01$) all affected lambing date. When Rambouillet ewes were not included in the analysis for the 1979-born ewes, (table 9) season was the only effect which remained highly significant. The effect of ewe breed, ewe breed by season interaction and the random ewe effect only tended toward significance.

Table 10 contains least-squares means for lambing date (expressed as Julian days). On average, 1979-born Finn ewes lambed earlier than ewes of other breed groups, being par-

TABLE 8. LEAST-SQUARES ANALYSIS OF VARIANCE FOR EWE PERFORMANCE (PER LAMBING)

Source of variation	Degrees of freedom	Mean squares: Lambing date	Number born	Number reared[a]
Ewe birth year	1	21209***	.605	1.302†
Ewe breed/ewe birth year				
Ewe breed/1979	5	360***	2.999***	1.068*
Ewe breed/1980	4	293**	2.748***	1.081*
Ewe/ewe breed/ewe birth year[b]	134	78**	.419***	.437
Season/ewe birth year				
Season/1979	4	669004***	2.703***	3.354***
Season/1980	3	397252***	.413	.404
Ewe breed x season/ewe birth year				
Ewe breed x season/1979	20	139***	.344	.650*
Ewe breed x season/1980	12	45	.310	.758*
Error	309	55	.287	.391

†$p < .1$.

*$p < .05$.

**$p < .01$.

***$p < .001$.

[a]Alive at 2 wk.

[b]Ewe birth year and ewe breed/ewe birth year were tested against the ewe mean square.

TABLE 9. LEAST-SQUARES ANALYSIS OF VARIANCE FOR PERFORMANCE OF 1979-BORN EWES EXCLUDING RAMBOUILLETS (PER LAMBING)

Source of variation	Degrees of freedom	Mean squares: Lambing date	Number born	Number reared[a]
Ewe breed	4	$222^{\dagger}$	3.128^{***}	1.332^{*}
Ewe/ewe breed	58	$91^{\dagger}$	.448	.405
Season	4	510990^{***}	2.690^{***}	2.918^{***}
Ewe breed x season	16	$119^{\dagger}$	.335	$.722^{\dagger}$
Error	139	71	.377	.454

$^{\dagger}p < .1$.

$^{*}p < .05$.

$^{**}p < .01$.

$^{***}p < .001$.

[a] Alive at 2 wk.

TABLE 10. LEAST-SQUARES MEANS FOR LAMBING DATE (JULIAN DAYS) FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	259±3	99±2	20±2	287±3	257±3	185±1
	Finn	246±3	103±3	19±3	282±3	243±3	178±1
	Blackbelly x Dorset	261±3	100±3	19±2	281±2	250±3	182±1
	Dorset x Finn	249±4	103±4	19±4	283±4	249±4	181±2
	Finn x Dorset	255±3	98±3	17±3	285±4	250±3	181±1
	Rambouillet	262±4	102±2	18±2	288±2	259±2	186±1
	Mean	255±1	101±1	19±1	284±1	251±1	
1980	Dorset		106±3	26±3	291±3	262±3	171±2
	Finn		102±2	19±2	282±3	249±3	163±2
	Blackbelly x Dorset		102±2	16±2	286±2	256±2	165±1
	Dorset x Finn		98±4	14±4	283±5	253±4	162±3
	Finn x Dorset		99±4	24±4	288±3	254±4	166±2
	Mean		101±1	20±1	286±2	255±2	

ticularly early for both April, 1980, May, 1982, and April, 1983 matings. Dorset and Rambouillet ewes were later than average, being especially late for the April, 1980 and April, 1983 matings. Therefore, it seems that for 1979-born ewes, breed differences in mean lambing date were associated with the ewe's ability to mate and conceive early in the out-of-season matings (assuming equal gestation lengths for all breed groups). For 1980-born ewes, Dorsets had a mean lambing date which was later than for all other breed groups. This result was generally consistant across mating seasons; no breed x season interaction was observed.

Number of lambs born and reared. Both number of lambs born and number reared per ewe lambing (table 8) were affected by ewe breed ($p < .001$ for both traits of 1979-born ewes and $p < .05$ for both traits of 1980-born ewes) and season within the 1979 birth year ($p < .001$ for both traits). For number of lambs reared, the ewe breed x season interaction was significant for both birth years and the ewe birth year effect approached significance. Random ewe effects affected only the number of lambs born per ewe lambing ($p < .001$).

Least squares means for number of lambs born and number reared are presented in tables 11 and 12, respectively. For 1979-born ewes, number born and number reared were lowest

TABLE 11. LEAST-SQUARES MEANS FOR NUMBER OF LAMBS BORN PER EWE LAMBING FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	1.58±.21	1.48±.16	1.84±.16	1.95±.24	1.40±.23	1.65±.09
	Finn	1.50±.20	2.62±.19	2.16±.18	2.37±.24	2.26±.18	2.18±.10
	Blackbelly x Dorset	1.22±.22	1.82±.18	2.01±.16	2.00±.18	1.88±.20	1.79±.09
	Dorset x Finn	1.03±.29	1.76±.25	2.00±.26	2.16±.26	1.76±.26	1.73±.13
	Finn x Dorset	1.88±.21	2.40±.18	2.32±.18	2.51±.25	2.07±.21	2.24±.10
	Rambouillet	1.25±.31	1.81±.11	1.85±.12	1.67±.14	1.88±.13	1.69±.08
	Mean	1.41±.10	1.98±.07	2.02±.07	2.11±.09	1.87±.08	
1980	Dorset		1.14±.22	1.48±.22	1.48±.23	1.76±.25	1.46±.14
	Finn		2.18±.17	2.18±.18	2.31±.20	2.22±.20	2.22±.12
	Blackbelly x Dorset		1.24±.12	1.89±.13	1.88±.14	1.59±.14	1.65±.08
	Dorset x Finn		1.62±.32	1.62±.32	2.12±.40	1.62±.32	1.75±.22
	Finn x Dorset		1.95±.26	2.13±.28	1.79±.25	1.58±.28	1.86±.16
	Mean		1.63±.10	1.86±.11	1.92±.11	1.76±.11	

TABLE 12. LEAST-SQUARES MEANS FOR NUMBER OF LAMBS REARED[a] PER EWE LAMBING FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					Mean
		April 80	November 80	August 81	May 82	April 83	
1979	Dorset	.73±.22	1.23±.17	1.40±.17	1.68±.26	1.52±.25	1.31±.09
	Finn	1.08±.21	1.97±.21	1.90±.20	1.58±.26	1.00±.20	1.51±.10
	Blackbelly x Dorset	1.05±.23	1.87±.19	1.78±.17	1.63±.19	1.92±.21	1.65±.09
	Dorset x Finn	.34±.31	1.37±.27	.97±.28	1.97±.28	1.57±.28	1.24±.13
	Finn x Dorset	1.55±.22	1.79±.19	1.84±.19	1.54±.27	1.46±.23	1.64±.10
	Rambouillet	.80±.33	1.62±.12	1.74±.13	1.49±.15	1.73±.14	1.48±.08
	Mean	.92±.11	1.64±.08	1.61±.08	1.65±.10	1.53±.09	
1980	Dorset		.68±.27	1.01±.27	.85±.28	1.65±.31	1.05±.15
	Finn		1.14±.21	1.84±.22	1.55±.24	1.22±.25	1.44±.12
	Blackbelly x Dorset		1.09±.15	1.69±.15	1.71±.17	1.59±.17	1.52±.08
	Dorset x Finn		1.63±.39	.97±.39	2.08±.49	.63±.39	1.34±.22
	Finn x Dorset		1.49±.32	1.40±.35	1.25±.30	1.13±.35	1.32±.17
	Mean		1.21±.13	1.38±.13	1.49±.14	1.24±.14	

[a]Number alive at 2 wk

for April, 1980, highest for November, 1980; August, 1981 and May, 1982, and showed only a slight decline for April, 1983. Number born and number reared were highest for May, 1982 and August, 1981, and lowest for November, 1980 for ewes born in 1980. Thus, for both 1979- and 1980-born ewes the lowest number for both traits was recorded for their first lambing, indicating that age may have had a primary effect. Although prolificacy is confounded with age, there does not seem to be a dramatic decrease in litter size due to season. The high mean litter sizes for the November, 1980 (for 1979-born ewes) and August, 1981 matings were somewhat lower than those reported by Notter and Copenhaver (1980) (2.21 for August mating) but higher than those reported by Dzakuma et al. (1982) (1.80 for October and November matings) and Fogarty et al. (1984a) (1.8 for August mating). Mean litter size for the April, 1983 mating was considerably higher than that reported by Fogarty et al. (1984a) (1.4 for April mating) but similar to that reported by Notter and Copenhaver (1980) (1.84 for April mating). Mean litter sizes as a result of the May, 1982 mating (2.11 for 1979-born and 1.92 for 1980-born ewes) were higher than those reported by Thomas and Whiteman (1979b) for ewes lambing in October and November.

Number of lambs born per ewe lambing for 1979-born ewes was highest for Finn and Finn x Dorsets. However, number reared was highest for Blackbelly x Dorset and Finn x Dorset ewes. Similarly, number born for 1980-born ewes was highest for Finns, but number reared was highest for Blackbelly x Dorset ewes. Thus, in both birth years Finns had larger litters than Blackbelly x Dorset ewes, but lamb survival was considerably lower. The large mean litter size for 1979-born Finn x Dorset ewes was in agreement with the results of studies conducted by Cedillo et al. (1977), Dzakuma et al. (1982), Land et al. (1973), Notter and Copenhaver (1980) and Speedy and FitzSimons (1977) which concluded that Finn-cross ewes had litter sizes greater than those for other breed crosses. However, the similar litter sizes for 1979-born Finn and Finn x Dorset ewes were in contrast to work done by Land et al. (1973) in which Finn ewes had considerably larger litter sizes than either Merino x Finn (1.7) or Finn x Merino (1.7) ewes.

Heterosis for ewe performance

Percentage heterosis (Dorset x Finn and Finn x Dorset verses Finn and Dorset) for pregnancy rate and prolificacy (per ewe lambing) for the various mating seasons are presented in table 13. Heterosis for pregnancy rate was vari-

TABLE 13. HETEROSIS (%) FOR EWE PERFORMANCE TRAITS

Season	Pregnancy rate[a]	Prolificacy[b]
April, 1980[b]	-.22±11.76	-.52
November, 1980	-8.69±7.26	9.63
August, 1981	-13.29±8.39	5.22
May, 1982	.77±8.85	5.67
April, 1983	-10.17±9.23	-7.85
Mean[c]	-8.17±8.64	5.72

[a]Number of ewes lambing per ewes exposed.

[b]Number of lambs born per ewe lambing.

[c]1979-born ewes only.

[d]Mean has been calculated over all seasons excluding April, 1980.

able, ranging from -13.29% in August, 1981 to .77% in May, 1982 with a mean percentage heterosis for pregnancy rate of -8.17%, but never approached significance. This variability in heterosis for pregnancy rate may have been due to breed differences in both the timing and duration of the breeding season. Heterosis estimates for prolificacy were also quite variable, ranging from 9.63% in November, 1980 to -7.85% in April, 1983. The mean percentage heterosis, however, was 5.72% indicating that in general, the Finn x Dorset and Dorset x Finn ewes were better (for prolificacy) than the average of the parental breeds.

Analysis of variance for ewe weights

Mean squares for ewe weights are presented in table 14. For weight I (only 1979-born ewes), ewe breed was a significant source of variation. Ewe weights differed among ewe birth years for weight II ($p < .001$), weight III ($p < .01$) and weight IV ($p < .1$). However, ewe birth year was not significant for weight V. Therefore, as ewes got older, the difference in age between 1979- and 1980-born ewes became less important as a source of variation for ewe weight.

TABLE 14. LEAST-SQUARES ANALYSIS OF VARIANCE FOR EWE WEIGHTS (kg) THROUGHOUT THE STUDY

		Mean squares for ewe weights:				
Source of variation	Degrees of freedom	I[a]	II[b]	III[c]	IV[d]	V[e]
Ewe birth year	1	[f]	8020.16***	1658.05**	676.41†	214.90
Ewe breed/ewe birth year						
Ewe breed/1979	5	1027.15***	1503.62***	1702.08***	1928.99***	2457.34***
Ewe breed/1980	4	[f]	441.90*	663.06*	1084.60**	1202.73**
Error	92[g]	208.39	158.37	224.36	227.65	356.75

[a]Weight taken April 1, 1980.

[b]Weight taken August 5, 1981.

[c]Weight taken May 7, 1982.

[d]Weight taken April 7, 1983.

[e]Weight taken November 11, 1983.

[f]Effect not fitted in the model.

[g]Error degrees of freedom are 92 for weight I, 129 for weight II, 119 for weight III, 102 for Weight IV, and 91 for weight V.

Analysis of variance for ewe longevity traits

Table 15 contains least-squares means for ewe weights throughout the study. Mean final weight over all breeds (with the exception of Rambouillet ewes which were not included in the mean) was 68.60 kg. The greatest increase in mean ewe weight was observed between weights I and II (+14.49 kg for 1979-born ewes); increases in ewe weight between other weight periods were considerably lower but generally consistant. Final ewe weight averaged over birth years was heaviest for Dorset ewes (76.52 kg) and lightest for Finn ewes (57.32 kg).

Table 16 contains mean squares for ewe longevity traits. Longevity (total number of days in the study) was significantly affected by ewe birth year and by ewe breed within the 1979 ewe birth year. For percentage of ewes completing the study, only the ewe breed effect for 1979-born ewes was significant.

Least-square means for longevity and percentage of ewes completing the study are presented in tables 17 and 18, respectively. Mean number of days in the study averaged over both birth years was highest for Finns and Dorset x Finns (1151.9 and 1131.9 d, respectively) and lowest for Dorset ewes (900.6 d). Among 1979-born ewes, Finn (1304.3 d) and Rambouillet (1228.9 d) ewes stayed in the study long-

TABLE 15. MEAN EWE WEIGHTS (kg) FOR EWE BREED GROUPS THROUGHOUT THE STUDY

Ewe breed group	Ewe birth year	Weight period				
		Weight I[a]	Weight II[b]	Weight III[c]	Weight IV[d]	Weight V[e]
Dorset	1979	44.80±1.43	60.41±1.38	62.77±1.70	68.69±2.28	75.75±3.24
	1980		52.50±2.02	61.62±2.57	67.59±3.06	77.29±3.83
Finn	1979	37.92±2.07	49.99±1.81	49.71±2.15	53.89±2.16	55.24±2.86
	1980		48.41±1.72	52.21±2.15	59.67±2.28	61.39±2.86
Blackbelly x Dorset	1979	43.48±1.82	59.18±1.58	60.56±1.96	61.92±2.16	69.40±3.08
	1980		49.08±1.28	53.75±1.60	55.77±1.66	65.01±2.14
Dorset x Finn	1979	51.86±2.67	67.31±2.55	65.50±3.04	73.57±3.06	77.56±4.28
	1980		53.07±2.86	58.74±3.40	65.54±3.42	64.86±4.94
Finn x Dorset	1979	47.23±1.69	60.85±1.58	63.34±2.05	68.41±2.06	67.95±2.71
	1980		56.12±2.16	59.19±2.77	65.54±2.79	71.58±3.83
Rambouillet	1979	47.50±1.14	62.91±1.01	64.10±1.22	66.16±1.32	71.83±1.68
Mean[f]		45.06±2.06	55.69± .61	58.74± .74	64.05± .75	68.60±1.10

[a]Weight taken April 1, 1980.

[b]Weight taken August 5, 1981.

[c]Weight taken May 7, 1982.

[d]Weight taken April 7, 1983.

[e]Weight taken November 11, 1983.

[f]Mean does not include Rambouillet ewes.

TABLE 16. LEAST-SQUARES ANALYSIS OF VARIANCE FOR LONGEVITY OF EWES IN THE STUDY

Source of variation	Degrees of freedom	Mean squares: Longevity[a]	Mean squares: Fraction of ewes completing the study
Ewe birth year	1	1024434***	.243
Ewe breed/ewe birth year			
Ewe breed/1979	5	256972**	.687**
Ewe breed/1980	4	58272	.161
Error	141	72114	.192

** $p < .01$.

*** $p < .001$.

[a] Number of days in the study.

TABLE 17. TOTAL NUMBER OF DAYS IN THE STUDY FOR EWE BREED GROUPS

Ewe breed group	Ewe birth year		
	1979	1980	Mean
Dorset	956± 59	845± 90	901±57
Finn	1304± 85	1000± 81	1152±62
Blackbelly x Dorset	1188± 75	970± 59	1079±50
Dorset x Finn	1172±110	1092±134	1132±92
Finn x Dorset	1113± 69	901± 95	1007±62
Rambouillet	1229± 46		
Mean[a]	1147± 39	962± 45	

[a]Mean does not include Rambouillet ewes

TABLE 18. PERCENTAGE OF EWES COMPLETING THE STUDY FOR EWE BREED GROUPS

Ewe breed group	Ewe birth year		
	1979	1980	Mean
Dorset	38.1± 9.6	55.6±14.6	46.8± 9.2
Finn	90.0±13.8	81.8±13.2	85.9±10.0
Blackbelly x Dorset	61.5±12.1	76.2± 9.6	68.9± 8.1
Dorset x Finn	66.7±17.9	100.0±21.9	83.3±14.8
Finn x Dorset	66.7±11.3	75.0±15.5	70.8±10.1
Rambouillet	85.3± 7.5		
Mean[a]	65.6± 6.2	77.7± 9.2	

[a]Mean does not include Rambouillet ewes

est and Dorset ewes (955.7 d) remained in the study for the shortest period of time. However, for 1980-born ewes Dorset x Finns were in the study longer (1092.0 d) and Dorsets left the study earlier (845.4 d) than all other breed groups. Therefore, it follows that a higher percentage (averaged over both birth years) of Finn and Dorset x Finn ewes (85.9 and 83.3%, respectively) completed the study, and that among 1979-born ewes, a higher percentage of Finns and Rambouillets finished than for other breed groups. Furthermore, of the Dorset ewes which began the study, only 46.8% finished.

These results are in contrast to those reported by Hohenboken and Clarke (1981) in which Finn cross ewes were reportedly equal in longevity (measured as a ewe's age when she left or completed the study) to Dorset and Romney crosses.

Lamb Performance

Analysis of variance for birth and preweaning traits

Table 19 contains mean squares for preweaning lamb performance traits.

Birth weight. Birth weight was significantly affected by ewe birth year, sex of lamb, ewe breed, season for 1979-born ewes, and ewe breed by season interaction.

TABLE 19. LEAST-SQUARES ANALYSIS OF VARIANCE FOR BIRTH AND PREWEANING TRAITS OF LAMBS

Source of variation	Degrees of freedom	Mean squares: Birth weight	Proportion died[a]	Proportion sold[b]	Proportion weaned
Ewe birth year	1	3.230*	.021	.070	.000
Sex of lamb	1	7.463**	.112	.026	.279
Ewe breed/ewe birth year					
Ewe breed/1979	5	54.093***	.160*	.044	.285*
Ewe breed/1980	4	15.680***	.175*	.030	.675***
Season/ewe birth year					
Season/1979	4	2.029*	.136†	.245***	.341*
Season/1980	3	1.521	.036	.019	.036
Sex of lamb x (season/ewe birth year)					
Sex of lamb x season/1979	4	.989	.048	.011	.174
Sex of lamb x season/1980	3	.341	.045	.025	.155
(Ewe breed x season)/ewe birth year					
Ewe breed x season/1979	20	1.655**	.096*	.037	.139
Ewe breed x season/1980	12	1.451*	.149**	.022	.143
Error	815	.755	.060	.030	.117

†$p < .1$.
*$p < .05$.
**$p < .01$.
***$p < .001$.

[a]Dead at birth or died within 3 d.
[b]Sold at 1 to 3 d of age.

Least-square means for birth weight are presented in table 20. Mean birth weights were generally higher for lambs out of 1980-born ewes than for lambs out of 1979-born ewes. Mean birth weights for lambs out of ewes born in 1979 were highest for the November, 1980 and August, 1981 matings (3.79 and 3.82 kg, respectively) and lowest for the April, 1980 and May, 1982 matings (3.48 and 3.51, respectively). Birth weights for lambs out of 1979-born ewes mated in November, 1980 and August, 1981 were relatively heavy despite the large mean litter sizes during these seasons (table 11). Conversely, lambs out of 1979-born ewes mated in April, 1980 had unusually low birth weights when litter sizes were small. Results for differences in birth weight due to season generally agreed with results reported by Strizke and Whiteman (1982) and Gould and Whiteman (1971) indicating that birth weight was lightest for lambs born during the fall.

Among 1979-born ewes, Rambouillets and Blackbelly x Dorsets had lambs with the heaviest birth weights (4.70 and 4.42 kg, respectively) and lambs from Finn ewes had the lightest birth weights (2.49 kg). Birth weights for lambs from 1980-born ewes were heaviest for Blackbelly x Dorset (4.38 kg) and lightest for Finn (3.18 kg) ewes. With the exception of 1979-born Blackbelly x Dorset ewes, breed dif-

TABLE 20. LEAST-SQUARES MEANS FOR BIRTH WEIGHT (kg) OF LAMBS FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					Mean
		April 80	November 80	August 81	May 82	April 83	
1979	Dorset	3.08±.21	4.30±.19	3.94±.17	3.21±.25	3.79±.28	3.66±.10
	Finn	2.08±.24	2.63±.18	2.81±.19	2.38±.24	2.56±.24	2.49±.10
	Blackbelly x Dorset	4.67±.28	4.34±.19	4.25±.17	4.39±.19	4.45±.21	4.42±.10
	Dorset x Finn	3.45±.44	3.75±.28	3.64±.33	3.09±.28	3.61±.33	3.51±.15
	Finn x Dorset	2.77±.22	3.28±.17	3.49±.18	2.93±.22	3.19±.23	3.13±.09
	Rambouillet	4.83±.39	4.42±.12	4.81±.12	5.03±.15	4.43±.14	4.70±.09
	Mean	3.48±.13	3.79±.08	3.82±.08	3.51±.09	3.67±.10	
1980	Dorset		5.05±.36	4.06±.28	3.41±.29	3.97±.29	4.12±.15
	Finn		3.04±.18	3.28±.19	3.18±.21	3.21±.22	3.18±.10
	Blackbelly x Dorset		4.61±.17	3.97±.14	4.19±.16	4.51±.17	4.32±.08
	Dorset x Finn		3.60±.51	3.96±.44	3.55±.62	4.26±.88	3.84±.32
	Finn x Dorset		4.29±.28	3.52±.29	3.79±.30	3.37±.29	3.74±.15
	Mean		4.12±.14	3.76±.13	3.63±.16	3.86±.20	

ferences in birth weight accurately reflected differences in litter size (ewe breeds which had lambs with the lightest birth weights also recorded the larger litter sizes). The low birth weights for lambs out of Finn ewes agreed with the low birth weights for lambs out of Finn and Finn-cross ewes reported by Oltenacu and Boylan (1981b) and Magid et al. (1981).

Birth weights for lambs out of Dorset ewes were highest for ewes mated in November, 1980 and lowest for ewes mated in in April, 1980, and May, 1982. Conversely, birth weights for lambs out of Rambouillet ewes were highest for ewes mated in May, 1982 and were lowest for ewes mated in November, 1980 and April, 1983. Differences between birth weights for lambs out of Dorset and Rambouillet ewes were greatest for the May, 1982 mating. Birth weight differences for lambs out of ewes from these breed groups were probably the primary source of the breed x season interaction for birth weight.

Ram lambs had heavier birth weights (3.85 kg) than did ewe lambs (3.65 kg). Differences in birth weight due to the sex of the lamb strongly supported those reported by both Gould and Whiteman (1971) (.21 kg advantage for ram lambs), and Oltenacu and Boylan (1981b) (.28 kg advantage for ram lambs).

Survival to weaning. Mean squares for percentage of lambs dying (at birth or within 3 d), percentage sold (at 1 to 3 d of age) and percentage weaned are presented in table 19. Percentage of lambs dying was significantly affected by ewe breed and ewe breed x season interaction. Percentage of lambs sold was affected only by season for 1979-born ewes. Ewe breed, and season within the 1979 birth year were significant for percentage weaned.

Table 21 contains least squares means for percentage of lambs dead at birth or dying shortly after birth. Mean survival rate for lambs of 1979-born ewes was highest for ewes mated in August, 1980; May, 1981 and April, 1983 and was poorest for ewes mated in April, 1980 and November, 1980. Conversely, for 1980-born ewes, lambs from the August, 1981 mating had the poorest survival rate and lambs from the May, 1982 mating had the best. Survival was better for ewe lambs (6.5% dying) than for ram lambs (8.5% dying) despite the heavier birth weights for the male lambs. Results from this study tended to support the high survival rates for lambs born in September (93.4%) and lower survival rates for January born lambs (86.5%) reported by Fogarty et al. (1984a).

For 1979-born ewes, lambs out of Blackbelly x Dorset, and Rambouillet ewes had the best survival (.9 and 1.7% dying, respectively) while lambs out of Finn and Dorset ewes

TABLE 21. LEAST-SQUARES MEANS FOR PERCENTAGE OF LAMBS DEAD AT BIRTH OR DYING SHORTLY AFTER BIRTH[a] FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	29.3± 5.9	5.3± 5.5	14.7± 4.6	.7± 6.8	.4± 7.9	10.1±2.8
	Finn	22.9± 6.8	4.2± 5.0	- .2± 5.5	7.4± 6.8	22.8± 6.8	11.4±2.8
	Blackbelly x Dorset	-1.0± 7.8	.0± 5.5	.3± 4.8	5.0± 5.3	.2± 6.0	.9±2.7
	Dorset x Finn	26.2±12.3	21.3± 7.8	.2± 9.2	.8± 7.9	.3± 9.3	9.8±4.2
	Finn x Dorset	6.5± 6.3	17.2± 4.9	3.7± 5.0	6.3± 6.1	6.8± 6.3	8.1±2.6
	Rambouillet	-1.4±11.1	7.3± 3.2	- .1± 3.2	2.7± 4.2	.0± 4.0	1.7±2.7
	Mean	13.8± 3.5	9.2± 2.3	3.1± 2.3	3.8± 2.6	5.1± 2.8	
1980	Dorset		16.7±10.0	22.5± 7.9	11.9± 8.2	.6± 8.2	12.9±4.3
	Finn		20.8± 5.2	9.5± 5.2	6.0± 5.9	6.5± 6.3	10.7±2.8
	Blackbelly x Dorset		.0± 4.7	8.6± 4.0	6.9± 4.4	- .8± 4.9	3.7±2.2
	Dorset x Finn		.2±14.4	-2.1±12.3	-2.5±17.5	-1.9±24.6	-1.6±8.9
	Finn x Dorset		- .1± 7.8	21.8± 8.1	1.4± 8.3	43.8± 8.2	16.7±4.1
	Mean		7.5± 4.0	12.0± 3.6	4.8± 4.4	9.7± 5.7	

[a]Within 3 d after birth.

had the poorest survival (11.4 and 10.1% dying, respectively). Lambs out of 1980-born Finn, Dorset, and Finn x Dorset ewes all had survival rates which were low. With the exception of the Dorset ewes, differences in lamb survival accurately reflected differences in birth weights of lambs out of ewes from the respective breed groups (table 20); lambs with heavier birth weights had higher survival rates and lambs with lighter birth weights had poor survival rates. Survival rate for lambs out of 1979-born Dorset ewes was poor despite a small mean litter size (table 11) and a relatively high mean birth weight of their lambs. Thus, survival rate of lambs out of Finn ewes was as good as survival rate of lambs out of Dorset ewes despite the larger mean litter size and lower mean birth weight of lambs out of Finn ewes.

Number of lambs sold soon after birth (in an attempt to reduce litter size to two lambs) was highest for Finn x Dorset, and Dorset ewes (6.9 and 5.8%, respectively) and lowest for Rambouillets (1.5%). Similarly, for 1980-born ewes, a greater number of lambs were sold from Finn x Dorset and Finn ewes (5.0 and 3.6%, respectively).

Least-squares means for percentage of lambs weaned are presented in table 22. Mean number of lambs weaned each season was greatest for April, 1983 and lowest for the April, 1980 mating.

TABLE 22. LEAST-SQUARES MEANS FOR PERCENTAGE OF LAMBS WEANED FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	65.2± 8.3	84.8± 7.7	77.5± 6.5	84.0± 9.7	99.0±11.0	82.1± 3.9
	Finn	77.6± 9.5	75.0± 7.0	95.4± 7.7	77.2± 9.5	77.6± 9.6	80.5± 3.9
	Blackbelly x Dorset	93.3±11.0	100.0± 7.7	91.5± 6.7	85.5± 7.5	99.5± 8.4	94.0± 3.7
	Dorset x Finn	45.8±17.2	79.1±10.9	70.9±12.9	89.3±11.0	99.3±13.0	76.9± 5.9
	Finn x Dorset	87.2± 8.8	75.7± 6.9	84.6± 7.0	62.5± 8.6	86.3± 8.9	79.3± 3.6
	Rambouillet	65.0±15.5	87.5± 4.5	96.7± 4.5	91.4± 5.9	97.4± 5.6	87.6± 3.7
	Mean	72.4± 5.0	83.7± 3.2	86.1± 3.3	81.7± 3.6	93.2± 4.0	
1980	Dorset		66.7±14.0	66.1±11.0	67.7±11.5	99.5±11.5	75.0± 6.0
	Finn		61.3± 7.3	81.2± 7.3	88.4± 8.3	86.8± 8.8	79.4± 4.0
	Blackbelly x Dorset		93.7± 6.6	91.1± 5.6	91.4± 6.1	100.1± 6.8	94.2± 3.2
	Dorset x Finn		94.3±20.2	103.2±17.2	97.0±24.5	101.6±34.5	99.0±12.5
	Finn x Dorset		82.4±10.9	67.4±11.4	68.3±11.6	56.1±11.5	68.5± 5.7
	Mean		79.6± 5.6	81.8± 5.0	82.6± 6.2	88.9± 8.0	

Among 1979-born ewes, Blackbelly x Dorsets weaned the highest percentage of lambs (94.0%). However, for 1980-born ewes, the highest percentage of lambs weaned was recorded by Dorset x Finn ewes (99.0%) followed by Blackbelly x Dorsets (94.2%).

Analysis of variance for weaning weight and ADG

Mean squares for weaning weight and ADG are presented in table 23. Weaning weight was significantly affected by ewe birth year, sex of the lamb, ewe breed, ewe breed by season interaction and weaning age. ADG was affected by ewe breeds for 1979-born ewes ($p < .05$), ewe breed x season interaction ($p < .05$ for 1979-born and $p < .001$ for 1980-born ewes) and weaning age ($p < .001$) but only tended to be affected by ($p < .1$) ewe birth year, sex of lamb, ewe breed for 1980-born ewes, season for 1980-born ewes and sex of lamb by season interaction for 1979-born ewes. Results from this study did not find season effects to be significant for weaning weight as did Fogarty et al. (1984a), Strike and Whiteman (1982), and Gould and Whiteman (1971).

Table 24 contains least-squares means for weaning weight. Lambs born from 1979-born Rambouillet and Blackbelly x Dorset ewes had the heaviest weaning weights (17.66 and 17.26 kg, respectively) and lambs from Finn ewes had the

TABLE 23. LEAST-SQUARES ANALYSIS OF VARIANCE FOR WEANING TRAITS FOR LAMBS

Source of variation	Degrees of freedom	Mean squares: Weaning weight	ADG[a]
Ewe birth year	1	30.382*	.007†
Sex of lamb	1	36.050*	.007†
Ewe breed/ewe birth year			
Ewe breed/1979	5	83.400***	.007*
Ewe breed/1980	4	27.133**	.006†
Season/ewe birth year			
Season/1979	4	7.625	.002
Season/1980	3	12.611	.005†
Sex of lamb x (season/ewe birth year)			
Sex of lamb x season/1979	4	15.935†	.005†
Sex of lamb x season/1980	3	2.439	.001
(Ewe breed x season)/ewe birth year			
Ewe breed x season/1979	20	12.445*	.004*
Ewe breed x season/1980	12	24.941***	.008***
Weaning age	1	1463.342***	.112***
Error	691	7.227	.002

†$p < .1$. *$p < .05$. **$p < .01$. ***$p < .001$.

[a]Average daily gain to weaning.

TABLE 24. LEAST-SQUARES MEANS FOR WEANING WEIGHT (kg) OF LAMBS FOR EWE BREED GROUPS IN VARIOUS SEASONS

Ewe birth year	Ewe breed group	Breeding date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	14.74± .86	16.83± .65	16.43± .59	16.73± .82	15.75± .87	16.10±.34
	Finn	12.07± .85	15.72± .67	14.51± .62	14.52± .86	16.05± .86	14.58±.35
	Blackbelly x Dorset	18.78± .87	16.40± .60	16.95± .55	17.80± .64	16.37± .66	17.26±.30
	Dorset x Finn	12.83±1.94	17.05±1.02	16.33±1.20	15.10± .92	17.13±1.02	15.69±.57
	Finn x Dorset	16.21± .62	15.74± .60	15.09± .82	15.14± .75	18.78± .87	15.51±.32
	Rambouillet	18.62±1.36	16.96± .38	17.65± .36	17.90± .48	17.16± .44	17.66±.32
	Mean	15.40± .48	16.53± .28	16.27± .29	16.19± .32	16.27± .32	
1980	Dorset		21.07±1.21	17.78±1.03	15.84±1.10	14.71± .90	17.35±.53
	Finn		13.97± .72	15.60± .64	16.08± .70	16.24± .75	15.48±.35
	Blackbelly x Dorset		17.97± .53	15.27± .46	16.17± .51	17.42± .54	16.71±.26
	Dorset x Finn		17.56±1.59	18.32±1.35	15.16±1.93	21.42±2.71	18.11±.98
	Finn x Dorset		16.28± .91	15.11±1.10	16.54±1.10	16.54±1.20	16.12±.54
	Mean		17.37± .47	16.42± .43	15.96± .52	17.27± .65	

lightest weaning weights (14.58 kg). However, for 1980-born ewes, Dorset x Finn, Finn x Dorset and Dorset ewes produced lambs with weaning weights that were not significantly different from those of Blackbelly x Dorset lambs. Weaning weights for ram lambs were heavier on average (16.69 kg) than weaning weights for ewe lambs (16.20 kg).

Least-squares means for average daily gain to weaning are presented in table 25. The lowest ADG for lambs out of 1979-born ewes was recorded for Finn ewes (.25 kg/day) and the highest for Rambouillet and Blackbelly x Dorset ewes (.28 kg/day). These differences in ADG are reflected in the weaning weights for these breed groups.

TABLE 25. LEAST-SQUARE MEANS FOR AVERAGE DAILY GAIN (kg/d) FROM BIRTH TO WEANING

Ewe birth year	Ewe breed group	Breeding Date					
		April 80	November 80	August 81	May 82	April 83	Mean
1979	Dorset	.25±.02	.27±.01	.27±.01	.28±.02	.26±.02	.26±.01
	Finn	.21±.02	.27±.01	.25±.01	.25±.02	.28±.02	.25±.01
	Blackbelly x Dorset	.32±.02	.26±.01	.27±.01	.29±.01	.26±.01	.28±.01
	Dorset x Finn	.19±.04	.28±.02	.26±.02	.25±.02	.29±.02	.26±.01
	Finn x Dorset	.27±.01	.28±.01	.26±.01	.26±.02	.25±.01	.26±.01
	Rambouillet	.30±.03	.27±.01	.27±.01	.28±.01	.27±.01	.28±.01
	Mean	.26±.01	.27±.01	.26±.01	.27±.01	.27±.01	
1980	Dorset		.35±.02	.29±.02	.26±.02	.24±.02	.29±.01
	Finn		.23±.01	.26±.01	.27±.01	.28±.01	.26±.01
	Blackbelly x Dorset		.29±.01	.24±.01	.25±.01	.28±.01	.27±.01
	Dorset x Finn		.30±.03	.30±.03	.25±.04	.35±.05	.30±.02
	Finn x Dorset		.27±.02	.25±.02	.27±.02	.26±.02	.26±.01
	Mean		.28±.01	.27±.01	.26±.01	.28±.01	

SUMMARY

In order to investigate the differential ability of breed groups to mate and conceive out-of-season, a study involving Dorset, Finn, Blackbelly x Dorset, Dorset x Finn, Finn x Dorset, and Rambouillet ewes was conducted. Ewes were born in 1979 and 1980 with the exception that no Rambouillet ewes were born in 1980. Ewes were bred in April, 1980; November, 1980; August, 1981; May, 1982; and April, 1983 (1980-born ewes entered the study in November, 1980).

During the normal breeding season (November, 1980 and August, 1981 matings) pregnancy rates were uniformly high for all breed groups with the exception of 1980-born Dorset x Finn and Finn x Dorset ewes which recorded pregnancy rates considerably below the mean for those matings. Litter sizes were high for both the November, 1980 and August, 1981 matings, particularly for the Finn and Finn x Dorset ewes; Dorset ewes had smaller litter sizes than all other breed groups. However, number of lambs reared per ewe exposed (a function of pregnancy rate, litter size and lamb survival) was highest for Finn and Blackbelly x Dorsets. Rambouillet, Blackbelly x Dorset, and Dorset ewes had the heaviest lambs

at birth, while Finn ewes had the lightest. Percentage of lambs dead at birth or dying shortly after birth was particularly high for Dorset ewes, especially for the August, 1981 mating whereas, lambs out of Blackbelly x Dorset ewes exceeded all other breed groups for survival. Thus, percentage of lambs weaned was highest for the Blackbelly x Dorset ewes. Weaning weights for the November, 1980 and August, 1981 matings were lowest for lambs out of Finn and Finn x Dorset ewes.

Overall, during the normal breeding season, ewes of all breed groups performed quite well. Finn ewes excelled in prolificacy, however, their lambs had low birth weights and light weaning weights. On the other hand, Blackbelly x Dorset ewes were somewhat less prolific, but had lambs with heavier weights and good survival rates. Furthermore, the Blackbelly x Dorset ewes weaned a higher percentage of lambs than did ewes of all other breed groups.

Pregnancy rates for ewes mated outside the normal breeding season were lowest for April, 1980 but were considerably improved for the May, 1982 and April, 1983 matings. Although the mean conception rate was low for April, 1980, the mean pregnancy rate for Finn ewes was quite high (90.1%). Pregnancy rates for May, 1982 and April, 1983 were highest for the Blackbelly x Dorset and Finn ewes with the exception of the 1979-born Finn ewes, which recorded a lower pregnancy rate for the May, 1982 mating (60.1%), equalling the pregnancy rates of the the Finn x Dorset and Rambouillet ewes. Thus, if the out-of-season breeding program included a May mating, Finn or Finn x Dorset ewes may not be desirable.

With the exception of the April, 1980 mating, mean litter sizes for the out-of-season matings were as large as those for matings during the normal breeding season. As for matings which occured during the normal breeding season, Finn ewes were most prolific. Birth weights for lambs out of ewes mated in April, 1980, May, 1982 and April, 1983 were somewhat lighter than birth weights of lambs out of ewes mated in November, 1980 or August, 1981. However, for the out-of-season matings, as for the matings during the normal breeding season, Blackbelly x Dorset and Rambouillet ewes had lambs with heavier birth weights than lambs out of ewes from all other breed groups. Once again, birth weights were lightest for lambs out of Finn ewes. The breed groups which weaned the lowest percentage of lambs for the May, 1982 and April, 1983 matings were Finn and Finn x Dorset ewes. Percentage of lambs weaned for ewes of all other breed groups mated out-of-season were acceptable.

Thus, in general, ewe performance was as good for ewes mated out-of-season as for ewes mated during the normal breeding season (with the exception of the April, 1980 mating). Averaged over all seasons, the Blackbelly x Dorset ewes seemed to excel in a majority of the traits considered. However, this study offers information on the capability of these various breed groups to mate and conceive during different seasons but tells little about the ability of these breed groups to perform in a specific accelerated lambing program.

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