SEASONAL VARIATION OF PROLACTIN IN PLASMA OF MALE GOATS

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In the course of studies on the secretion of prolactin by goats in different physiological states, the concentrations of prolactin in the plasma of male goats were measured throughout the year.

Three intact male goats aged 5½ (Miljohn), 2½ (Rupert) and 1½ (Minto) years at the beginning of the sampling period were used. The goats were maintained under the usual husbandry conditions, being turned out to pasture in the summer and kept in individual pens in a separate male goat house in winter; supplementary heating from infra-red lamps was used when necessary. During the breeding season, all three males were used to mate with females in the herd and all three were fertile. Samples of blood were withdrawn from a jugular vein once a week, between 14.30 and 15.30 hours for a period of 15 months. The blood samples were taken by venepuncture into heparinized syringes, centrifuged at 4°C for 20 min at 1800 g and the plasma was stored at –20°C until required for assay.

The following year (1972), the same three intact males and another, Ulysses, aged 1 year, and also four castrated males were sampled hourly for 24 hr on 22nd to 23rd June and again on 19th to 20th December. All animals were confined to individual pens for 1 week before sampling started. The day before sampling, polyethylene cannulae were inserted into a jugular vein. Supplementary lighting needed to take samples at night was used as little as possible.

Prolactin concentration was determined by a radioimmunoassay for ovine prolactin by the technique of Buttle, Forsyth & Knaggs (1972) with the modification that labelled prolactin (NIH-PS-6) was prepared by an enzymatic iodination method adapted from Morrison & Bayse (1970). As far as possible, all samples from one goat were included in one assay. In these circumstances, the smallest significant difference ($P=0.05$) between any two samples was ± 0.150 of the $\log_{10}$ concentration.

The results for the year for each individual goat are shown in Text-fig. 1. A wide range of values occurred both within and between individuals, ranging from 1 ng prolactin/ml plasma (the lower limit of sensitivity of the assay used) to 256 ng/ml, with fluctuations within individuals from week to week. Concentrations of 8 ng prolactin/ml plasma or less were found only between November and February, whereas the highest concentrations of 60 ng/ml or more in

Rupert and 100 ng/ml or more in Minto were consistently found in May, June and July. In Miljohn, the high concentrations were found from February to August. The results of the diurnal sampling routine are given in Table 1. In mid-summer, high concentrations of prolactin were found in both the intact and castrated males; in mid-winter, low or undetectable concentrations were found in both groups. There was no overlap between the values obtained for the

TEXT-FIG. 1. The concentrations of prolactin in three intact male goats over the period October 1970 to December 1971.

summer and winter samples from any of the intact males. Consistent rhythmic diurnal changes in prolactin concentration were not found in any of the goats. In winter, however, three of the four castrates examined showed a pre-dawn increase in prolactin concentration, in that the mean values obtained between 03.30 hours and 06.30 hours were 2.9 times higher than the mean daily concentration.

The results show that goats experience a yearly seasonal rhythm in the

concentration of prolactin in their plasma, with high concentrations in summer and low in winter. The data for the individuals suggest that there is a simple gradation in prolactin concentration between the seasons, with acute changes attributable to other stimuli being superimposed on this basic yearly rhythm. The variation seen in consecutive samples from an individual is to be expected because of the number and variety of stimuli that are known to increase prolactin concentration in goats and other ruminants: such stimuli are feeding, water deprivation, teasing and mating, and unfamiliar physical stimuli (Bryant, Linzell & Greenwood, 1970; Convey, Bretschneider, Hafs & Oxender, 1971; McAtee & Trenkle, 1971; Raud, Kiddy & Odell, 1971).

Table 1. The concentration of prolactin in plasma of male goats in mid-summer and in mid-winter

Goat	Diurnal prolactin concentration (ng/ml plasma)	
	Mid-summer	Mid-winter
Intact		
Miljohn	40.9 ± 21.8	1.49 ± 0.77
Minto	102.2 ± 54.1	2.21 ± 1.79
Rupert	102.8 ± 58.2	4.43 ± 4.98
Ulysses	76.3 ± 15.4	4.20 ± 3.07
Castrated		
502	82.5 ± 35.8	—
507	121.7 ± 14.9	—
510	121.9 ± 30.2	—
515	87.8 ± 22.6	—
607	—	14.2 ± 7.01
620	—	4.77 ± 5.44
629	—	8.0 ± 8.04
633	—	5.77 ± 3.76

The values are expressed as means ± S.D. of 24-hr samples.

The yearly rhythmic change in prolactin concentration is in phase with both daylength and mean temperature, the correlation coefficient between log prolactin concentration and daylength is 0.78 ($P < 0.01$) and between log prolactin concentration and the weekly averages of maximum and minimum temperatures is 0.50 ($P < 0.01$). Similar seasonal changes in prolactin concentration occur in non-lactating cattle (Schams, 1972). Lactating cattle release more prolactin in response to the milking stimulus in summer than in winter (Koprowski & Tucker, 1973), and the same effect has been shown in goats (Hart, 1973) but in the latter species, the effect is modified by the stage of lactation. A pre-dawn release of prolactin has also been reported in pseudo-pregnant rats (Freeman & Neill, 1972). Relkin (1972) has shown that duration of exposure to light affects the concentration of prolactin in rats, with increased length of exposure resulting in decreased prolactin concentration in plasma and vice versa; and Yamamoto & Ieiri (1972) have shown increased synthesis and release of prolactin by the rat pituitary after subjection of the animal to cold. Both these observations are opposed to light or temperature being the cause of the seasonal changes found here in goats.

A possible clue to the effects of seasonal rhythm in prolactin concentration is provided by Horrobin, Manku & Burstyn (1973) who have shown that prolactin has a restorative action upon the saluretic effect of aldosterone. It is possible that the high concentrations found in summer are concerned with salt retention. Alternatively, there may be a connection with the breeding season. Goats are similar to sheep in that spermatogenesis continues throughout the year but the rate increases during the breeding season (Bishop & Walton, 1960); in some other ungulates, the male has a more sharply defined breeding season (Skinner, 1971). The rate of spermatogenesis in sheep has been found to be associated with variation in daylength, decreasing daylength resulting in an increase in the numbers of spermatozoa found in the epididymis (Ortavant & Thibault, 1956). The earlier stages of spermatogenesis, the division of spermatogonia, are considered to be independent of control by the pituitary (Steinberger, 1971) because spermatogonia do not regress after hypophysectomy in rats. If high concentrations of prolactin in plasma are capable of stimulating an increase in the rate of cell division by spermatogonia, however, the observed changes in prolactin concentration fit reasonably well with the known increase in sperm numbers that occurs from September to December, especially when the 50 days necessary for sperm maturation from spermatogonia to spermatozoa (Bishop & Walton, 1960) are taken into account.

There have been several reports that prolactin when used in conjunction with LH is capable of stimulating the gonads in male rodents (Bartke, 1971; Hafiez, Lloyd & Bartke, 1972) indicating that prolactin is part of the gonadotrophic complex in male as well as in female rodents. Thus, it is suggested that prolactin also forms part of the gonadotrophic complex in male ruminants as indeed it does in female sheep (Denamur, Martinet & Short, 1973).

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