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REPRODUCTIVE HORMONE PATTERNS IN FEMALE PYGMY GOATS

by

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DEDICATION

In The Memory Of

LUCY ASIIMWE

NYAMUHANGA AMUHUUMUZE

ABSTRACT

Reproductive Hormone Patterns in Female Pygmy Goats

Grace Richardson Engwe Kakusya

Blood samples collected from four female pygmy goats were assayed by radioimmunoassay (RIA) techniques to determine reproductive hormone profiles during various reproductive states (onset of puberty, anestrus, transtion from anestrus to breeding activity, behavioural estrus during the breeding season, pregnancy and parturition).

Ovarian cyclicity resumed (or started, in case of the prepubertal does) in mid-November and continued up to late May. The two prepubertal does reached puberty at an age of 248 and 251 days, respectively. Progesterone profiles suggest that all four animals resumed (or started) their breeding activity by exhibiting an ovulation that was not accompanied by overt estrus. The average length of the estrous cycle in the female pygmy was estimated to be 19.0 $\pm$ 1.2 days.

During the breeding season the nature of Luteinizing Hormone (LH) release was dependent on the reproductive state of the animal. The relationships between circulating progesterone and LH levels during the cycle, lend support to the thesis that during the breeding season progesterone exerts a dominant inhibitory effect on tonic LH release.

Luteinizing hormone peaks were less frequent but higher in magnitude during anestrus than during the breeding season.

Luteal regression, as indicated by falling progesterone levels occurred by day-3 to day-2 (with reference to the subsequent cycle) and was followed or accompanied by increases in estrogen, Follicle Stimulating Hormone (FSH) and LH secretion, all of which peaked at or around day 0 (first day of estrus) of the succeeding cycle.

During behavioural estrus, the onset of the preovulatory LH surge occurred on an average of 6.5 ± 0.7h after the onset of estrus and was followed by a FSH surge an average of 1.1 ± 0.4h later. LH secretion appeared to be episodic in nature as indicated by minor fluctuations, prior to the beginning of the preovulatory surge. The duration of the LH preovulatory surge was estimated to be 15.2 ± 0.5h, while the FSH preovulatory surge was found to be an average of 1.7 ± 0.7h shorter in duration than that of LH. However, these difference were not significant ($P>0.05$). During anestrus and the inter-estrous periods of the breeding season, the LH peaks were not accompanied by concurrent FSH peaks. Taking into consideration the interval from the onset of estrus to the beginning of the gonadotropin preovulatory surge and its duration, ovulation was estimated to occur on an average of 36h after the onset of estrus, and the most optimum time for insemination or mating would appear to be about 30h after the onset of estrus.

In this study, the mean gestation length of the pygmy goat was estimated to be 148.5 ± 1.4 days. During pregnancy, it was evident from the progesterone concentration profiles that there were two phases of increased progesterone secretion. The first phase was associated with the period from the 2nd to the 4th week of pregnancy; the second increase began in the 9th week of pregnancy. These increases were probably attributable to the activity of the corpus luteum as it became fully functional early in gestation, while the later increase in progesterone possibly could be related to a "rejuvenation" of the corpus luteum by luteotropic placental lactogen since it is reported to appear in the circulation at about day 60 of pregnancy.

Estrogen concentration increased steadily from the 10th week of pregnancy up to parturition. The stage of pregnancy affected progesterone and estrogen production significantly ($P<0.01$, and $P<0.05$, respectively). Although the type of pregnancy (single vs multiple) significantly ($P<0.01$) affected progesterone concentration, it failed to have similar effects on estrogen concentration.

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INTRODUCTION

The goat is a major constituent of the total world livestock population, making up to 15 percent of the world population of domesticated animals (FAO, 1977). It is estimated that, together with sheep, they contribute nearly 50 percent of the world production from indigenous animals. More than a third of the world human population relies on the goat rather than on cattle for milk and meat (Jeffrey, 1975). In addition to providing milk and meat, goats also provide fiber and skins and utilize forages that otherwise would be wasted and/or are perhaps noxious.

The world goat population is largely located in equatorial and tropical regions with more than two-thirds of the total lying within 30° of the equator. Biologically, their small size, large surface area relative to body weight, and limited subcutaneous fat covering adapt them poorly to cold climates, and make them relatively more adaptable to regions of high ambient temperatures (Shelton, 1977). Their small size in relation to the cow also makes them attractive to smallholder agricultural systems. Economically, this is the situation in many developing nations. Thus, the value of the goat and its contribution to human welfare is greater than is indicated by statistical figures because their products fill a greater need. In addition, new interest in dairy goats is rapidly gaining ground in the more developed and affluent societies because of the special health and nutritive value attached to goat milk and goat milk products. It is estimated that in the USA alone, 350 million kg of goat milk is produced annually (Haenlein, 1977). In other societies where religious beliefs (Jews, Muslims, and Hindus) do not allow for the consumption of pork, fat meat or beef, goat meat becomes a ready and equally nutritious substitute.

Although the goat was for a long time the least recognized of farm animals, there is now a growing tendency to acknowledge its desirable, good characteristics. It possesses great adaptability and has such relatively low nutritive requirements that it adjusts easily to a wide range of environmental conditions.

Goats differ in diet selection and gastrointestinal physiology from other domestic ruminants (cattle and sheep); being more similar to deer in some respects. Therefore, under environmental conditions unsatisfactory for other animals, the goat's requirements can easily be satisfied (Huston, 1978). Experimental evidence is now available showing that goats have greater digestive capacity (Cordova and Wallace, 1975) and that they are better able to produce milk more efficiently than cattle in relation to resource-availability and animal adaptability. It is this adaptability to harsh environments and their greater agility in search of food, together with their propensity for eating almost anything and everything that makes them thrive in mountainous and arid regions which the larger and more sedentary domestic animals cannot tolerate.

In addition, in the more recent past, the goat has emerged as a major animal model in the study of ruminant physiology and its use in investigations relating to cardiovascular physiology in biomedical research is increasing (Hoversland, 1965; Shelton, 1977).

Reproduction is a major contributing factor to efficiency of goat production -- for whatever purpose. The understanding of various reproductive physiologic states vis-a-vis circulating hormone levels for many goat breeds, and under many environmental conditions to which they may be subjected during rearing is incomplete or totally lacking. Such information is not only useful in planning future breeding experiments and programmes per se but is also welcome as an addition to the general pool of knowledge relative to the many facets of endocrinology and their interaction in eliciting specific animal behaviour. Investigations were therefore carried out to find out the reproductive hormone patterns in anestrus, cycling, and pregnant female pygmy goats. Although these studies were conducted in the temperate latitudes of southern Canada, it was hoped that the observations would also be applicable to the more tropical regions previously referred to, where goats are a more numerous and important domestic species.

LITERATURE REVIEW

Introduction

Although it is generally recognized that the goat is a seasonal breeder in the temperate regions, very little is known abouts its endocrinology of reproduction throughout the year. Much of the information commonly used to explain its reproductive behaviour is "borrowed" from research that has been done on its closest relative -- the sheep. This, however, has the disadvantage that the information may not be necessarily so truly applicable as is usually assumed. For example, the two species differ in the way they synthesize progesterone to maintain pregnancy. Whereas sheep placenta is able to replace the corpus luteum as a major progesterone synthesizing tissue, the goat relies on the corpus luteum as the sole source of progesterone as long as the pregnancy is maintained. The removal of the corpus luteum without adequate hormone replacement therapy will result in abortion at any stage of pregnancy; whereas in the sheep a similar treatment will not result in abortion if it is done after day 50 of gestation. Therefore, caution must be exercised when trying to explain certain reproductive phenomena in the goat by extrapolation from sheep data.

Seasonal Effects on Breeding Activity in the Goat

Like the sheep, goats are seasonally polyestrous in the temperate regions. Their sexual activity is suggested to be controlled by three environmental factors: photoperiod, temperature and relative humidity. Of the three factors, the changing pattern of daylength is the principal environmental cue which is thought to control the timing of the onset of reproductive activity and ovarian cyclicity in sheep and goats (Bissonnette, 1941; Hafez, 1952; Shelton, 1960; Godley et al., 1966; Thimonier and Mauleon, 1969; Palmer et al., 1972; Dyrmundson, 1973; Ortavant, 1977; Schanbacher and Lunstra, 1977; Lincoln et al., 1977; Lincoln, 1978; Sanford et al., 1978; Muduuli, 1978; Turek and Campbell, 1979).

Temporal Hormonal Relationships During Transition from Anestrus to Breeding Activity

Whereas a fair amount of information has been accumulated in relation to the interplay of various hormones in the ewe, during the breeding season vis-a-vis the non-breeding season, such information is still unavailable with regard to the doe. It has been suggested that a change from long to short days results in increases in levels of circulating gonadotropins. This observation is suggested to be the result of the reduced sensitivity of the hypothalamus-pituitary system toward the ovarian-hormonal feedback system and culminates in the resumption of cyclic sexual activity in the sheep and goat (Pelletier and Ortavant, 1964; Pelletier, 1973; Rawlings et al., 1977).

Luteinizing Hormone (LH) secretion in domestic animals studied so far is episodic in fashion (Foster et al., 1975; Ravault, 1976; Katongole et al., 1974; Davies et al., 1977; Lincoln et al., 1977; Sanford et al., 1977; Muduuli, 1978). Lincoln et al., (1977) and Sanford et al (1977) found that in the ram, LH peaks increase in number but decrease in magnitude during the breeding (short day) season. Thereafter episodic LH releases increase in magnitude but decrease in number during the non-breeding (long day) season. The target organs (the testes in this case) are therefore subjected to lower but more constant circulating levels of gonadotropins during the breeding season. There also exists in the ram and buck a circadian rhythm during which plasma levels of LH, testerone (T) and to a lesser extent Follicle-Stimulating Hormone (FSH) increase during the dark phases of the 24-h cycle (Lincoln et al., 1977; Lincoln and Peet, 1977; Muduuli, 1978). Earlier work by Falvo et al. (1975) had, however, failed to reveal such rhythmicity. The discrepancy in these observations may be attributed to the frequency of sampling.

During a 12 month period, Muduuli (1978) found that plasma LH concentrations in the buck displayed one large peak in September and October; a second smaller peak was detected in February and May. Associated with the smaller peak was an extremely high animal-to-animal variation. During the September-October peak, plasma LH mean concentrations ranged from 0.9 to 3.1 ng/ml, while those of the lowest month (November) varied between a maximum of 0.5 ng/ml to non-detectable levels.

Temporal relationships between the various hormones involved in reproduction during the transition from anestrus to breeding activity in the female goat have not been reported. However, in the ewe Yuthasastrakosol et al. (1975) and Walton et al. (1977) found that LH levels fluctuated throughout most of the anestrus period. Day to day fluctuations in FSH levels were also observed with no overall change in circulating levels except for some high values that were associated with high LH levels. The short-term relationships between peaks of plasma LH and FSH suggest and support the notion that a single hypothalamic hormone Gonadotropin-Releasing Hormone (GnRH) regulates the secretion of both gonadotropins (Burgus et al., 1972; Guillemin and Burgus, 1972; Reeves et al., 1974; Donovan and ter Haar, 1977; Simaraks, 1978; Reichlin, 1978).

Although brief minor rises in progesterone were reported

(Yuthasastrakosol, 1975), circulating levels of this hormone remained consistently low for most of the anestrus period. As shown by the profile of circulating progesterone, the first ovulation was not accompanied by estrus.

In the ewe, all the components of the hypothalamo-hypophyseal-ovarian axis are capable of functioning during the entire period of anestrus (Roche et al., 1970; Karsh et al., 1978). Experiments by Goding et al. (1969); Beck and Reeves (1973); and Reeves et al. (1974b) demonstrated that the administration of estradiol-17β or GnRH stimulated the release of LH during anestrus. It was also reported (Yuthasastrakosol et al., 1975; Karsch and Foster, 1975; Scaramuzzi and Baird, 1977; Karsch et al., 1978) that both positive and negative feedback effects of the gonadal steroids are readily demonstratable on the hypothalamo-hypophyseal axis during anestrus.

Recent investigations by Legan et al. (1977); Hauger et al., (1977); Karsch et al. (1977); Rawlings et al. (1977); and Karsch et al. (1978), have led to certain speculations on the possible mechanisms involved in the onset of the anestrus condition and the consequent resumption of ovarian cyclicity in the breeding season in the ewe. It is possible that similar mechanisms are operative at the onset of seasonal anestrus and resumption of breeding activity in the goat.

In one such all-year-round experiment using ovariectomised ewes implanted with silastic capsules that maintained physiologic levels (3-7pg/ml) of circulating estradiol, Karsch et al. (1978) observed a striking biannual change in circulating LH. The pattern of biannual changes in serum LH concentration was coincident with the transition between breeding and anestrus periods in intact ewes; elevated LH levels being associated with the breeding season while undetectable LH levels occurred during the anestrus period. It was hypothesized by Karsch et al. (1978) that in the ewe there occurs a profound seasonal change in the sensitivity of the system which governs tonic LH secretion in response to the "feedback" action of estradiol. Estradiol was found to be a potent negative-feedback hormone during anestrus but was ineffective in this regard during the breeding season. The mechanism as proposed by Karsch et al. (1978) and Legan and Karsch (1979) is as follows: During the follicular phase of the estrous cycle during the breeding season the regression of the corpus luteum (CL) is followed by progesterone withdrawal; this effects a major opening in the negative-feedback loop which controls LH secretion. This is followed by a progressive increase in circulating LH which in turn causes an increase in estradiol production by the follicles. The estradiol secretion is sustained until it reaches a threshold for triggering the pre-ovulatory LH surge. As observed in a normal cycle, concurrent sustained increase in both LH and estradiol can occur because physiologic levels of estradiol alone cannot inhibit LH secretion during the breeding season. During the transition period into anestrus, the system governing tonic LH release gains response to the negative-feedback action of estradiol. As the CL of the last cycle regresses, both LH and estradiol begin to rise in the same manner as described earlier. However, the response to the negative-feedback action of estradiol is now higher and so terminates the progressive increase in tonic LH release; an increase that is necessary for sustained estradiol production. As a result estradiol levels begin to fall before reaching the threshold required for the initiation of the pre-ovulatory LH surge. Hence, without the pre-ovulatory surge, ovulation does not occur and ovarian acyclicity sets in. At the onset of the next breeding season, the system which governs LH secretion again becomes unresponsive to the negative-feedback effect of estradiol. Concurrent increases occur in circulating estradiol and the LH and estrous cycles and ovarian cyclicity are reinitiated.

Presumably, environmental photoperiodicity lends its control of reproductive activity by somehow changing the responsiveness of the hypothalamo-hypophyseal axis to the