THE UNIVERSITY OF MANITOBA

SEASONALITY IN REPRODUCTION IN FOUR DIFFERENT BREEDS OF RAMS

BY

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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DEDICATION

This thesis is dedicated to Mr. E.G. Dickson and

Mr. and Mrs. D.S. Vlahovich

ABSTRACT

This study investigated the effect of genetic background upon the pattern of seasonal changes in reproductive processes of rams. Various assessments were made on 15 yearling rams of four breeds (three Finnish Landrace and four Suffolk, Dorset and Scottish Blackface rams) from June 1979 through July 1980. Measurements of scrotal circumference (SC) were taken twice a month. Every 3 or 4 months, daily sperm output (DSO) was determined by counting spermatozoa voided in urine and libido was assessed by recording the frequency of mating during a 4h period. At monthly intervals, blood samples were collected by venipuncture from the jugular vein at 20-min. intervals for an 8h period; serum pools representing these periods were assayed for LH, FSH, PRL and testosterone (T) concentrations. Individual ram serum samples collected over an 8h period in July, October, January and April were assayed for LH-profile characteristics; T-profile characteristics were determined for the months of October and April.

As rams entered the fall ovine-breeding season, SC and DSO increased considerably. In comparison with other rams, increases in testicular size occurred earlier and maximum size was maintained longer for the Dorset rams, and seasonal variations in SC were less pronounced for the Finn rams (breed x month, $P<.01$). DSO of Suffolk rams during the breeding season was significantly ($P<.05$) greater than that of Finn and Blackface rams. However, Finn rams had consistently higher ($P<.01$) mating frequencies in comparison with other rams, perhaps attributable in part to their higher circulating T levels throughout most of the year (breed x month, $P<.01$). Although significant breed differences in mean serum

LH and PRL concentrations were not observed, Suffolk rams did have considerably higher FSH concentrations in the summer and fall (breed x month, $P<.01$). Significant ($P<.01$) seasonal differences in LH-profile (excluding baseline levels, $P>.05$) and T-profile characteristics were observed; all of the profile characteristics were higher in July and/or October than they were in January and/or April. No consistent breed differences were noted from one month to the next in LH-profile mean and baseline levels, peak height and delta values, but a significant ($P<.05$) breed x time interaction was recorded for mean levels. Dorset rams had higher LH baseline levels than the other rams in July (significant, $P<.05$) and in January and April. T-profile characteristics were comparable for the four breeds of rams in October and April. In summary, seasonal-directional changes in the reproductive parameters investigated were similar for rams of all breeds; however, for many parameters, the extent and/or duration of seasonal change varied between breeds.

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INTRODUCTION

It is well known that in temperate regions of the world the reproductive capability of sheep varies throughout the year. The extent and/or duration of seasonal change is likely due to a combination of factors such as the genetic makeup of the animal, the social environment and the climatic conditions (primarily photoperiod) to which the animal is exposed. Although rams do not become totally sexually quiescent, they do exhibit a definite season of infertility. This "nonbreeding" season is a major problem to livestock producers who are interested in increasing the productivity of their flocks on a year-round basis. With this goal in mind, animal scientists have concerned themselves with improving the productivity of the livestock in a number of different ways; for instance, genetic selection of superior flock sires and dams, improved management techniques and improved nutrition and health of the animals. In sheep, hormone therapy has been used on the ewe so that she has been able to cycle out of season, and thus, breed and conceive out of season as well. This is a fairly reliable method of increasing ewe productivity, however this procedure may not be feasible for the average sheep farmer eg. hormones are expensive and this method requires more labor. Another alternative then, might be the genetic selection of sheep that have extended breeding seasons. It has been fairly well documented that some breeds of ewes exhibit estrous cycles for a longer period of time than other breeds, however not much information is available on their male counterparts regarding seasonal-breed differences. With that in mind, this study was undertaken to compare the seasonal-reproductive patterns of four different ram breeds exposed to natural climatic conditions preva-

lent in southern Manitoba. The breeds were chosen on the basis of their reported differences in fertility and length of breeding season, and to some extent, their popularity. It is hoped that this study will provide some insight into the effect breed may have upon the seasonal reproductive performance of the male ovine species.

The following literature review focuses on the function and secretion of testosterone (T) and the gonadotropins. In addition, it includes how these hormones are affected by seasonal changes in photoperiod and how they influence testicular function and sex drive. Mention is also given to research that has been carried out illustrating the breed-effect upon reproduction in the male.

LITERATURE REVIEW

LH and FSH: Function and Regulation of Secretion

In the male, the gonadotropins, luteinizing hormone (LH) and follicle stimulating hormone (FSH) are principally involved in the maintenance of testicular functions. In the sexually-maturing male, FSH participates in the formation of the lumen and lengthening of the seminiferous tubules, the conversion of testicular androgens to estrogens and the production of androgen-binding protein (ABP). FSH is thought to promote spermatogenesis, but this function is more important in the pubertal animal than in the adult. In mature males, FSH appears to have a beneficial supporting role in sperm production by influencing Sertoli cell function.

LH binds to testicular Leydig cells, stimulating them to produce androgens which are required for spermatogenesis (Steinberger, 1976). In the male, FSH binds specifically to the Sertoli cells in the seminiferous tubules. The Sertoli cells, or nurse cells, provide a suitable medium for maturing sperm cells, promoting development and maintenance of spermatogenesis. FSH stimulates Sertoli cells to produce ABP, which retains the T produced by the Leydig cells in the vicinity of the developing germ cells to promote their maturation. FSH has also been observed to regulate many Sertoli cell processes, i.e. protein synthesis and secretion, cell division, enzyme activity and cell-to-cell communication (Means et al., 1980).

The regulation of FSH and LH synthesis and secretion from the anterior pituitary is generally controlled by a number of different factors, such as: 1) hypothalamic releasing hormone(s), 2) negative feedback upon the

hypothalamus by gonadal steroids, 3) a protein, inhibin, found in relatively high concentrations in testicular fluid and seminal plasma, 4) the pineal gland, 5) autoregulation by the gonadotropins themselves, as well as 6) regulation by other hormones, for example prolactin.

Gonadotropin-releasing hormone (GnRH) produced in the hypothalamus is believed to be the major factor controlling the synthesis and release of LH and FSH from the anterior pituitary. GnRH has been reported to be produced from two types of neurons, the magnocellular and parvicellular nuclei in the arcuateventromedial region of the hypothalamus. When the arcuateventromedial region is stimulated, GnRH is transferred from the hypothalamus by portal vessels to the anterior pituitary where it interacts directly with pituitary receptors to influence gonadotropin release. Contrarily, when the arcuateventromedial region is destroyed, gonadotropin release is inhibited.

There is controversial evidence that the pineal gland may be another source of GnRH. Kotaras et al. (1977) using several extracts of sheep pineal glands, caused the release of 120 µg FSH and 25 µg LH from 1 g of sheep pituitary slices. Chromatography of the pineal gland extracts yielded peaks with GnRH activity, leading to the conclusion that the pineal gland does contain GnRH. Exactly what the relationship is between hypothalamic and pineal GnRH remains to be elucidated.

There is some doubt that GnRH is responsible for the secretion of both LH and FSH. However, a number of studies have been conducted where research animals have been immunized against GnRH to demonstrate that there is only one releasing hormone responsible for the secretion of both gonadotropins. In female rats and ewes, active immunization against

GnRH ends ovarian cyclicity, lowers serum LH and FSH levels and reduces ovarian luteal tissue. In male rats, rabbits and rhesus monkeys, immunoneutralization of GnRH results in decreased serum and pituitary levels of gonadotropin concentrations, testicular atrophy, decreased testicular steroid secretion, oligospermia and reductions in the weight of accessory sex glands (Chappel et al., 1980).

The action of GnRH upon gonadotropins may be summarized as follows:

(1) Under the influence of gonadal steroids, GnRH is secreted from the hypothalamus and travels by way of portal vessels to the anterior pituitary where GnRH interacts directly with pituitary receptors to influence gonadotropin release.

(2) GnRH controls the synthesis and release of both FSH and LH, but the concentrations of these hormones in the circulation do not change in parallel, i.e. changes in FSH concentration are smaller than those of LH. One to two hours after the administration of GnRH, levels of circulating LH reach their peaks. The rise in FSH levels requires more time than LH. The differences in the circulating levels of LH and FSH are probably due to differences in the secretion and metabolic clearance rates of these hormones (Lincoln, 1979).

Chronic treatment with high doses of GnRH have been shown to have a paradoxical inhibitory effect on reproductive function, resulting in involution of the testes and accessory sex glands. Pharmacological treatments of GnRH resulted in loss of responsiveness at the pituitary and testis level. Fraser and Lincoln (1980) injected adult rams with 10 µg of a GnRH agonist per day for 8 days and observed a decline in testicular response to LH due to a reduction in the number of LH receptors

on the Leydig cells. Unusually high levels of LH were observed following agonist treatment, which led to impaired testicular T secretion. Presumably the impaired T secretion was the result of Leydig cell exposure to abnormally high LH levels.

Schanbacher and Lunstra (1977) have demonstrated that GnRH has a beneficial effect on spermatogenesis in rams. When rams were injected twice daily for seven weeks with 50 µg of GnRH, serum T, testis size and semen quality increased. Presumably, these increases in reproductive activity of the testes were the result of increased gonadotropin secretion in response to GnRH treatment and greater stimulation of testicular gonadotropic receptors on Sertoli and Leydig cells. Gonadal steroids have been reported to have negative feedback effects upon gonadotropin release. When testosterone proprionate was injected into rams (Pelletier and Ortavant, 1975b), it was observed that there was a decline in LH release. This negative feedback effect was more pronounced under long days than under short days. Pelletier and Ortavant (1975b) hypothesized that increasing light photoperiod heightened the negative feedback effects of androgens on hypothalamo-hypophyseal activity.

Regulation of gonadotropin secretion is also under the influence of inhibin, a nonsteroidal testicular factor of Sertoli cell origin. Inhibin has been found to act directly upon pituitary cells to decrease FSH secretion in response to exogenous GnRH (Franchimont et al., 1978; Moodbidri et al., 1980), but it may also act directly upon the hypothalamus (Franchimont et al., 1978). When extracts from rete testis fluid were injected into the third ventricle of bulls, FSH secretion was reduced (Franchimont et al., 1978).

Inhibin is not totally specific for FSH, because increasing the amounts of inhibin (obtained from rams) administered *in vitro* results in a reduction in the amount of LH secreted (Franchimont *et al.*, 1978). It has been demonstrated that 10-20 µg/pituitary of inhibin will inhibit FSH secretion, while >25 µg/pituitary of inhibin are needed to suppress LH secretion. Inhibin has been observed to have no effect on the secretion of prolactin (PRL) and thyroid stimulating hormone (TSH) by pituitary cells, indicating that it is specific for gonadotropin secretion.

The pineal gland has been suggested to have an antigonadotrophic role in sheep at certain times of the year. Barrell and Lapwood (1978) observed that pinealectomized rams produced more LH and T than sham-operated rams when the rams were exposed to varying photoperiods (either under normal (14.5h light) or reversed photoperiodic conditions common to New Zealand). It was thought that pinealectomy could have altered the sensitivity of the hypothalamo-hypophyseal release mechanisms to androgen feedback. Extracts from bovine pineal glands have been reported to inhibit both serum and pituitary levels of LH in rats (Orts and Benson, 1973). Melatonin, a compound produced by and elaborated from the pineal gland, may be responsible for inhibiting gonadotropin secretion by causing a reduction of GnRH (Kano and Miyachi, 1976). Alternatively, seasonal changes in the pattern of melatonin secretion may provide a biological cue to hypothalamic centers regulating gonadotropin secretion and indirectly cause changes in LH and FSH secretion (Rollag *et al.*, 1978).

There is also evidence that the secretion of FSH and LH is autoregulated by circulating levels of these gonadotropins in male rats

(Schally and Kastin, 1970; Sandow et al., 1979). It is possible that in some species when FSH and LH are present in the circulating system in relatively high concentrations, they may inhibit the release of GnRH (short-loop feedback system), thus resulting in decreased gonadotropin levels.

Prolactin: Function and Regulation of Secretion

The role(s) of PRL in the male is (are) still being ascertained. PRL is believed to be involved in the regulation of FSH and LH secretion, but the experimental results are contradictory.

A number of researchers (Hafiez et al., 1972; Johnson et al., 1973; Thomas et al., 1976) have shown that PRL increases the effect of T on accessory sex glands and has a synergistic effect with LH on spermatogenesis and on testicular androgen secretion. Animal studies have indicated that physiological levels of PRL are required for normal testicular function and growth of accessory sex organs. PRL may increase androgen production by the testes, possibly by activating steroidogenic pathways. PRL would seem to be involved in the maintenance of testicular function, because there is evidence that PRL is required for the maintenance of testicular gonadotropic receptors. Bartke and Dalterio (1976) reported that both FSH and PRL can act on the Leydig cells to increase the responsiveness of these cells to LH.

PRL is also thought to exert antigonadotrophic effects at the gonadal level when it is present in abnormally high levels (Faglia et al., 1977). In the human male, hypersecretion of PRL (hyperprolactinemia) interferes with both gonadal responsiveness to gonadotropins and the hypothalamic

regulatory mechanisms of gonadotropin secretion. Long-term hyperprolactinemia has a negative effect in humans on the metabolism of androgens and interferes with spermatogenesis (Magrini et al., 1976; Segal et al., 1976).

The hypothalamus is suggested to contain prolactin releasing factors (PRF) and/or prolactin inhibiting factors (PIF) which control the secretion of PRL by the pituitary. Dopamine, a hypothalamic catecholamine, may be one of these factors, possibly PIF (MacLeod, 1977). However, there is evidence that more than one hormonal factor controls PRL secretion.

When dopamine receptors on the anterior cells of the pituitary are stimulated, PRL secretion is diminished. Bromocriptine, a dopamine agonist, has been observed to reduce PRL secretion in rams; however, it has no effect on LH or T levels (Ravault et al., 1977). When PRL was inhibited in prepubertal rams, the weight of the seminal vesicles and their fructose concentrations were reduced, indicating that PRL may have a role in the secretory activity of these glands.

Thyrotropin releasing hormone and estrogen have been shown to be stimulators of PRL secretion in males (Dorrington et al., 1978; Schanbacher and Ford, 1978). Shin (1979) infused dopamine (a theoretical PIF) in ether stressed male rats and observed that a surge in PRL still occurred. He concluded that the surge in PRL was due to the release of PRF rather than an inhibition of PIF release, because the surge occurred during a constant infusion of PIF. However, it is possible that the dopamine receptors may have been affected and therefore PRL-secreting cells would no longer be responsive to dopamine.

PRL, like the gonadotropins, is capable of inhibiting its own secretion (autoregulation) in some species (Nicholson et al., 1980). Increases in serum PRL are believed to stimulate dopaminergic neuronal activity in the median eminence of the hypothalamus to increase dopamine secretion. Dopamine will then act upon its receptor cells in the anterior pituitary and tonically inhibit endogenous PRL release. Nicholson et al., (1980) increased the PRL content of the cerebrospinal fluid (CSF) to observe its role in autoregulation; changes in PRL levels in the CSF parallel those in serum. Increases in CSF levels of PRL did inhibit PRL release from the pituitary, suggesting that the CSF may serve as an access for PRL to the neural structures that are concerned with the regulation of PRL secretion, i.e. CSF mediates PRL autoregulation.

PRL secretion is influenced by temperature, photoperiod and stressful conditions as well. Increased ambient temperature results in elevated serum PRL levels, while cold temperatures have the reverse effect (Horrobin, 1976; Dellman et al., 1977; Sanford et al., 1978). Maximum PRL secretion in rams is observed under relatively long daylengths (16h daylight/24h), whereas minimal PRL secretion is observed when there is only 8h of daylight (Pelletier, 1973; Ravault and Ortavant, 1977); studies involving the control of artificial light produce changes in circulating PRL levels that are similar to those occurring from the non-breeding to the breeding season in response to changing natural photoperiod.

Testosterone: Function and Regulation of Secretion

Testosterone (T), a gonadal steroid derived from cholesterol, is produced and secreted by testicular Leydig cells in response to various

stimuli; the primary controlling factor being stimulation of the Leydig cells by LH (Amir and Volcani, 1965; Barrell and Lapwood, 1979). Changes in photoperiod indirectly regulate the secretion of T by influencing the release of gonadotropins from the anterior pituitary. Under decreasing photoperiods, increased LH is released more frequently from the pituitary and this stimulates the Leydig cells to secrete T; however, under long daylengths LH and T production and secretion are reduced (Lincoln and Davidson, 1977; Barrell and Lapwood, 1979).

The pineal gland is also thought to have a role in the regulation of T secretion in rams by influencing gonadotropin secretion (Barrell and Lapwood, 1979). In male rats, high melatonin concentrations in the pineal gland and presumably increased melatonin secretion during long daylengths have been shown to cause a reduction in GnRH secretion; this indirectly results in a decrease in T secretion from the testes (Kano and Miyachi, 1976). As melatonin production and secretion decrease under short daylengths, gonadotropin and T secretion increase.

In some animal species (rats), PRL increases testicular binding of LH and increases the sensitivity of the Leydig cells to LH. Therefore, Barrell and Lapwood (1979) suggest that PRL is involved in the regulation of T secretion in rams, by mediating the effects of LH on the Leydig cells.

T is released and circulates in the bloodstream for about 15 to 30 minutes, until it either becomes bound to receptors in target cells in the form of dihydrotestosterone (DHT) or it is degraded into inactive products that are secreted from the body. T has a number of functions in the body, but it is primarily involved in maintaining secondary sex glands (structural

integrity and secretory activity) and spermatogenesis in the male. During fetal development, T is involved in the development of the male reproductive tract, i.e. the development of the prostate, seminal vesicles and genital ducts, and in the descent of the testes into the scrotal sac. After puberty, T is responsible for the growth of the testes, scrotum and penis, as well as the further development of the secondary sex glands and characteristics. In the human adult male, these secondary sex characteristics are in the form of growth of body hair, baldness, deepened voices, increased thickness of the skin over the body, increased melanin content in the skin, increased rate of secretion from the sebaceous glands (resulting in acne) and muscle development (Guyton, 1971). T is thought to be anabolic, i.e. it increases the protein (nitrogen) content of the body (Guyton, 1971; Niswender et al., 1974) resulting in bone growth (increase in strength and size), increased calcium and sodium retention, and in increased basal metabolic rate when T is present in exceptionally large quantities (Guyton, 1971).

High T levels influence gonadotropin secretion by negatively feeding back upon the hypothalamus to inhibit GnRH release, which in turn, inhibits the release of LH and FSH from the pituitary (Pelletier and Ortavant, 1975a; Sanford et al., 1976; Wilson and Lapwood, 1978). In addition high T levels in rams have been associated with increased aggressive and sexual behavior and enlarged testicular sizes which are attributed to increased spermatogenesis during the fall ovine-breeding season (Amir and Volcani, 1965; Niswender et al., 1974; Lincoln and Davidson, 1977; Schanbacher and Lunstra, 1977). T is believed

to promote spermatogenesis by stimulating the germinal epithelium in the seminiferous tubules to produce spermatogonia. It is also required for the division of pachytene spermatocytes to secondary spermatocytes (Niswender et al., 1974). T is made available for maintenance of spermatogenesis by androgen binding protein (ABP), a substance present in the rete testis fluid which retains T in the vicinity of sperm production in the testes.

Seasonal Variation in Reproductive Function

Although rams of most breeds are capable of mating at any time of the year, it is fairly well documented that they do undergo marked seasonal differences in reproductive characteristics which coincide with the seasonal changes that occur in ewes. Rams experience marked seasonal changes in spermatogenesis (Johnson et al., 1973; Schanbacher and Ford, 1976; Tomkins and Bryant, 1976; Colas and Courot, 1978; Ortavant, 1978), sperm quality (fertilizing ability) and quantity (Cupps et al., 1960; Sanford et al., 1974b; Colas and Brice, 1976; Tomkins and Bryant, 1976; Colas and Courot, 1978), sex drive (Pepelko and Clegg, 1965; Land, 1970; Schanbacher and Lunstra, 1976; Land and Sales, 1977; Lincoln and Davidson, 1977), testicular size (Land, 1970; Sanford et al., 1974c; Hanrahan, 1977; Islam and Land, 1977; Lincoln and Davidson, 1977; Colas and Courot, 1978) and the secretion of gonadal steroids and gonadotropins (Pelletier and Ortavant, 1975a and b; Sanford et al., 1976, 1977; Schanbacher and Lunstra, 1976; Wilson and Lapwood, 1978; Barrell and Lapwood, 1979b).

There are a number of environmental stimuli that influence seasonality in reproductive activity, the major factors being photoperiod and

temperature. Of the two factors, photoperiod is decidedly more influential (Pepelko and Clegg, 1965; Lincoln, 1978; Sanford et al., 1978; Barrell and Lapwood, 1979a, b; Turek and Campbell, 1979), and therefore, will be the main topic of further discussion.

Hormone Secretion. The secretion of FSH, LH and T is markedly altered throughout the year under varying photoperiods. Lincoln and Davidson (1977) exposed rams to artificial photoperiods of 16h light: 8h darkness (16L:8D) and then abruptly switched them over to 8L:16D. During the long days, the rams were sexually quiescent. After the abrupt change to short days, plasma LH and FSH levels increased within 2 to 4 weeks, followed by elevated plasma T concentration and growth of the testes. When the animals were returned to long days (16L:8D), there was a decline in plasma gonadotropins within 2 weeks. Similar results were obtained when the rams were tested under natural environmental conditions.

Sanford et al. (1976) observed that mean FSH levels in rams were lower in January than levels attained in August. Similarly, Wilson and Lapwood (1978) perceived that the daily output of LH and T was lower during the late winter than the late summer months although the pulsatile secretion of these hormones persisted during both seasons.

As the fall-breeding season commences, there are marked increases in the mean and baseline levels, and in the peak height and frequency of T. Peak frequency of LH also increases at this time, but it has been reported that LH peak height and mean level decline (Sanford et al., 1977; 1978). Increases in the levels of T as the breeding season pro-

gresses may be responsible for the decline in the mean levels of LH and LH-peak height because when rams are treated with T, LH secretion is depressed via increased negative feedback inhibition. This is thought to be due to changes in both GnRH secretion and the responsiveness of the pituitary to endogenous GnRH. In an earlier experiment, Sanford et al. (1974c) remarked that intervals between LH releases in Finnish Landrace (Finn) rams were shorter in January (breeding season) than they were in August (nonbreeding season). They noted that small LH releases were capable of elevating T to higher levels in January than were the larger LH releases which occurred in August. It was postulated that the testes were more responsive to LH in January since progressively smaller pulses of LH were followed by increasingly larger elevations in serum T concentration. Therefore, increased testicular steroidogenic activity in rams during November and December (breeding season) may be due to changes in both LH-peak frequency and testicular responsiveness to LH.

Circulating gonadotropin and T levels have been reported to be low in the spring and early summer (i.e. when the females are not cycling), but the levels become elevated during the fall breeding season (Katongole et al., 1974; Purvis et al., 1974; Pelletier and Ortavant, 1975a; Lincoln, 1976a; Schanbacher and Lunstra, 1976; Lincoln and Peet, 1977). It is thought that the negative feedback of androgens upon gonadotropin secretion is reduced under short days (Pelletier and Ortavant, 1975b). Similar results in seasonal hormone fluctions were observed by Barrell and Lapwood (1979b); however, when rams were pinealectomized, the effects of changes in daily photoperiod on patterns of T and PRL secretion were

reduced. This indicates that the pineal is an important mediator of seasonal reproductive changes.

In contrast to the other experiments mentioned, Darbeida and Brudieux (1980) have reported that in Algeria, ram plasma T levels were lowest in the autumn and early winter months, increased in February and March, and reached their highest levels (5 ng/ml) in the early summer before decreasing in autumn. These results are similar to those obtained by Gomes and Joyce (1975) in Ohio where T production was maximal during the summer solstice, but minimal during the winter solstice. Both groups of researchers conclude that increasing daylengths may be the major stimulus to testicular steroidogenesis where summer temperatures are moderate, but in hotter climates or during acute elevated temperatures, thermal factors may override photoperiod.

The secretion of PRL appears to parallel changes in photoperiod (Ravault, 1976; Ravault et al., 1976; Ravault and Ortavant, 1977; Lincoln et al., 1978; Ortavant, 1978; Barrell and Lapwood, 1978 / 1979a, b; 1979b).

In adult rams, circulating PRL shows marked seasonal fluctuations, with peak levels occurring when the daily photoperiod is maximal. The timing of the seasonal changes in PRL can be modified by artificially altering the photoperiod. Photoperiods which favor PRL secretion have the reverse effect on gonadotropin secretion, and under natural conditions there is an inverse relationship between PRL and gonadotropin release.

Wilson and Lapwood (1978) observed stable and significantly greater PRL concentrations in the summer, whereas in the winter they observed

that basal PRL levels were low, but interspersed with large pulsatile secretory peaks. The high levels of PRL in the summer suggested that PIF was tonically suppressed, whereas the low winter levels of PRL indicated inhibitory control by the PIF. However, the secretory pulses of PRL seen during the winter may have been responses to a periodic cessation of PIF release or due to the secretion of a yet unknown PRF.

In an experiment by Bremner et al. (1978), Romney and Merino rams exhibited a four to eight fold increase in plasma PRL levels in the two months immediately preceding the onset of the breeding season. They noticed that the marked seasonal changes in testicular size, mating behavior and plasma T levels occurred in the Merinos without significant changes in mean plasma LH and FSH levels. This suggested to these authors that the large PRL increase in these rams may have enhanced Leydig cell responsiveness to the relatively constant levels of LH and FSH; PRL would appear to potentiate the stimulatory effect of LH and FSH on testicular size and function.

Ravault and Ortavant (1977) observed 220±2 ng/ml (mean ± SE) of PRL in the serum of rams during long photoperiods, and levels of 12±2 ng/ml during short photoperiods. Similar patterns in PRL levels have been observed in wethers (Driver et al., 1974). Ravault and Ortavant (1977) hypothesized that there was an endogenous daily rhythm in photosensitivity. This rhythm has two halves per cycle or 24 hours. During one half, the animal is light "insensitive" and during the other half, the animal becomes light "sensitive". The physiological process of PRL secretion is stimulated only if light coincides with the "sensitive" phase of the daily cycle. Winter photoperiods are believed to be too short to reach the "sensitive" phase, but in the spring, the photoperiods

are long enough to reach the "sensitive" phase, and therefore PRL secretion is stimulated.

The significance of the seasonal variations in PRL secretion is not easy to assess. PRL administered to PRL-deficient mice stimulates T production, testicular growth and spermatogenesis (Bartke et al., 1977). PRL may increase androgen production by the testes by activating steroidogenic pathways (Ambrosi et al., 1976). PRL has been shown to promote the accumulation of esterified cholesterol in the testes, which is used in steroid production (Hafiez et al., 1972; Bartke, 1974). Both FSH and PRL in rats can act on Leydig cells to increase their responsiveness to LH (Bartke and Dalterio, 1976). PRL then synergizes with LH and T to maintain spermatogenesis and testicular function (Magrini et al., 1976). In a study by Sanford and Dickson (1980) it was noted that in the absence of the springtime increase in PRL secretion, daily sperm output was reduced and seasonal increases in testicular growth and circulating T levels were delayed. In contrast hyperprolactinemia can cause hypogonadism, oligospermia and impotence in human males and in rats (Thorner et al., 1974). Presumably, high levels of PRL believed to be antigonadotrophic, interfere with both gonadal responsiveness to gonadotropins and hypothalamic regulatory mechanisms of gonadotropin secretion. Nevertheless, short-term hyperprolactinemia has been shown, in men, to have a stimulatory effect on T secretion (Rubin et al., 1975). Sanford and Duffy (1980) observed that the short-term hyperprolactinemia in rams during the spring only temporarily retarded testicular growth and did not adversely affect T secretion.

Testicular Function. As mentioned earlier, the secretion of

gonadotropins will influence the activities of the gonads and vice versa. In rams androgenic activity, as reflected by fructose and citric acid concentration in the seminal plasma, attains maximum levels in the fall and minimum levels in the spring (Cupps et al., 1960; Amir and Volcani, 1965). Fructose concentration not only reflects T secretion, but it indirectly reflects gonadotropin secretion as well. LH is responsible for the stimulation of the Leydig cells which respond by secreting androgens. During short days, when the concentrations of circulating T and LH increase, the testes begin to increase in size (Sanford et al., 1974a; Carr and Land, 1975; Islam and Land, 1977; Land and Sales, 1977; Lincoln and Davidson, 1977). Elevated androgen levels cause changes in the peripheral target organs, i.e. the epididymus begins to grow, sexual flush develops on the exposed ventral skin and the genitals heighten in sensitivity (Lincoln and Davidson, 1977). The weight of the testes also increases as the photoperiod decreases (Colas and Courot, 1978; Ortavant, 1978). Ortavant (1978) observed that testicular weight was 35% lower from January to May than from the end of June to October.

Seasonal variations in spermatogenesis and testicular metabolic activity, which are reflected by changes in testicular weight and size, parallel changes in testicular steroidogenesis and LH secretion (Johnson et al., 1973). When daylength increases, testicular weight and gonadal and extragonadal sperm reserves decrease as a consequence of altered spermatogenesis; fewer spermatozoa are produced and released into the lumen of the seminiferous tubules and ejaculated (Colas and Courot, 1978; Carter et al., 1980).

Fluctuating photoperiod will cause seasonal differences in semen

quality and quantity (Jackson and Williams, 1973; Purvis et al., 1974; Colas and Brice, 1976; Tomkins and Bryant, 1976; Sanford et al., 1977; Barrell and Lapwood, 1978/1979a; Colas and Courot, 1978). Longer day-lengths result in increased spermatozoan abnormalities, such as cytoplasmic droplets in the distal positions which suggest that the maturation process and/or the transit of the spermatozoa in the epididymis are affected by increasing photoperiods. Motility indices and the percentage of motile sperm are known to decline in the spring and increase again in the fall.

Ejaculate volume of rams increases during the ovine mating season and decreases during the nonbreeding season. It has been noted that the highest ejaculate volumes coincide with maximal T levels (Sanford et al., 1977).

Libido. Libido is also influenced by the seasonal patterns of reproductive hormone secretion. Increased T levels in the fall promote aggressiveness, the Flehmen response and the sexual behavior of the rams (Lincoln and Davidson, 1977). Schanbacher and Lunstra (1977) have demonstrated that mating behavior of rams is restored in castrated rams when T is administered. Thus, mating behavior is thought to be androgen dependent (Sanford et al., 1974b; D'Occhio and Brooks, 1976; Lincoln and Davidson, 1977).

The greatest mating activity in rams has been observed during the breeding season. Sanford et al. (1977) have indicated that the number of mates in November was 21.5±1.5 for an 8h period, compared to 7.6±1.6 mates per 8h in August. The greatest mating activity was observed in December. Schanbacher and Lunstra (1977) noticed that by late spring

and summer mating activity had declined 50% from the peak levels during the fall breeding season. The improvements in mating performance during the breeding season were attributed, in part, to increased T secretion.

During the nonbreeding season (spring) rams ejaculate less frequently; however, Pepelko and Clegg (1965) have observed that the number of mounts prior to an ejaculation increases when breeding activity is low. They suggest that rams have low sexual motivation at this time. That is, the rams have a short interest span during mounting and they fail to persist in their aggressive attempts to gain intromission. With decreased sexual desire, courting behavior may extend over a prolonged period of time before sufficient sexual excitement is achieved to complete the mating act. Lincoln and Davidson (1977) have recorded the following results which summarize reproductive activity in Soay rams throughout the year (not necessarily characteristic of all ram breeds):

Spring - the rams are sexually quiescent

June - sexual activity increases, the testes begin to grow and gonadotropin levels increase

October - testes size and T reach maximum levels

November - increased evidence of the Flehmen response and pronounced sexual aggressiveness occurs

Winter - involution of the testes and a slow decline in aggressiveness and sexual behavior occur.

Schanbacher (1979) states that sexual activity peaks in the autumn when there is increased synthesis and secretion of LH and FSH. T production and spermatogenesis are also increased, the former resulting in improved mating behavior.

Breed Influence on Seasonality in Reproduction

Seasonality in the ram is dependent not only upon the environmental conditions to which the animal is exposed, but upon the genetic makeup of the ram as well. Breed differences may considerably influence the duration of the mating season (i.e. period of heightened sexual activity), the patterns of secretion of the various reproductive hormones and sperm production, as well as other testicular functions.

The pattern of mating behavior displayed by a ram is closely related to the breed of the animal. Land (1970) observed the mating behavior of Finn and Scottish Blackface rams for 10 min. at 21-day intervals over 19 months. The Finnsheep consistently mounted more often than the Blackface rams, and exhibited greater activity in searching for and mating ewes in heat. The Finn rams mated regularly between early June and late March, whereas the corresponding time for the Blackface rams was between late September and mid-February. The Blackface seemed to resume interest in the ewes less quickly than did the Finn rams. In both breeds of rams, it was noticed that the average number of mounts increased from a low of 5 in the summer to approximately 35 in the fall. It should be noted that once the Blackface rams entered their specific "breeding season" (i.e. became sexually active), it was impossible to differentiate between the ability of the two groups to mate.

Schanbacher and Lunstra (1976) detected similar seasonal trends in Suffolk and Finn rams. They noted that mating activity was highest for both breeds in October, but by late spring and summer, it had declined by 50%. There was a positive correlation between mean T concentration and mating scores across months, suggesting that seasonal fluctuations

in serum T influence the sexual behavior of rams. The Finnsheep had consistently higher T concentrations than the Suffolks for the majority of the study, which may have been the reason why the Finns tended to be more sexually active than the Suffolks. Some individuals within each breed group continually scored higher in mating performance, suggesting that regardless of hormone levels, sexual aggressiveness is an inherent trait for which genetic selection may be useful.

Breed differences have also been observed in the age at which the animal reaches sexual maturity and the time at which testis diameter begins to increase in response to decreasing daylength. Land and Sales (1977) have observed that Finn rams reach sexual maturity earlier and are more sexually active than Merino rams. However, the testes of the Merino rams begin to increase in size earlier than do those of the Finn rams. The reproductive performance of the male seems to follow closely that of the female since as Merino ewes start their breeding season, the testis diameter of Merino rams begins to increase. It is suggested that the variation in testis diameter for rams of a given breed during the year may give an indication of the susceptibility of the females of the same breed type to changes in photoperiod. In addition, testicular weight is greater in those breeds of sheep whose females have higher ovulation rates, and the diameter of the testes has been positively related to the ovulation rate of the females of those breeds (Braun et al., 1980).

Land (1970) observed that there was no difference in semen quality between Finn and Blackface rams, but the service season of the Finn was longer than that of the Blackface rams. This coincided with the females of each breed in that the breeding season of the Finn ewes was twice as

long as that of the Blackface ewes. Land (1970) postulated that Finnsheep may have a higher sensitivity to gonadotropins or a higher level of circulating gonadotropins than the Blackface sheep, and that the longer breeding season of the Finns may result from their being above a fertility threshold for a longer proportion of the year. Perera and Munro (1976) stated that in Scottish Blackface rams, peak frequencies of gonadotropins were higher during the mating season and lower during sexual quiescence than in other breeds of rams. Secretion of androgens, as well as testicular growth, is known to be influenced by LH levels which differ considerably between breeds (Carr and Land, 1975). Thus, it is possible that the differences noted in androgen levels in this study may represent breed variation in either testicular responsiveness to gonadotropins or in the pattern of trophic hormone release.

Similar seasonal patterns in hormone levels and testicular size have been observed in different breeds of sheep. Romney and Merino rams had three-fold higher plasma T levels in the breeding season than in the nonbreeding season. In both breeds, plasma PRL levels revealed a marked four- to eight-fold increase in the 2 months preceding the onset of the breeding season, suggesting that PRL potentiates the stimulatory effect of LH and FSH on testicular growth and function. This role of PRL may be more important for Merino rams than for Romneys because plasma FSH and LH levels underwent statistically different seasonal changes in the Romney rams, but the Merino gonadotropin levels remained relatively constant (Bremner et al., 1978).

Differences in semen quality have been observed for some breeds of sheep. Romney rams, when compared to Dorset and Merino rams, had lower

overall mean values for the percentage of motile spermatozoa and the concentration of sperm per ml of ejaculate. Merinos, on the other hand, had higher overall mean values for total ejaculate fructose content, seminal fluid fructose concentration and seminal plasma fructose concentration than did the Dorset rams; this was largely due to the fact that Dorsets did not exhibit an autumnal peak in these parameters. Breed differences in PRL levels were recorded, with Romney rams having the highest levels, followed by Dorsets and then the Merino rams. All of the rams had similar seasonal patterns of secretion for LH, FSH, PRL and T (Barrell and Lapwood, 1978/1979a).

Dorset and Romney rams may exhibit similar seasonal patterns in T secretion, but the T levels are significantly different between the two groups (Barrell and Lapwood, 1978/1979a). Romneys display a greater increase in T during the summer, indicating that they may respond more quickly to changing photoperiod. When rams of both breeds are introduced to ewes during the transition from the nonbreeding to the breeding season, a high proportion of the ewes display early estrous activity and synchronization of estrus. This event is known as the ram effect and it has been observed that ewes joined with Dorset rams enter into estrus earlier than those joined with Romney rams (Tervit and Peterson, 1978). Dorset rams appeared to have an earlier rise in T than did the Romney rams; this could have caused an earlier production of pheromones in Dorsets, thus enabling them to stimulate ewes earlier in the breeding season than Romney rams.

In all studies cited in this review, breed differences have been reported in: 1) peripheral blood gonadotropin, PRL and T levels and in

hormone-profile characteristics, 2) libido, 3) sperm output, 4) semen quality and 5) scrotal circumference. However, it appears that the different breeds do exhibit similar seasonal trends in the reproductive parameters under observation.

The present study was undertaken to further investigate breed differences in reproductive parameters of rams, as well as breed x season interactions with respect to changes in these reproductive parameters. In many ways this is a unique study. For example, it offers the opportunity to observe all 3 gonadotropins and many testicular and behavioral sexual characteristics over a 14-month period. In addition, four breeds of sheep were involved in this study - more than most studies. The breeds were selected on the basis of their reported large differences in ewe fertility and on their popularity in Canada. Unlike most studies cited in this review, the rams were exposed to extremes in temperatures. In southern Manitoba, the temperatures vary anywhere from 30 to 35^{o}C in the summer to approximately -30 to -40^{o}C in the winter. It was hoped that this study would provide some insight into sire performance under these conditions that would aid in the selection of flock sires to meet particular management demands, i.e. early breeding or out of season breeding, good teaser rams to promote early breeding of ewes, etc. In other words, this study would appear to be more comprehensive and relevant for use in Canada.

MATERIALS AND METHODS

Experimental Animals

Three Finnish Landrace (Finn) and four each of Suffolk, Dorset and Scottish Blackface rams were selected for this study on the basis of their reported differences in fertility and length of breeding season. Scottish Blackface rams in Canada and the United Kingdom have a very restricted breeding season, with little or no mating done prior to September (MacEwan, 1941); this is consistent with the known restricted mating season of the Blackface ewes. When Finn ewes were compared to Blackface ewes, it was observed that the breeding season of the Finn is twice as long as that of the Blackface (Land, 1970). The Finn and Dorset rams are reported to have prolonged breeding seasons, with the Finn exhibiting remarkable sexual aggressiveness throughout the year. Suffolk rams are reported to have an intermediate breeding season, falling somewhere in between the extremes set by the Finn and Blackface rams.

The experimental rams were all one year old at the time the study commenced in June, 1979, and they weighed between 36.0 and 69.7 kg. The animals remained in good health throughout the 14-month study, which concluded in July, 1980, except during the month of March. A number of rams lost quite a bit of weight during this month attributed to poor quality hay that they were receiving.

The rams were housed outside all year round, but they had access to a three-sided, open-front barn for shelter from inclement weather. The animals were fed a legume hay and grain ration in feeders located outside of the barn. Water and salt licks (blocks with mineral supplements) were available *ad libitum*.

Eight ovariectomized ewes were used to stimulate the rams during the libido assessment periods. The ewes were brought into estrus by injecting 20 mg of progesterone (in 1 ml corn oil) intramuscularly 3 days prior to the trial date. The day before the libido test, each ewe was injected i.m. with 1 mg of estradiol-17β (in 1 ml corn oil). Usually the ewes were in estrus 16 to 18h later. Estrus was maintained until the end of the libido trials by administering another 1 ml of E_2 every 12h.

Experimental Plan

This study was originally designed using four yearling rams of each breed (Finn, Suffolk, Dorset, and Blackface). However, one of the Finn rams broke a leg early in the study and had to be put to sleep.

Blood Sampling. The bleedings were conducted on 2 days at monthly intervals, with two rams from each breed bled on the first day (day 1) and the remainder of the rams bled on the second day (day 3). Rams were divided into two groups for the blood collections because it would not have been practical, to try to bleed all 15 rams together at 20-min intervals. This is especially true in the winter when vacutainers and hands do not work very efficiently!

Blood collection started at approximately 0900h, with samples taken at 20-min intervals for 8h (the last collection being taken at 1640h).

Scrotal Circumference and Body Weight. Scrotal circumference was measured every 2 weeks during the study by two people and an average of the two measurements was calculated for each ram. Rams were weighed once a month, usually in the middle of the month. Body weight measurements were taken inside the barn which was heated in winter (13-18^{o}C).

Libido Testing. The mating performance of the rams was assessed inside the barn every 3 months (July, November, February and June). Four rams, one of each breed, were observed simultaneously for 4 hours. Each ram was penned with two estrual ewes for 2h and then exposed to another pair of ewes for a further 2h to ensure that the rams maintained their mating incentive. The number of mounts and mates per 4h were recorded for each ram.

Because few of the rams had any mating experience prior to the first assessment period, a trial period was set up. This allowed the rams to become familiar with the ewes and their new environment, and hopefully prevented any sexual inhibition due to a novel situation when the actual libido trials were started.

Daily Sperm Output Determination. Daily sperm output (DSO) was assessed in September/October, January/February and May/June to observe seasonal differences in sperm production between the breeds. Six rams at one time, at least one of each breed, were brought into the barn for assessment. DSO was assessed by counting spermatozoa voided in urine. Urine was collected for a minimum of 6 consecutive days from each animal, to ensure that an accurate estimate of DSO was obtained since marked day-to-day fluctuations in sperm output normally occur. DSO fluctuates considerably because of the capacity of the cauda epididymis, vas deferens, and ampulla to retain large numbers of spermatozoa for an ejaculatory reserve and because of variations in the rate of transfer through the male reproductive tract (Lino and Braden, 1972).

Collection and Handling of Blood

At the onset of the study, the rams were not accustomed to the procedure of blood collection. Most of the rams, excluding #16 (Blackface), adapted very quickly to the bleeding routine. Almost all of the rams showed some sign of stress at the beginning of each bleeding session, but after the first few samplings they appeared to calm down.

Blood was collected from each ram at 20-min intervals for 8h. Approximately 7 ml of blood was collected from the jugular vein by venipuncture using 20 gauge, 1½" (3.3 cm) long needles and 7 ml vacutainer tubes. The blood samples were kept in a cooler containing ice during the 8h sampling period and afterwards were placed in a refrigerator maintained at 4 to 5°C. The samples were centrifuged for 20 to 25 min, within 24h of the termination of the collection period. The sera were then decanted into 1 dram vials and stored in a freezer at approximately -20°C until they were thawed and aliquots were assayed by radioimmunoassay for various hormone concentrations.

Collection and Handling of Urine

The animals were placed in metabolism crates (.6 m x 1.2 m) located inside the barn the day before the urine trials were to begin. Before entering the crates, wool in the abdominal area in the vicinity of the sheath was sheared and a flexible plastic cone was glued into place with bull cement (3M Brand. Adhesives, Coatings and Sealers Division, 3M Center, St. Paul, MN. 55101). The cone consisted of a hollow cylindrical projection (4 cm diameter and 15 cm length) secured at a 45° angle to a rectangular base (25 cm x 30 cm).

The plastic cones were made prior to the trial period with a commercial compound, Plastisol Base (F.H. & Sons Manufacturing Ltd., 1929 Hwy. #7, Concord, Ontario. L4K 1B1).

To prepare the cones, a metal mold is first placed in an oven (160^{o}F) for 1 hour. Then the mold is sprayed with a lubricant (6075 Dry Film lubricant release agent (TFE), Crown Industrial Products, Hebron, Ill.) for easy removal and dipped into the liquid Plastisol container for approximately 1 min; if the mold is not hot, the Plastisol will not adhere to it. The plastic covered mold is then removed and placed back into the oven for about 45 to 60 min. At the end of this time, the mold is removed from the oven and placed in a waterbath of cold water (2-5^{o}C). The cone can easily be cut from the mold with the use of a scalpel and is ready to be glued to the underside of the experimental animal.

The glued cone was permitted to dry on the ram for up to 24h, although 3h would have been sufficient; this was done to insure that there were no leaks around the sides of the cone base. Also, this allowed the animals time to acclimatize to their new surroundings prior to the urine collection.

The following day (A.M.) a rubber stopper was inserted into the end of the cylindrical portion of the cone. The stopper, which was fitted with a 4 cm length of stiff plastic tubing, was attached to a length of plastic Tygon tubing having an internal diameter of 5 mm. This length of tubing was connected to another rubber stopper inserted in a vacuum chambered 9 liter Pyrex glass bottle. The second stopper was joined to another length of Tygon tubing which was fastened to a vacuum pump.

The vacuum created in the collection system resulted in urine quickly being transferred from inside the animal's cone to the glass bottle at the time of urination.

The Pyrex bottles were treated with silicone to prevent the adhesion of sperm cells to the glass. A saponin-formalin solution (300 ml), described by Lino and Braden (1972) was added to each bottle to prevent clumping of the sperm cells.

The bottles containing the urine were changed daily and the urine output per 24h was measured. An aliquot (30 ml) of urine was retained for each ram for DSO determination and the rest of the urine was discarded.

Each day, two hemocytometers were filled with undiluted urine from a given ram and the number of spermatozoa in all four chambers were counted. DSO was calculated using the following equation:

$$\text{DSO} \times 10^6 = \frac{(\text{hemocytometer \#1 avg. \# sperm/chamber}) + (\text{hemocytometer \#2 avg. \# sperm/chamber})}{2} \times \text{ml urine per 24h} \times .01$$

.01 = a correction factor that takes into account the hemocytometer volume. Urine was collected from each animal for 6 consecutive days and an average DSO from each ram over the 6-day period was calculated. Approximately 95% of unejaculated sperm is voided in the urine (Lino, 1972; Lino and Braden, 1972).

Hormone Assay Procedures

To determine the secretory profile characteristics of LH and T during certain months, aliquots of the serum samples collected during the 8h bleeding periods were assayed for LH (.2 ml) and T (.1 ml). All

of the samples from each ram, during an 8h period, were included in the same LH assay. However for the T assays, sera obtained from only four rams (one of each breed) during an 8h period were included in one assay. In total, four assays were conducted to determine LH profile characteristics for the months of July, October, January and April, and eight assays were performed to determine T-profile characteristics for the months of October and April. In addition, sera pooled from all of the collections during the 8h periods (i.e. .1 ml from each 20-min bleeding during the 8h for each ram was pooled) were assayed for LH, FSH, PRL and T. Aliquots of .2, .2, .05, and .1 ml were used for LH, FSH, PRL and T, respectively. A single assay, containing the aliquots of pooled sera from all the rams was run for FSH, LH and PRL. Four assays containing the pooled sera from each of 3 or 4 rams (one of each breed) were run to determine the T concentration.

LH Assay. A modified version of the double-antibody radioimmunoassay (RIA) described by Niswender et al. (1969) was employed to determine serum LH concentrations. The modified procedural details have been reported by Howland (1972). Antiovine LH (anti-oLH) serum GDN #15 was used in this assay. Labelling of NIH-LH-S22 with ^{125}I (Cambridge Nuclear Corporation) was performed by Dr. B.E. Howland (University of Manitoba, Department of Oral Biology) using a modification of the method employed by Greenwood et al. (1963). This modified procedure has been described by Sanford (1974). LH values were expressed as ng/ml of NIH-LH-S14 standard. The antiovine LH serum was used at an initial dilution of 1:100,000 in .5% rabbit serum-phosphate-disodium-ethylene dinitrolotetracetate (.5% RS-phosphate-EDTA) buffer. The procedure for making

this buffer has been detailed by Yarney (1980).

The inter- and intra-assay coefficients of variation (Rodbard, 1971) for five replicate samples from a pooled serum standard with a mean concentration of 1.51 ng/ml were 18.4% and 1.4%, respectively. The lowest levels of LH detectable, defined as 95% of the initial binding, ranged from .04 to .23 ng/ml. Samples which had values below the minimum detectable level (in this and other hormone assays) were assigned the matching minimum detectable value.

FSH Assay. Serum FSH concentrations were determined by using a procedure developed by Dr. K.W. Cheng of the Health Sciences Campus, University of Manitoba (Cheng et al., 1981). Cheng's rabbit anti-b FSH serum was used at an initial dilution of 1:60,000 in .5% RS-phosphate-EDTA buffer. ^{125}I was used to label Dr. Cheng's own purified bFSH preparation. The amount of free hormone was separated from bound hormone by anti-rabbit gamma globulin. FSH values were expressed as ng NIH-FSH-S12/ml.

The intra-assay coefficient of variation for two replicate samples from a standard serum pool with a concentration of 183.4 ng/ml was 3.7%. The minimum detectable level of FSH was 3.0 ng/ml.

Prolactin Assay. The concentrations of serum PRL were determined by a modification of the procedure described by Sanford et al. (1978). An anti-ovine PRL (anti-oPRL) serum developed in rabbits (Friesens #73) and ^{125}I-labelled NIH-PRL-S12 were used in this assay. The anti-oPRL serum was initially diluted 1:12,000 in .5% RS-phosphate-EDTA buffer. Anti-rabbit gamma globulin serum was used to separate free hormone from bound hormone. PRL values were expressed in ng/ml of NIH-PRL-S12

standard.

The intra-assay coefficient of variation was 1.3% and the minimum detectable PRL level was 9.0 ng/ml.

Testosterone Assay. The details of the methodology used in this assay have been extensively described by Yarney (1980). The antiserum employed was raised in sheep immunized with T-3-carboxy-methyloxime conjugated to bovine serum albumin (Sanford et al., 1978) and used at an initial dilution of 1:2400. Labelled T (T-1,2,6,7-H^3) was purchased from New England Nuclear and the T used to prepare the standard curve was purchased from Steraloids Inc.

The inter- and intra-assay coefficients of variation were 16.5% and 6.7%, respectively, for the 12 duplicate determinations on a standard pool of ram serum. The mean T standard concentration was 9.88 ng/ml and the minimum detectable T levels ranged from .3 to .6 ng/ml. The percentage recovery for the T assays averaged 88.6%.

Definitions of Hormone Profile Characteristics

Mean baseline - The mean of the lowest single value(s) between peaks, which are not obviously associated with a peak, i.e. usually those which immediately preceded an elevation (Sanford et al., 1977).

Peak - A measurable rise in concentration followed by two or more successive declining values (Lincoln, 1976). "The rise was considered measurable when the difference between consecutive low and high values were higher than three standard deviations of the overall sampling period mean" (Blanc et al., 1978).

Peak height - The highest value associated with a peak.

Delta (Δ) value - The difference between peak height and baseline value.

Peak frequency - The total number of peaks in an 8h period.

Statistical Procedures

The intra-assay coefficient of variation was calculated according to the method described by Rodbard (1971), while the inter-assay coefficient of variation was determined using the standard statistical procedure outlined in Snedecor and Cochran (1978).

Data obtained for a given sampling or assessment period were subjected to a one-way analysis of variance and differences between means for the four breeds were tested for significance using the Duncan's new multiple range test. Additionally, all of the data for a given measurement were analyzed together by analysis of variance using the BMDP Biomedical Computer Program (P2V) developed by R. Jennrich and P. Sampson (1977). This program was devised to take into account the fact that repeated measurements were taken on the same animals.

RESULTS

Scrotal Circumference

There were definite similar seasonal-directional trends in scrotal circumference exhibited by rams of all breeds (Figure 1b and Table 1). Testicular size started to increase in June, 1979. The Dorset rams attained their maximal scrotal circumference of approximately 35 cm in early July; this was considerably earlier than the other rams, who reached their peak circumference in September or October. The Dorsets also maintained their maximum scrotal circumference for a longer period of time than did the other breeds of rams. The period of peak circumference for the Dorsets was from mid-July to the end of October; whereas in the Finn, Suffolk and Blackface rams the period of maximum testicular size was much shorter, with peaks occurring in September or early October. Nevertheless, testicular size had declined by November in all rams.

The Blackface rams had the smallest and most variable scrotal circumferences throughout the year, with the mean circumference ranging from a low of 23.6±.4 cm in June 1979 to a high of 32.6±.8 cm in October 1979. In contrast, the Finn rams had, on average, the least variable testicular size, with only a 5.3 cm change in size throughout the year. The Finn and Dorset rams exhibited a slight increase in scrotal circumference between mid-December and early February, but testes size had decreased again by mid-February. By the end of the following May, testicular size had begun to increase, with increases being particularly evident in the Dorset and Blackface rams. There were times during the year when significant differences ($P<.05$) in testes size were not

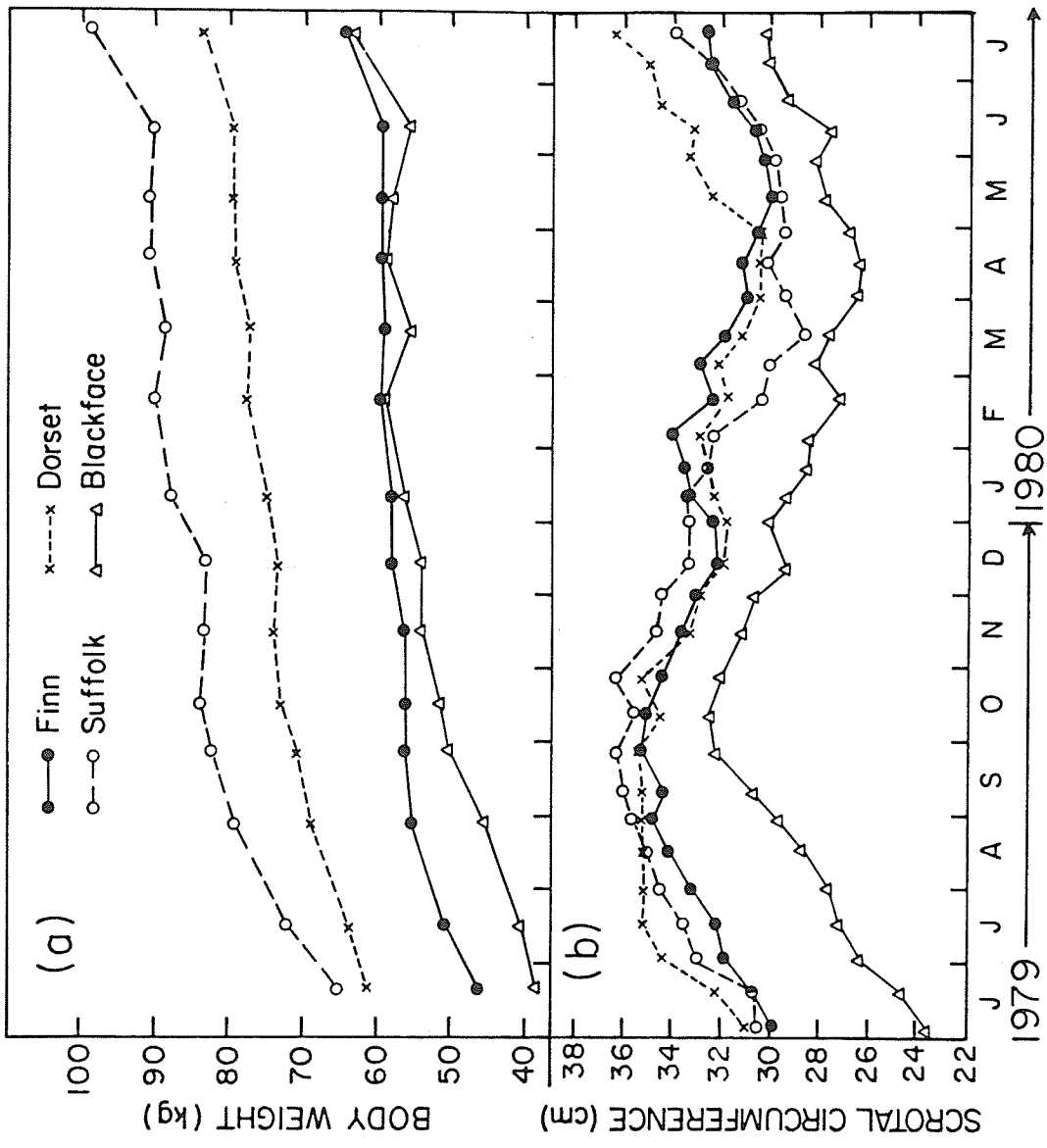

Figure 1. Mean body weight (a) and scrotal circumference (b) measurements. Values for the Finn breed represent three rams, and for the other breeds, represent four rams.

Table 1. Mean (±SE) scrotal circumference (cm) measurements

Date	Breed*			
	Finn	Suffolk	Dorset	Blackface
June 4	29.9±1.4[b]	30.5±.5[b]	31.0±.6[b]	23.6±.4[a]
18	30.8±1.3[b]	30.7±1.4[b]	32.1±1.1[b]	24.8±.7[a]
July 3	31.9±.9[b]	33.0±.9[b,c]	34.5±.5[c]	26.2±.8[a]
16	32.2±.9[b]	33.7±.8[b,c]	35.2±.6[c]	27.0±.8[a]
31	33.2±.9[b]	34.6±.3[b]	35.1±.6[b]	27.7±.8[a]
Aug. 14	34.2±1.2[b]	35.1±.2[b]	35.1±.5[b]	28.6±.7[a]
27	34.8±1.0[b]	35.7±.3[b]	35.4±.8[b]	29.7±.7[a]
Sept.10	34.4±1.1[b]	36.0±.1[b]	35.2±.8[b]	30.8±.9[a]
25	35.2±.7[b]	36.2±.5[b]	35.3±.8[b]	32.3±.7[a]
Oct. 11	35.1±.9[a]	35.5±.3[a]	34.6±1.0[a]	32.6±.8[a]
26	34.5±.7[b]	36.2±.2[b]	35.2±.8[b]	32.0±.5[a]
Nov. 15	33.7±.8[b]	34.7±.4[b]	33.5±1.1[b]	31.1±.4[a]
30	33.1±1.0[a,b]	34.5±.4[b]	33.0±.9[b]	30.8±.4[a]
Dec. 12	32.2±.8[a,b]	33.4±.4[b]	32.0±1.2[b]	29.4±.7[a]
20	32.4±.9[a]	33.4±.5[a]	31.9±1.1[a]	30.1±.9[a]
Jan. 10	33.2±.8[a]	33.4±.7[a]	32.3±1.3[a]	29.3±1.1[a]
23	33.5±.7[b]	32.7±.7[b]	32.7±.9[b]	28.6±1.5[a]
Feb. 6	34.0±.6[b]	32.4±1.0[b]	32.8±.7[b]	28.5±1.1[a]
20	32.4±.4[b]	30.3±.6[b]	31.8±.4[b]	27.1±1.0[a]
Mar. 5	32.9±.4[c]	30.1±.7[a,b]	32.1±.6[b,c]	28.3±.9[a]
18	31.9±.8[b]	28.8±.6[a]	31.2±.8[b]	27,8±.6[a]
Apr. 2	31.0±.9[b]	29.5±.6[b]	30.7±.6[b]	26.6±.9[a]
17	31.5±1.2[b]	30.1±.2[b]	30.7±.9[b]	26.5±.6[a]
29	30.6±.9[b]	29.5±.4[b]	30.6±.6[b]	26.9±.5[a]
May 13	30.0±1.8[a,b]	29.7±1.2[a]	32.5±.5[b]	27.9±.2[a]
28	30.4±1.1[a]	29.9±.3[a]	33.5±1.0[b]	28.3±.2[a]
June 11	30.8±1.4[b,c]	30.5±.3[b]	33.2±.9[c]	27.6±.5[a]
24	31.8±1.3[a]	31.3±.7[a]	34.7±.4[b]	29.3±.7[a]
July 9	32.6±1.2[a,b,c]	32.5±.8[b]	35.0±.4[c]	30.1±.7[a]
22	32.7±1.0[a,b]	34.0±.6[a]	36.3±.4[c]	31.2±.6[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time x breed interaction significant ($P<.01$).

Table 2. Mean (±SE) body weight (kg) measurements

Date	Breed*			
	Finn	Suffolk	Dorset	Blackface
June 18	46.9±1.7^{b}	66.5±1.2^{c}	61.7±2.5^{c}	38.2±1.0^{a}
July 16	51.4±.7^{b}	72.6±1.0^{d}	64.2±2.1^{c}	41.0±1.4^{a}
Aug. 27	55.7±1.5^{b}	78.9±1.8^{d}	68.6±1.6^{a}	46.6±3.1^{a}
Sept.25	56.6±.6^{a}	83.4±2.6^{c}	71.6±1.6^{b}	50.5±3.1^{a}
Oct. 26	56.7±.6^{a}	84.0±2.5^{c}	72.5±1.9^{b}	52.0±2.9^{a}
Nov. 15	56.8±.7^{a}	83.9±2.5^{c}	74.4±2.0^{b}	54.4±1.9^{a}
Dec. 12	57.6±.6^{a}	83.7±2.1^{c}	73.1±2.6^{b}	54.2±2.8^{a}
Jan. 10	57.1±1.7^{a}	87.9±2.1^{c}	76.0±3.5^{b}	56.8±2.7^{a}
Feb. 20	59.6±.3^{a}	90.2±2.1^{c}	77.6±3.2^{b}	59.2±3.1^{a}
Mar. 18	57.9±.3^{a}	88.3±2.1^{c}	77.1±3.3^{b}	56.0±3.4^{a}
Apr. 18	59.4±.2^{a}	91.5±1.8^{c}	79.6±2.6^{b}	58.9±4.2^{a}
May 12	59.6±.3^{a}	91.5±2.3^{c}	79.6±2.4^{b}	58.2±4.1^{a}
June 11	59.1±1.1^{a}	90.6±3.5^{c}	79.6±2.0^{b}	56.6±4.0^{a}
July 22	64.6±.7^{a}	98.5±3.0^{c}	83.6±1.8^{b}	64.0±3.8^{a}

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time x breed interaction significant ($P<.01$).

observed between the breeds (October 11, December 20 and January 10).

As the rams aged, testicular size increased; as indicated by comparing the differences in scrotal circumference measurements in June and July, 1979 to those recorded during the same months the following year (Figure 1b). This applied particularly to the Dorset and Blackface rams and was likely related to the increase in body weight that was observed as the animals matured (Figure 1a and Table 2). For most of the breeds (Blackface excluded) increases in body weight slowed down and/or ceased during the breeding season (from late August-early September to the end of December). In January, body weight started to gradually increase again for some rams, with a sharp elevation in weight occurring for all rams in July 1980.

Mean Hormone Levels

All of the hormones assayed for in this study (LH, FSH, T and PRL) exhibited definite seasonal variations in serum levels (Figure 2). In addition, it was established that the pattern of seasonal change of T and FSH levels varied between breeds (Time x breed significant $P<.01$ and $P<.05$). These trends are illustrated in Figure 2 and in Tables 3 through 6. T levels were higher for all rams during the fall breeding season (September through December) than they were between March and July. During the breeding season, the Finn rams had the highest serum T concentrations, however these levels were only significantly different ($P<.05$) from those of the majority of the other breeds in October and December. While Finn rams also had significantly ($P<.05$) higher T levels in January and February, there were no breed differences in T

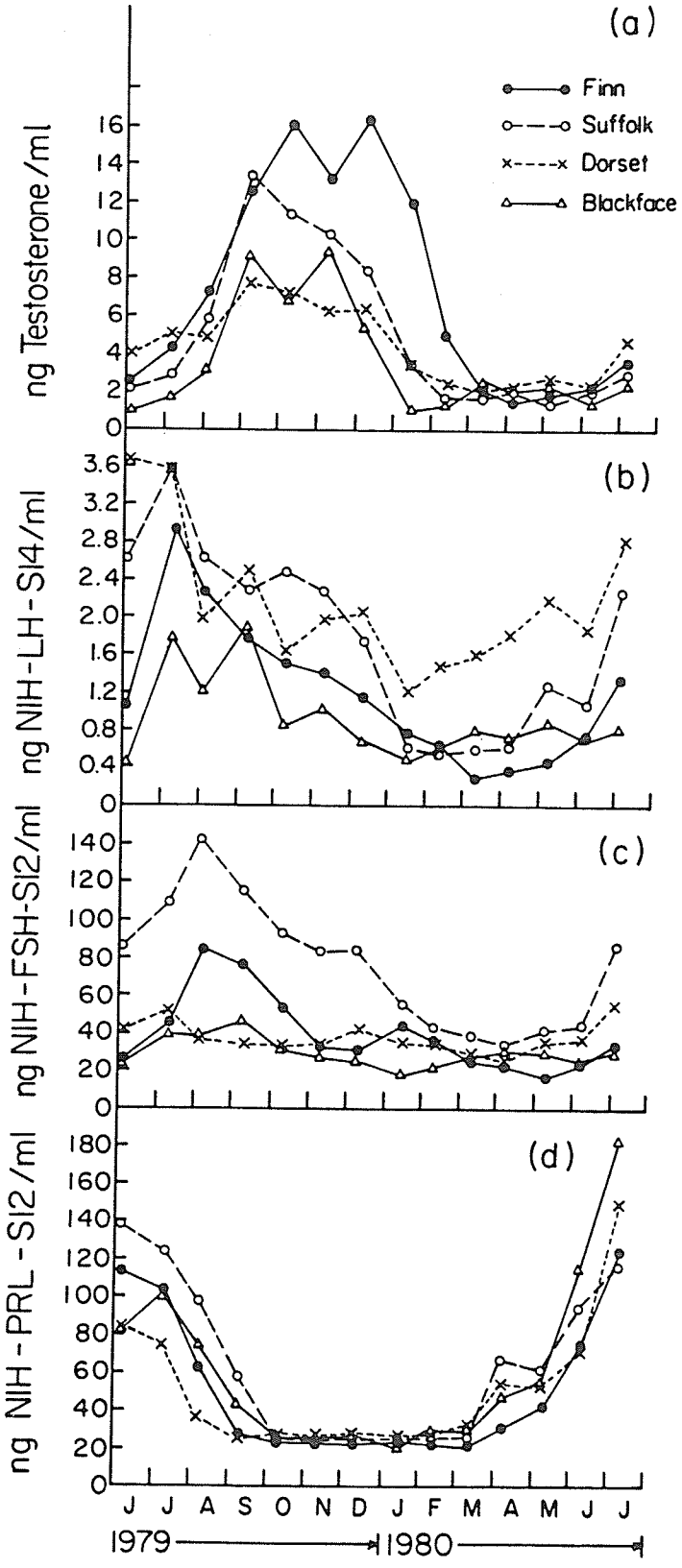

Figure 2. Mean serum concentrations (ng/ml) of testosterone (a), LH (b), FSH (c), and PRL (d). Values for the Finn breed represent three rams and for the other breeds represent four rams. Rams were bled at 20-min. intervals for 8h.

Table 3. Mean (±SE) serum testosterone concentration (ng/ml) for rams bled at 20 min intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
June 4/6	2.63±.45[a,b]	2.08±.58[a]	4.01±.83[b]	.93±.24[a]
July 9/11	4.4±.58[a]	2.88±.75[a]	5.11±1.21[a]	1.81±.73[a]
Aug. 6/8	7.34±1.43[a]	5.90±1.45[a]	4.94±.60[a]	3.14±.75[a]
Sept.10/12	12.72±4.92[a]	13.35±1.42[a]	7.83±.91[a]	9.27±2.32[a]
Oct. 9/11	16.05±.22[c]	11.42±1.10[b]	7.44±.60[a]	6.86±.46[a]
Nov. 12/14	13.20±.04[a]	10.40±1.80[a]	6.34±1.61[a]	9.62±2.31[a]
Dec. 10/12	16.39±3.62[b]	8.64±1.77[a,b]	6.37±1.92[a]	5.44±2.62[a]
Jan. 14/16	12.01±.32[c]	3.56±.78[b]	3.38±.77[b]	.97±.25[a]
Feb. 11/13	5.04±1.11[b]	1.79±.45[a]	2.60±1.12[a,b]	1.35±.43[a]
Mar. 10/12	2.16±.26[a]	1.76±.61[a]	2.13±.42[a]	2.69±.83[a]
Apr. 7/9	1.57±.45[a]	2.00±.46[a]	2.47±.34[a]	2.10±.43[a]
May 5/7	1.97±.21[a]	1.45±.74[a]	2.83±.63[a]	2.29±.57[a]
June 9/11	2.25±.39[a]	2.11±.54[a]	2.58±.43[a]	1.45±.26[a]
July 8/9	3.70±.11[a]	3.03±.57[a]	4.83±.96[a]	2.35±.37[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time x breed interaction significant ($P<.01$).

levels between March and July 1980. Peak T levels in Suffolk, Dorset and Blackface rams were attained in September, while the Finn rams did not obtain their highest T concentrations until October. There was a slight and transient decline from peak T levels in Finn rams during November. Serum T concentrations for Suffolk and Blackface rams declined in October. However, the Blackface rams exhibited an increase in T concentration again in November, which was followed by a sharp and stable decline in T levels in December. Blackface T levels increased slightly in February and March. By January, the Finn, Dorset and Suffolk rams displayed sharp reductions in serum T concentrations. All of the ram breeds disclosed minimum T levels in the spring with subsequent increases in T occurring in July.

Although there were no significant ($P<.05$) breed differences in serum LH levels during any month (Table 4), the Dorsets and Suffolks tended to have higher circulating LH levels throughout many months of the year (Figure 2b). The Dorset LH levels were especially high (averaging between 1.23-2.39 ng/ml) between January and July 1980; whereas the other breeds had levels averaging <1 ng/ml during this time, except the Suffolk rams which displayed a mean of 1.29 ng/ml in May.

In July 1979, LH levels for Finn, Suffolk and Blackface rams increased while Dorset LH concentrations were maintained at their previously relatively high levels. During the subsequent five months, levels of LH tended to decline for all rams.

Minimum or near minimum LH levels were detected for the Dorset, Blackface and Suffolk rams in January, and in March for the Finn rams. Following a period of minimal concentration, LH levels increased to

Table 4. Mean (±SE) serum LH concentrations (ng/ml) for rams bled at 20 min intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
June 4/6	1.09±.40	2.62±1.36	3.73±.93	.45±.08
July 9/11	2.93±1.88	3.57±.85	3.59±.75	1.79±.19
Aug. 6/8	2.29±.98	2.63±1.03	1.93±.16	1.20±.14
Sept.10/12	1.75±1.20	2.27±.42	2.48±.54	1.90±.48
Oct. 9/11	1.52±.47	2.47±.77	1.64±.17	.85±.10
Nov. 12/14	1.42±.65	2.26±.49	1.94±.33	1.03±.14
Dec. 10/12	1.15±.38	1.75±.34	2.07±.83	.69±.23
Jan. 14/16	.78±.18	.62±.16	1.23±.25	.52±.17
Feb. 11/13	.65±.27	.56±.13	1.52±.83	.60±.24
Mar. 10/12	.31±.05	.80±.28	1.61±.69	.79±.22
Apr. 7/9	.39±.80	.82±.07	1.82±.60	.74±.11
May 5/7	.46±.12	1.29±.32	2.39±.72	.90±.25
June 9/11	.76±.32	1.10±.52	1.86±.26	.75±.18
July 8/9	1.36±.59	2.30±.64	2.82±.84	.83±.23

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant ($P<.05$) differences between horizontal means for any month.

Time ($P<.01$) significant.

different extents in all breeds throughout the remainder of the study. Increases in circulating LH levels were particularly evident in Suffolk, Dorset and Finn rams in July 1980.

Seasonal variations were also noted in mean FSH levels, with the highest circulating concentrations occurring in the late summer and fall and the lowest levels occurring in the late winter and spring. The Suffolks exhibited significantly higher ($P<.05$) FSH levels than did the other breeds during the breeding season (Table 5), as well as having the highest FSH levels throughout the year (Figure 2c). Breed differences in FSH levels were not noted between January and July, 1980. Seasonal variations in FSH appeared to occur to a greater extent in the Suffolks with averages ranging between 34.4 and 140.4 ng/ml, while the Dorset and Blackface rams showed the least variability with averages ranging between 27.1 and 55.8 ng/ml and 18.4 and 46.9 ng/ml, respectively. Dorset rams were the first to reach their peak FSH levels in the summer with their highest mean concentration being observed in July. FSH levels in Suffolk and Finn rams peaked in August, while maximal FSH levels in Blackface rams were not reached until September. FSH levels declined during the months immediately following the peak months. The Blackface rams attained minimum levels in January; the Dorset and Suffolk rams displayed their minimum FSH levels in April; however, the Finns did not reach their lowest levels until May. Differences between breeds during months of maximum and minimum FSH levels and the extent of seasonal changes exhibited, probably accounted for the significant ($P<.05$) breed x time interaction. In all the rams, FSH levels began to increase the month after minimum concentrations were detected. Suffolk and Dorset

Table 5. Mean (±SE) serum FSH concentrations (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
June 4/6	26.5±6.7[a,b]	88.3±24.5[c]	41.5±7.3[b]	25.4±6.7[a]
July 9/11	45.4±6.9[a]	109.8±33.9[a]	50.2±7.6[a]	39.8±15.9[a]
Aug. 6/7	86.0±6.9[b]	140.4±6.9[c]	37.5±8.5[a]	38.3±23.0[a]
Sept. 10/12	77.8±21.5[a,b]	115.8±24.1[b]	36.2±6.8[a]	46.9±20.6[a]
Oct. 9/11	53.4±11.5[a]	94.0±4.3[b]	32.7±6.5[a]	32.2±13.8[a]
Nov. 12/14	32.4±6.2[a]	83.7±9.7[b]	34.0±8.2[a]	27.6±8.4[a]
Dec. 10/12	30.8±4.1[a]	85.1±6.0[b]	42.0±10.2[a]	25.6±9.2[a]
Jan. 14/16	43.9±13.0[a]	56.7±8.2[a]	35.6±13.1[a]	18.4±4.5[a]
Feb. 11/13	37.4±7.7[a]	43.0±3.2[a]	35.2±10.3[a]	22.4±9.0[a]
Mar. 10/12	25.7±5.9[a]	39.6±11.4[a]	29.6±9.1[a]	29.1±9.9[a]
Apr. 7/9	22.9±6.1[a]	34.4±8.5[a]	27.1±6.9[a]	32.1±11.7[a]
May 5/7	18.3±7.6[a]	42.0±16.7[a]	36.9±10.0[a]	30.0±13.4[a]
June 9/11	23.8±5.5[a]	45.7±24.8[a]	37.9±7.5[a]	26.6±13.0[a]
July 8/9	33.1±10.5[a]	87.6±34.9[a]	55.8±17.2[a]	30.7±13.5[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time x breed interaction significant ($P<.05$).

rams appeared to exhibit moderate elevations in circulating FSH levels during July 1980. It should be noted that both circulating FSH and LH levels peaked 2 months before T; and, as T levels began to increase, LH and FSH levels began to decline.

Seasonal patterns were detected in PRL concentration with minimum PRL levels occurring between October and March in all breeds (Table 6). By April serum PRL concentrations had increased slightly, but the most dramatic increases had occurred by June and July for all rams (Figure 2d). The Suffolk rams had the highest PRL levels between June and September 1979; the Dorset rams had the lowest levels in July and August; and in June and July 1980, the Blackface rams displayed the highest serum PRL concentrations (Table 6). However, none of these breed differences were significant ($P>.05$). The only significant breed difference in PRL concentration occurred in November when the Dorset rams had slightly higher PRL levels than every other breed except the Blackface rams (Table 6).

Profile Characteristics of LH and Testosterone

All of the LH-profile characteristics that were examined revealed marked seasonal variations, with differences being significant ($P<.01$) for mean levels (Table 7), peak frequency (Table 9), peak height (Table 10) and delta values (Table 11). Seasonal variations in baseline values were not significant ($P>.05$) (Table 8). Consistent breed differences within each month in mean and baseline levels and in peak height and delta values were not observed. However, a significant ($P<.05$) breed x time interaction was recorded for mean levels.

Table 6. Mean (±SE) serum PRL concentrations (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
June 4/6	114.9±5.2[a]	139.2±15.1[a]	84.4±28.9[a]	83.1±25.7[a]
July 9/11	107.3±18.8[a]	125.1±6.9[a]	76.1±27.6[a]	101.5±31.9[a]
Aug. 6/8	61.5±7.0[a]	98.8±16.4[a]	37.4±10.9[a]	75.7±27.1[a]
Sept. 10/12	29.1±2.1[a]	58.8±20.4[a]	27.5±7.4[a]	44.4±16.3[a]
Oct. 9/11	22.6±2.2[a]	25.1±.7[a]	28.5±1.8[a]	25.1±1.2[a]
Nov. 12/14	22.4±1.3[a]	24.0±.3[a,b]	27.2±.6[c]	25.9±1.3[b,c]
Dec. 10/12	22.6±2.2[a]	25.2±1.7[a]	28.8±1.9[a]	26.6±1.2[a]
Jan. 14/16	23.3±2.1[a]	25.7±1.0[a]	28.3±1.3[a]	21.7±4.3[a]
Feb. 11/13	22.1±1.9[a]	26.5±1.1[a]	27.4±.5[a]	29.2±3.8[a]
Mar. 10/12	21.9±1.43[a]	26.8±2.0[a]	32.5±2.9[a]	29.2±3.8[a]
Apr. 7/9	30.9±5.1[a]	68.6±8.7[a]	56.0±16.1[a]	48.6±15.8[a]
May 5/7	43.0±8.4[a]	62.0±17.7[a]	54.4±20.9[a]	56.5±17.5[a]
June 9/11	76.1±6.8[a]	95.1±14.6[a]	71.6±22.7[a]	116.0±13.5[a]
July 8/9	124.5±22.6[a]	117.6±42.6[a]	150.1±65.0[a]	183.9±53.8[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time ($P<.01$) significant.

Table 7. Serum LH-profile characteristics; mean (±SE) concentrations (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
July 9/11	2.17±1.07[a]	2.69±.53[a]	5.65±1.81[a]	.93±.07[a]
Oct. 9/11	1.64±.39[a]	1.92±.78[a]	1.31±.16[a]	1.05±.25[a]
Jan. 14/16	.52±.10[a]	.40±.20[a]	1.43±.32[b]	.26±.07[a]
Apr. 7/9	.21±.02[a]	.59±.25[a]	1.47±.35[b]	.51±.19[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time x breed interaction significant ($P<.05$).

Table 8. Serum LH-profile characteristics; mean (±SE) baseline concentrations (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
July 9/11	.46±.25[a]	.36±.14[a]	1.76±1.05[b]	.26±.07[a]
Oct. 9/11	.71±.18[a]	1.26±.64[a]	.60±.09[a]	.69±.16[a]
Jan. 14/16	.17±.03[a]	.23±.09[a]	.62±.33[a]	.18±.04[a]
Apr. 7/9	.11±.00[a]	.12±.01[a]	.54±.34[a]	.33±.09[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Breed ($P<.05$) significant.

Table 9. Serum LH-profile characteristics; mean (±SE) peak frequencies (number/8h) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
July 9/11	2.7±.7	2.3±.5	3.5±.9	2.3±.6
Oct. 9/11	4.7±.3	4.5±.3	4.0±.9	3.0±.4
Jan. 14/16	2.3±.6	2.0±.9	2.5±.5	1.0±.7
Apr. 7/9	1.0±.0	1.0±.4	1.8±.3	1.8±.3

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant (P>.05) differences between horizontal means for any month.

Time (P<.05) significant.

Table 10. Serum LH-profile characteristics; mean (±SE) peak heights (ng/ml) for rams bled at 20 min intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
July 9/11	8.45±2.85^{a,b}	11.09±1.89^{b}	14.63±2.61^{b}	4.04±.82^{a}
Oct. 9/11	3.35±.94^{a}	3.47±1.28^{a}	3.76±1.17^{a}	2.20±.61^{a}
Jan. 14/16	1.97±.45^{a}	.95±.39^{a}	5.22±.65^{b}	1.72±.48^{a}
Apr. 7/9	1.18±.28^{a}	3.54±1.43^{a,b}	6.12±1.12^{b}	1.68±.41^{a}

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly (P<.05) different.

Time (P<.01) and breed (P<.05) significant.

There were no significant breed differences in mean LH levels (Table 7) during July and October, even though the Blackface rams displayed their highest mean levels in October, while the other ram breeds exhibited their highest mean levels in July. In addition, the highest mean levels for a given breed were recorded in either July or October. Dorset rams did have significantly ($P<.05$) greater mean LH levels in January and April in comparison with the other breeds of rams, although these values were substantially lower than those observed in these rams in July.

LH baseline levels also showed seasonal trends, but these were not significant ($P>.05$, Table 8). The highest baseline levels were displayed in July (Dorset) or October (all other breeds), and the lowest levels were observed in January (Blackface) or April (all other breeds). Significant ($P<.05$) breed differences were noted in July when the Dorset rams had higher baseline values than did the other rams. Dorset rams also exhibited markedly higher baseline LH levels than did other rams in January and April.

There were no breed differences recorded in LH-peak frequencies, but there were definite seasonal variations. The highest frequencies were recorded in October, while the lowest peak frequencies generally occurred in April, except for the Blackface rams which had their lowest frequencies in January (Table 9).

Peak height and delta values were significantly different between breeds ($P<.05$, Table 10) and between months ($P<.01$, Table 11). In July, when peak heights and delta values were the greatest, values for the Blackface rams were significantly ($P<.05$) lower than for the Dorset and

Suffolk rams which had the highest peak height and delta values. In January, the Dorset rams had significantly ($P<.05$) greater peak heights and delta values than did the other rams. In April, the Dorsets still had higher values for these two characteristics, but they were only significantly ($P<.05$) higher than those of the Finn and Blackface rams.

Within 40 to 60 min. after an LH peak was observed, a peak in serum T levels usually occurred (Tables 7A-21A). Unlike the LH-profile characteristics, there were no significant ($P>.05$) differences between breeds in mean and baseline levels, delta values and peak heights and frequencies.

However, there were definite seasonal differences in all characteristics examined (Tables 12-16). That is, values for all of the T-profile characteristics were greater in October (breeding season) than they were in April (nonbreeding season). In October, the Finn rams had markedly higher mean levels than all the other rams and generally higher T-peak frequencies. Finn rams had slightly greater peak heights at this time, relative to Suffolk and Blackface rams, and along with the Suffolk rams, relatively higher baseline values. In April, the Dorset rams had slightly higher mean and baseline levels, peak frequencies and heights, and delta values than did rams of most of the other breeds.

Mating Performance and Daily Sperm Output

Significant seasonal differences in mating performance ($P<.05$) were observed only for the number of mounts per mate (Figure 3b), and not for the total number of mates per 4h. Yet, the only significant

Table 11. Serum LH-profile characteristics; mean (±SE) Δ value (ng/ml) for rams bled at 20 min intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
July 9/11	8.02±2.64[a,b]	10.68±1.90[b]	12.68±2.57[b]	3.68±.89[a]
Oct. 9/11	2.65±.77[a]	2.23±.64[a]	3.19±1.16[a]	.96±.19[a]
Jan. 14/16	1.80±.50[a]	.70±.28[a]	4.60±.41[b]	1.49±.56[a]
Apr. 7/9	1.07±.28[a]	3.42±1.41[a,b]	5.59±1.13[b]	1.35±.38[a]

*Values for Finn breed represent three rams, and for the other breeds, four rams.

Horizontal means not sharing a similar letter are significantly ($P<.05$) different.

Time ($P<.01$) and breed ($P<.05$) significant.

Table 12. Serum testosterone-profile characteristics; mean (±SE) concentrations (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
Oct. 9/11	18.00±2.00	13.10±2.50	11.50±4.10	10.00±2.00
Apr. 7/9	1.60±.40	2.30±.50	3.30±.80	1.90±.40

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant ($P>.05$) differences between horizontal means for either month.

Time ($P<.01$) significant.

Table 13. Serum testosterone-profile characteristics; mean (±SE) baseline concentrations (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
Oct. 9/11	7.10±.80	7.10±2.40	5.00±1.00	4.10±2.50
Apr. 7/9	.40±.20	.60±.10	.90±.50	.30±.20

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant ($P>.05$) differences between horizontal means for either month.

Time ($P<.01$) significant.

Table 14. Serum testosterone-profile characteristics; mean (±SE) peak frequencies (number/8h) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
Oct. 9/11	3.7±.3	3.5±.7	2.3±.3	2.5±.3
Apr. 7/9	1.0±.0	1.3±.3	1.5±.4	1.0±.0

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant ($P>.05$) differences between horizontal means for either month.

Time ($P<.01$) significant.

Table 15. Serum testosterone-profile characteristics; mean (±SE) peak heights (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
Oct. 9/11	28.40±3.20	22.20±3.30	28.90±15.30	21.80±3.90
Apr. 7/9	8.30±1.50	6.60±1.40	8.40±1.60	6.70±.90

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant ($P>.05$) differences between horizontal means for either month.

Time ($P<.01$) significant.

Table 16. Serum testosterone-profile characteristics; mean (±SE) Δ values (ng/ml) for rams bled at 20 min. intervals for 8h

	Breed*			
Date	Finn	Suffolk	Dorset	Blackface
Oct. 9/11	21.40±2.40	15.10±1.40	24.0±14.50	17.70±4.20
Apr. 7/9	7.80±1.30	5.80±1.30	7.50±1.20	6.40±.70

*Values for Finn breed represent three rams, and for the other breeds, four rams.

No significant ($P>.05$) differences between horizontal means for either month.

Time ($P<.01$) significant.

(P<.01) breed difference over all the assessment periods was reported for the total number of mates. In each libido assessment trial, the Finn rams mated more frequently than did the other rams (Figure 3a), however the only significant (P<.05) differences between the rams were noted in November and February. The Dorset rams seemed to have the least variability during the year in regard to the number of mates per 4h. The number of mounts per mate (Figure 3b) was higher in November and February in comparison to the results obtained in July and June; the greatest increases were observed in the Dorset and Blackface rams. The Blackface rams appeared to show the most seasonal variation in the number of mounts required to mate a ewe. Throughout the year, the Finnish Landrace rams tended to be the most efficient breeders, followed by the Suffolk rams. However, breed differences were not significant (P>.05).

During the first two DSO collection periods (September/October and January/February) the Suffolk rams had the greatest estimated sperm output, but these estimates were only significantly (P<.05) different from the Finn and Blackface rams. For the May/June collection period, there were no significant (P>.05) breed differences between rams, but the Finnsheep did have the greatest estimated DSO. There were definite seasonal differences in DSO (Time significant, P<.01) with the greatest output for all breeds occurring in the January/February collection period and the lowest output (except for the Finnsheep) occurring in May. Throughout the year, the Blackface rams were consistently lower in DSO than the other breeds of rams (Breeds significant, P<.01). Nevertheless, like the Finn rams, they had relatively little seasonal variability in DSO. Estimated DSO for the Finn, Blackface, Dorset and Suffolk

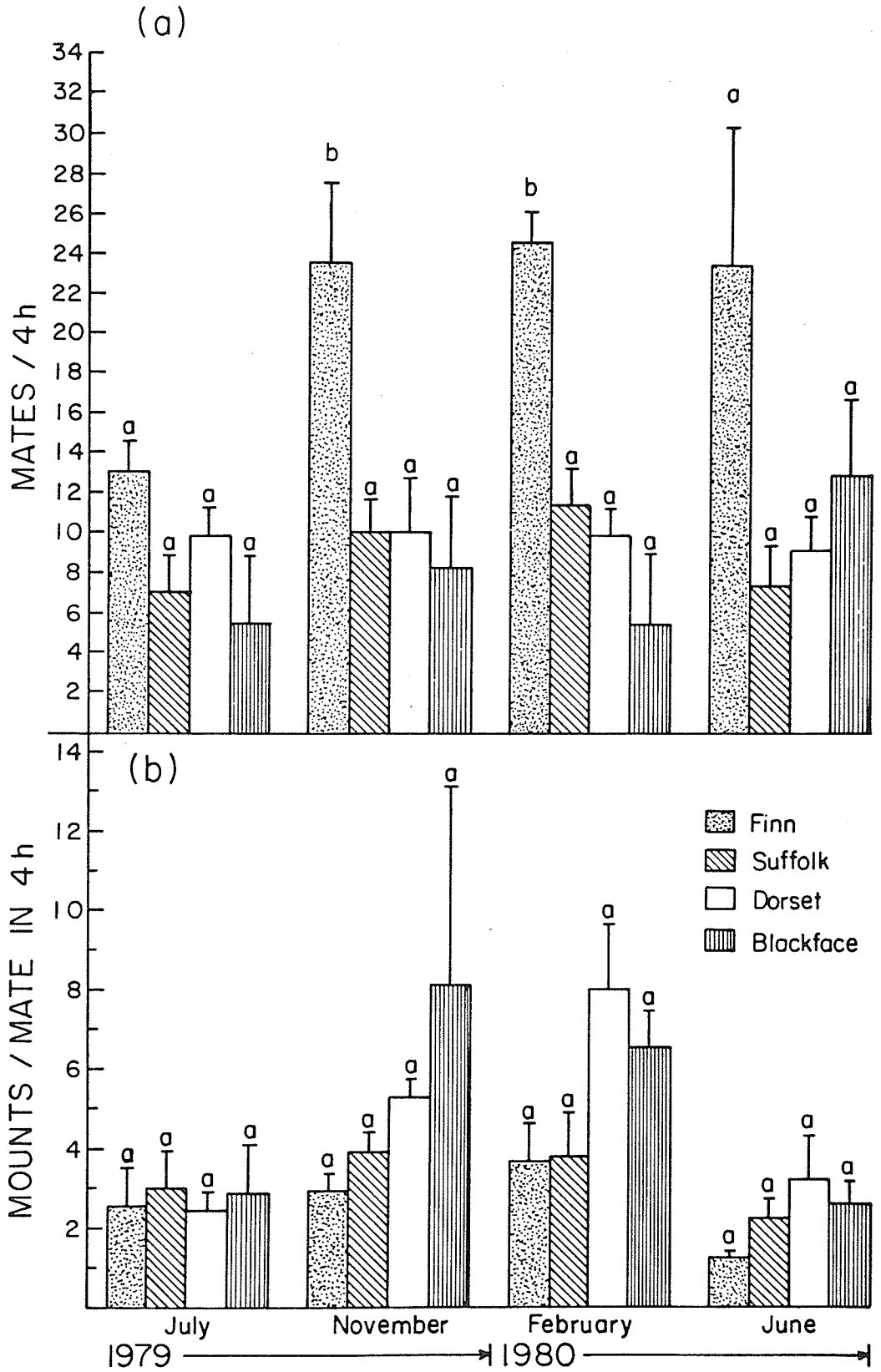

Figure 3. Mean (±SE) number of mates/4h (a) and mounts/mate in 4h (b). Horizontal means within each assessment period not sharing a similar letter are significantly (P<.05) different. Values for the Finn breed represent three rams, and for the other breeds represent four rams. Breed (P<.01, Panel a) and month (P<.05, Panel b) significant.

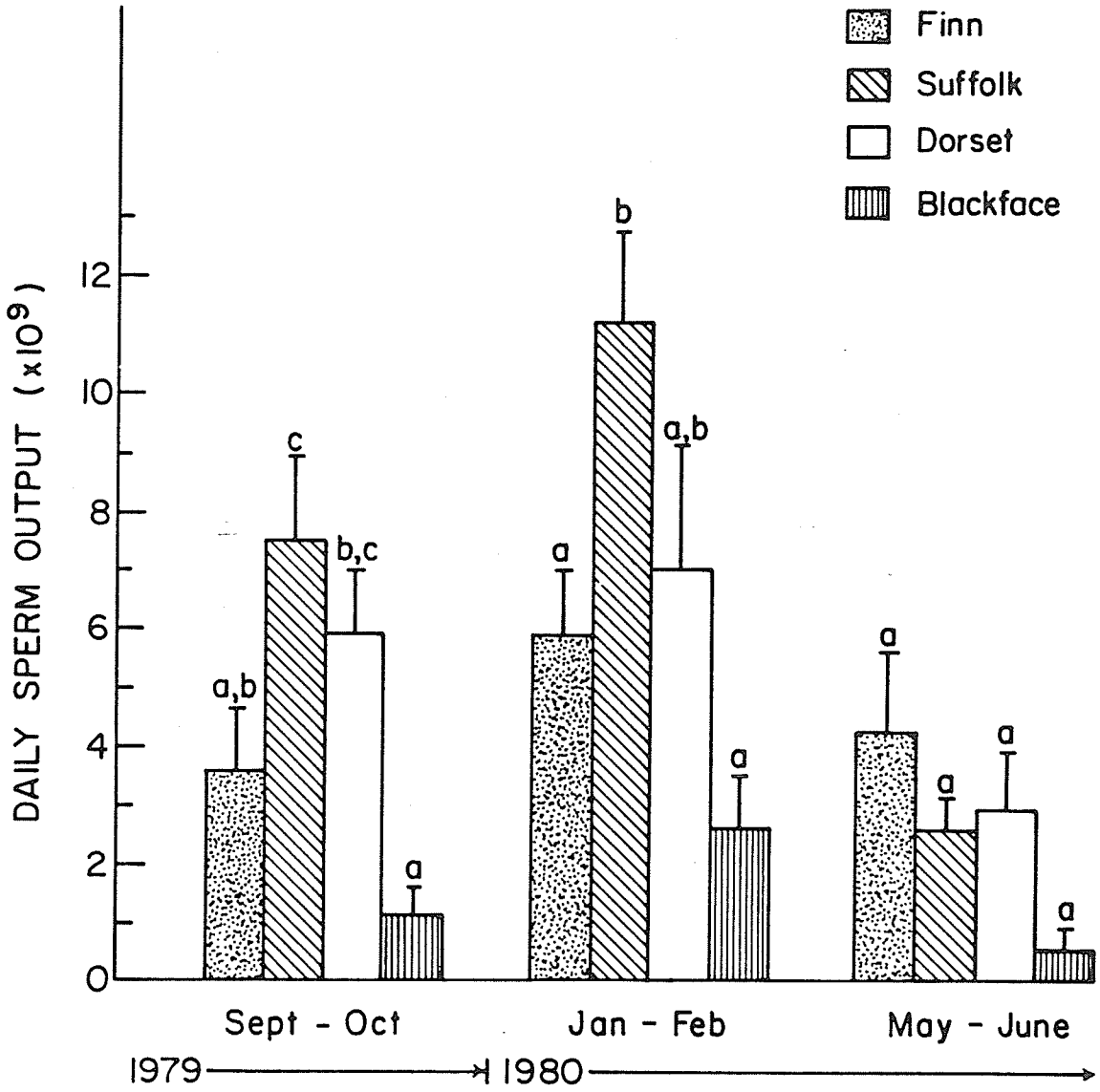

Figure 4. Mean (±SE) daily sperm output. Horizontal means within each assessment period not sharing a similar letter are significantly (P<.05) different. Values for the Finn breed represent three rams, and for the other breeds represent four rams. Time and breed significant (P<.01).

rams ranged from 3.6 to 5.8, .6 to 2.6, 2.8 to 7.0 and 2.6 to 11.3 x 10^9 sperm cells/24h, respectively; this indicates that in terms of total sperm produced the Suffolk rams had the most seasonal variability in estimated DSO (Figure 4).

DISCUSSION

The results of the gonadotropin and steroid assays indicated that LH, FSH, and T secretion is greater in the summer and/or fall than in the spring. Because of this, one would assume that GnRH release from the hypothalamus is also greater during the summer and fall breeding season. In the present study, PRL levels began to decline in June and July as the LH and FSH levels began to increase, suggesting that any antigonadotrophic effect that high PRL levels may have had was diminishing.

In all the ram breeds, mean gonadotropin levels peaked 1 to 2 months (June-August) prior to the peaks in mean T levels (September-October) indicating that gonadotropins assist in T production, i.e. LH stimulates the Leydig cells to increase T synthesis and secretion. PRL is thought to synergize with FSH to enhance the effect of LH on the Leydig cells, or it may act as a "conditioning hormone" which prepares the testes for a subsequent rise in LH (Barrell and Lapwood, 1978; 1979). In some species, PRL is also believed to activate steroidogenic pathways to increase testicular androgen production, possibly by synergizing with LH (Barrell and Lapwood, 1978; 1979).

As mean T levels reached their maximum heights, a decline in the gonadotropin levels became evident. This decline in serum FSH and LH may have been due to the increased negative feedback inhibition of elevated circulating androgens upon the hypothalamic secretion of GnRH and thus, upon FSH and LH release; these observations and suggested explanations are similar to those reported by Lincoln and Peet (1977). It is not likely that autoregulation by the gonadotropins themselves, could have assisted in the decline because supraphysiological levels of the

gonadotropins were not evident (Schally and Kastin, 1970; Sandow et al. 1979). The initial reduction in serum LH and FSH from September to January was probably not due to the antigonadotrophic behavior of PRL, because circulating PRL levels were minimal ($\leq$30 ng/ml) at this time.

Seasonal variations were exhibited in the circulating levels of all of the reproductive hormones studied. Serum gonadotropin levels were observed to be higher in the late summer and fall (July-December) than they were in the spring (March-May). These results are very similar to those documented by other researchers who found that gonadotropin levels were minimal during long photoperiods, and began to rise as the photoperiod began to decrease (June) (Katongole et al., 1974; Pelletier and Ortavant, 1975a; Sanford et al., 1976; Lincoln and Davidson, 1977; Lincoln and Peet, 1977; Schanbacher and Lunstra, 1977; Lincoln et al., 1978; Ortavant, 1978 and Barrell and Lapwood, 1978/1979a, b). The LH-profile characteristics, except for baseline levels, also displayed seasonal trends. Mean levels, peak frequencies, peak heights and delta values were greater in July and October (summer-fall) than they were in January and April (winter-spring). The LH-peak frequency seasonal changes differ from those of Ortavant (1978), but are similar to those obtained by Lincoln (1976a, b). Ortavant found that peak frequency increased from February through June and decreased between September and December. However, in his experiment, blood samples were collected only once an hour for 24h. Since the half-life of LH is approximately 20 to 30 min., it is possible that some of the small peaks may have been missed as a result of infrequent collections.

Carr and Land (1975) stated that LH levels are breed dependent.

Confirming their results, we did observe significant differences ($P<.05$) between breeds for peak height, baseline concentrations, mean levels and delta values of the LH profiles, however, peak frequencies were not noted to be different between the four breeds. Similar to the results reported by Carr and Land (1975), breed differences in mean serum LH concentrations were sometimes observed in the present study.

LH peaks were followed 40 to 60 min. later by a peak in T levels, which corresponds to the data recorded by Sanford et al. (1974c, 1977), Carr and Land (1975), Moore et al. (1978) and Wilson and Lapwood (1978).

Mean serum T levels and T-profile characteristics were also higher under short daylengths vs. long daylengths in rams of all breeds. The T-profile data is similar to those obtained by Katongole et al. (1974), Perera et al. (1976) and Sanford et al. (1977) where values for various T characteristics were greater in the fall than in the spring. Similarly, seasonal trends in mean serum T levels correspond to those documented by Amir and Volcani (1965), Purvis et al. (1974), Schanbacher and Lunstra (1976), Lincoln and Davidson (1977), Barrell and Lapwood (1978), Bremner et al. (1978) and Wilson and Lapwood (1978).

The results of this study indicate further (Sanford et al., 1977) that the negative feedback inhibition of the gonadal steroids on GnRH release changes with daylength in response to concurrent variations in steroid (testosterone) secretion. Decreased secretion of steroids in the spring may mean less inhibition of GnRH release. Subsequently, inhibition may increase as the days become shorter in the late summer and fall as gonadal steroid secretion increases.

Serum PRL levels exhibited seasonal variations that paralleled

changes in photoperiod and thus, had an inverse pattern of secretion in relation to LH, FSH and T. PRL concentrations were minimal (<30 ng/ml) during short daylengths (October-March) but they began to increase in the spring (April) as the days began to lengthen and environmental temperature began to increase. In July 1980, PRL levels averaged more than 110 ng/ml for the four breeds, representing at least a four-fold increase in concentration above the minimum levels. These seasonal PRL variations correspond to those obtained by Pelletier (1973), Ravault et al. (1976), Ravault and Ortavant (1977), Lincoln et al. (1978), Ortavant (1978), Wilson and Lapwood (1978) and Barrell and Lapwood (1979b).

The presumed increase in GnRH and the known increase in gonadotropin secretion, as well as the declining PRL levels in the autumn, had a beneficial effect on testicular function; this was reflected by changes in scrotal circumference, DSO, libido and increased T release. T secretion is believed to increase due to more LH stimulation of the Leydig cells, i.e. a shift in the pattern of release to smaller but more frequent pulses. The androgen then becomes "trapped" in the testis by being bound to ABP at the site of spermatogenesis in the seminiferous tubules and could be used in the production of new germ cells. Increases in the production of spermatozoa are reflected by enlarged testes which are evident during the breeding season (Johnson et al., 1973; Land and Sales, 1977; Lincoln and Davidson, 1977).

The results of the present study demonstrated that scrotal circumference began to increase for all breeds in June, in preparation for the autumnal mating season. Testicular size remained elevated until approximately November. Similar to the results described by Lincoln

and Peet (1977), it was speculated in this study that high FSH levels in the rams during the summer stimulate testicular growth perhaps by affecting Sertoli cell function and hence, spermatogenesis. Once the period of testicular growth was completed, a decline in circulating FSH levels was observed in all four breeds. Peak T levels coincided with maximum testicular size in all the rams, which supports the results obtained by Lincoln (1978).

Although not significantly different from the Finnsheep, the Suffolk and Dorset rams had the largest testicular sizes during the breeding season, possibly an indication of greater spermatogenesis. This may be attributed not only to greater body weights but to differences in hormone secretion and responsiveness as well. From June to December the Suffolk rams had the highest levels of FSH (except for July, significant $P<.05$), which may indicate that ABP production activity was greater in the Suffolk rams at this time than in the other rams. In addition, the Dorsets and Suffolks tended to have higher LH levels throughout the year, possibly signifying that the Leydig cells in these two breeds were being stimulated to produce more T which could be used in the maintenance of spermatogenesis. Nevertheless, the Leydig cells in the Dorset rams may have been less responsive to LH in this regard. The Dorset rams had relatively high LH levels throughout the year in comparison with rams of other breeds; however, T levels for the Dorsets were lower than those of the other breeds between August and January. One reason for this apparent inconsistency is that high mean LH levels for Dorsets were not associated with higher frequencies of LH release. LH peak frequency is known to be strongly and positively related to circulating T levels

(Sanford et al., 1977).

The DSO results from September/October and January/February assessment periods indicate that the Suffolk and Dorset rams had the highest and most comparable estimated sperm outputs. However, the Dorset rams had considerably lower serum T and significantly ($P<.05$) lower FSH levels than did the Suffolk rams throughout the summer and fall. This could signify a difference between these two breeds in testicular responsiveness to these hormones. Since the Dorset rams had lower FSH concentrations than the Suffolks, one might expect that in the Dorset, less T is bound by ABP and made available for sperm production since less ABP may be produced by Sertoli cells. One might also conclude that the Dorset ram requires less T than the Suffolk ram to maintain spermatogenesis. The observations that rams of both breeds have comparable sperm outputs, scrotal circumferences and body weights, but that the Dorset has lower serum concentrations of FSH and T raise some interesting questions for future investigation.

The negative feedback inhibition of testicular steroids upon gonadotropin secretion may be of a shorter duration in the Dorset ram than in rams of some of the other breeds. Mean LH levels in the Dorsets during January were higher relative to the other breeds (1.23±.25 ng/ml vs. <.78±.18 ng/ml) and tended to remain high and increase earlier than LH levels in the Finns and Suffolks. This occurred in the presence of T levels that were not at all dissimilar between these three breeds from March through July. The Blackface rams did exhibit a slight elevation in LH levels between January and March, but LH concentration tended to level off and remained fairly constant between March and July.

The fact that Dorset testes increase in size earlier than those of rams of the other breeds might also lead one to conclude that LH levels might be increasing earlier as well, especially since LH has been positively correlated with changes in scrotal circumference (Carr and Land, 1975).

The Scottish Blackface rams consistently had the smallest testes throughout the year. In addition, their mean concentrations of serum LH and T were lower than those for most of the other breeds of rams during the breeding season. Although scrotal circumference measurements are correlated to some extent with body weight (Braun et al., 1980), one can observe a definite breed difference in scrotal circumference between Blackface and Finn rams. Both groups of rams had similar body weights throughout the course of the study, yet the Finn rams generally had significantly ($P<.05$) larger testes. This difference in testicular size indirectly reflected differences in sperm production as indicated by the DSO estimates where the Blackface rams generally had both the lowest sperm output and the smallest testes of all the breeds. DSO and thus, sperm production may have been lower in the Blackface rams than in other rams as a result of generally lower circulating levels of some of the reproductive hormones during most of the mating season and/or a decreased responsiveness of testicular target cells to these hormones.

There were no breed differences noted in scrotal circumference on October 11, December 20 and January 10. This may have been possible because in early October, all the rams had reached their maximum testes sizes and in late December and early January the scrotal circumferences were more variable in size. Finn, Dorset and Blackface rams exhibited a slight transient increase in circumference during the winter, while

the Suffolk rams displayed a brief period of no testicular regression.

Finnish Landrace rams showed the least variability in testes size throughout the study; they exhibited only a 5.3 cm change throughout the year, compared to change of 5.7 cm, 7.4 cm, 9.0 cm for the Dorset, Suffolk and Blackface rams, respectively. This phenomenon may be related to the higher T levels for the Finn rams between August and February; levels were significantly ($P<.05$) higher for the Finns than for most of the other rams in October, December, January and February. Circulating LH levels in Finns, though not significantly different ($P>.05$) from those in other rams were not as high as in the Dorset and Suffolk rams. It is possible therefore, that the Finn testes were more responsive to LH than were the testes of other rams. This is indicated by the fact that in Finns, relatively low levels of LH were associated with comparatively high T levels during the fall and winter in comparison with most of the other breeds of rams. In May, the Finn rams had relatively high DSO (4.3×10^9 sperm/24h) in comparison with those of other breeds, although breed differences were not significant ($P>.05$). The Finn rams possibly may have had higher outputs of spermatozoa because they had significantly ($P<.05$) higher T levels for a longer duration of time preceding the May assessment period than did the other ram breeds. Schanbacher and Lunstra (1976) observed that Finn rams consistently had higher T concentrations than Suffolk rams throughout the year, with a definite breed difference occurring in January. The data from the present study is in agreement with their results.

The sex drive of rams has been demonstrated to be androgen dependent (Amir and Volcani, 1965; Knight, 1973; Schanbacher and Lunstra, 1976; and Lincoln and Davidson, 1977). During all of the libido assessment

periods in this study, the Finn rams consistently had the highest number of mates per 4h. This observation was similar to the libido data obtained by Schanbacher and Lunstra (1976) who compared Finn and Suffolk rams, and to the data of Land (1970) who compared Finn and Blackface rams. In the present study, the mating frequency of Finn rams was particularly high in November and February, compared to that of other breeds (significant, $P<.05$). The fact that Finn rams did have significantly greater ($P<.05$) T levels than rams of the other breeds during the months of October, December, January and February (i.e. during a long period of the ovine-breeding season) suggests that T may be initiating a greater response at the hypothalamic center responsible for libido in the Finn rams than in the other rams. Alternatively, T may simply be maintaining a different pattern of sexual behavior in Finn rams that was laid down genetically during fetal development.

Although there were no significant breed differences recorded in the number of mounts per mate during the 4h test period (indicative of mating efficiency) the Finn rams required fewer mounts to have a successful ejaculation. Definite seasonal trends in mounts per mate were observed in all of the rams. In November and especially in February, mating efficiency appeared to decline for the Dorset and Blackface rams. Seasonal trends for these two breeds were similar to those obtained by Pepelko and Clegg (1965) where they noted that the number of mounts increased during the nonbreeding season; a result that they attributed to a shorter sexual attention span. In this study and especially during the nonbreeding season, Blackface and Dorset rams appeared to lose interest in the ewes faster than the Finn and Suffolk rams. It must be

noted here that some rams, regardless of breed and circulating T levels were more sexually active than other rams (Table 23A). Therefore, when rams are being chosen for flock sires they should be considered not just on breed attributes but on individual attributes as well.

Changes in photoperiod are believed to indirectly affect libido of rams. As daylength shortens, circulating gonadotropin levels increase and T synthesis by the testes is stimulated. Elevated T levels are, in turn, suggested to stimulate the libido of rams (D'Occhio and Brooks, 1976; Lincoln and Davidson, 1977; Sanford et al., 1977). In this experiment no significant ($P>.05$) seasonal differences were detected in the number of mates recorded per 4h.

During the summer (July) of 1979 the number of mounts per mate and mates per 4h were relatively low. In November of that year, the middle of the fall-breeding season, both mating frequency and mounts per mate increased to some extent for most of the rams. However, mating frequency did not decrease appreciably during the nonbreeding season (June) of 1980, but mating efficiency did change by approximately 50%. As in July 1979, the rams became more efficient breeders (fewer mounts required per mate) in June of 1980. Schanbacher and Lunstra (1976) recorded a 50% decrease in mating frequency of Suffolk and Finn rams by the late spring and summer compared to the frequencies observed in the fall. Their results were not duplicated in this study in any of the breeds of sheep. The reason(s) for the absence of a decline in mating frequency during the 1980 nonbreeding season is not clear; perhaps it could be accounted for on the basis of further sexual maturation of rams.

It was noted in this study that some of the rams influenced the

mating activity of other rams in adjacent pens. For example, some rams started fights with other rams, charged fences and disrupted the mating process of neighboring rams. This was particularly noticeable for one Suffolk ram (#5) who was especially adamant towards the other rams mating ewes. In fact, following the changing of ewes between pens after 2 hours of mating during the November assessment period, this particular ram jumped a 1 m. fence to return to the ewes he was with originally. Lindsay et al. (1976) observed that dominant rams can inhibit the mating behavior of subordinate rams, without having physical contact. This was found to be true in some instances in the present study, and points out a limitation of the pen testing situation for libido assessment. A problem associated with libido testing was the fact that the rams could observe each others mating activities. To correct for this, one would have to employ higher fences than were used to block out all sight of the other animals. During the trial period prior to the first actual assessment period, partitions were used to divide the pens. It soon became obvious that this was not a good idea because the rams fought constantly. Burlap sacks were then placed over the partitions to prevent the animals from seeing each other through the wire. This reduced the number of fights considerably, but the animals still had glimpses of each other over the top of the fence.

During short days, when the circulating concentrations of LH and T increased, it was observed that the testes increased in size as well; these seasonal trends correspond to the data obtained by Sanford et al. (1974a), Carr and Land (1975), Islam and Land (1977), Land and Sales (1977) and Lincoln and Davidson (1977). As mentioned previously in

the Literature Review, seasonal changes in testicular size are believed to be an indication of seasonal trends in sperm production; sperm production in turn can be assessed indirectly by counting sperm voided in the urine of rams (Lino, 1972). During the two breeding season assessment periods (September-February) the DSO increased from 7.5±1.4 to 11.3±1.6, 5.4±1.6 to 7.0±2.2, 3.6±1.1 to 5.8±1.2, and 1.2±.4 to 2.6±.9 x 10^9 sperm cells for the Suffolk, Dorset, Finn and Blackface rams, respectively. During the spring nonbreeding season, represented by the May assessment period, DSO values (x 10^9) had dropped to 2.6±.6 for the Suffolks, 2.8±1.0 for the Dorsets, 4.3±1.5 for the Finns and .6±.3 for the Blackface rams. It would be expected that DSO would be higher at the end of the breeding season (January-February) than earlier on in the season (September). In September, prior to the peak of the mating season, the testes would not have reached their maximum spermatogenic potential (i.e. gonadal and extra-gonadal reserves would not be maximal). In January and February however, this potential would have been attained. These results closely correspond with those reported by Johnson et al. (1973) and Colas and Courot (1978). Both groups of researchers acknowledged that as the days grew longer and the environmental temperature increased, spermatogenic activity declined gradually; this trend is similar to that for DSO observed in the present study.

SUMMARY AND CONCLUSIONS

Fifteen yearling rams, three Finnish Landrace and four Suffolk, Dorset and Scottish Blackface, were studied over a 14-month period (June 1979-July 1980) to further investigate differences in reproductive traits that may or may not be influenced by the breed of the animal. The rams were bled monthly at 20-min. intervals for 8h and serum pools representing the 8-hour collection periods were assayed to assess mean LH, FSH, T and PRL concentrations. Individual serum samples collected in July, October, January and April were assayed to determine LH-profile characteristics; sera collected in October and April were assayed for T-profile characteristics. Scrotal circumference was measured every 2 weeks throughout the study. In July, November, February and June, the rams were exposed to estrual ewes for a 4-h period and libido was assessed. Since it has been reported that 90 to 95% of unejaculated sperm in rams is voided in the urine (Lino, 1972; Lino and Braden, 1972), urine was collected from the rams over 6 consecutive days in September/October, January/February and May/June to obtain an estimate of daily sperm output (DSO) from each ram.

As the rams entered the breeding season, scrotal circumference and DSO increased. Each breed displayed similar, yet different seasonal-directional changes in scrotal circumference (breed x month, $P<.01$). Dorset rams attained maximum scrotal circumference in July, 1 to 3 months earlier than the other breeds. They also maintained this maximum size for a longer period of time than did rams of the other breeds, possibly due to the relatively high LH levels exhibited by the Dorsets at this time; baseline LH levels were higher for Dorset rams in July ($P<.05$), January and April than for the other breeds. Both Suffolk and Dorset

rams tended to have larger testes throughout the year than the other breeds although testicular size for these two breeds was not always significantly ($P<.05$) different from that of the Finn rams. Suffolks and Dorsets also had the largest DSO throughout the breeding season, but only the Suffolk rams were significantly ($P<.05$) different from the Finn and Blackface rams. Although there were no significant breed differences ($P>.05$) in mean LH and PRL concentrations, both the Suffolk and Dorset rams had high LH levels throughout the year. These high LH levels may have indirectly influenced the testicular growth and DSO of these rams. FSH and T levels, which also may have influenced DSO and scrotal circumference, were different between these two breeds of rams. The Suffolk T levels were on average approximately 2 to 5 ng/ml higher than those of the Dorset rams between September and December (significant, $P<.05$, only in October); while Suffolk FSH levels were significantly ($P<.05$) higher than those of the other breeds between August and December (breed x month, $P<.01$). This suggests that the testes of the Suffolks may be more responsive to LH in the production of T by the Leydig cells than those of the Dorsets, and (or) the testes of the Dorsets may be more responsive to T and FSH than the testes of the Suffolks. One might also conclude that in Dorset rams, less T may be bound to ABP and made available for sperm production since less ABP may be produced by the Sertoli cells in response to FSH.

Throughout most of the year, Finn rams had consistently higher circulating T levels than did the other rams (significant, $P<.05$, in October, December, January and February). It is possible that the Finn testes may be more sensitive to circulating LH than those of the other breeds.

Relatively low LH levels in the Finns were capable of initiating relatively large seasonal elevations in mean T levels (up to 16.39±3.62 ng/ml) compared to the other breeds of rams. These elevated T levels were associated with a superior mating activity by the Finn rams, as well as in relatively high scrotal circumference and estimated DSO for the May/June collection period. Mating frequency was significantly ($P<.05$) higher for the Finn rams than for the other ram breeds; the Finns were also more efficient in mating than the other rams. Finn scrotal circumferences were similar to those of the Suffolk and Dorset rams, but they were appreciably larger than those of the Blackface rams even though the Finn and Blackface rams were of similar body weights.

All of the breeds exhibited similar seasonal trends in their reproductive hormone levels. Mean serum LH, FSH and T levels, as well as most LH-profile characteristics (excluding baseline levels) and T-profile characteristics were significantly ($P<.01$) higher in the late summer and fall than they were in the spring. No consistent breed differences from one month to the next were noted for hormone profile characteristics; but, a significant ($P<.05$) breed x time interaction was observed for mean LH-profile levels. Serum LH and FSH levels began to decline in August and September as mean serum T became elevated, suggesting that increased negative feedback inhibition by gonadal steroids was occurring. Serum T concentrations for the Suffolk, Dorset and Blackface rams began to decline in October. However, Blackface rams exhibited a slight rise in T concentration in November which was followed by a sharp and steady decline in concentration in December. In contrast, the Finn rams, maintained elevated T levels until December when T began to fall dramatically. All four ram breeds displayed T levels of <3 ng/ml from

March until June. In contrast, mean serum PRL levels were higher during the spring and early summer than they were during the fall and winter. Serum PRL levels began to decline in June and July, just as the serum gonadotropins were attaining peak heights. It is thought that PRL may have a role in conditioning the testes for the autumnal increase in LH and it may possibly synergize with LH to benefit testicular androgen production (Hafiez et al., 1972; Johnson et al., 1973; Thomas et al., 1976).

Seasonal-directional changes in the reproductive parameters investigated were similar for rams of all breeds; however, for many parameters, the extent and/or duration of the seasonal change varied between breeds. Each breed of ram, excluding the Scottish Blackface, appeared to excel in at least one reproductive characteristic at a certain time of the year. Therefore, based on this study, one may conclude that there is not a breed of ram which is completely reproductively superior in a certain trait at one time of year, it may not retain this status at another time of year.

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A P P E N D I X

Table 1A. Scrotal circumference measurements (cm) for individual rams

Date	Finn			Suffolk				Dorset				Blackface			
	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
June 4	32.2	27.3	30.1	29.3	31.4	29.8	31.4	30.9	29.7	30.7	32.5	23.1	23.4	23.0	24.8
18	32.7	28.3	31.3	29.2	32.5	30.0	31.2	32.1	31.1	31.5	33.6	24.4	24.9	24.1	25.6
July 3	32.8	30.0	32.8	30.8	34.5	32.4	34.1	34.5	34.0	33.6	35.8	23.9	26.8	26.7	27.3
16	33.4	30.4	32.7	31.6	34.5	33.4	35.2	35.7	34.5	33.9	36.7	24.8	27.0	27.8	28.2
31	34.7	31.6	33.3	33.9	35.4	34.1	34.8	34.8	35.5	33.7	36.5	25.7	27.2	29.0	28.7
Aug. 14	36.3	32.3	34.0	35.1	35.5	34.7	34.9	34.3	36.2	34.0	35.7	26.7	28.7	29.8	29.3
27	36.5	33.0	34.9	35.5	36.5	35.4	35.5	34.8	37.7	34.0	35.0	27.8	29.4	30.4	31.2
Sept.10	36.7	33.2	33.4	36.0	35.7	36.0	36.1	35.1	37.4	33.4	35.0	28.5	30.4	31.6	32.6
25	36.2	33.8	35.6	26.8	37.2	34.9	36.0	34.8	37.7	34.3	34.3	30.3	33.4	32.2	33.4
Oct. 11	36.4	33.5	35.3	36.1	35.0	35.0	36.0	34.4	37.2	32.1	34.6	30.6	32.2	34.1	33.3
26	35.2	33.2	35.1	36.7	36.1	35.7	36.2	34.7	37.6	34.8	33.8	30.6	32.5	32.0	32.8
Nov. 15	35.2	32.5	33.5	35.6	34.1	33.8	35.1	32.7	35.7	35.1	30.6	30.3	30.4	31.5	32.1
30	34.9	31.7	32.7	35.6	33.8	34.0	34.6	33.5	34.5	33.7	30.3	29.9	30.6	31.1	31.7
Dec. 12	33.6	30.8	32.1	33.6	32.5	33.1	34.3	31.7	33.9	33.6	28.9	27.8	28.6	30.3	30.9
20	33.4	30.7	33.1	34.1	32.7	32.2	34.4	30.1	34.2	33.5	29.8	27.9	29.2	31.3	32.0
Jan. 10	34.5	31.3	33.4	34.0	32.5	32.2	35.0	30.3	34.7	34.2	30.1	26.8	27.9	30.9	31.5
23	34.4	32.1	33.9	33.8	32.0	31.1	33.8	31.5	34.2	34.3	30.7	24.7	28.2	30.5	31.1
Feb. 6	35.0	32.8	34.1	34.5	30.4	31.1	33.4	31.6	33.9	34.4	31.7	25.7	28.4	29.0	31.0
20	32.5	31.7	33.1	31.8	28.9	30.1	30.3	31.6	31.1	32.8	31.4	24.2	27.5	28.3	28.5
Mar. 5	33.5	32.1	33.2	30.8	28.1	30.6	30.7	30.9	31.7	33.9	31.7	25.6	28.6	29.8	29.1
18	33.5	31.2	31.1	30.4	28.5	28.2	27.9	30.7	30.2	33.5	30.4	26.3	27.2	29.3	28.1
Apr. 2	32.7	30.1	30.1	30.7	28.1	29.3	29.9	29.5	30.7	32.5	30.2	24.6	25.4	28.6	27.6
17	33.8	30.1	30.6	30.3	29.9	29.6	30.4	29.3	30.0	33.3	30.3	25.2	26.1	27.1	27.7
29	32.3	29.3	30.3	30.3	29.5	28.5	29.6	29.3	30.0	32.1	30.9	25.9	26.2	27.4	27.9
May 13	32.8	26.6	30.7	30.8	30.6	28.5	28.8	31.3	32.1	33.3	33.1	27.7	27.5	28.1	28.4
28	31.2	28.3	31.8	30.2	30.6	29.0	29.9	32.2	31.6	34.7	35.6	27.6	28.4	28.4	28.6
June 11	33.2	28.4	30.9	30.1	31.4	29.9	30.6	32.6	31.1	33.8	35.4	26.4	27.7	27.7	28.6
24	33.8	29.3	32.4	30.7	32.8	29.5	32.1	30.7	32.8	29.5	32.1	34.2	34.5	34.3	35.7
July 9	34.6	30.6	32.6	31.0	34.4	31.2	33.3	34.9	35.2	34.0	36.0	28.7	31.2	29.0	31.4
22	34.4	31.1	32.6	33.0	35.5	33.4	34.0	36.4	36.5	35.2	37.1	30.3	32.3	30.1	32.2

Table 2A. Body weight measurements (kg) for individual rams

	Finn			Suffolk				Dorset				Blackface			
Date	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
June 18	50.1	46.3	44.4	69.7	65.1	64.2	67.0	57.5	57.9	67.8	63.6	36.0	37.4	40.1	39.4
July 16	52.3	52.0	50.0	74.1	72.6	69.6	73.8	60.5	62.2	69.8	64.5	37.0	41.2	42.8	42.9
Aug. 27	58.2	55.8	53.1	83.0	79.5	74.3	78.9	66.4	68.5	73.3	66.4	38.3	46.1	52.6	49.4
Sept.25	56.5	57.7	55.6	87.5	84.6	76.0	85.6	68.6	71.8	76.0	69.9	41.1	53.1	53.9	53.6
Oct. 26	62.6	57.7	55.6	88.1	85.5	76.9	85.4	68.7	72.9	77.5	70.9	43.6	53.1	56.1	55.1
Nov. 15	58.0	56.8	55.6	89.1	86.5	77.6	82.4	70.2	75.7	79.3	72.3	49.5	53.6	58.0	56.6
Dec. 12	58.9	57.0	57.0	88.6	84.6	78.7	82.9	69.2	72.8	80.4	70.1	47.4	53.6	60.8	55.1
Jan. 10	53.9	59.7	57.6	90.9	90.1	81.8	88.7	70.7	75.0	86.1	72.2	49.7	55.9	62.4	59.3
Feb. 20	59.1	59.8	59.9	94.7	91.0	84.9	90.1	71.7	77.4	86.6	74.8	52.0	56.9	66.1	61.7
Mar. 18	58.3	57.4	57.9	92.7	87.0	83.0	90.5	70.4	76.5	86.1	75.7	47.0	55.6	63.1	58.4
Apr. 18	59.1	59.5	65.6	93.8	92.4	86.0	93.6	74.5	79.1	86.8	77.8	47.7	57.8	67.2	62.7
May 12	59.6	60.1	59.1	93.9	91.4	85.2	95.4	75.0	78.6	86.4	78.1	47.5	57.7	66.6	60.9
June 11	59.8	60.6	56.9	93.4	85.8	84.1	99.3	75.8	78.6	85.2	78.6	45.7	56.8	64.8	59.2
July 22	66.0	63.7	64.2	101.8	93.6	93.2	105.2	79.6	84.3	88.1	82.5	55.5	60.1	71.9	68.6

Table 3A. Mean serum testosterone concentrations (ng/ml) for individual rams

	Finn			Suffolk				Dorset				Blackface			
Date	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
June 4/6	2.24	2.11	3.53	1.40	1.04	2.22	3.66	2.55	2.81	4.57	6.12	.37	1.04	.80	1.51
July 9/11	3.97	5.54	3.68	1.43	3.15	2.07	4.85	2.88	3.40	8.07	6.10	1.57	1.45	.37	3.85
Aug. 6/8	7.47	9.75	4.79	2.12	7.01	5.47	9.00	4.13	3.89	5.22	6.50	1.64	2.23	3.76	4.93
Sept. 10/12	19.52	15.47	3.18	10.90	16.60	11.04	14.87	7.91	5.95	7.19	10.27	3.12	8.25	13.21	12.50
Oct. 9/11	15.76	16.49	15.94	14.56	9.42	11.12	10.58	6.97	9.19	7.09	6.50	6.12	6.11	7.18	8.02
Nov. 12/14	5.56	13.17	13.28	10.14	8.91	7.10	15.45	4.83	11.04	5.64	3.85	9.24	3.45	11.45	14.33
Dec. 10/12	23.56	12.06	13.54	12.38	7.36	4.33	10.50	3.21	8.20	10.57	3.01	1.41	1.18	12.21	6.97
Jan. 14/16	11.94	11.49	12.59	4.80	1.31	3.83	4.29	3.09	4.87	4.20	1.34	1.08	.56	.60	1.64
Feb. 11/13	6.47	5.78	2.86	1.31	2.11	.85	2.89	.94	2.14	5.88	1.42	1.26	.26	1.50	2.36
Mar. 10/12	2.34	1.64	2.50	.65	1.60	1.27	3.50	1.09	2.48	3.04	1.90	1.45	1.18	3.48	4.64
Apr. 7/9	.98	1.28	2.46	1.56	2.51	.94	2.97	1.83	2.44	3.42	2.17	1.10	1.68	2.88	2.72
May 5/7	1.55	2.21	2.15	.88	.21	1.11	3.60	2.65	1.68	4.62	2.38	1.03	1.63	3.44	3.04
June 9/11	2.91	1.57	2.27	1.32	3.05	1.02	3.04	3.17	1.56	2.17	3.42	1.56	1.31	.85	2.08
July 8/9	3.77	3.49	3.85	2.10	3.94	1.99	4.10	4.72	2.28	6.86	5.47	2.25	1.36	3.00	2.79

Table 4A. Mean serum LH concentrations (ng/ml) for individual rams

	Finn			Suffolk				Dorset				Blackface			
Date	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
June 4/6	.51	1.86	.89	.45	14	5.44	4.43	1.39	3.13	5.46	4.94	.23	.55	.58	.42
July 9/11	.54	6.65	1.61	1.22	3.40	4.76	4.91	2.83	2.59	5.83	3.12	.38	1.04	1.23	1.08
Aug. 6/8	.87	4.17	1.82	.98	1.62	5.61	2.31	1.56	1.87	2.35	1.94	1.29	1.42	1.28	.80
Sept. 10/12	.69	4.14	.42	1.78	1.41	2.60	3.27	1.51	1.60	3.58	3.23	.60	1.91	2.19	2.91
Oct. 9/11	.88	2.43	1.24	1.51	.90	3.19	4.26	1.22	1.52	1.99	1.81	.60	.96	1.04	.80
Nov. 12/14	.52	2.68	1.05	1.64	1.23	3.22	2.94	2.81	1.67	1.99	1.28	.94	1.02	1.40	.74
Dec. 10/12	.50	1.80	1.15	1.60	1.44	1.21	2.75	.68	1.77	4.47	1.37	.23	.43	1.23	.88
Jan. 14/16	.57	1.29	.49	.92	.23	.48	.86	1.68	1.55	1.14	.56	1.00	.39	.45	.23
Feb. 11/13	.36	1.19	.39	.44	.70	.85	.34	1.10	3.96	.69	1.23	1.23	.23	.72	.23
Mar. 10/12	.23	.40	.30	.32	.35	1.07	1.46	.23	2.18	3.26	.77	.49	.46	1.41	.78
Apr. 7/9	.23	.45	.50	.68	.99	.90	.72	.68	1.04	3.32	2.23	.58	1.04	.94	.58
May 5/7	.23	.64	.51	.23	2.21	1.39	1.32	2.49	.94	4.34	1.77	.42	1.47	1.18	.53
June 9/11	.23	.72	1.33	.37	2.64	.82	.55	1.59	1.52	2.64	1.70	.37	1.21	.59	.83
July 8/9	.43	2.45	1.20	1.11	1.42	3.87	2.80	1.41	1.32	4.15	4.41	.39	.52	1.36	1.06

Table 5A. Mean serum FSH concentrations (ng/ml) for individual rams

	Finn			Suffolk				Dorset				Blackface			
Date	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
June 4/6	15.3	38.4	25.9	62.5	161.9	66.7	62.2	26.8	55.4	31.4	52.5	19.9	45.1	14.7	21.9
July 9/11	31.6	51.3	53.4	86.0	209.0	56.0	88.1	44.8	67.9	32.4	55.9	18.6	86.5	21.2	32.7
Aug. 6/8	91.7	94.0	72.3	145.4	136.0	156.2	124.0	54.5	55.9	15.6	44.2	20.2	106.9	9.1	17.0
Sept. 10/12	36.9	109.8	86.7	163.4	99.1	144.9	56.0	39.8	52.0	19.5	33.4	20.6	104.1	13.7	49.2
Oct. 14/16	33.7	73.6	52.8	105.7	88.1	96.1	86.2	29.7	48.6	17.2	35.1	15.3	73.5	20.8	19.3
Nov. 12/14	21.1	33.4	42.6	111.9	67.2	78.0	77.8	35.1	56.6	25.1	19.3	19.9	52.0	14.5	24.0
Dec. 10/12	24.9	38.5	28.9	92.4	85.7	67.9	94.4	24.6	65.2	25.1	53.4	3.0	42.7	18.3	38.4
Jan. 14/16	32.5	69.8	29.4	67.1	54.7	34.5	70.7	27.4	72.9	11.4	30.6	12.6	28.6	9.1	22.3
Feb. 11/13	47.5	42.4	22.4	36.9	52.0	42.6	40.4	15.4	60.2	21.9	43.5	10.7	48.2	9.2	21.4
Mar. 10/12	30.8	32.4	13.9	11.1	64.3	49.7	33.4	17.7	56.4	18.5	26.0	16.9	58.7	20.3	20.5
Apr. 7/9	17.7	15.9	35.1	13.7	52.7	42.9	28.2	16.9	27.6	17.4	46.3	11.0	65.4	24.7	27.5
May 5/7	13.0	8.5	33.3	11.9	88.5	25.6	42.1	17.5	43.2	24.8	62.2	17.1	70.1	18.6	14.4
June 9/11	19.8	17.0	34.8	11.6	119.4	22.5	29.5	37.4	39.3	19.1	55.7	14.3	65.4	14.1	12.5
July 8/9	19.8	25.8	53.7	25.2	185.4	85.5	54.3	35.6	75.9	18.9	92.6	15.4	71.0	22.2	14.3

Table 6A. Mean serum PRL concentrations (ng/ml) for individual rams

	Finn			Suffolk				Dorset				Blackface			
Date	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
June 4/6	106.1	124.1	114.1	177.0	142.5	103.5	138.8	9.0	74.7	144.7	109.0	9.0	125.7	91.8	105.9
July 9/11	71.7	114.8	135.4	120.6	109.4	128.1	142.4	9.0	69.6	143.8	82.1	14.2	154.2	94.5	143.2
Aug. 6/8	49.1	62.3	73.2	119.7	133.7	73.0	68.7	9.0	50.6	57.6	32.5	9.0	121.3	53.9	118.6
Sept. 10/12	28.3	26.0	33.0	67.4	113.0	26.9	27.9	9.2	45.0	26.2	29.8	9.0	74.5	24.5	69.7
Oct. 9/11	19.7	26.9	21.3	26.4	24.0	26.2	24.0	27.3	25.9	33.9	26.7	25.3	24.2	22.5	28.3
Nov. 12/14	20.0	24.4	22.9	24.7	24.2	23.8	23.3	27.4	25.3	27.6	28.2	29.4	24.8	23.2	26.2
Dec. 10/12	18.3	25.0	24.6	24.2	23.0	23.6	30.2	34.1	26.7	25.8	28.7	25.5	28.7	23.6	28.5
Jan. 14/16	20.1	27.2	22.6	25.0	24.4	24.7	28.7	31.4	28.9	25.2	27.8	9.0	27.2	24.0	26.6
Feb. 11/13	18.4	24.8	23.0	26.8	26.0	23.8	29.3	28.5	27.2	27.9	26.3	10.0	25.6	26.4	29.8
Mar. 10/12	19.3	24.2	22.2	23.3	23.7	31.0	29.2	33.1	25.7	39.9	31.3	26.8	24.6	24.8	40.5
Apr. 7/9	21.9	39.6	31.1	80.4	43.2	78.8	71.8	9.0	76.8	76.8	51.4	15.0	46.5	41.7	91.3
May 5/7	26.6	47.8	54.6	39.7	24.3	88.6	95.6	12.3	30.1	105.7	69.6	35.6	29.0	55.3	106.1
June 9/11	74.2	65.3	88.7	124.2	57.2	88.5	110.4	9.0	76.5	117.7	83.2	105.2	133.5	83.2	141.9
July 8/9	79.4	149.1	145.1	117.4	83.1	234.9	34.8	9.0	77.2	293.5	220.5	85.8	124.0	195.8	330.1

Table 7A. Serum LH and testosterone profiles for Finn Ram #2

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.37	1.13	.27	.11	10.20	.70
2	.31	.57	.33	.11	20.20	1.10
3	.19	.37	2.27	.11	15.30	.80
4	.15	1.07	1.49	.11	13.60	.80
5	.14	1.10	.91	.11	15.00	.90
6	.14	.82	.53	.11	16.90	.50
7	.14	.60	.43	.15	16.10	.40
8	.14	.55	.33	.15	11.70	.60
9	.14	.57	.23	.11	7.80	.80
10	.14	.27	.14	.16	2.30	.90
11	.14	1.65	.14	.11	3.90	.70
12	.14	1.17	.14	.21	9.50	.70
13	.14	.92	.14	.12	21.40	.70
14	.14	.44	.26	.12	27.10	.70
15	6.17	.36	.14	.25	18.40	.80
16	4.02	1.79	1.85	.11	8.40	.70
17	2.03	.98	.90	.14	9.70	.70
18	1.14	.79	.49	.29	18.70	.70
19	.66	.64	.30	.11	15.00	.70
20	.29	.45	.33	.11	11.80	.60
21	.39	2.02	1.24	.74	8.70	.30
22	.14	1.36	.76	.18	17.00	.30
23	.14	.74	.52	.19	18.20	.30
24	.14	.62	.39	.27	20.20	.20
Level:						
mean	.73	.87	.61	.11	14.10	.79
baseline	.14	.36	.24	.11	8.25	.70
Peak:						
frequency	1	5	3	0	5	0
height	6.17	1.54	1.79	-	20.64	-
Δ value	6.03	1.18	1.55	-	12.37	-

Table 8A. Serum LH and testosterone profiles for Finn ram #3

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	11.78	1.58	.14	.22	33.0	.80
2	4.90	.75	.14	.16	19.60	.80
3	3.04	.89	.55	.25	13.80	.80
4	2.14	.97	4.01	.12	8.80	.80
5	1.18	1.10	1.39	.11	7.70	.80
6	.87	1.03	.76	.11	6.50	.80
7	.90	4.37	.34	.11	6.30	.80
8	9.50	3.56	.53	.11	43.00	.80
9	3.84	2.35	.53	.11	35.90	.80
10	2.18	1.41	.36	.11	38.50	.80
11	1.10	1.49	.19	.22	15.90	.80
12	1.00	1.12	.17	.11	9.60	.80
13	.75	8.75	.14	.11	7.90	.80
14	.62	3.63	.14	.27	19.60	.80
15	.42	1.65	.29	.16	29.50	1.00
16	.55	1.44	.14	.11	22.60	1.50
17	.79	1.20	.14	.11	14.40	1.50
18	10.24	3.24	.20	.21	14.80	.90
19	3.59	1.58	.30	.11	14.30	.80
20	2.71	1.11	1.64	.19	10.30	2.20
21	1.60	.69	1.05	1.11	8.00	2.90
22	24.87	.38	.85	.55	17.70	7.60
23	8.59	4.66	.46	.55	17.00	8.90
24	4.96	2.37	.50	.44	9.90	9.80
Level:						
mean	4.26	2.14	.62	.24	17.72	2.0
baseline	.96	.79	.14	.11	7.40	.80
Peak:						
frequency	4	4	2	1	4	1
height	14.10	5.26	2.83	1.11	30.08	9.80
Δ value	13.23	4.47	2.69	1.00	22.68	9.00

Table 9A. Serum LH and testosterone profiles for Finn ram #4

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	3.65	1.75	.14	.11	29.30	.90
2	2.40	1.00	.14	.11	28.20	.80
3	1.39	3.24	.51	.11	27.20	.50
4	.85	1.79	.85	.11	35.30	.30
5	.48	1.03	.33	.11	26.30	.60
6	.54	.90	.20	.11	20.10	.90
7	.37	.90	.14	.11	10.90	.80
8	.33	3.05	.14	.11	9.80	1.00
9	.27	2.18	.14	.11	22.10	1.20
10	.34	1.24	.14	.11	29.10	.80
11	.34	1.08	.14	.11	22.50	1.20
12	.46	.90	.14	.11	15.00	.90
13	.65	.90	.14	.11	8.70	.70
14	7.58	5.36	.14	1.70	6.80	1.30
15	3.79	2.97	.14	.67	29.40	1.70
16	2.27	1.71	.14	.42	35.80	5.00
17	1.01	.90	.14	.11	23.00	6.80
18	.81	.90	.14	.11	13.70	6.00
19	.49	.90	1.74	.11	11.30	6.40
20	.42	4.37	.81	.11	7.40	4.20
21	.30	3.40	.75	.11	19.90	2.40
22	3.97	2.60	.24	.11	25.90	1.70
23	2.83	1.40	.14		22.40	1.30
24	.99	1.30	.16	.11	19.30	.80
Level:						
mean	1.52	1.91	.32	.21	20.81	2.00
baseline	.29	.90	.14	.11	8.37	.85
Peak:						
frequency	3	4	2	1	4	1
height	5.07	4.00	1.30	1.70	31.53	6.80
Δ value	4.71	3.10	1.16	1.59	23.16	5.95

Table 10A. Serum LH and testosterone profiles for Suffolk ram #5

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	1.50	.49	.80	.47	4.80	.90
2	1.21	2.92	.67	.40	11.30	.90
3	.64	1.71	1.08	.28	15.90	.80
4	.74	1.35	.32	.11	16.00	.90
5	.66	1.07	.38	.11	9.00	.80
6	.40	.93	.31	.11	7.50	.80
7	.39	.60	.29	.11	6.40	.90
8	.32	.41	.38	.11	5.20	1.10
9	.34	2.74	.42	.11	13.60	.90
10	.34	1.72	.41	.11	17.40	1.00
11	.24	1.13	.89	.19	13.10	2.60
12	.14	.72	.67	.23	6.40	4.00
13	.23	.75	.42	3.19	9.20	5.50
14	.14	1.79	.62	3.28	5.30	9.10
15	.25	1.40	.55	1.43	16.70	6.40
16	.14	1.25	.75	.97	25.80	10.20
17	.20	.53	1.45	.81	21.90	10.50
18	.14	.70	.87	.55	12.00	8.70
19	7.03	2.23	.54	.40	9.30	7.00
20	4.65	1.38	.99	.19	18.10	4.80
21	3.90	1.05	1.85	.19	22.10	2.20
22	2.15	.66	3.40	.11	17.90	3.10
23	1.01	.52	2.91	.11	13.70	1.40
24	1.08	.28	3.13	.11	10.20	2.70
Level:						
mean	1.16	1.18	1.00	.57	12.87	3.63
baseline	.14	.55	.48	.11	6.96	.95
Peak:						
frequency	1	4	4	1	4	1
height	7.03	2.42	1.71	3.28	20.32	10.50
Δ value	6.85	1.87	1.23	3.17	13.36	9.55

Table 11A. Serum LH and testosterone profiles for Suffolk ram #6

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.14	.17	.14	.31	.10	.70
2	.14	.24	.14	.11	.10	.40
3	4.52	.44	.14	.52	.10	.50
4	4.22	.54	.14	.47	.10	1.00
5	16.50	2.15	.14	.11	9.20	1.10
6	7.06	1.00	.14	.62	14.80	.70
7	5.83	.87	.14	1.27	14.20	.40
8	4.73	1.25	.14	.40	16.70	.90
9	2.82	.93	.14	.29	9.70	2.10
10	1.52	.65	.14	.49	7.10	2.50
11	1.35	.58	.14	.28	2.80	1.60
12	.83	5.40	.14	.21	8.70	1.50
13	.42	2.50	.14	8.29	12.40	.90
14	.42	1.26	.14	5.40	13.10	3.80
15	.44	.87	.14	2.51	8.80	5.40
16	.14	.42	.14	1.76	4.80	6.00
17	.24	.33	.14	.25	2.40	4.80
18	.21	.48	.22	.52	4.80	3.80
19	14.29	.19	.22	.49	.10	2.70
20	7.72	.24	.14	.36	.10	1.00
21	4.17	.24	.14	.22	1.10	1.00
22	2.51	.21	.14	.11	3.00	1.00
23	1.49	.89	.35	.23	3.50	1.30
24	1.29	.69	.55	.20	10.80	.70
Level:						
mean	3.46	.94	.17	1.06	6.19	1.91
baseline	.14	.43	.17	.16	.56	.83
Peak:						
frequency	2	4	0	2	2	2
height	15.45	2.03	-	4.78	14.90	.96
Δ value	15.31	1.60	-	4.62	14.34	.13

Table 12A. Serum LH and testosterone profiles for Suffolk ram #7

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.22	4.18	.14	.35	6.40	4.20
2	.17	2.70	.14	.11	7.40	3.90
3	2.23	2.44	.14	.21	7.00	1.90
4	16.76	2.07	.14	.11	9.90	1.10
5	5.26	1.90	.14	.11	7.10	.80
6	6.14	7.92	.14	.11	7.70	1.20
7	2.80	6.03	.45	.11	18.80	.80
8	1.75	4.40	.23	.14	24.70	.80
9	1.06	3.56	.32	.20	36.30	.80
10	.87	2.85	.30	.18	22.00	.80
11	.68	3.08	.25	.11	15.00	1.00
12	.53	8.68	.14	.11	14.70	.80
13	.38	4.94	.14	.11	34.30	.80
14	.22	5.06	.14	.11	24.90	.80
15	.19	3.43	.14	.11	19.90	.80
16	.52	6.48	.14	.11	15.40	.80
17	6.24	5.53	.14	.11	18.50	.80
18	5.38	4.02	.14	.11	22.00	.80
19	2.46	3.23	.14	.11	17.00	.80
20	2.73	6.11	.14	.42	12.30	.80
21	1.80	4.61	.14	.34	15.10	.80
22	4.12	3.36	.14	1.21	14.40	2.00
23	2.86	2.70	.14	.66	12.40	4.10
24	1.40	2.55	.14	.51	13.90	5.60
Level:						
mean	2.78	4.24	.18	.24	16.56	1.51
baseline	.72	3.17	.18	.11	11.43	.85
Peak:						
frequency	3	4	0	1	5	1
height	9.04	7.30	-	1.21	23.52	5.60
Δ value	8.39	4.13	-	1.10	12.09	4.75

Table 13A. Serum LH and testosterone profiles for Suffolk ram #8

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.45	2.76	.14	.75	13.50	4.50
2	.32	1.70	.18	.43	11.70	5.80
3	.36	1.22	.66	.41	15.50	4.80
4	11.60	.90	.37	.51	16.10	4.50
5	4.32	.59	.41	.22	12.50	4.50
6	2.90	.75	.14	.25	8.80	4.30
7	1.44	2.43	.14	.49	6.10	2.70
8	1.18	1.62	.15	.16	17.50	3.00
9	.86	1.17	.89	.17	23.80	2.50
10	.66	.95	.38	.17	19.00	2.10
11	.39	1.31	.25	.11	14.30	1.40
12	.70	1.64	.14	.11	9.60	.80
13	10.89	1.51	.14	.11	21.80	.90
14	8.09	.75	.14	.11	23.60	1.20
15	3.65	.92	.14	.11	21.50	1.00
16	2.82	1.23	.22	.11	16.10	.70
17	1.38	1.16	.14	.11	14.40	.60
18	1.19	.88	.14	.11	21.80	.70
19	.72	1.65	.14	.11	17.20	.60
20	.54	2.52	.14	.11	13.90	.70
21	1.10	1.32	.14	.12	16.70	.60
22	4.13	.97	.22	.45	25.40	1.20
23	9.05	.96	.55	.44	28.20	1.10
24	4.55	.66	.24	.39	17.10	1.10
Level:						
mean		1.32	.26	.25	16.92	2.14
baseline	.42	.79	.14	.11	1.11	.86
Peak:						
frequency	3	5	3	0	5	1
height	10.51	2.12	.70	-	22.70	5.80
Δ value	10.09	1.33	.56	-	21.59	4.94

Table 14A. Serum LH and testosterone profiles for Dorset ram #9

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.40	.41	.14	.11	8.60	3.90
2	.46	.39	.14	.11	5.40	2.80
3	.28	.33	.21	.29	4.70	2.40
4	1.75	.33	.14	.16	3.50	3.40
5	8.21	.43	.14	2.12	2.50	4.20
6	10.37	.70	.14	2.98	2.40	7.50
7	3.07	.42	.14	1.16	5.80	10.40
8	2.20	.37	.21	.86	2.80	11.70
9	1.58	.44	.24	.40	3.80	11.00
10	1.19	.42	.20	.80	3.10	12.20
11	.95	.70	.22	.63	3.70	11.60
12	.73	.82	.21	.41	4.00	9.30
13	.63	1.25	.22	.30	6.30	6.90
14	29.56	3.61	3.87	.11	11.20	5.50
15	14.78	1.31	2.26	.11	14.50	4.00
16	6.14	1.54	7.24	.11	19.20	4.00
17	3.83	1.19	4.69	.11	12.80	2.20
18	1.76	1.25	5.82	.11	12.90	1.90
19	1.21	1.34	2.30	.11	11.00	1.30
20	1.05	1.29	3.01	.11	7.10	1.10
21	.90	8.02	10.00	.11	6.80	1.40
22	.75	2.66	4.25	.11	10.80	1.70
23	.52	2.30	2.11	.11	17.90	1.40
24	.47	1.82	1.51	.11	16.40	1.70
Level:						
mean	5.46	1.39	2.06	.46	8.22	5.15
baseline	.46	.76	1.07	.11	3.62	1.79
Peak:						
frequency	2	2	4	1	2	1
height	19.97	5.82	6.73	2.98	18.55	12.20
Δ value	19.31	5.06	5.66	2.87	14.93	10.41

Table 15A. Serum LH and testosterone profiles for Dorset ram #10

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	1.34	.31	.52	.40	2.80	.40
2	1.08	1.15	.60	.38	3.30	.30
3	9.84	1.02	.57	.50	2.70	.40
4	3.60	9.58	5.58	.30	12.70	.40
5	2.46	3.05	3.88	2.65	46.00	.50
6	1.67	2.16	2.55	1.67	22.90	2.60
7	1.21	1.21	1.35	1.56	14.50	3.90
8	.90	.65	.95	12.26	17.20	5.00
9	.50	.82	.77	5.46	5.10	7.80
10	.68	.92	.53	2.74	8.00	8.60
11	.54	.79	.56	3.47	4.70	7.10
12	.83	.62	.53	1.90	20.40	7.40
13	.24	4.19	.61	1.26	22.30	6.40
14	11.70	2.53	.21	1.28	28.50	3.40
15	3.85	.49	.41	.79	16.10	1.70
16	3.28	.88	3.58	.79	10.90	3.00
17	2.09	.86	1.60	.56	9.40	1.10
18	1.43	.70	.93	.59	2.00	1.00
19	14.90	.77	1.14	.33	.90	1.00
20	6.34	.70	3.93	.38	1.10	.60
21	5.70	.64	2.19	.28	.90	.20
22	1.47	1.82	1.32	.34	8.10	.60
23	.60	3.47	1.01	.30	16.00	.30
24	.69	1.90	.90	.40	23.80	.30
Level:						
mean	3.21	1.72	1.51	1.69	12.45	2.67
baseline	.92	.47	.55	1.53	2.77	.40
Peak:						
frequency	3	4	3	3	2	1
height	12.15	5.75	4.36	6.13	26.38	8.60
Δ value	11.23	5.28	3.81	4.60	23.61	8.20

Table 16A. Serum LH and testosterone profiles for Dorset ram #11

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	3.09	.43	.57	.29	1.70	1.50
2	1.32	.21	.66	.20	2.50	1.40
3	7.51	1.21	.79	.49	3.40	1.20
4	2.38	.72	.36	.63	7.50	.80
5	2.17	.91	5.53	7.19	9.80	1.60
6	1.34	2.03	3.28	5.34	9.00	3.70
7	14.78	1.48	1.92	2.64	11.50	7.70
8	13.31	.60	.41	1.32	11.30	8.90
9	6.65	.51	.14	1.16	7.80	8.00
10	4.61	6.17	6.08	.80	5.80	5.10
11	2.39	5.83	2.15	.62	4.60	4.20
12	2.32	.42	1.55	.51	5.00	2.80
13	1.23	.70	6.79	7.66	6.80	1.70
14	21.49	.73	4.50	9.03	8.00	3.20
15	10.69	.44	.14	3.98	7.80	5.60
16	8.09	.47	.14	2.03	7.60	8.00
17	26.82	.50	.14	1.63	4.40	6.50
18	13.41	.40	1.01	.86	4.10	6.50
19	9.35	.70	.71	.92	3.30	5.70
20	8.33	.53	.40	.48	6.10	1.80
21	18.30	.53	.34	.32	5.10	2.60
22	9.15	.18	.30	.34	4.50	2.70
23	13.01	.35	.19	.62	8.60	1.50
24	7.83	.34	.21	.34	3.80	1.30
Level:						
mean	10.79	1.10	1.60	2.06	6.25	3.92
baseline	4.91	.41	.21	.36	3.53	1.42
Peak:						
frequency	6	4	3	2	4	2
height	16.99	2.53	6.13	8.11	8.55	8.45
Δ value	11.36	2.11	5.92	7.75	5.02	7.03

Table 17A. Serum LH and testosterone profiles for Dorset ram #12

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.28	.96	.44	.38	11.30	2.50
2	.35	1.32	.24	.23	7.10	1.70
3	.33	1.56	.14	.11	5.90	1.00
4	.35	.70	.35	.12	5.40	1.00
5	8.77	.70	.14	.30	8.00	1.00
6	6.57	.65	.14	.23	9.50	1.00
7	3.47	.72	.14	.11	6.20	.80
8	1.96	1.42	.22	.12	3.80	1.00
9	1.44	1.49	.14	.31	4.00	.50
10	10.18	.71	.22	9.15	5.20	.10
11	6.79	.84	.14	3.05	8.90	.40
12	6.52	1.05	.14	1.58	5.50	2.40
13	4.48	1.40	.14	.85	4.60	2.50
14	2.14	.81	.14	.60	4.10	1.80
15	1.57	1.34	.14	.39	3.40	1.50
16	1.05	1.29	.14	.26	3.80	1.20
17	.76	1.05	.14	.18	5.00	1.10
18	.86	.59	.14	.17	9.20	.70
19	.54	.65	.56	.28	15.20	1.10
20	.58	1.35	.47	7.36	9.50	.50
21	4.40	2.15	.22	7.26	8.40	1.50
22	2.30	.95	.41	3.39	12.10	5.20
23	1.99	.68	5.27	1.80	13.10	6.20
24	1.76	.36	2.81	1.34	12.50	6.30
Level:						
mean	2.89	1.03	.54	1.65	7.57	1.79
baseline	.75	.74	.14	.14	5.00	.79
Peak:						
frequency	3	5	1	2	4	2
height	7.78	1.59	5.27	7.36	11.68	4.40
Δ value	6.93	.85	5.13	7.22	6.68	3.61

Table 18A. Serum LH and testosterone profiles for Blackface ram #13

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.14	.64	.25	.11	7.20	1.30
2	.14	.50	.70	.11	5.10	1.70
3	.14	.47	.61	.11	5.30	.80
4	.14	.54	.21	.11	2.80	1.00
5	.14	.80	.25	.11	2.50	.90
6	.14	.59	.14	.11	3.20	1.40
7	.14	1.23	.14	.11	4.60	1.50
8	.14	.83	.14	.11	6.80	.90
9	.14	.56	.14	.11	11.60	.60
10	.14	.34	.14	.11	8.80	.60
11	.14	.92	.14	.11	7.30	1.00
12	4.35	.60	.14	.11	7.70	.60
13	3.66	1.47	.14	.11	8.40	.90
14	3.23	.44	.14	.11	7.40	.70
15	1.64	.43	.14	.11	8.80	.70
16	1.22	.23	.14	.11	9.70	1.10
17	.94	.25	.14	.11	6.70	1.30
18	.53	.67	.14	.78	3.50	.30
19	.28	.44	.14	.45	3.60	.40
20	.17	.32	.14	1.87	6.40	2.50
21	.14	.33	.14	1.02	5.60	5.20
22	.14	.19	1.07	.65	5.70	6.70
23	.14	.30	.55	.71	4.00	7.50
24	.14	.42	1.96	1.14	2.50	6.50
Level:						
mean	.76	.56	.33	.35	6.05	1.92
baseline	.14	.41	.31	.28	3.65	.93
Peak:						
frequency	1	4	3	2	3	1
height	4.35	1.07	1.24	1.33	9.23	7.50
Δ value	4.21	.66	.93	1.05	5.58	6.57

Table 19A. Serum LH and testosterone profiles for Blackface ram #14

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.91	1.17	.81	.34	.10	.20
2	.65	.45	.14	.35	.10	.20
3	.53	.53	.14	.51	.10	.10
4	.47	.52	.14	.57	.10	.10
5	.49	1.33	.14	.81	10.10	.10
6	.28	1.53	.14	1.01	15.70	.10
7	.49	1.26	.14	.87	6.10	.30
8	.32	.89	.14	.63	11.50	.10
9	.45	.65	.14	.73	9.60	.80
10	.36	.51	.14	.97	5.60	.30
11	.42	.62	.14	.96	1.50	.80
12	6.82	.45	.14	.97	.10	.70
13	4.22	.66	.14	.98	1.30	.90
14	2.82	.63	.14	4.76	.90	2.50
15	1.61	.36	.14	2.37	.10	2.60
16	1.30	.49	.14	1.76	.10	4.10
17	.94	.35	.18	1.33	.10	4.20
18	.69	.54	.54	1.18	.10	4.20
19	.36	1.96	.67	.91	10.80	2.20
20	.60	1.87	.77	.90	19.10	2.40
21	.40	.90	2.19	.78	21.80	.40
22	.41	.58	1.34	.61	29.20	.50
23	.54	.39	1.02	.61	18.40	.40
24	.35	.61	.78	.75	10.90	.10
Level:						
mean	1.10	.80	.43	1.07	7.28	1.00
baseline	.32	.40	.14	.49	.77	.22
Peak:						
frequency	1	3	1	2	3	1
height	6.82	1.55	2.19	2.89	18.8	4.20
Δ value	6.50	1.15	2.05	2.40	18.30	3.98

Table 20A. Serum LH and testosterone profiles for Blackface ram #15

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.26	2.90	.14	.78	20.20	8.10
2	.14	1.76	.16	1.20	23.60	8.30
3	.14	1.29	.14	1.18	17.90	8.00
4	.14	1.45	.14	.60	10.80	8.40
5	.14	.90	.14	.15	6.10	7.40
6	8.59	1.20	.14	.11	5.10	6.10
7	4.39	.90	.14	.15	4.10	3.40
8	1.63	.90	.14	.11	2.70	2.30
9	.87	1.07	.14	.11	4.40	1.00
10	.63	1.51	.14	.11	4.20	.80
11	.46	4.94	.14	.11	5.10	.80
12	.29	2.82	.14	.11	20.00	1.00
13	.26	1.78	.14	.11	23.40	.80
14	.20	1.42	.14	.11	21.80	.80
15	.29	2.34	.14	.11	11.30	1.00
16	.18	2.01	.14	.11	6.80	.80
17	3.42	1.67	.14	.11	2.30	.80
18	2.50	1.40	.14	.11	19.40	.80
19	1.22	1.51	.14	.18	30.60	.80
20	.71	2.82	.14	.11	8.90	.90
21	.55	1.69	.14	.46	19.80	1.40
22	.36	.90	.14	.41	13.10	1.00
23	.33	.90	.14	.89	13.00	1.40
24	.32	.90	.14	.56	10.90	3.10
Level:						
mean	.96	1.71	.14	.35	12.73	2.88
baseline	.16	1.03	.14	.45	4.43	.94
Peak:						
frequency	2	3	0	2	4	1
height	6.01	3.37	-	1.05	24.35	8.40
Δ value	5.78	2.34	-	.60	19.92	7.46

Table 21A. Serum LH and testosterone profiles for Blackface ram #16

	LH				Testosterone	
Sample	July	October	January	April	October	April
1	.14	1.07	.14	.41	14.90	6.40
2	.16	.90	.14	.16	9.00	6.70
3	.14	.90	.14	.11	8.00	6.00
4	.14	.90	.14	.11	4.80	3.90
5	.14	.90	.14	.11	4.00	1.80
6	1.70	.90	.14	.11	2.60	1.40
7	1.68	.90	.14	.11	3.90	1.40
8	.99	.90	.14	.11	4.60	.90
9	3.58	1.14	.14	.11	9.20	.90
10	1.61	.90	.14	.11	23.50	.60
11	1.03	.90	.14	.11	18.90	.70
12	.86	.90	.14	.11	17.90	.50
13	.82	1.76	.14	.11	12.40	.40
14	.63	.90	.14	.11	17.80	.10
15	.42	2.06	.14	.11	20.50	.50
16	.32	.90	.14	.11	30.90	.50
17	.91	.90	.14	.11	24.80	.30
18	.73	.90	.14	.11	18.80	.20
19	.27	3.05	.14	.11	13.70	.60
20	.38	1.68	.14	.11	29.20	.70
21	2.07	1.16	.14	.18	19.70	.80
22	1.21	.90	.14	1.46	11.00	.60
23	.60	.90	.14	1.31	8.20	1.50
24	.65	.90	.14	1.07	5.20	3.90
Level:						
mean	.88	1.13	.14	.27	13.90	1.72
baseline	.43	.90	.14	.11	6.97	.50
Peak:						
frequency	4	3	0	1	3	1
height	2.07	2.29	-	1.46	27.89	6.70
Δ value	1.54	1.39	-	1.35	20.90	6.20

Table 22A. Daily sperm output (x 10^9) for individual rams

Assessment period	Finn			Suffolk				Dorset				Blackface			
	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
Sept. 12-Oct. 19	5.36	1.60	3.79	9.01	4.91	5.35	10.60	5.27	6.86	.97	8.52	.19	.77	1.92	1.93
Jan. 16-Feb. 9	7.49	3.41	6.44	13.63	14.51	8.55	8.64	6.38	3.39	13.35	4.70	1.55	1.11	4.86	3.00
May 13-June 4	6.73	1.63	4.43	2.42	1.41	2.46	4.24	5.38	1.95	.49	3.22	.89	.24	1.29	.13

Table 23A. Libido characteristics for individual rams

Assessment period		Finn			Suffolk				Dorset				Blackface			
		R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16
July 4-20	Mates/4h	15	14	10	7	9	2	10	11	11	11	6	6	1	15	0
	Mounts/mate	2.2	1.5	4.2	1.9	2.4	5.5	2.1	1.9	1.6	3.7	2.5	3.2	1.5	6.2	0
Nov. 1 & 2	Mates/4h	16	27	27	10	10	6	14	16	3	12	9	16	11	6	0
	Mounts/mate	3.8	1.9	2.7	2.1	3.5	5.3	4.2	6.1	5.7	5.6	4.0	6.8	2.9	22.5	0
Feb. 18-20	Mates/4h	23	27	23	16	8	12	9	6	7	10	6	6	7	20	10
	Mounts/mate	4.5	1.6	5.0	1.4	3.9	3.0	6.7	11.5	6.0	4.7	9.7	8.7	4.3	7.3	5.9
June 5 & 6	Mates/4h	18	13	36	7	4	5	13	10	4	12	10	10	9	24	8
	Mounts/mate	1.3	1.4	1.2	1.9	1.8	3.4	2.2	1.3	6.3	2.7	3.0	3.5	1.4	4.2	3.3

Table 24A. Mean scrotal circumference

Analysis of variance

Source	df	SS	MS	F
Mean	1	4479.28	4479.28	
Breed (B)	3	13.95	4.65	15.44**
Error	11	3.31	.30	
Time (T)	29	12.66	.44	36.26**
TxB	87	5.50	.06	5.25**
Error	319	3.84	.01	

**P<.01

Table 25A. Mean body weight

Analysis of variance

Source	df	SS	MS	F
Mean	1	4549497.10	4549497.10	
Breed (B)	3	172254.40	57418.13	44.44**
Error	11	14211.29	1291.94	
Time (T)	13	37684.35	2898.80	148.41**
TxB	39	2666.60	68.37	3.50**
Error	143	2793.20	19.53	

**P<.01

Table 26A. Mean serum LH concentration

Analysis of variance

Source	df	SS	MS	F
Mean	1	472.94	472.94	
Breed (B)	3	56.91	18.97	2.50
Error	11	83.44	7.59	
Time (T)	13	65.43	5.03	6.94**
TxB	39	37.57	.96	1.33
Error	143	103.69	.73	

**P<.01

Table 27A. Mean serum T concentration

Analysis of variance

Source	df	SS	MS	F
Mean	1	5357.59	5357.59	
Breed (B)	3	275.69	91.90	4.24*
Error	11	238.35	21.67	
Time (T)	13	2315.97	178.15	33.38**
TxB	39	585.83	15.02	2.81**
Error	143	763.20	5.34	

*P<.05
**P<.01

Table 28A. Mean serum prolactin concentration

Analysis of variance

Source	df	SS	MS	F
Mean	1	688792.33	688792.33	
Breed (B)	3	7561.86	2520.62	.45
Error	11	62307.20	5664.29	
Time (T)	13	287433.21	22110.25	21.35**
TxB	39	35158.95	901.51	.87
Error	143	148107.93	1035.72	

**P<.05

Table 29A. Mean serum FSH concentration

Analysis of variance

Source	df	SS	MS	F
Mean	1	441177.22	441177.22	
Breed (B)	3	69633.62	23211.21	5.03*
Error	11	50784.96	4616.81	
Time (T)	13	42205.76	3246.60	7.57*
TxB	39	37077.55	950.71	2.22*
Error	143	61350.71	429.03	

*P<.05
**P<.01

Table 30A. Serum LH-profile characteristics; mean levels

Analysis of variance

Source	df	SS	MS	F
Mean	1	100.70	100.70	
Breed (B)	3	31.43	10.48	6.68**
Error	11	17.26	1.57	
Time (T)	3	48.35	16.12	13.76**
TxB	9	23.93	2.66	2.27*
Error	33	38.64	1.17	

*P<.05
**P<.01

Table 31A. Serum LH-profile characteristics; baseline levels

Analysis of variance

Source	df	SS	MS	F
Mean	1	11.68	11.68	
Breed (B)	3	3.96	1.32	5.63*
Error	11	2.58	.23	
Time (T)	3	1.81	.60	1.36
TxB	9	3.14	.35	.78
Error	33	14.71	.45	

*P<.05

Table 32A. Serum LH-profile characteristics; peak frequency

Analysis of variance

Source	df	SS	MS	F
Mean	1	.65	.65	
Breed (B)	3	.01	.004	1.79
Error	11	.03	.002	
Time (T)	3	.11	.037	13.83**
TxB	9	.02	.002	.76
Error	33	.09	.003	

**P<.01

Table 33A. Serum LH-profile characteristics; peak height

Analysis of variance

Source	df	SS	MS	F
Mean	1	666.39	666.39	
Breed (B)	3	191.09	63.70	8.25*
Error	7	54.05	7.72	
Time (T)	3	304.74	101.58	16.68**
TxB	9	72.30	8.03	1.32
Error	21	127.89	6.09	

*P<.05
**P<.01

Table 34A. Serum LH-profile characteristics; delta values

Analysis of variance

Source	df	SS	MS	F
Mean	1	543.05	543.05	
Breed (B)	3	149.49	49.83	7.74**
Error	7	45.08	6.44	
Time (T)	3	256.79	85.60	14.74**
TxB	9	45.44	5.05	.87
Error	21	121.92	5.81	

*P<.05
**P<.01

Table 35A. Serum testosterone-profile characteristics; mean levels

Analysis of variance

Source	df	SS	MS	F
Mean	1	16.65	16.65	
Breed (B)	3	.70	.23	1.63
Error	9	1.28	.14	
Time (T)	1	8.37	8.37	50.58**
TxB	3	.61	.20	1.22
Error	9	1.45	.16	

*P<.01

Table 36A. Serum testosterone-profile characteristics; baseline levels

Analysis of variance

Source	df	SS	MS	F
Mean	1	3.08	3.08	
Breed (B)	3	.13	.04	.72
Error	11	.67	.06	
Time (T)	1	2.04	2.04	31.21**
TxB	3	.12	.04	.60
Error	11	.72	.07	

**P<.01

Table 37A. Serum testosterone-profile characteristics; peak frequency

Analysis of variance

Source	df	SS	MS	F
Mean	1	.195	.195	
Breed (B)	3	.007	.002	3.30
Error	10	.007	.001	
Time (T)	1	.043	.043	36.80**
TxB	3	.010	.004	2.98
Error	10	.011	.001	

**P<.01

Table 38A. Serum testosterone-profile characteristics; peak height

Analysis of variance

Source	df	SS	MS	F
Mean	1	72.33	72.33	
Breed (B)	3	1.63	.54	.33
Error	10	16.26	1.63	
Time (T)	1	22.22	22.22	14.21**
TxB	3	.69	.23	.15
Error	10	15.63	1.56	

**P<.01

Table 39A. Serum testosterone-profile characteristics; delta values

Analysis of variance

Source	df	SS	MS	F
Mean	1	46.72	46.72	
Breed (B)	3	1.49	.50	.34
Error	10	14.45	1.45	
Time (T)	1	11.27	11.27	8.40*
TxB	3	.67	.22	.17
Error	10	13.41	1.34	

*P<.05

Table 40A. Mates per 4h

Analysis of variance

Source	df	SS	MS	F
Mean	1	8484.94	8484.94	
Breed (B)	3	1312.96	437.65	9.36**
Error	11	514.44	46.77	
Time (T)	3	200.93	66.98	2.86
TxB	9	268.65	29.85	1.28
Error	33	771.81	23.39	

**P<.01

Table 41A. Mounts per mate in 4h

Analysis of variance

Source	df	SS	MS	F
Mean	1	908.91	908.91	
Breed (B)	3	62.35	20.78	1.27
Error	11	179.44	16.31	
Time (T)	3	105.23	35.08	4.63**
TxB	9	55.36	6.15	.81
Error	33	250.04	7.58	

**P<.01

Table 42A. Daily sperm output ($\times 10^9$)

Analysis of variance

Source	df	SS	MS	F
Mean	1	918.93	918.93	
Breed (B)	3	196.00	65.33	13.07**
Error	11	55.00	5.00	
Time (T)	2	124.63	62.32	9.32**
TxB	6	66.90	11.15	1.67
Error	22	147.06	6.68	

**P<.05