Libido and scrotal circumference of rams as affected by season of the year, altered photoperiod, and ram lambs of different breeds and selection lines

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A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Animal Science
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Abstract:
Four trials were conducted to examine libido and scrotal circumference. The trials were I) Hour long libido test, II) Artificially altered photoperiod to simulate short days, III) Seasonal changes for one year, and IV) Ram lambs of different breeds and selection lines. A serving capacity test was designed to measure libido. The test used three six by six meter pens, with four estrous induced ewes and one ram in each pen. Tests were conducted every 14 days. Prior to testing, SC of the ram was measured. Trial I determined a 30-minute test was as valid as a 60-minute test as indicated by the high correlation between total mounts and services in 30 minutes and total mounts and services in 60 minutes, r=.93 and r=.95, respectively.

The 30-minute serving capacity test measured 1) reaction time (RT), time from entry into the pen to first mount and/or service, 2) number of mounts in two 15-minute intervals (M1 and M2), 3) total mounts in 30 minutes (TM), 4) number of services in two 15-minute intervals (S1 and S2), and 5) total services in 30 minutes (TS). A 30-minute test was conducted in Trial II and III, and a 15-minute test in Trial IV.

Trial II determined that the treated rams (8L:16D) had more TS and TM than the control rams, 2.7 vs. 1.6 and 6.9 vs. 5.7, respectively. The treated rams had a larger SC than the control rams, 31.7 vs. 30.2, respectively. This difference in SC between the two groups occurred after 28 days of treatment. However, in all trials, no relationship existed between SC and those traits measuring libido.

Trial III showed increases in TM and TS, a shorter RT, plus a greater SC with the onset decreased daylight associated with short days of the year which starts the breeding season. These rams were chosen from three selection lines. Line one (H) consisted of ’high fertility’ rams which were selected based on a flock history of twinning. Line two (L) consisted of 'low fertility' rams which were based on a flock history of singles. Line three (C) consisted of randomly selected control rams. The high line rams had an increased number of TM and TS and a shorter RT than the low line. 18.1, 3.0 and 1.0 vs. 9.9, 2.4 and 2.3, respectively.

Trial IV determined that of ram lambs from three selection lines, the high line exhibited more TM and TS, with a shorter RT than the low line, with the control line variable in its similarity to the high and low lines. SC of the high line was greater than the low line. Of the two breeds, the Columbia x Rambouillet crossbreds outperformed the straightbred Rambouillets as evidenced by a greater number of TM and TS, a shorter RT, plus a larger SC.

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Date September 8, 1981

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Abstract

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Introduction

United States sheep numbers in 1980 were 12.9 million. This figure shows a substantial increase of 2% from 1979. Average annual lamb crops have also risen as reflected by lambing percentages of 92, 95 and 98 in 1978, 1979 and 1980, respectively. These increases reverse a downward trend that has lasted for 19 years. Since 1960, the decline in sheep numbers has been due in part, to decreases in large range operations. The present increases are a result of increases in smaller, more intensely managed operations. This stabilization of sheep numbers reflects a concerted effort by the industry to build and expand.

Investments by people and government in agricultural research have contributed to this expansion. With this support, the rewards of increased agricultural productivity are shared by farmers, ranchers, and ultimately by the consumers of America.

The intent of this thesis is to focus on one aspect of agricultural productivity, i.e. improving reproductive performance of sheep, specifically the ram. Rams selected based on their pedigree will not benefit the producer unless the ram can perform at a satsfactory level reproductively, and transmit to his progeny the desired characteristics. The ram's desire to breed, i.e. libido, is variable. This study examined the effects of 1) seasonal changes and their influence on scrotal circumference and libido of the ram, 2) artificial adjustments in photoperiod and the resulting effects on scrotal circumference and libido in the ram, and 3) factors influencing onset of puberty and sexual maturity in ram lambs.

Literature Review

Mating behavior of the ram has the capacity to influence reproductive efficiency (Hulet, 1966). Over the years the importance placed on the behavioral aspect of reproduction has declined due in part to the difficulty in measuring, quantitatively, the factors involved. One specific factor contributing to mating behavior of rams is termed libido. Although libido is more generally a behavioral phenomena, its absence or presence in the male can be indicative of the animal's physiological reproductive state.

The necessity to examine ram mating behavior has now been recognized. Serving capacity tests were developed in order to measure sexual activity i.e. degree of libido and aggression. Researchers in Australia and New Zealand developed a 20-minute pen libido test using five ovariectomized estrous ewes to quantitatively measure mounts and services which would indicate degree of libido (Mattner and Braden, 1975; Allison, 1978; Kilgour and Whale, 1980). Mounts were classified as the ram straddling and clasping the ewe, contacting her rump with his brisket, with no subsequent intromission. A service was defined as a mount accompanied by intromission and ejaculation, a characteristic pelvic thrust with the head thrown back, usually followed by a period of disinterest in the ewe (Mattner et al., 1966; Winfield and Kilgour, 1977; Kilgour and Whale, 1980). In studies by Kilgour and Whale (1980), the mean number of services gave the best estimate of the number of ewes that would be inseminated in flock mating (r=.88). Mattner and Braden (1975) also studied mating dexterity (assessed by mount:service ratio). They reported that as the number of services increased, mating dexterity decreased, a high mount:service ratio being indicative of poor dexterity (Mattner et al., 1971). It was thought that the mount:service relationship found in mating dexterity could be due to variations in the receptivity of the ewes. A ram placed with highly receptive estrous ewes achieves a similar number of mounts and services but, with estrous ewes low in receptivity the ram performs more mounts than services. Mating competency is also used in reference to the mount:service ratio (Winfield and Cahill, 1978). Low mating competency in the pen test is associated with a lower proportion of services achieved in a flock mating situation. Although low mating competency is not directly related to fertility, it is related to poor serving performance and may indirectly affect fertility. Mattner et al. (1971) reported correlation coefficients of .66 and .72 between number of services by rams in a pen libido test and the service frequency in flock mating, respectively. As indicated by these coefficients, libido tests can be used in predicting mating performance in a flock situation. Wiggins and Terrill (1953) reported a significant correlation between ram libido (number of services in a pen libido test) and the percentage of ewes lambing. However, other researchers have not found these correlations to be significant (Hulet et al., 1962; Walkey and Barber, 1976).

Seasonal Changes Influencing Ram Sexual Activity

Sheep are generally considered to be seasonal breeders. This is especially true of ewes who have a definite anestrous (non-cyclic) period starting in March and lasting through August (Lees, 1965; Shackell et al., 1977). However, rams tend to exhibit more of a general decline or disinterest in sexual activity versus a true anestrous period (McKenzie and Berliner, 1937; Katongle et al., 1974; Gomes and Joyce, 1975). Seasonal effects on sexual behavior specifically male libido are manifested through changes in hormone levels, which, in turn, affect spermatogenesis and scrotal circumference (Lunstra and Schanbacher, 1976). Maximum spermatogenic and steroidogenic activity occurs in October and decreases slowly with increasing photoperiod of spring (Johnson et al., 1973). According to Lunstra and Schanbacher (1976) seasonal changes were reported in serum testosterone concentration, testicular diameter, sexual aggressiveness, and sperm concentration including alterations in progressive motility and acrosome morphology. The aforementioned results duplicate studies by McKenzie and Berliner (1937) and Sanford et al. (1977) who showed that mating activity was highest in November when serum testosterone levels were highest. A greater volume of ejaculate was also noted in November, thus coinciding with increased serum testosterone. Katongle et al. (1974), Sanford et al. (1977), and Winfield and Cahill (1978) studied the correlation that exists between LH and testosterone peaks. They demonstrated that increases of testosterone during the breeding season are brought about by seasonal increases in LH frequency. The correlation between seasonal changes in testosterone concentrations and mating activity was also evident. These findings may indicate seasonal differences in pituitary testicular functions in the ram (Sanford et al., 1974). During the nonbreeding months of March through August, the ram's sexual activity declines. This decline is due in part, to elevated body temperature which decreases spermatogenesis and therefore, fertility (Clegg and Ganong, 1969). Shearing can counteract decreasing spermatogenesis by lowering body temperature. Decreases in reproductive hormones are believed to be a result of light stimulus. Longer photoperiod causes steroidogenic activity to decrease (Johnson et al., 1973). Land (1970) and Land and Sales (1977) stated that seasonal fluctuations of libido and semen quality are influenced to a higher degree by light versus temperature variations which develop with changing seasons. Effect of temperature on libido is minimal (Cupps et al., 1960).

Effects of Artificial Adjustments in Photoperiod on Ram Sexual Activity

Over the years, natural selection has operated to develop reproductive photoperiods. Consequently, young were born at a time optimum for their survival (Clegg and Ganong, 1959). Seasonal breeders are greatly influenced by the amount of daylight they are exposed to and are at their maximum reproductive efficiency during short days of fall and winter. The ewe is particularly affected by photoperiod, in contrast, rams continue to exhibit sexual behavior as evidenced by libido and aggression but at lower levels. Spermatogenesis also continues but in decreased amounts (Ortavant et al., 1964; Katongle et al., 1974).

Daylight length affects sheep through a photosensitive mechanism initiated through the retina, which in turn, influences the hypothalamus and gonadotropic secretions from the pituitary (Yeates, 1947; Dutt, 1960; Pelletier and Ortavant, 1975; Lincoln 1976; Ortavant, 1977; Lincoln, 1979; Schanbacher, 1979). This mechanism causes a change in levels of male reproductive hormones, specifically LH, FSH, and testosterone (Ortavant et al., 1964; Pelletier and Ortavant, 1975; Lincoln, 1976; Ortavant, 1977; Lincoln and Davidson, 1977; Sanford et al., 1978; Schanbacher and Ford, 1979). Schanbacher (1979) demonstrated that short daylengths stimulated 1) synthesis and release of LH and FSH, 2) increases in testosterone production and spermatogenesis, and 3) increases in observed sexual aggressiveness and mating behavior improvement. The increase in overall male sexual activity is mediated by higher concentrations of circulating reproductive hormones (Kammalade et al., 1952; Gomes and Joyce, 1975; Schanbacher and Lunstra, 1976; Lincoln et al., 1977; Sanford et al., 1977). Follicle stimulating hormone effects the Sertoli cells of the testes, thereby increasing spermatogenesis (Yeates, 1949; Lincoln and Peet, 1977). Luteinizing hormone (ICSH) causes growth of interstitial cells which, in turn, increases testicular size and testosterone production (Lincoln and Peet, 1977).

Altered light schemes cause a hypothalamo-pituitary-testicular interaction. Simulation of short days aids in greater release of hormones; thereby increasing total blood hormone concentration (Pelletier and Ortavant, 1975; Lincoln, 1979). It has been speculated by Ortavant et al. (1964) and Pelletier and Ortavant, (1966) that decreasing light periods facilitate release of gonadotropic hormones; whereas, increasing dark periods may encourage their synthesis, yet inhibit their release. During the anestrous or non-breeding season, the pituitary contains more gonadotropic hormones due to decreased secretion; therefore, with a smaller concentration of hormones circulating, a decline in sexual interest occurs.

Studies conducted by Lincoln and Davidson (1977) show that abrupt changes from long (16L:8D) to short (8L:16D) days produced increases in LH and FSH blood levels. This increase began 2-4 weeks after change in daylength followed by an immediate rise in plasma testosterone levels. Testes growth also accompanied these increases. High levels of testosterone were associated with increases in aggressive and sexual behavior. Increase in scrotal circumference was found to occur approximately three weeks following commencement of short days (Lincoln et al., 1977; Lincoln, 1978; Winfield et al., 1978; Schanbacher, 1979). Ortavant (1977) found testicular weights to be 35% lower in January through May versus June to October. Schanbacher (1979) showed that when short day rams were mated to ewes, the number of lambs born to each ewe lambing was 35% higher than in ewes mated to control rams. Semen tests were also conducted on both groups of rams. Findings indicate that the percent of sperm with normal acrosomes decrease in control rams with no change resulting in short day rams. It was therefore, concluded that short day rams were more fertile, and that decreasing photoperiod is associated with a reduced sensitivity of the negative feedback system to testicular steroids (Schanbacher, 1979).

Factors Influencing Puberty and Sexual Maturity of Ram Lambs

In literature reviewed by Dyrmundsson (1973) it was reported that puberty in ram lambs occurs at a relatively early age. Puberty is measured by the onset of spermiogenesis and endocrine functions which lead to normal sexual behavior. Exhibition of reproductive capacity as expressed by sexual maturity, develops at a later age. Hence, puberty (the physiological expression) in the ram lamb is not to be confused with sexual maturity (the behavioral expression). According to Dyrmundsson (1973) the onset of puberty is due to release of gonadotropins (follicle stimulating homone and luteinizing hormone) from the pituitary and is more a function of body weight than age. It is also believed that ram lambs usually have developed motor patterns (mounting, nosing, flehmen, nudging, pelvic oscillations) used by adults in courtship long before physiological puberty (Banks, 1964). Dyrmundsson (1973) reported that pituitary gonadotropin content increased greatly from 42 days of age. This is due in part, to the positive relationship between increases in testes weight and pituitary weight. Dyrmundsson (1973) stated that small amounts of testosterone were released into the blood stream by the testes of 3.5 month old rams, testosterone being the principle testicular androgen in the ram. The total amount of androgens present increases with an increase in testicular weight. Carr (1975) hypothesized that testis growth in the lamb may be used as an indicator of circulating gonadotropins. Androgen concentrations were also found to be higher in yearlings versus mature rams (Dyrmundsson, 1973).

Testicular growth of the ram lamb is slow for the first 2-3 months but, increases when spermatogenesis begins. When puberty is reached, the rate of testicular growth declines. Specific anatomical development such as 1) descent of the testes into the scrotum and 2) a gradual breakdown of preputial adhesions to free the penis, must occur preceeding puberty (Dyrmundsson, 1973). These developments are greatly influenced by testosterone which is secreted at a faster rate prior to puberty (Dyrmundsson, 1973; Williams et al., 1976). These events are also more closely associated with body growth versus chronological age.

Studies have shown that penis development is slower in twins versus singles and body size in twins is also smaller. Sexual development has been shown to be adversely affected by inbreeding (Wiggins and Terrill, 1953).

The ejaculate of prepuberal rams is of a lower quality versus that of mature rams (Dyrmundsson, 1973). Morphology of the spermatazoa is inferior, plus the volume and concentration are less. These semen qualities have been reported to increase during the postpuberal period (Pretorius and Marincowitz, 1968; Dyrmundsson, 1973).

Nutrition plays a definite role in affecting the reproductive capabilities of immature rams. In young rams, low planes of nutrition will retard sexual development (Dyrmundsson, 1973). This is evidenced by the fact that rate of sexual development is dependent upon growth rate of the animal. Therefore, ram lambs born as singles are more likely to attain puberty at an earlier age when compared to twin born ram lambs (Dyrmundsson, 1973). Results of studies reported by Pretorius and Marincowitz (1968) show that ram lambs reared on a high plane of nutrition reach puberty at a younger age but heavier body weight. Under low nutritional levels (specifically low energy intake) androgenic functions of the testes are hindered. This inhibition of function is caused by a lack of gonadotropins from the hypophysis versus an inability of the testes to produce testosterone (Dyrmundsson, 1973). Dyrmundsson, (1973) also stated that in addition to detrimental effects of low energy on growth rate and sexual development, vitamin deficiencies such as vitamin A were found to impair sexual maturation.

The evidence that sexual behavior of ram lambs may appear at an early age is demonstrated by prepuberal mounting of both hetero and homosexual type. Signs of libido may also be observed in prepuberal ram lambs (Dyrmundsson, 1973).

Homosexual activity incurred due to monosexual group rearing of ram lambs may prove to be injurious to their normal mating ability (Hulet et al., 1964; Hulet, 1966; Marincowitz et al., 1966; Pretorius, 1967; Mattner et al., 1971; Bryant, 1975; Zenchak and Anderson, 1980). When introduced to estrous ewes, ram lambs display a wide range of behavior from total lack of interest to intense mounting activity. Inhibition of these young rams is demonstrated by poor mating dexterity (incorrect orientation) and inability to complete a service. However, it has been shown that both mating dexterity and ability to service improved gradually with an increase in number of sexual encounters (Pretorius, 1967; Dyrmundsson, 1973). One hypothesis postulated by Zenchak et al. (1973) states dominant ram lambs of a monosexual group used courtship behavior and mounting to establish dominance over subordinate rams. Dominant ram lambs were unable to respond appropriately (as evidence by a failure to mount and service) to a stimulus of an estrous ewe. In contrast, the subordinate rams interacted with ewes and were able to respond correctly.

Explanations for the inability of these dominant rams to successfully mate estrous ewes are believed to be 1) fear response, 2) use of courtship behavior in dominance assertion, and 3) odor and masculine features. The fear response is shown when the young ram is introduced to the pen containing estrous ewes. In many cases the ram will avoid eye contact with the ewe, run erratically about the pen or emit high pitched sounds. Use of courtship behavior (mounting, vocalizations, and aggression) have been used by the ram to assert his dominance in the monosexual rearing group. It was concluded that the amount of early sex-like behavior engaged in by dominant young rams influenced their subsequent failure to mate estrous ewes. Other factors influencing the young ram's mating ability were odor and masculinization. If the ram was confronted with an estrous ewe, he did not find the familiar odor and masculine features present in previous monosexual group encounters with other rams. The ram was then unable to respond to the ewe. This reaction is also associated with the fear response (Zenchak et al., 1973; Zenchak and Anderson, 1980).

Another factor influencing ram lamb mating efficiency is body size. If a ram is small, and is mated with mature ewes, it may become physically impossible for the ram to successfully service the ewe (Dyrmundsson, 1973).

As noted by Lightfoot and Smith (1968), young rams have a smaller mating capacity than mature rams. It is therefore, wise to mate a smaller number of ewes (approximately 25) to a young ram.

It is also necessary to emphasize the importance of normal testicular development of ram lambs. Routine palpation may show existing abnormalities deleterious to the reproductive efficiency of the ram. Measurements of scrotal circumference are also indicative of the rate of sexual development.

With advances in research, it has become increasingly apparent that seasonal factors including temperature and light influence sexual development. According to Dyrmundsson (1973) a relationship may exist between photoperiodism and puberal development in ram lambs. It is believed light environment affects sexual development and libido of ram lambs (Dyrmundsson and Lees, 1972a,b). Land and Sales (1977) reported that testis growth for autumn born rams (which is a stimulatory environment - short days) is more rapid, and puberty occurs at an earlier age than for males of the same breed born in spring. Conclusive information concerning temperature effects on puberty of ram lambs is lacking.

Factors influencing puberty and sexual maturity of ram lambs are diverse. However, these factors are interrelated, and all influence sexual development.

<u>Influence of Genetic Differences on Ram Sexual Activity</u>

Two factors complicate the evaluation of seasonal effects on ram's sexual activity: 1) breed differences in response to environmental factors, and 2) individual ram differences in breeding capacity (McKenzie and Berliner, 1937). Differences in seasonal variation in testes diameter and the time of seasonal increase in testes diameter can be seen among breeds (Islam and Land, 1977). Certain breeds such as the Finnish Landrace are more active in searching out and finding estrous ewes. The breeding capacity of an individual ram is also influenced by the number of ewes in estrus and the ram's preference for those ewes most recently in estrus and not yet mated (Hulet, 1966; Allison, 1978). The libido of Finn rams during the breeding season was also greater when compared to that of Scottish Blackface (Land, 1970). Length of the breeding season was found to vary significantly between breeds, the Finnish Landrace being active June through March versus September through February in the Blackface breed. It is hypothesized that there may be genetic differences in ram libido and that seasonal breeding behavior can be modified by genetic means (Hafez, 1951). These views are in contrast with those of Kelly et al. (1975) and Shackell et al. (1977) who stated that age and breed do not affect performance of rams in pen libido tests. It is interesting to note that the female of the Finn breed is well known for her large litter size in comparison to other breeds. A positive correlation was found to exist between large testes weight in the male and higher ovulation rates in the female within the same breed (Land, 1973; Land and Sales, 1977). Hence, there may be a relationship between between male and female reproductive parameters. According to Land (1973) breed and seasonal differences in ovine female fertility are associated with differences in male libido.

In a study using Finnish Landrace and Blackface breeds, it was found that not only did Finn rams have greater libido (as exhibited by a greater number of mounts and services), but the Finn ewes had greater litter sizes in comparison to their blackface counterparts. One possible explanation being that the Finnish Landrace has a greater sensitivity to circulating gonadotropins (Land, 1970). Breed differences have also been noted for serum testosterone concentrations, mean testicular diameter, and number of completed matings (Lunstra and Schanbacher, 1976).

Puberty and sexual maturity of ram lambs is influenced by genetic and environmental variation. Age at puberty is affected by breed but somewhat complicated or confounded by seasonality of mating. The Finnish Landrace breed is known to achieve rapid sexual maturity. This is evidenced by ewe lambs showing estrus in the first breeding season, and ram lambs mounting, gaining intromission, and ejaculating. In contrast ewe and ram lambs of the Merino breed at the same age did not exhibit these characteristics. It was concluded that different breeds react differently in the same environment (Islam and Land, 1977; Land, 1978).

Dominance Effects on Sexual Activity of Rams

In view of the aforementioned topics of season, age of ram, and photoperiod, the effect of dominance on the reproductive performance of rams must be considered. Social structure within a ram group affects mating behavior. Dominance exhibited by some rams increases their breeding efficiency, while the less dominant, subordinate rams are found at the bottom of the social ladder (Hulet, 1966; Shreffler and Hohenboken, 1974). Therefore, in flock mating situations, a dominant ram will have a harem group (cluster of estrous ewes), (Mattner et al., 1966; Mattner et al., 1973). If a large pasture or range area is being dealt with, there are no adverse results from formation of a harem group. The subordinate ram is allowed to circulate among other ewes and seek out those which are exhibiting estrus but have not joined the dominant group. According to Bourke (1967) and Mattner et al. (1971), competition may even increase breeding activity since the dominant ram stays with his harem, leaving the subordinate ram available to search the flock. Ram dominance was also found to have no influence on ram performance or flock fertility (Mattner and Braden, 1975). In contrast, results reported by Marincowitz et al. (1966) state that dominant rams will prevent subordinate rams from mating even when they themselves are unable to serve. Data reported by Lindsay et al. (1976) also suggests that dominant rams can inhibit subordinate rams with physical contact or mere presence. Therefore, the dominance, which exists within ram groups, plays a critical role in their sexual behavior. Dominance interacts with season, age of ram, and photoperiod to contribute to the overall effectiveness of the ram's performance.

Materials and Methods

This study commenced in February 1980 at Fort Ellis, five miles east of Bozeman, Montana and ended in March 1981. Four trials were conducted to examine libido and scrotal circumference. The trials were: 1) Hour long libido test, II) Artificially altered photoperiod to simulate short days, III) Seasonal changes for one year, and IV) Ram lambs of different breeds and selection lines. A serving capacity test was designed to measure libido and was conducted using three pens, approximately 6 by 6 meters in size. Four estrous ewes were placed in each pen (Kilgour, personal communication). Rams were simultaneously introduced, one to each pen.

Scrotal circumference was measured for each ram prior to placement in the pen. This procedure used a flexible metal tape for measurement. The testes were firmly pulled down into the base of the scrotum. The tape was placed around the scrotum. A measurement was taken at the widest part of the scrotum with both testes included (Sorensen, 1979; Braun et al., 1980).

Trial I: Hour Long Libido Test

In Trial I, a one hour test was conducted to determine if the time span of a 60-minute test could be reduced and retain its validity. The hour long test used 12 two-year-old Rambouillet rams to measure those factors involved with quantitatively examining libido such as reaction time (time from entry into the pen to first mount and/or service), number of mounts in four 15-minute intervals, and number of services in four 15-minute intervals. After four periods (8 weeks), a statistical analysis was conducted which indicated that a 30-minute test was as valid as the 60-minute test (see Results and Discussion). The original 60-minute test was then modified to a 30-minute test, (two 15 intervals), which was conducted once every two weeks.

Estrus was induced in ovariectomized ewes with intramuscular injections of progesterone and estrogen. The treatment schedule began on day 1 with a 25 mg injection of progesterone dissolved in peanut oil, followed on day 3 with another 25 mg injection of progesterone in peanut oil. On day 5, the ewes were injected with .2 mg of estradiol benzoate dissolved in peanut oil. Twenty to twenty-two hours following the last estrogen injection, the ewes were in estrus, which continued for approximately 24 hours.

The 30-minute test measured 1) reaction time (RT), which is the time from entry into the pen to first mount and/or service, 2) number of mounts in two 15 minute intervals (M1 and M2), and 3) number of services in two 15 minute intervals (S1 and S2). If during the course of the test, the ram failed to react (no mounts and/or services), a reaction time of 31 minutes was recorded. Action by the ram was classified as a mount if the ram's front feet left the ground and his brisket came into contact with the rump of the ewe with no resulting intromission and ejaculation. Action by the ram was classified as a service if the ram mounted, gained intromission followed by pelvic thrusts, head thrown back, and ejaculation; after which the ram usually displayed disinterest in the ewe. Two or three observers recorded data.

Trial II. Artificially Altered photoperiod to simulate short days

This trial began 4-18-80 and was terminated 7-24-80. Twelve rams divided into two groups and exposed to two different light regimes. Each group consisted of two Targhees, three Suffolks, and one 1/2-Finn. The control group was exposed to ambient conditions for the length of the study. The treated group was exposed to 8 hours of daylight and 16 hours of darkness (8L:16D), thereby simulating short days. The treated rams (8L:16D) were housed in a dark, ventilated barn in pens approximately six by six meters. Rams were let out at the same time each morning to feed and water and 8 hours later were returned to the barn. All rams were fed alfalfa-grass hay _ad libitum,_ until approximately the middle of May when they were put on pasture.

Analysis was conducted using least-squares analysis of variance (Harvey, 1977). The dependent variables in the model were SC, RT, M1, M2, TM, S1, S2 and TS. The independent variables in the analysis were treatment (T, control vs. 8L:16D), day of test (D), and TxD interaction.

Trial III: Seasonal Changes for One Year

Twelve two-year-old Rambouillet rams were used in this trial which started 2-21-80 and ended 3-20-81. Rams were chosen from three selection lines and were divided into three groups of four rams. Line one (H) consisted of "high fertility" rams. These rams were selected from a flock based on a history of twinning. Line two (L) consisted of "low fertility" rams. The rams were selected from a flock based on a history of singles. Line three (C) consisted of randomly selected control rams. All 12 rams were placed in serving capacity tests once every two weeks. These rams were exposed to ambient conditions throughout the year. In the course of this experiment, one ram in the "low fertility" (L) line died (4-17-80) of unknown causes. Prior to his death, his performance in the pen test was low. It was decided to remove his records from the data base. He was not replaced. June 15, 1980, another ram in the "low fertility" (L) line ate loco weed. He was unable to perform for one month, but was then put back in the trial.

Rams were fed alfalfa hay <u>ad libitum</u> except when season permitted grazing.

Due to unequal subclass numbers, analysis was conducted using least-squares analysis of variance (Harvey, 1977). The dependent variables in the model were scrotal circumference (SC), reaction time (RT), mounts in the first 15 minutes (M1), mounts in the second 15 minutes (M2), services in the first 15 minutes (S1), services in the second 15 minutes (S2), total mounts (TM), and total services (TS).

The independent variables were day of test (D), line (L), and DxL interaction.

Trial IV: Ram Lambs of Different Breeds and Selection Lines

This trial began 9-23-80 and was terminated 1-29-81. Ninety-six Rambouillet and Rambouillet-Columbia cross ram lambs born in the spring of 1980 (table 1) were used in this study.

TABLE 1. TYPE OF MATINGS USED TO PRODUCE RAMS USED IN TRIAL IV.

Breed and Line of Ewe	Line of Sire		
	High	Low	Control
Rambouillet			
High	18	--	--
Low	--	20	--
Control	--	--	15
Columbia	14	15	14
Total	32	35	29

Rambouillet ewes in the high group were mated to four Rambouillet rams of the high group to produce 18 Rambouillet ram lambs in column one of the table. Rambouillet ewes in the low group were then mated to four rams to the low group to produce 20 Rambouillet ram lambs in column two. These matings were followed by ewes of the control group being mated to eight rams in the control group. All combinations of matings produced 53 Rambouillet ram lambs. A random sample of Columbia ewes were then mated with the same Rambouillet rams of the high, low, and control groups to produce 43 Rambouillet x Columbia cross ram lambs. All lambs were approximately five months old at the start of the trial. Rams were weighed, scrotal circumference was measured, and a 15-minute serving capacity test was conducted every two weeks. Rams were randomly divided into two groups, half were tested Thursday afternoon, and half were tested Friday morning.

Rams were fed alfalfa-grass hay. One-half of the rams received a concentrate ration of half wheat, half barley while the other half of the rams received only barley. Neither diet produced a significant (P>.10) difference in weight gains of the rams.

During the study, three rams died. Bloat was believed to be the cause of death in these rams. Two rams were straightbred Rambouillets, one from the high line and one from the low line. The third ram was a crossbred from the low line. These rams were not replaced in the study.

Analysis was conducted using least squares analysis of variance (Harvey, 1977). The independent variables in the model were breed group (BG, Rambouillet vs. Columbia), line of sire (high, low, and control), type of birth (single or twin), type of rearing (single or twin), age of dam (2, 3, 4, 5 and 6 years of age), and appropriate covariances with weight and age of lamb. Analysis of variance with weight gain as a covariate was not significant for any variable measuring libido. Therefore, gain as a covariate was not included in further analyses. The dependent variables were SC, RT, total mounts (number of mounts in the 15 minute test period, TM), total services (number of services in the 15 minute test period, TS), plus percentage of ram lambs mounting (PM), and percentage of ram lambs servicing (PS).

Results and Discussion

Trial 1: Hour Long Libido Test

Initially, the serving capacity test used in the study was an hour long as suggested by Kilgour (personal communication). The hour test consisted of four 15-minute intervals. Due to test length, half of the rams were tested on Thursday afternoon, and half were tested Friday morning, in 14 day intervals. After four periods, 2-21-80 through 4-3-80, the data for the 60 minute test were analyzed. The objective of this trial was to determine if libido could be measured in less time and if there was a difference between the two days of testing (treatment). The independent variables in the model were day of test period (D), (testing in 14-day intervals), treatment (T, Thursday pm vs. Friday am), and DxT interaction. The dependent variables of the model were mounts in four 15-minute intervals (M1, M2, M3, M4), services in four 15-minute intervals (S1, S2, S3, S4), total mounts in the first 30 minutes (M30), total mounts in 60 minutes (TM), total services in the first 30 minutes (TS30), and total services in 60 minutes (TS).

As indicated by tables 2 and 3, TS, TM, TS30, and TM30 were significantly affected by day of test ($P<.05$). There was no significant ($P>.10$) affect in any of the variables studied due to treatment. Relationships between mounts and services during various segments of the 60-minute test were examined. Table 4 shows a high correlation between total services in 30 minutes (TS30) and total services in 60 minutes (TS), r=.95. Services in the first 15 minute interval (S1) were highly correlated to TS30 and TS, r=.96 and r=.92, respectively. Total mounts in 30 minutes (TM30) was found to be highly correlated with total mounts (TM) r=.93. The correlations for S3 and S4 with TS were .65 and .40, respectively.

It was concluded that the Thursday pm treatment versus the Friday am treatment had no significant effect on ram activity. The decrease in TS that occurred with advancing period 1-4 (table 3) was due to increasing photoperiod brought about by season. The results of this trial indicated that the first 30 minutes of the test are most critical in evaluating the serving capacity of the ram.

TABLE 2. ANALYSIS OF VARIANCE FOR TRAITS MEASURING LIBIDO IN A 60-MINUTE SERVING CAPACITY TEST

Source of Variation		Mean Square			
	df	TS	TM	TS30	TM30
Day	3	336.7*	259.5*	150.4*	146.4*
Treatment	1	143.5	31.7	72.5	18.7
DxT	3	68.6	56.3	31.7	13.2
Error	40	90.3	87.6	50.6	60.8

*$P<.05$.

TABLE 3. EFFECT OF PERIOD AND TREATMENT ON TS, TM, TM30, AND TS30 FOR A 60-MINUTE SERVING CAPACITY TEST

Period	TS	TM	TM30	TS30
1	17.6[c]	3.0[a]	2.0[a]	11.2[a,b]
2	16.2[b,c]	14.1[b]	10.4[b]	12.4[a]
3	8.8[a,b]	10.4[a,b]	7.9[a,b]	6.2[b,c]
4	7.0[a]	8.9[a,b]	6.5[a,b]	5.3[c]
Treatment				
Thursday (pm)	14.1[a]	8.3[a]	6.1[a]	10.0[a]
Friday (am)	10.7[a]	9.9[a]	7.3[a]	7.6[a]

[a,b,c] Means within the same group with different superscripts are significantly different ($P<.05$).

TABLE 4. CORRELATION COEFFICIENTS AMONG TRAITS MEASURING LIBIDO AS AFFECTED BY A 60-MINUTE SERVING CAPACITY TEST.

	M2	M3	M4	TM30	TM	S1	S2	S3	S4	TS30	TS
M1	.54**	.15	.28*	.94**	.85**	.51**	.41**	-.15	.29*	.54**	.40*
M2		.40**	.11	.79**	.77**	.16	.31*	-.18	.03	.23	.11
M3			.39**	.27	.58**	.05	.13	-.04	-.10	.08	.03
M4				.25	.48**	.23	.14	-.10	.29*	.22	.20
TM30					.93**	.44**	.42**	-.18	.22	.48**	.33*
TM						.40**	.40**	-.17	.20	.45**	.31*
S1							.54**	.46**	.29*	.96**	.92**
S2								.24	.27	.75**	.69**
S3									-.08	.44**	.65**
S4										.31*	.40**
TS30											.95**
TS											

**(P<.01).

*(P<.05).

Trial II. Artificially Altered Photoperiod to Simulate Short Days

As indicated in tables 5 and 6 the scrotal circumferences of the treated (8L:16D) rams were greater ($P<.01$) compared to the control rams. The least squares mean for SC for the treated rams (8L:16D) was 31.7±.2 vs. 30.2±.2 for the control rams. The difference in SC between the two groups occurred after 28 days of the treatment (figure 1), which coincides with research by Lincoln (1976), Lincoln et al. (1977), and Schanbacher (1979) who also observed that after three weeks there was a difference in testicular size due to light treatment. Although testicular tone was not measured quantitatively, a difference between the two ram groups occurred. The testes of the treated group appeared to have more tone when compared to the control as determined through palpation during SC measurements. The total number of services in 30 minutes were greater ($P<.01$) for the treated rams (8L:16D) compared to the control rams (table 5). The least squares mean for TS in 30 min was 2.7±.2 vs. 1.6±.2 for the control rams (table 6). There were no significant differences between the treated and control rams for the first 28 days. At day 42 the treated rams had greater ($P<.05$) TS and this continued until day 70. At day 70 and for the remaining periods, while the rams were still on treatment, there were no significant differences between the treated and control groups. The treatments ended on day 98 (July 24, 1980). However, approximately 30 days following the end of the treatments, both groups of rams were given serving capacity tests (figure 2).

Since the serving capacity test was divided into 15 minute intervals both the first 15 minutes and second 15 minutes were analyzed. Least squares means for (S1) were 1.9±2 and 1.0±.2 for the 8L:16D and control rams, respectively (P<.01). Least squares means for the second 15 minutes (S2) were .8±.1 and .5±.1 for the 8L:16D and control rams, respectively (table 6) (P<.10). The difference in the least squares means for the two intervals could be due to an increased post ejaculatory interval (time between services). This interval has been shown to lengthen with successive matings if the stimulus female is not changed (Pepelko and Clegg, 1965a; Pretorius, 1972).

Neither total mounts nor mounts for either 15 minute interval were significantly affected by treatment, (table 5). The least squares means for total mounts (TM) in the treated group compared to the control group were 6.9±.8 vs. 5.7±.8, respectively (table 6). It is thought that mounting behavior is not indicative of active sex drive since mounting is rather constant during the breeding season and increases during anestrous or time of low breeding activity (Pepelko and Clegg, 1965b). During the course of the study, the number of mounts recorded varied greatly according to individual rams, treatment and day the experiment was conducted (figure 3).

Correlation coefficients for traits examined are shown in table 7. M1 was highly correlated to M2 and TM, .29 and .84, respectively. M2 was highly correlated to TM, r=.76. The correlations for S1, S2, and TS are also represented in table 7. S1 was highly correlated to S2 and TS, .43 and .91, respectively. S2 was highly correlated to TS, r=.76. SC was not significantly correlated to any of the test variables. A negative correlation existed between S1 and RT, r=-.21. This indicates that as services increased during the first 15-minute interval, RT decreased. No relationship existed between mount and service variables studied. Researchers have found that photoperiod affects the levels of certain reproductive hormones in rams (Ortavant, 1977; Ortavant et al., 1964; Pelletier and Ortavant, 1975; Sanford et al., 1978; Schanbacher and Ford, 1979; Lincoln, 1976; Lincoln and Davidson, 1977). These hormones include LH, FSH, and testosterone. Follicle stimulating hormone affects the sertoli cells of the testis thereby increasing spermatogenesis (Lincoln and Peet, 1977). LH (ICSH) causes growth of the interstitial cells which, in turn, increases testicular size and testosterone production (Lincoln and Peet, 1977). Using a short day light regime, these reproductive hormones undergo an increase in concentration (Pelletier and Ortavant, 1975; Lincoln, 1979). The visual results of this increase are shown in the ram by an increased scrotal circumference, increased libido as demonstrated through the number of services completed, plus an overall increase in aggressiveness.

Schanbacher (1979) has shown that by decreasing photoperiod, the hormonal cycles which initiate sexual activity are triggered. Five rams were exposed to 8 hr of light and 16 hr of darkness during May to simulate short days. The short day rams sired 2 1/2 times more lambs as those rams exposed to normal spring conditions at this time. Consequently, Schanbacher (1979) demonstrated the use of artificial photoperiods (8L:16D) to induce breeding activity in rams during the non-breeding season. With this altered lighting, there was an increase in testicular growth and semen quality. The short day rams had improved fertility when compared to the control rams. This study concluded that artificially altering daylength not only affected scrotal circumference but also increased ram libido as measured by total services in a serving capacity test. Therefore, if a producer is interested in twice a year breeding schemes using decreasing photoperiods, it would be advantageous to treat the ram in addition to the ewe.

TABLE 5. LEAST SQUARES ANALYSIS OF VARIANCE FOR TRAITS MEASURING RAM LIBIDO AS AFFECTED BY ALTERED PHOTOPERIOD TREATMENT

Source of	Mean Squares			
Variation	Trt. (T)	Day (D)	TxD	Error
df	1	8	8	90
SC	66.5**	186.1**	2.4	2.9
S1	20.2**	.3	1.7	1.4
S2	1.9*	.5	.5	.5
TS	34.4**	1.5	3.5	2.7
M1	26.1	78.6**	22.5	16.4
M2	1.6	15.6	3.9	11.2
TM	40.8	234.8**	27.9	35.3
RT	2.7	12.5	14.2	14.8

**(P<.01)
*(P<.10)

TABLE 6. LEAST SQUARES MEANS AND STANDARD ERRORS OF RAM REPRODUCTIVE TRAITS AS AFFECTED BY ALTERED PHOTOPERIOD TREATMENT

	Mean±Standard Error	
Variable	Control	8L:16D
SC	30.2±.2	31.7±.2**
S1	1.0±.2	1.9±.2**
S2	.5±.1	.8±.1
TS	1.6±.2	2.7±.2**
M1	3.8±.5	4.7±.5
M2	2.0±.5	2.2±.5
TM	5.7±.8	6.9±.8
RT	1.8±.5	2.1±.5

**(P<.01)
(P<.10)

TABLE 7. CORRELATION COEFFICIENTS AMONG TRAITS MEASURING LIBIDO AS AFFECTED BY ALTERED PHOTOPERIOD TREATMENT.

	M1	M2	TM	S1	S2	TS	RT (min)
SC (cm)	.03	-.09	-.03	.03	.03	.04	.03
M1		.29**	.84**	.00	.12	.07	.02
M2			.76**	-.06	.01	-.04	.08
TM				-.03	.12	.03	.06
S1					.43**	.91**	-.21*
S2						.76**	.01
TS							-.15

**(P<.01).
*(P<.05).

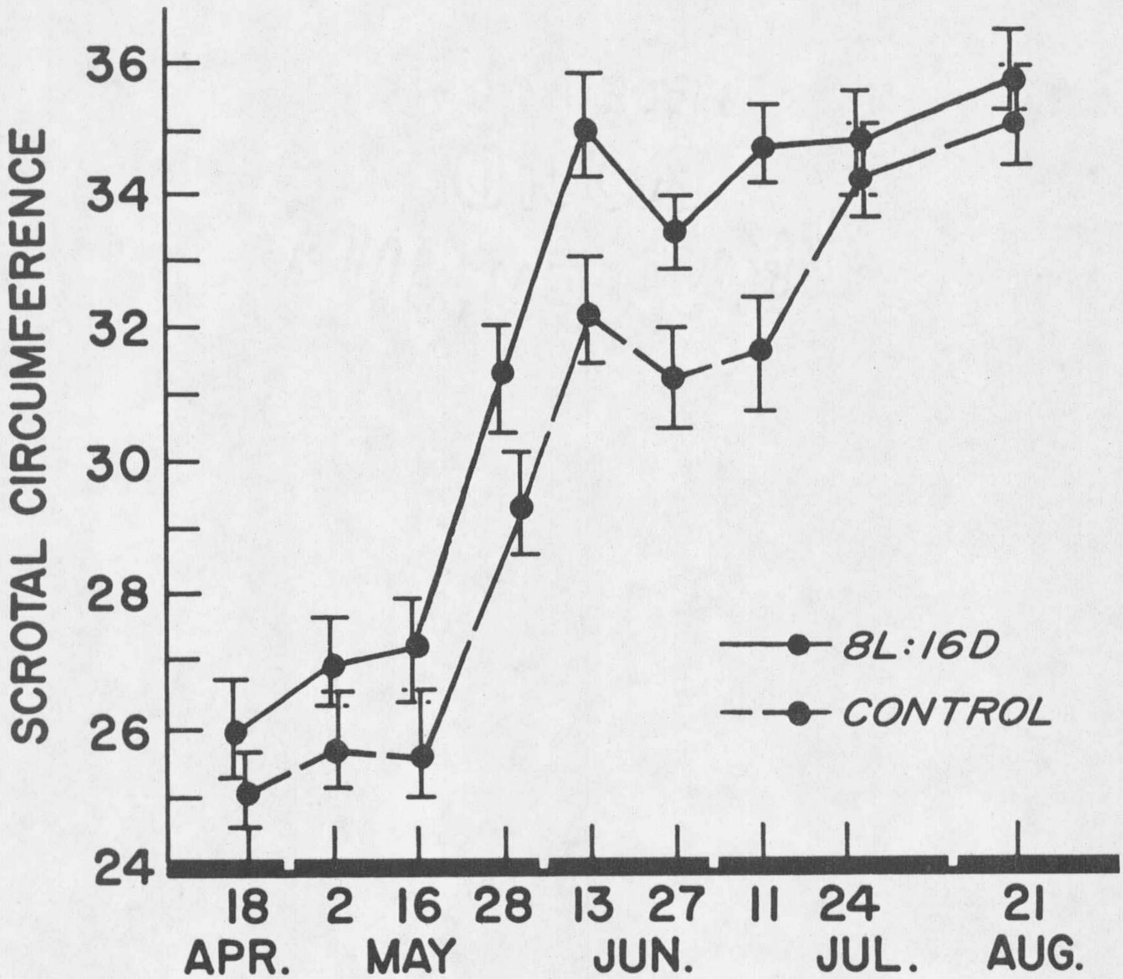

Figure 1: Effect on day and altered photoperiod on scrotal circumference.

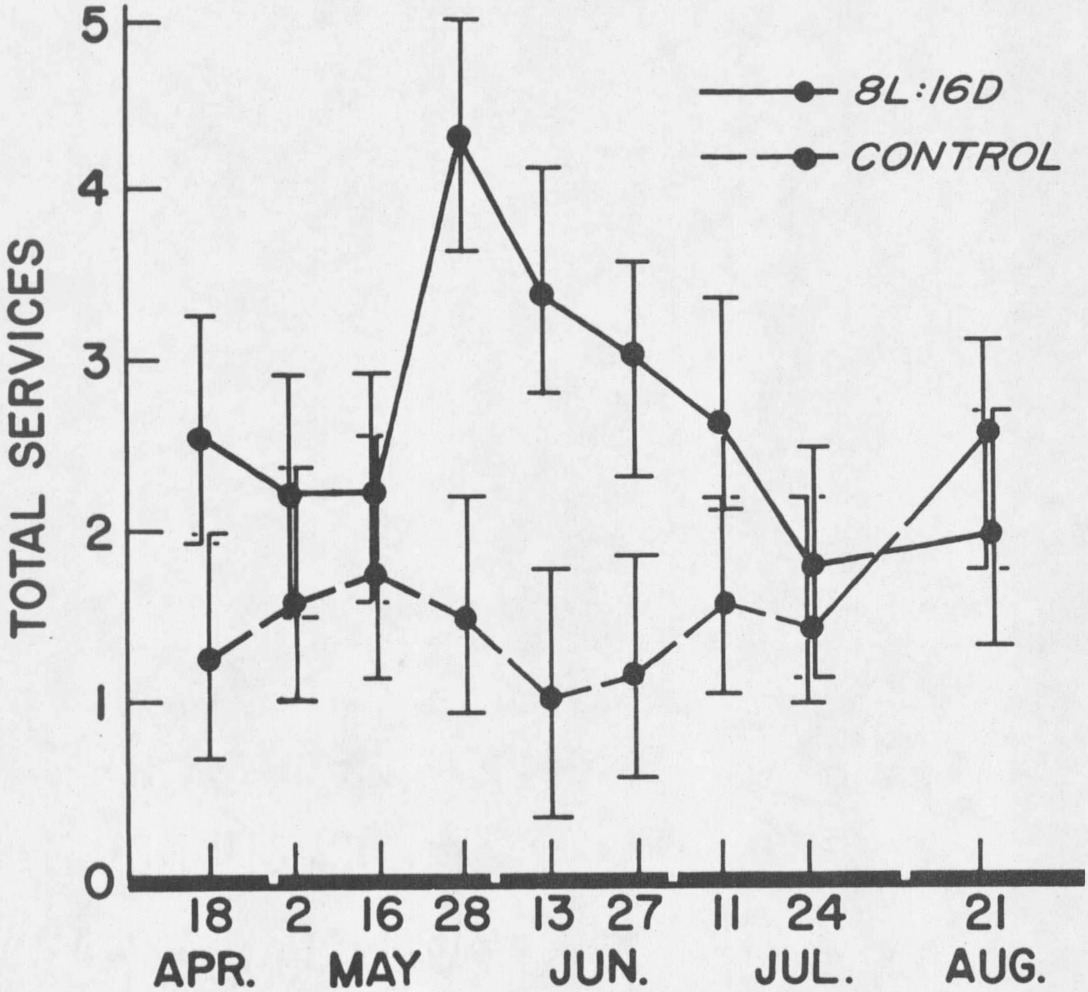

Figure 2: Effect on day and altered photoperiod on total services.

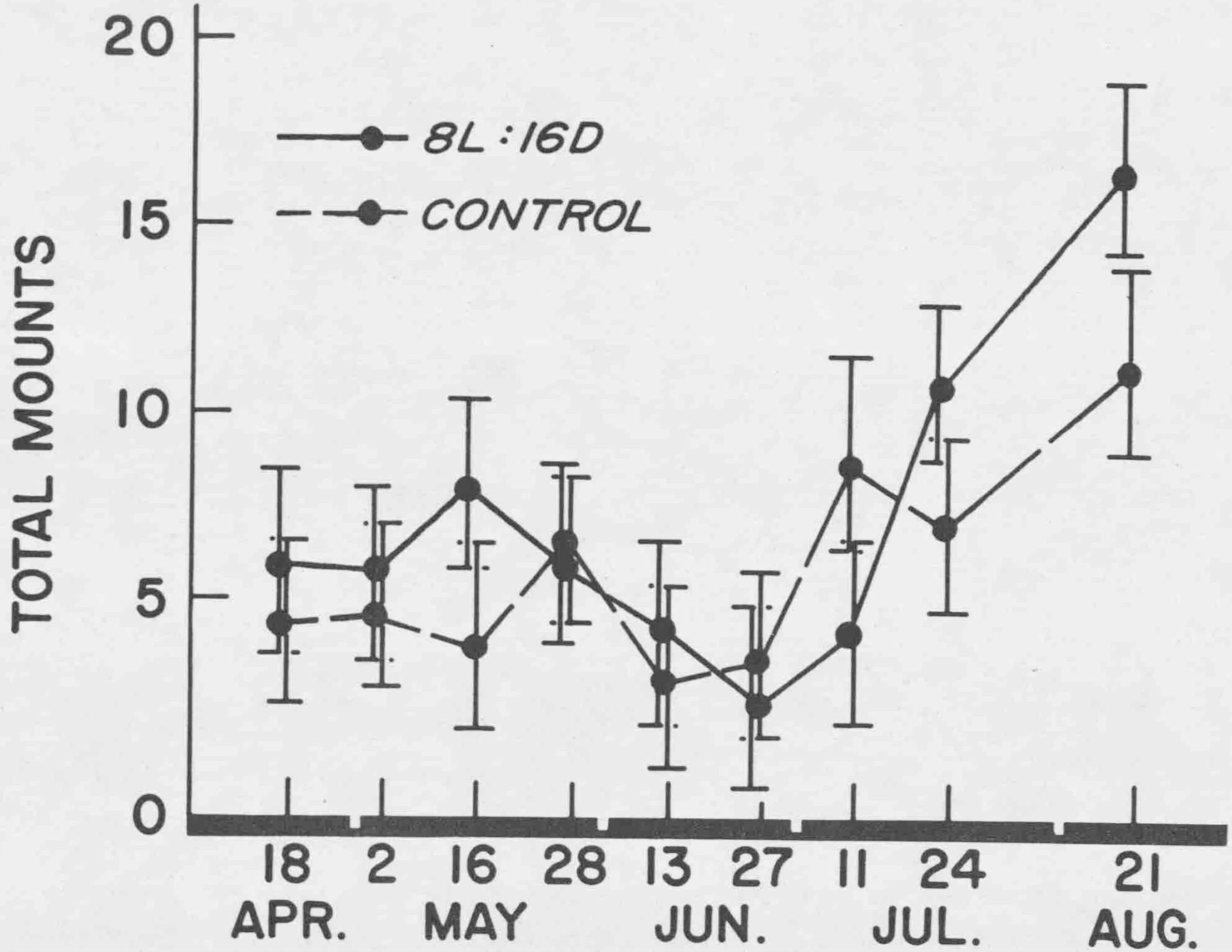

Figure 3. Effect of day and altered photoperiod on total mounts.

Trial III: Seasonal Changes for One Year

Libido and scrotal circumference as influenced by season of the year, were examined in eleven rams from three selection lines. These traits included scrotal circumference (SC), number of mounts in the first 15-minute interval (M1), number of mounts in the second 15-minute interval (M2), total mounts in 30 minutes (TM), number of services in the first 15-minute interval (S1), number of services in the second 15-minute interval (S2), total services in 30 minutes (TS), and reaction time (RT), time from entry in the pen to first mount and/or service. The analysis of variance is presented in table 8. Line of ram affected SC, M1, M2, TM ($P<.01$), and TS ($P<.10$). Line had no effect on S1, S2, or RT ($P>.10$). Day of test affected SC, M1, S1, and RT ($P<.01$) and TM and TS ($P<.05$), while having no significant ($P>.10$) effect on M2 or S2. There was no significant ($P>.10$) interaction between line and day of test for any parameter examined.

Table 9 shows least squares means for SC for the three selection lines (high, low, and control). The low line had a greater ($P<.05$) SC than did the high or control line. Figure 4 illustrates an increase which occurs on periods 4 and 5, day of test being May 27, 1980 and June 12, 1980, respectively. This increase in SC occurred at about the time the rams were put on pasture in the spring, and is believed to be associated with body growth. However, there were no body weights taken during the course of the experiment. This same trend was observed in the light/dark experiment (Trial II) at the same time of the year when those rams were put on grass. Visual examination of figure 4 shows the smaller SC evident during the spring of the year, followed by a gradual increase over the summer, and a peak occurring during the shorter days of October, November and December. As indicated earlier, there was no interaction between day of test and line of ram. This lack of interaction was evidenced by a consistently larger SC for the low line vs. the high and control lines throughout the study. It is interesting to note that SC, was not significantly correlated to any of the other traits examined (table 10).

As indicated in table 9, there was a difference ($P<.05$) between least squares means for M1 and TM for all three selection lines. Whereas, least squares means for M2 show the high and control lines being greater ($P<.05$) than the low line. Table 10 indicates correlations which existed for M1, M2, and TM. M1 was highly correlated to M2 and TM, .52 and .91, respectively. M2 was highly correlated to TM, $r=.82$. Figures 5, 6 and 7 depict seasonal influences on mounting behavior. All three figures indicate the variability which existed between the rams mounting frequency and day the test was conducted i.e. season. Since there was not a specific pattern encountered, it is believed that mounting behavior is not a reliable indicator of sexual drive and activity as shown by Pepelko and Clegg (1965b). It is interesting to note the negative correlations which occurred between the mount and service parameters in the study. M2 was negatively correlated ($P<.05$) to S1 and TS, - .17 and -.14, respectively. The negative correlations which existed between TM and S1 and TS were approaching significance ($P>.05$). These results would indicate that as mounting behavior increased, the ram's ability to service tended to decline. This phenomena is termed low mating competency and can be related to poor serving performance (Mattner et al., 1971).

Table 9 indicates the least squares means for S1 and TS were greater ($P<.05$) for the high line vs. the low line. The control line was not different from the high or low line. S2 showed no difference ($P>.05$) for any of the three lines. S1 was correlated with S2 and TS, 0.21 and .87, respectively. S2 was highly correlated to TS, $r=.67$ (table 10). Figures 8, 9 and 10 depict the seasonal influence on service ability of the ram. The resulting patterns indicate the decreased sexual activity i.e. services, which occurred during spring and summer, followed by increased activity during the short days of fall and winter. This increase in services associated with short days is again followed by a decline in service activity due to a return to the longer days of spring. It is interesting to note that S2 (figure 10) remains relatively low, with no real peaks observed. This decline in the number of services during the S2 period could be the influence of a "post-ejaculatory interval". This is defined as the time between services, and lengthens if the stimulus female is not changed (Pepelko and Clegg, 1965a; Pretorius, 1972). Due to the nature of the serving capacity test, this interval could indeed be an influencing factor.

RT as influenced by selection line is shown in table 9. The high line has a shorter reaction time than the low line, 1.0 minutes and 2.3 minutes, respectively. In contrast, the control line was intermediate and showed no difference when compared to the high and low line. As indicated in table 10, RT was negatively correlated to M1, TM, S1 and TS, -.21, -.19, -.29, and -.26, respectively. These correlations indicate that RT decreases as mounts or services increase. Examination of figure 11, shows least squares means for RT. RT was found to be longer during the spring and summer versus fall and winter. A shorter RT associated with fall and winter indicated an increase in sexual aggression corresponding to the breeding season. If after entry to the pen, for the 30-minute test, the ram displayed no sexual interest, as evidenced by no mounts and/or services, he was given a RT of 31 minutes. Therefore, when examining the figure, the peaks observed for day of test 2 and 23 are due to a recorded RT of 31 minutes, indicating one to 11 rams showed no sign of sexual activity.

The seasonal influences on sexual activity of the ram are apparent. The effect of the shorter days of fall and winter are observed through an increase in SC and an increase in libido as evidenced by a greater number of services in a serving capacity test.

The influence of selection lines on sexual drive of the rams is depicted through the difference between least squares means for the variable examined i.e. TM, TS, S1, M1, and RT. With the randomly selected control line rams, the mean differences were intermediate, and many times not significant. In contrast, the high and low lines consistently showed significant differences between the means. This would indicate that the selection for high and low prolificacy (twinning vs singles) does indeed exert an influence on the ram's libido as measured in a serving capacity test.

TABLE 8. LEAST SQUARES ANALYSIS OF VARIANCE FOR RAM REPRODUCTIVE TRAITS AS AFFECTED BY SEASON OF THE YEAR.

Source of variation	DF	Mean Squares							
		SC (cm)	M1	M2	TM	S1	S2	TS	RT (min)
Line	2	115.1**	620.9**	152.4**	1345.6**	3.0	.9	6.9†	39.0
Day	27	141.5**	141.9**	26.9	235.3*	3.5**	.9	5.3*	45.2*
LxD	54	1.2	63.7	24.5	120.9	1.1	.5	1.8	20.4
Error	223	3.1	58.5	29.3	130.7	1.6	.7	2.8	18.4

**(P<.01).

*(P<.05).

†(P<.10).

TABLE 9. LEAST SQUARES MEANS OF RAM REPRODUCTIVE TRAITS IN THREE SELECTION LINES.

	Traits Studied							
Line	SC(cm)	M1	M2	TM	S1	S2	TS	RT(min)
High	33.2^{a}	12.2^{a}	5.9^{a}	18.1^{a}	2.0^{b}	1.0^{a}	3.0^{b}	1.0^{a}
Low	35.5^{b}	6.7^{b}	3.2^{b}	9.9^{b}	1.6^{a}	$.8^{a}$	2.4^{a}	2.3^{b}
Control	33.7^{a}	9.1^{c}	5.2^{a}	14.2^{c}	1.8^{ab}	$.8^{a}$	2.6^{ab}	1.8^{ab}

^{a,b,c}Means within the same column with different superscripts are significantly different ($P<.05$).

TABLE 10. CORRELATION COEFFICIENTS AMONG TRAITS MEASURING LIBIDO AS AFFECTED BY SEASON OF THE YEAR

	SC (cm)	M1	M2	TM	S1	S2	TS	RT (min)
SC (cm)		.09	.09	.10	.02	-.07	-.02	-.08
M1			.52**	.91**	-.08	-.06	-.09	-.21**
M2				.82**	-.17*	-.02	-.14*	-.11
TM					-.13	-.05	-.13	-.19**
S1						.21**	.87**	-.29**
S2							.67**	-.07
TS								-.26**

**(P<.01).

*(P<.05).

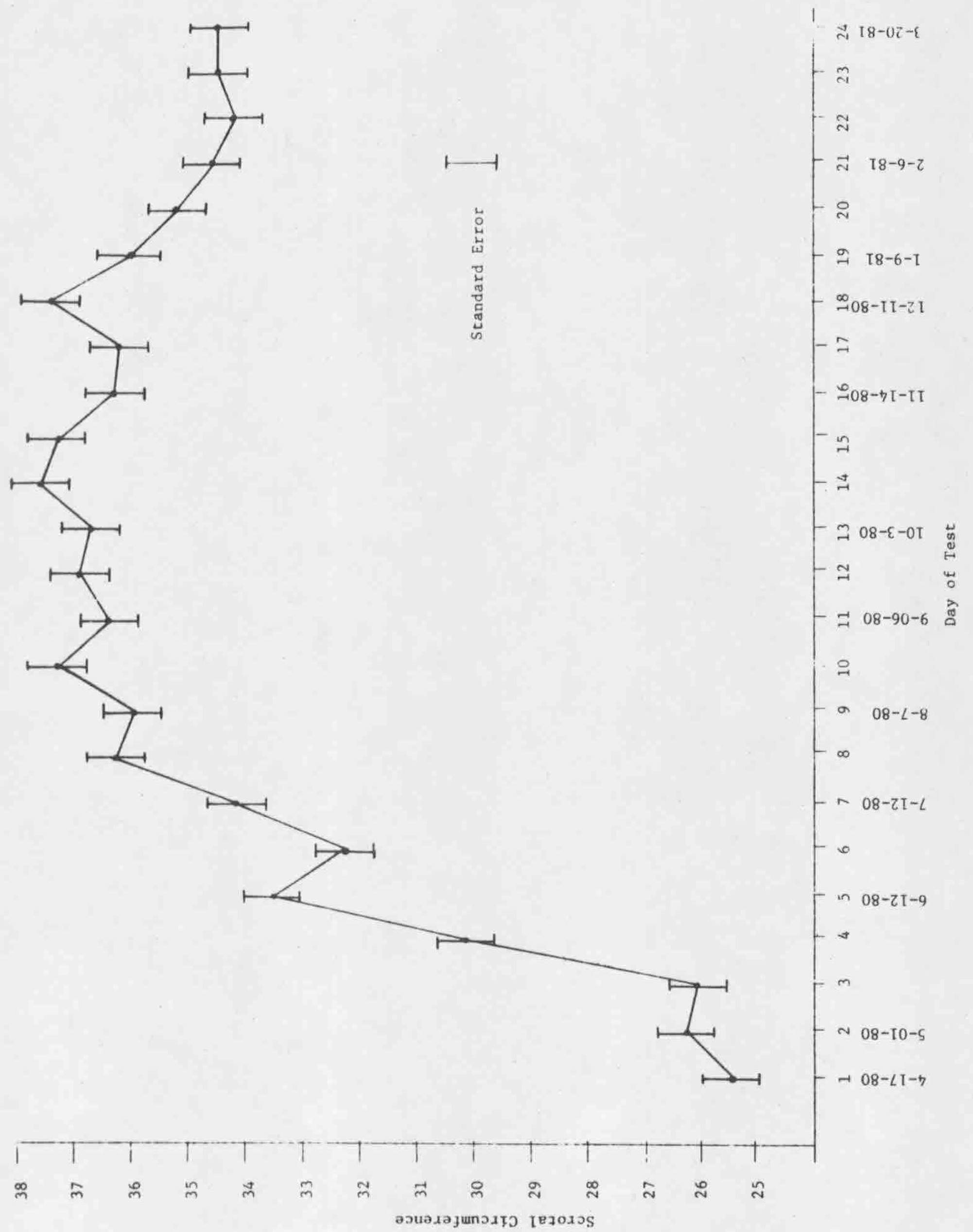

Figure 4. Least squares means for scrotal circumference of rams as affected by day of test.

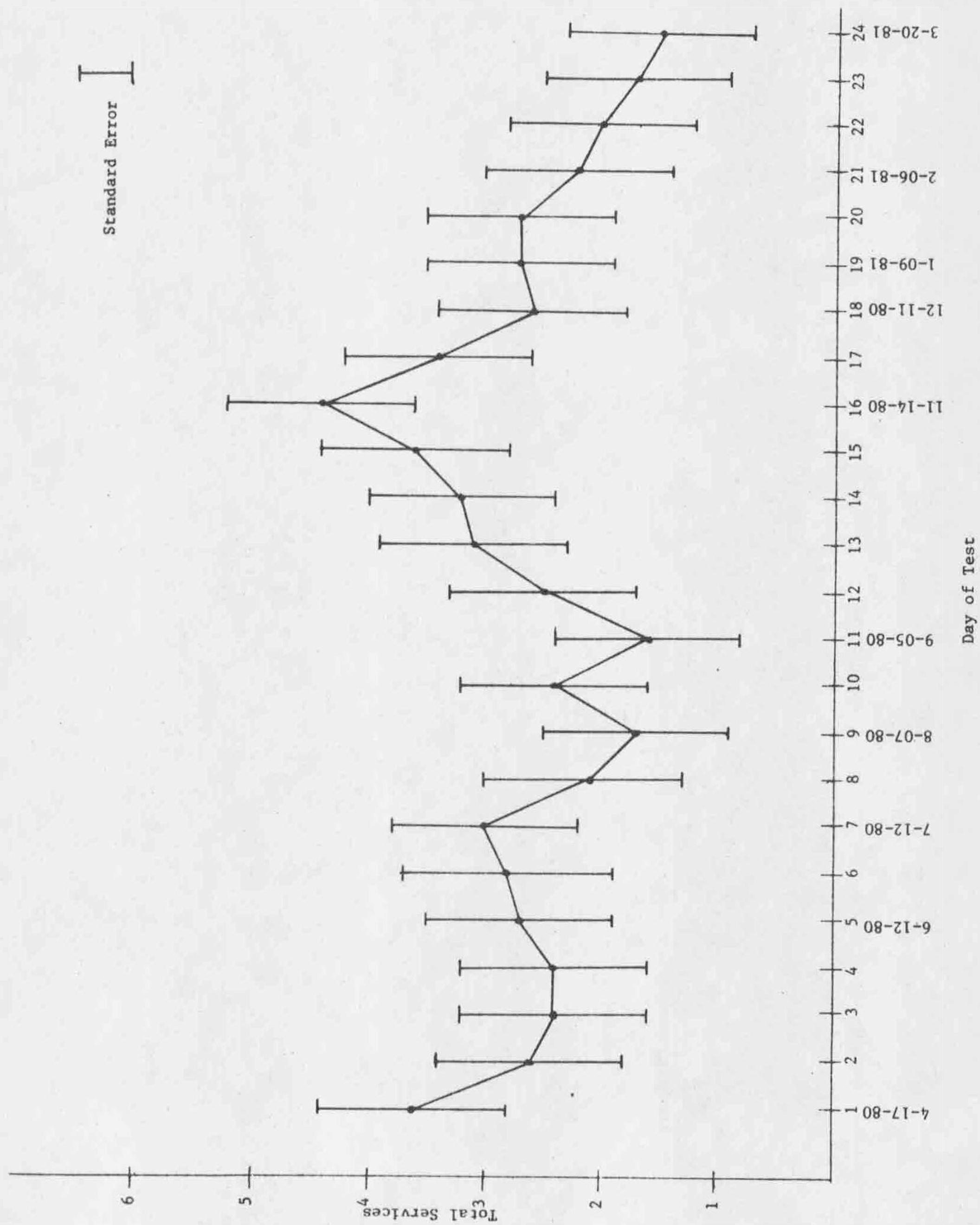

Figure 5. Least squares means for total services in a 30-minute serving capacity test for rams as affected by day of test.

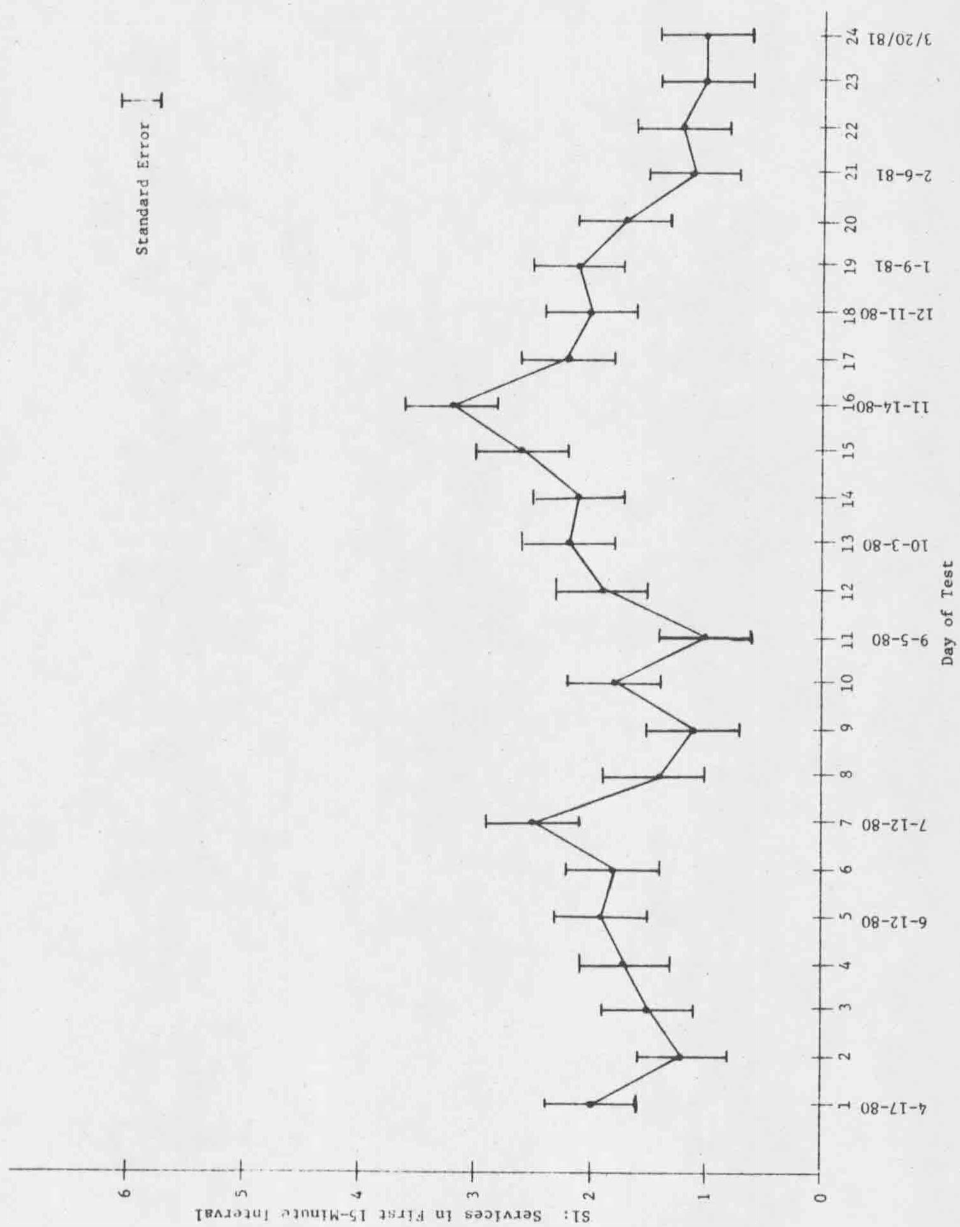

Figure 6. Least squares means for services in the first 15-minute interval of a 30-minute serving capacity test for rams as affected by day of test.

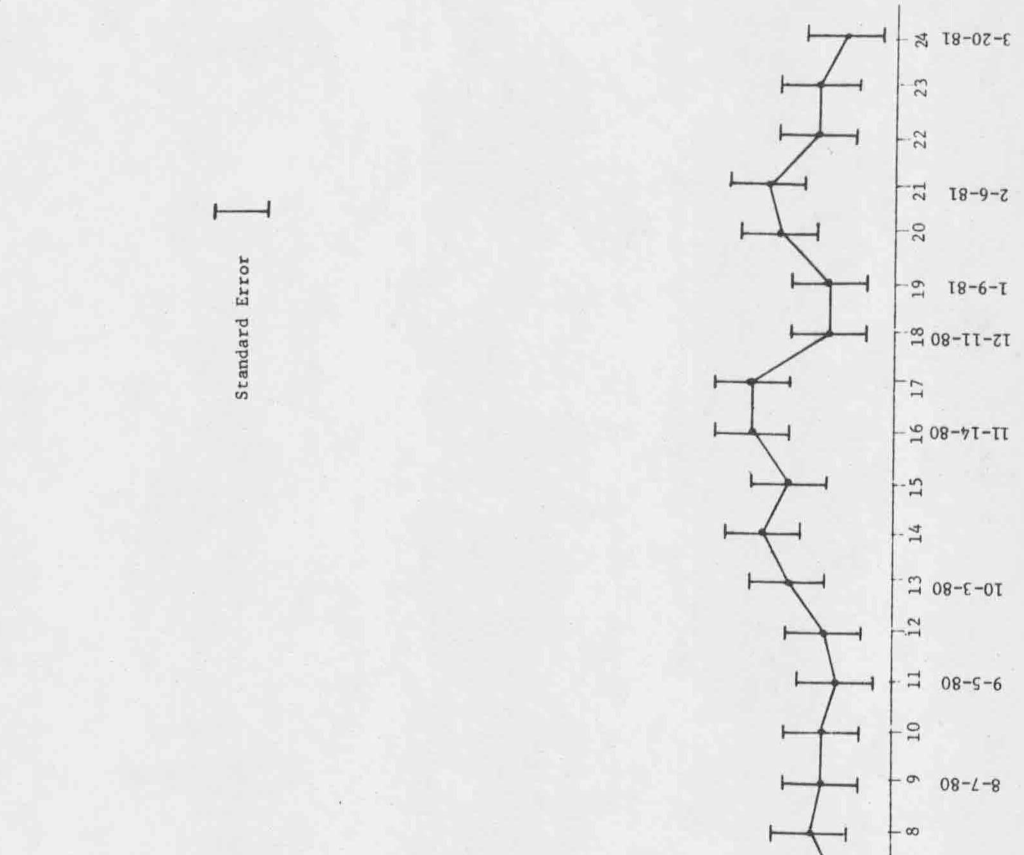

Figure 7. Least squares means for services in the second 15-minute interval of a 30-minute serving capacity test for rams as affected by day of test.

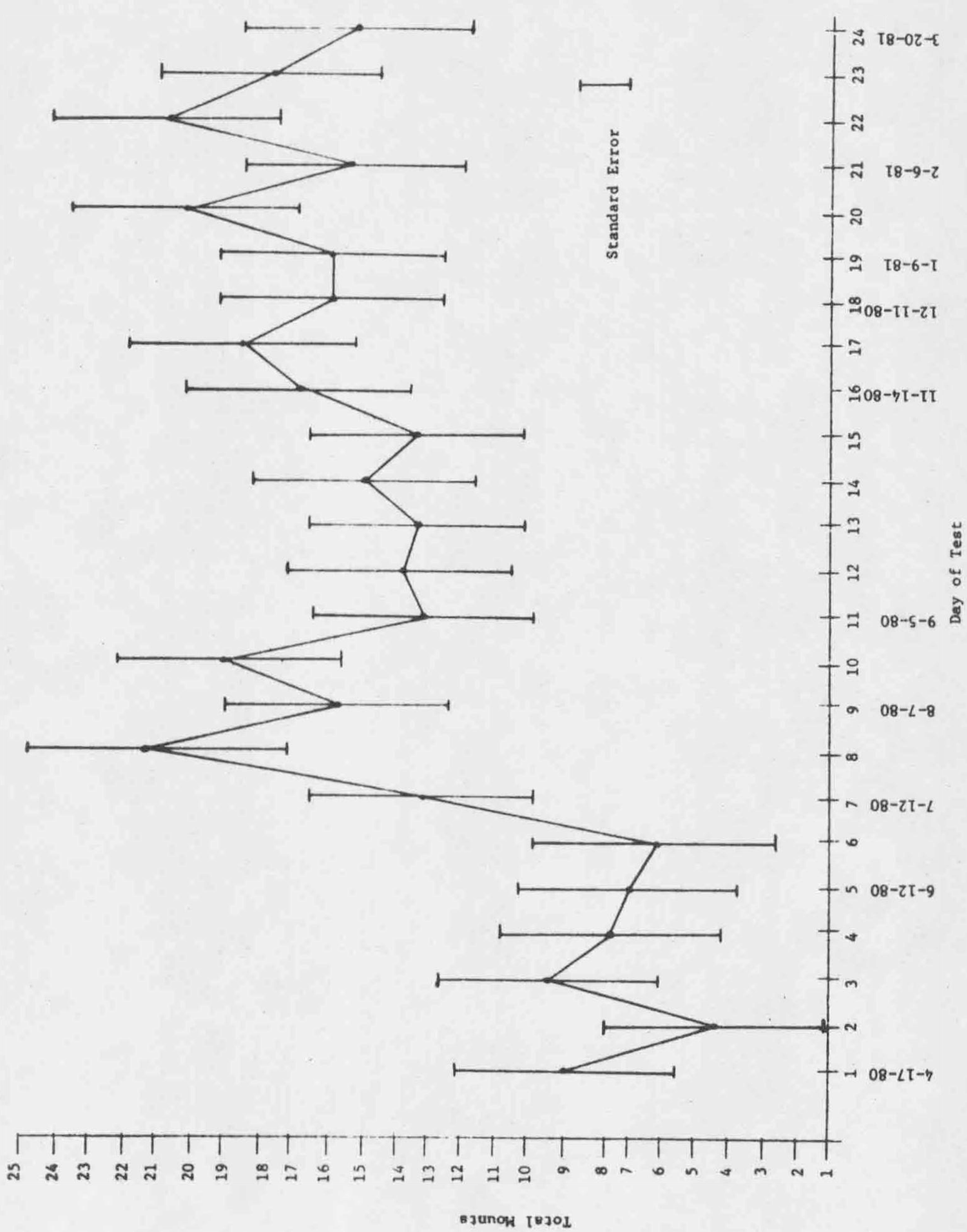

Figure 8. Least squares means for total mounts in a 30-minute serving capacity test for rams as affected by day of test.

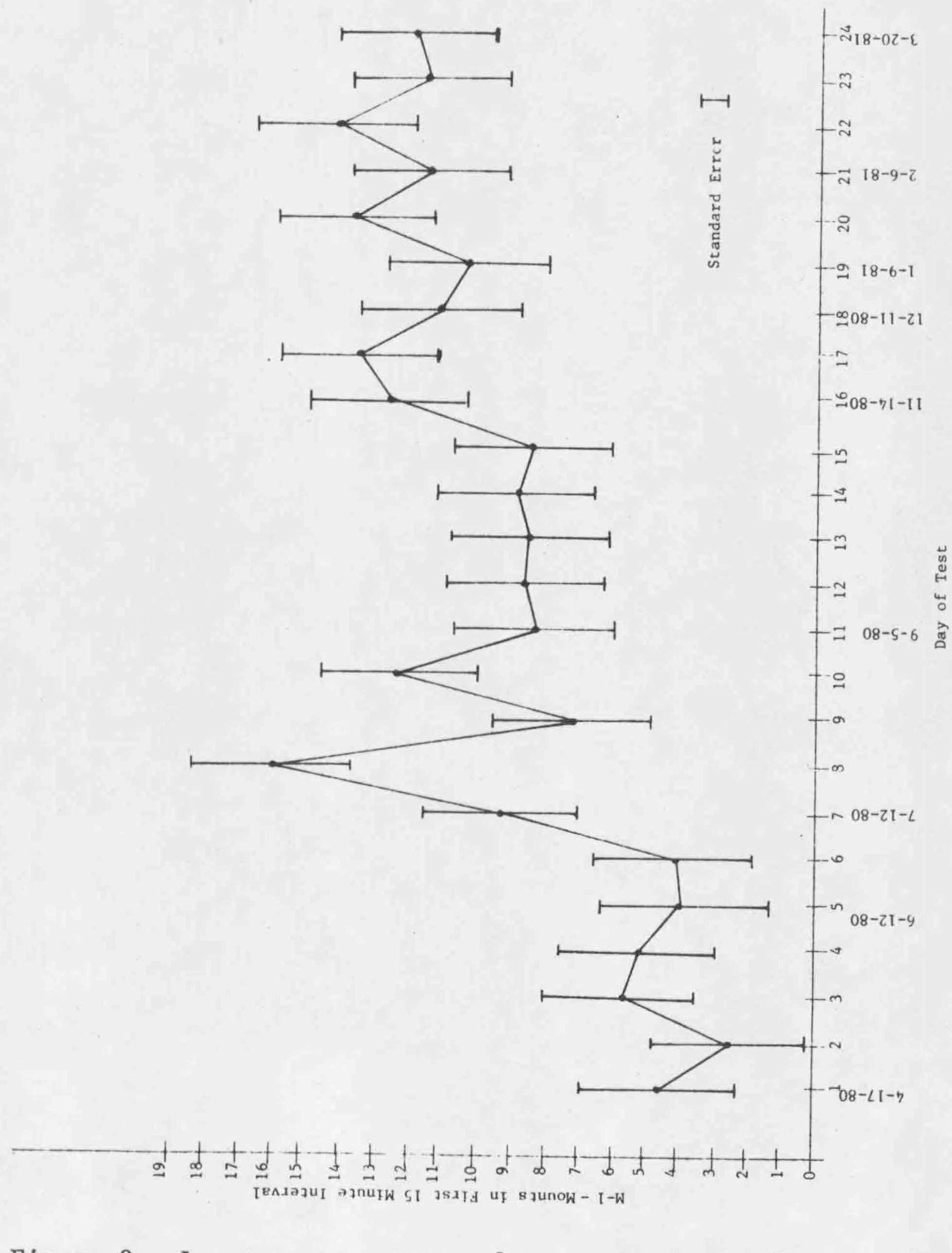

Figure 9. Least squares means for mounts in the first 15-minute interval of a 30-minute serving capacity test for rams as affected by day of test.

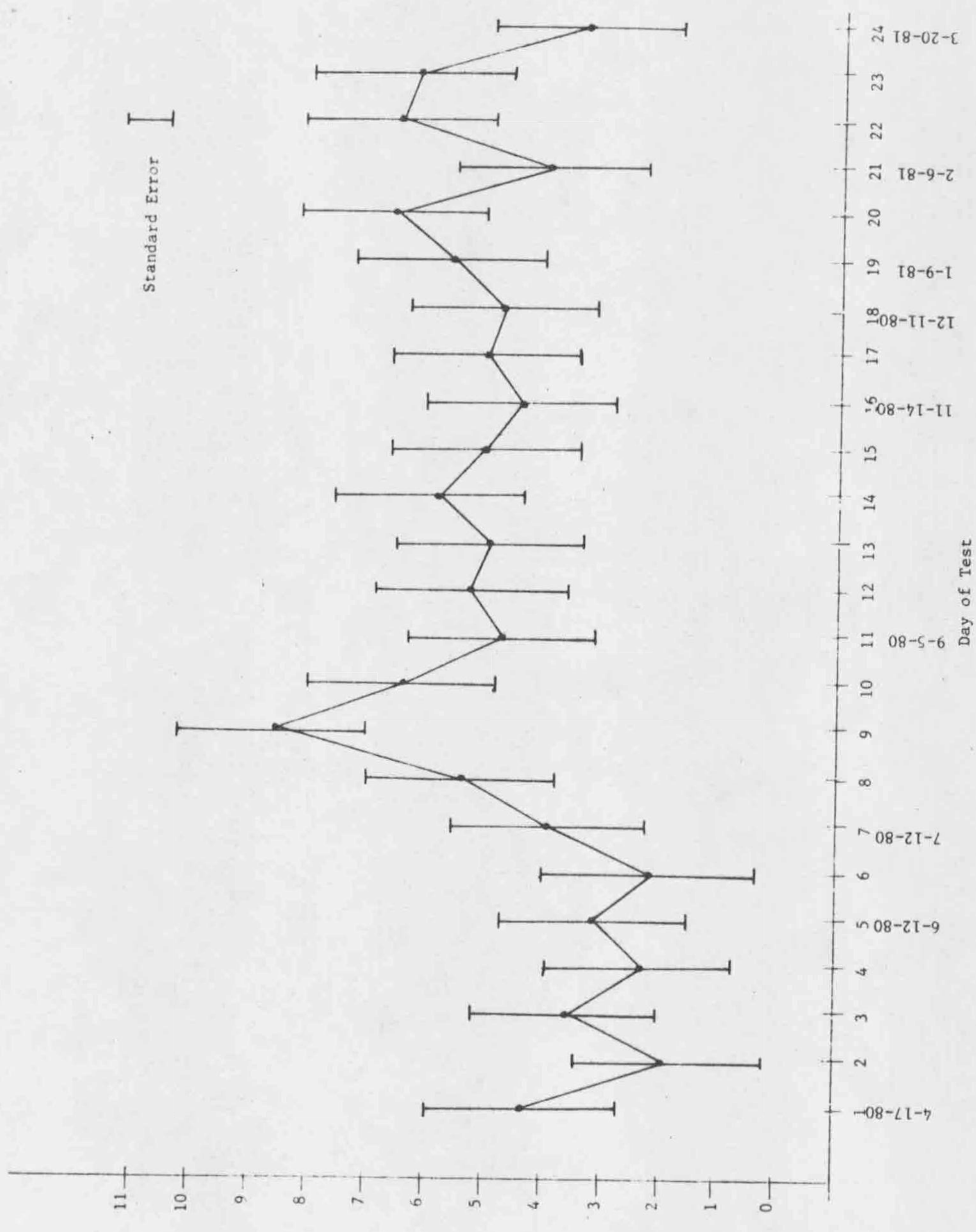

Figure 10. Least squares means for mounts in the second 15-minute interval of a 30-minute serving capacity test for rams as affected by day of test.

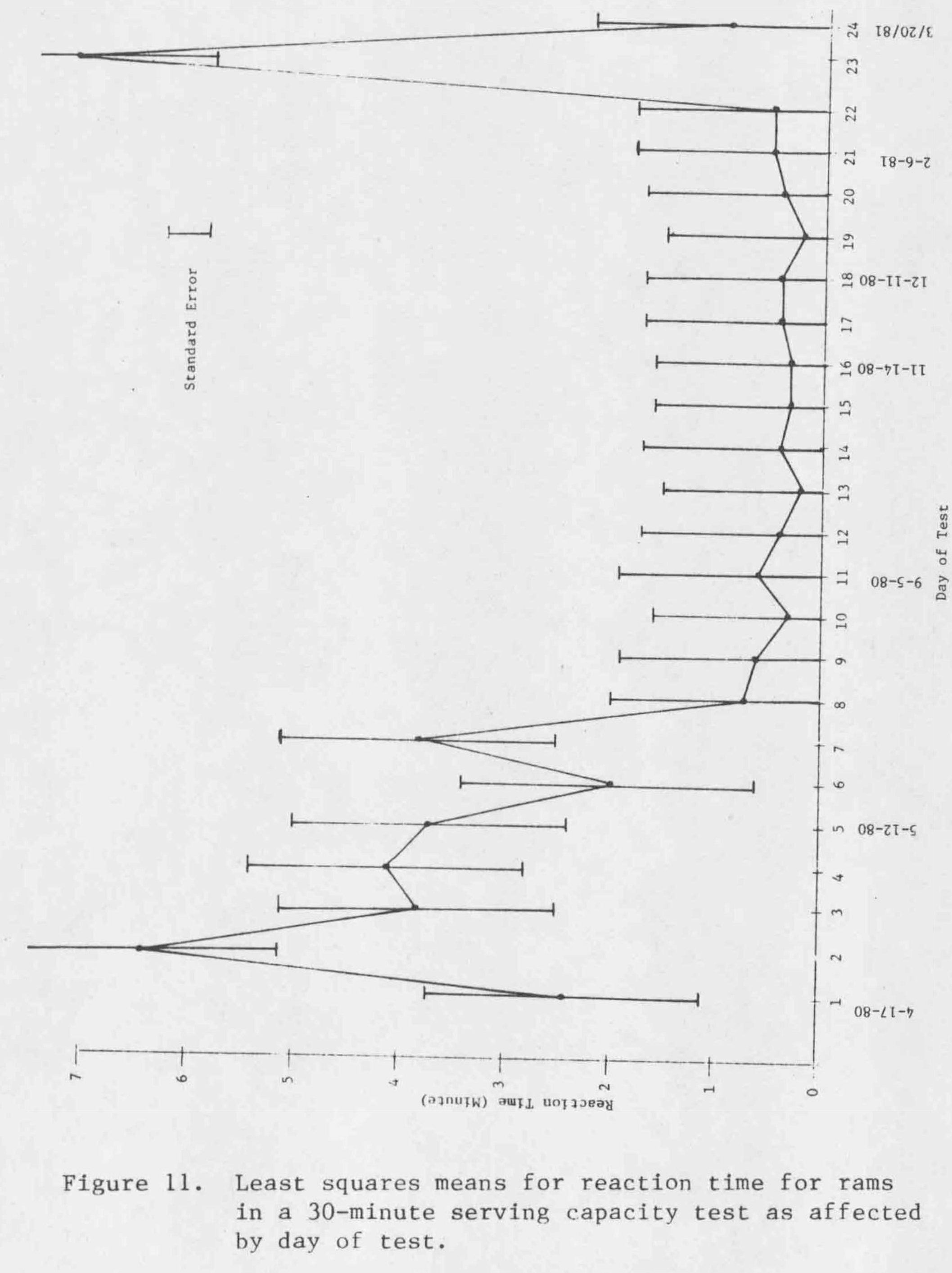

Figure 11. Least squares means for reaction time for rams in a 30-minute serving capacity test as affected by day of test.

Trial IV. Ram Lambs of Different Breeds and Selection Lines

Ninety-three ram lambs provided data for ten test periods. The traits studied were used as indicators of onset of sexual activity in the ram lambs. The traits included SC, TM, PM, TS, PS, and RT. Least squares analysis of variance was conducted for all six traits for periods one through ten as shown in tables 11, 14, 15, 16, 17, 18, and 19.

Table 11 shows breed had a significant effect on SC in periods 2 through 6. Figure 12 illustrates breed differences occurring for these same time periods. The Columbia x Rambouillet crossbred ram lambs had greater scrotal circumference than straightbred Rambouillet ram lambs. Heterosis could be an influencing factor in the breed differences. Line of ram lamb significantly affected SC in periods 3, 4, and 5. Figure 13 indicates that SC for the high line was greater when compared to the low and control lines throughout the ten test periods, although only significantly for periods 3, 4 and 5. No breed by line interaction was significant. Type of birth and type of rearing also were not significant. The age of dam variable in the model was significant for all test periods (table 11). Examining least squares means for age of dam (table 12) revealed no trend in dam ages associated with SC; and, since age of ram lamb and body weight were included in the model as covariates, there was no conclusive explanation for the significant age of dam effect that occurred. Body weight as a covariate affected SC throughout all ten periods (P<.01). Age of ram lamb as a covariate had no significant affect on SC, however, the range in age was small, approximately 20 days. The partial regression coefficients are presented in table 13.

Least squares analysis of variance for TM in 15 minutes is shown in table 14. Breed was significant for two of the ten periods. Figure 14 demonstrates the crossbred Columbia x Rambouillet ram lambs had a greater number of mounts throughout the test periods when compared to straightbred Rambouillet ram lambs, although the difference was significantly greater for only two periods, 6 and 7. The effect of line on TM was significant for periods 3, 4, 5 and 6. Examination of figure 15 indicates a trend in the high line to have more mounts compared to the low and control lines with the high line being significantly different for periods 3, 4, 5, 6 and 7. Table 14 and figure 14 were not in agreement for the number of periods in which line had a significant effect. Least squares means for the three selection lines show that the high line is indeed significantly different when compared to the low and control lines for period 7.

Breed by line interaction was not significant for TM for any test period, nor were TB or TR significant. Age of ram lamb and body weight as covariates were also not significant for TM.

Least squares analysis of variance for the percentage of ram lambs mounting (PM), for each test period, one through ten, is shown in table

15. Breed was significant for periods 6, 7, and 10 ($P<.01$) and for periods 8 and 9 ($P<.05$). Figure 16 depicts a larger percentage of the crossbred Columbia x Rambouillet ram lambs mounted during periods six through ten when compared to the straightbreds.

The effect of line on PM was significant for periods 2, 4 and 6 ($P<.01$) and periods 5 and 7 ($P<.05$). Figure 17 shows the high line had a greater percentage of ram lambs mounting than the low and control lines for periods two through seven.

Breed by line interaction was not significant for PM, nor were TB or TR. Age of ram lamb and body weight, included as covariates had no significant effect on PM.

Least squares analysis of variance for TS during the 15-minute test for periods one through ten is shown in table 16. The first three periods show no numerical value due to no services being recorded for any ram lambs for these test periods. Neither breed (figure 18) nor line (figure 19) had significant effects on TS. However, figure 18 does indicate a tendency for the crossbred Rambouillet x Columbia ram lambs to have more services in comparison to the straightbred rams.

No breed by line interaction affected TS. TB and TR also had no effect on TS. Covariates of age of ram lamb and body weight were not significant.

Least squares analysis of variance for percentage of ram lambs servicing (PS) for periods four through ten is shown in table 17.

Neither breed nor line had a significant effect on PS. However, a trend existed, as illustrated by figure 20, for the crossbred ram lambs to have a higher percentage of services (PS) when compared to the straightbred ram lambs. This trend is similar to that seen for TS. Figure 21 demonstrates the effect of line on PS, with high and control lines showing a trend to be greater when compared to the low line. This trend was similar to the trend observed for TS as affected by line.

Breed by line interaction did not affect PS, nor did TB or TR have an influence. Age of ram lamb, and body weight, included as covariates, were also not significant.

Least squares analysis of variance for reaction time (RT) for ten test periods is shown in table 18. Breed was significant for three periods (6, 7 and 8). Figure 22 demonstrates RT was lower for the Columbia x Rambouillet crossbreds when compared to straightbred Rambouillets; although only significantly different for periods 6, 7 and 8. Line significantly affected RT for five of the ten periods (table 18). Figure 23 depicts the high line having had a consistently lower RT when compared to both high and control lines, however, the difference was only significant for five periods.

Breed by line interaction had no significant effect on RT, nor did TB and TR. Age of ram lamb and body weight covariates were also not significant.

Least squares analysis of variance for body weight during the ten test periods is shown in table 19. Type of birth was significant for a majority of test periods, thereby, indicating that rams born as singles had consistently greater body weights than those born as twins (table 20). Type of rearing was shown to have no significant influence on body weight. Breed by line interaction was not significant for body weight.

Correlation coefficients for traits used to measure onset of sexual activity are found in table 21. No specific trends were visible in the correlations between SC and the other traits examined; however, SC was highly correlated to body weight, r=.72. Body weight was not correlated with any of the other traits measuring onset of activity, i.e., TM, PM, TS, PS. For ease of discussion, when consistent significant values were observed, the correlation coefficients were averaged over all ten periods to provide one coefficient as shown above. TM were highly correlated to PM. This relationship would be expected since TM is part of PM, r=.62. Both PM and TM were negatively correlated to RT throughout the ten test peridos, r=-.85 and r=-.58, respectively, thereby, indicating that with an increase in TM, i.e., percent mounting, RT decreased. PM was also moderately correlated to TS with r=.25.

TS was highly correlated to PS, r=.90. Again, this coefficient is expected due to the part-whole relationship which exists. TS and RT were moderately, negatively correlated, r=-.25. TS was also moderately correlated with TM, r=.26, thereby, indicating that as mounting activity increased, chances for completing a service increased. A similar trend is indicated by the correlation between PM and PS, r=.33. As percent mounting increased the percent serving also increased. PS was negatively correlated with RT, r=-.28.

The onset of sexual activity in ram lambs is a combination of puberty and sexual maturity (Dyrmundsson, 1973). In the testing situation, fear response along with use of courtship behavior in dominance assertion played key roles in the initiation of sexual activity in the ram lambs (Hulet et al., 1964; Hulet, 1966; Marincowitz et al., 1966; Mattner et al., 1971; Zenchak et al., 1973 and Zenchak and Anderson, 1980). Observed responses within the test ranged from immediate interest of the ram lamb in the estrous ewes to extreme nervousness, fear, and confusion. With increased exposure to estrous ewes, the latter type of behavior became less pronounced. All rams in this study were slow to achieve services in the serving capacity test. This situation was due in part to small body size and inexperience. Although the statistical analysis did not show body weight to be significantly correlated with the traits measured activity, body size does play a role in the ram's ability to mate successfully (Dyrmundsson, 1973). It is interesting to note that age of ram lamb also was not related statistically to the other traits i.e. TM, PM, TS, PS, and RT.

As mounting activity for the ram lambs increased throughout the test periods, so did their ability to service. This relationship is supported by the earlier correlations of PM and PS. Therefore, indicating that with experience and increased exposure, the ram lambs can become proficient breeders.

Two breeds and three selection lines were present in the ram lambs used. The high line generally exhibited a greater and earlier response to the stimulus ewes when compared to the low and control lines. The exception to this trend occurred in TS and PS, where the high and control lines exhibited similar trends. Of the two breeds, the Columbia x Rambouillet crossbreds had larger SC and greater, earlier responses when compared to straightbred Rambouillets in the serving capacity tests. Puberty and sexual maturity are influenced by genetic and environmental variation (Islam and Land 1977; Land, 1978). Heterosis is one contributing factor to the improved crossbred performance. Also, age at puberty can be affected by breed.

As a result, a composite of factors are integrated to bring about onset of sexual activity in the ram lamb. These factors range from nutrition, and genetics, to environment i.e. monosexual rearing and season.

TABLE 11. LEAST SQUARES ANALYSIS OF VARIANCE FOR SCROTAL CIRCUMFERENCE FOR PERIODS ONE THROUGH TEN.

Source of Variance	df	Mean squares for periods one through ten									
		1	2	3	4	5	6	7	8	9	10
Breed (B)	1	2.2	21.3*	21.0*	48.3**	47.9**	17.5†	5.7	.96	9.0†	7.1
Line (L)	2	14.0	8.0	27.0**	23.6*	23.6*	6.5	7.1	6.7	3.3	6.5
Age of dam	4	23.8*	18.9**	13.9*	22.4**	24.2**	17.2**	15.9**	14.4**	11.0**	6.1†
Type of birth	1	38.4*	13.7	17.1†	3.6	3.4	.38	.02	1.4	2.1	.18
Type of rearing	1	16.7	2.6	13.8	14.4	6.6	3.7	1.2	11.4†	6.9	5.7
BxL	2	2.9	4.0	.49	.17	.06	3.5	2.6	2.9	.99	3.5
Regression											
Age	1	23.3	12.5	12.8	4.0	.39	3.1	1.6	.91	.10	2.2
Body wt	1	509.2**	354.4**	435.6**	620.0**	533.0**	510.1**	380.4**	330.1**	248.1**	248.8**
Error	82[a]	9.1	5.4	5.2	5.4	5.5	4.5	4.5	3.6	2.6	2.9

**(P<.01)

*(P<.05)

†(P<.10)

[a]Error df were 82 for periods 1 through 4, 81 for periods 5 through 7, and 79 for periods 8 through 10 due to death of animals during the study.

TABLE 12. LEAST SQUARES MEANS (cm) FOR AGE OF DAM EFFECT ON SC FOR PERIODS ONE THROUGH TEN.

Age of dam	n	Periods 1	2	3	4	5	6	7	8	9	10
2	19	20^{c}	21^{ab}	23^{bc}	25^{b}	26^{c}	26^{bc}	27^{bc}	28^{b}	27^{ab}	27^{a}
3	25	19^{bc}	22^{b}	24^{c}	25^{b}	26^{c}	27^{c}	28^{c}	28^{b}	28^{b}	28^{a}
4	23	19^{bc}	20^{a}	22^{ab}	23^{a}	24^{ab}	25^{ab}	26^{ab}	26^{a}	26^{a}	27^{a}
5	12	17^{a}	20^{a}	21^{a}	23^{a}	23^{a}	24^{a}	25^{a}	26^{a}	26^{a}	27^{a}
6	16	18^{ab}	20^{a}	22^{ab}	23^{a}	25^{bc}	25^{ab}	26^{ab}	27^{ab}	27^{ab}	28^{a}

^{a,b,c}Means within the same period with different superscripts are significantly different ($P<.05$).