Effect on oestrus and ovulation of exposing creole goats to the male at three times of the year

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Summary. The characteristics of the oestrous and ovarian cycles of local goats were studied over 2 years, on 96 females in March, 60 in July and 100 in November. After 3 weeks of separation between sexes, the females with inactive ovaries were identified and harnessed males were introduced. Detection of oestrus was undertaken daily and the date and rate of ovulation were checked at laparoscopies.

The proportion of females with non-cyclic ovaries before the mating period varied according to the season and whether the females were nulliparous or suckling. Among the females with inactive ovaries before the mating period, 97% ovulated 2–8 days after the introduction of males; 68% of these initial ovulations were accompanied by oestrus and 76% resulted in short luteal phases (5–3 days) followed by a second ovulation accompanied by oestrus 89% of the time. The proportions of initial ovulations with oestrus and of initial ovulations followed by a short luteal phase were in linear relationship with the proportion of females with non-cyclic ovaries before the mating period. For the females with cyclic ovaries before the mating period, the distribution of first oestrus during the 8 days after the introduction of males was significantly different from the expected uniform distribution. A possible luteolytic action of teasing was suspected. The fertility of females in all groups was high ($> 79\%$). Litter size was not different for non-cyclic and for cyclic females.

Introduction

A study of the seasonal incidence of conceptions in 'creole' meat goats in Guadeloupe kept permanently with males on an Experimental Station has shown that these females have no marked reproductive season (Chemineau, 1981). However, in private flocks seasonal variation in available forage is accompanied by marked variation in breeding activity and conceptions (Cognié, Houix & Logeay, 1971). In tropical areas it is particularly advantageous to synchronize kiddings to make the best use of available forage and to reduce as much as possible the need for supplementary food. Such synchronization must be simple and inexpensive and to this end, the technique of 'teasing' as used by Oldham, Martin & Knight (1978) for sheep seems attractive. In tropical goats it is not known when 'teasing' is most effective or whether the characteristics of induced ovulation are such that fertility and prolificacy are equivalent to those of cyclic females.

The purpose of the present work was to answer these questions by studying the characteristics of oestrous and ovarian cycles, and the fertility and prolificacy of goats mated at three times of the year.

Materials and Methods

Geography and climate. The research farm is in the dry part of Guadeloupe (16°10'N, 61°40'W). Annual rainfall is 1236 mm. Despite large variation between years it is possible to differentiate a rainy season (August–November = 755 mm) and a dry season (December–July = 481 mm). Maximum air temperature varies from 27°C (January) to 32°C (August) and minimum air temperature from 21 to 25°C. Relative humidity is always above 55% and the daylength varies from 11 to 13 h.

Animals and mating periods. Animals were of the local 'creole' breed which is traditionally used for meat production (Cognié *et al.*, 1971). The 157 females were used at one or more of 6 consecutive mating periods from July 1979 to March 1981; 256 individual exposures to the male were observed but it was not possible to have equal numbers of animals of each age and physiological state at each mating period (Table 1). At mating the procedure was to separate the females from any contact with the male for at least 3 weeks. Then 5–10% of harnessed vasectomized males (Radford, Watson & Wood, 1960) were introduced. This was called Day 0. The occurrence of oestrus was checked daily, by identification of marked females, for at least 80 days after the beginning of mating. The oestrous females were mated with one of 5 previously selected, intact males. For the first 3 mating periods these males were used 8 days after the introduction of vasectomized males but for the last 3 periods mating began immediately females exhibited oestrus. All marked females were taken out of the flock in the morning (07:00–09:00 h) and after the first mating had been observed they were left with the intact male for 8–10 h.

Animals were kept permanently on a Pangola grass (*Digitaria decumbens*) pasture and given concentrate at the rate of 0.3 kg/female/day. This concentrate contained 10 600 kJ metabolizable energy/kg and 135 g digestible crude protein/kg.

Measurements and recordings. Three blood samples were taken 14, 7 and 1 or 0 days before males were introduced. By estimating the relative presence or absence of progesterone in plasma from these samples, females with inactive ovaries (i.e. non-cyclic females) could be differentiated from females with active ovaries (or cyclic females) before the mating periods (Terqui & Thimonier, 1974). The last sample taken before mating in November 1980 was used to measure the exact levels of progesterone by the RIA method of Yenikoye *et al.* (1981). The sensitivity of the assay was 5 pg/ml and the intra-assay coefficient of variation was 10.0%.

One or two laparoscopies were performed 4–7 and 14–18 days after introduction of the males. The age of the corpora lutea was estimated from their size and colour (Oldham & Lindsay, 1980). Kidding date and number of kids born were recorded. In August 1979 hurricane David killed 17 females, reducing to 27 the number of females providing fertility results in July 1979.

Treatment of results. The length of an oestrous cycle was defined as the number of days between two consecutive periods of oestrus. Although some females were present at several mating periods, they were regarded as independent samples each time for statistical analysis. Standard χ^2 , *t*, randomization tests or linear coefficients of regression were used as appropriate (Snedecor & Cochran, 1971).

Results

Response of non-cyclic females to teasing

The proportions of non-cyclic females before the mating period, pooling all physiological states (Table 1), differed significantly with time of year and were higher in July than in March and in March than in November (82, 49 and 21%, respectively; $P < 0.001$). If the mating period is disregarded, 94% of suckling females, 47% of non-suckling females and 32% of nulliparous females were non-cyclic ($P < 0.05$). Of the 117 non-cyclic females before introduction of males, 113 (94%) ovulated after teasing; the mean $\pm$ s.e.m. interval (days) was 2.9 ± 0.3 in July 1979; 2.0 ± 0.3 in

Table 1. Number of females and proportion of non-cyclic females before exposure to the male relative to their physiological state and to time of mating*

	July 1979				November 1979				March 1980				July 1980				November 1980				March 1981			
	N	S	NS	Total	N	S	NS	Total	N	S	NS	Total	N	S	NS	Total	N	S	NS	Total	N	S	NS	Total
No. of females	32	0	12	44	15	0	38	53	13	7	33	53	1	5	10	16	17	0	30	47	9	23	11	43
Proportion of non-cyclic females (%)	94		83	91	7		37	28	23	71	27	32	0	100	40	56	6		17	13	67	100	9	70

N = nulliparous; S = suckling; NS = not suckling.

* For 125 females the mean $\pm$ s.e.m. kidding to mating interval was 100 ± 4 days.

November 1979, 1.7 ± 0.3 in March 1980, 3.3 ± 1.0 in July 1980, 1.8 ± 0.7 in November 1980 and 3.8 ± 0.4 in March 1981 (overall mean, 2.8 ± 0.2). The interval seemed to be related to the proportion of non-cyclic females at the time of introduction of males because it averaged 3.3 days in the 3 periods when there were $> 50\%$ non-cyclic females, and only 1.8 days in the 3 periods when there were $< 50\%$ non-cyclic females ($P < 0.05$). For all 6 periods, 68% of first ovulations after teasing were accompanied by oestrus; this proportion (y) varied with the mating period and was significantly correlated with the proportion (x) of non-cyclic females in the flock ($y = -0.47x + 97.2$; $r = -0.81$, $P < 0.05$). However, 76% of these first ovulations were followed by corpora lutea with a short lifespan (< 17 days), almost all of which were < 9 days (Text-fig. 1), the mean being 5.3 ± 0.1 days. The proportion of short lifespan corpora lutea at each period (y) was significantly related to the proportion of non-cyclic females in the flock (x) ($y = 0.98x + 13.3$; $r = 0.95$, $P < 0.01$) and with the proportion of nulliparous plus suckling females among the non-cyclic females (x) ($y = 0.80x + 21.7$; $r = 0.88$, $P < 0.01$). After this short cycle the goats ovulated a second time and this second ovulation was accompanied by an oestrus 89% of the time and was always followed by corpora lutea of normal lifespan.

For those females that had a short ovarian cycle after teasing and for which the two successive ovulations could be observed (50% of the total), the ovulation rate was significantly ($P < 0.05$) lower at the first ovulation (1.56) than at the second (2.05) and the proportion of females with multiple ovulations increased from 42 to 72%.

Text-fig. 1. Frequency of short cycles after teasing in females non-cyclic before the introduction of males.

Text-fig. 2. Distribution of first oestrus after introduction of males (Day 0) in females (N = 136) that were cyclic before teasing. The broken line represents the uniform distribution. For Days 1-19, $\chi^2 = 142.58$, $P < 0.001$.

Oestrous cycle characteristics of cyclic females before the mating period

Out of the 137 cyclic females, 136 came into oestrus within 21 days after introduction of males, but the distribution of oestrus was significantly different from the expected uniform distribution (Text-fig. 2). The difference was observed during the first 8 days ($\chi^2 = 134.45$; $P < 0.001$). The highest frequency of oestrus was observed during the first 2 days and contrasted with the lowest incidence of oestrus during Days 5, 6 and 8. After Day 8 the distribution of oestrus was uniform (from Day 9 to 19: $\chi^2 = 8.13$; $P > 0.50$).

In November 1980, 65% of the 37 females that were cyclic before the experimental period were in oestrus during the first 3 days of pairing instead of the 14% ($\chi^2 = 18.37$; $P < 0.001$) expected if the patterns were regular. Among the females in the luteal phase (progesterone > 0.5 ng/ml) on the day before introduction of males, those which came into oestrus before Day 6 had significantly ($P < 0.05$) less circulating progesterone (2.95 ng/ml) the day before introduction of males than did those which came into oestrus after this date (5.06 ng/ml) (Text-fig. 3).

Oestrous cycle patterns observed during the 6 mating periods showed a high proportion of short lifespan cycles relative to normal cycles (Table 2).

Table 2. Distribution of oestrous cycle lengths in goats after teasing

	Short (< 17 days)	Normal (17-26 days)	Long (> 26 days)
No. of cycles	39	39	10
(%)	(44)	(44)	(12)
Mean $\pm$ s.e.m. duration (days)	6.3 ± 0.4	20.7 ± 0.3	36.2 ± 2.1

Text-fig. 3. Distribution of first oestrus after introduction of males (Day 0) in 28 cyclic females in which plasma progesterone concentrations (mean $\pm$ s.e.m.) were also measured on Day -1. All females were considered to be in the luteal phase of the cycle on Day -1 (>0.5 ng progesterone/ml).

Fertility and prolificacy

Fertility (Table 3) did not differ significantly for any of the categories of female or after mating in March, July or November. Prolificacy (Table 3) was lower for nulliparous than for primi- and multiparous females and in July than in March and November, but did not differ between females that were cyclic or non-cyclic before the introduction of males.

Table 3. Fertility and prolificacy of females relative to their ovarian activity before introduction of males, their parity and the time of mating

	No. of litters	Fertility %	Prolificacy
Goats cyclic before introduction of male	109	81	1.97
Goats non-cyclic before introduction of male	88	87	1.85
Nulliparous	59	80	1.61*
Primiparous & multiparous	138	85	2.05*
Mating in March	86	90	1.92
Mating in July	33	82	1.64†
Mating in November	79	79	1.99
Total	198	84	1.92

* $P < 0.001$.

† Significantly different from values for March and November, $P < 0.01$.

Discussion

The proportion of non-cyclic females before the mating period varied according to season (13–91%) and physiological state of the females (32–94%) and reflects interactions between seasonal 'anoestrus' (Y. Cognié, personal communication; Chemineau, 1981) and prepubertal or post-partum ovarian inactivity periods (Mauléon, 1980).

For the 'creole' meat goat with inactive ovaries before the mating period, introduction of males induces ovulation in almost all females, as shown for other breeds of goat with a single introduction just before the breeding season (Shelton & Morrow, 1965; Gonzales-Stagnaro, 1976; Ott, Nelson & Hixon, 1980). This first ovulation is accompanied by oestrus in most cases as has been shown for the dairy (Ott *et al.*, 1980) and Angora (Shelton & Morrow, 1965) nanny goat. This response differs from that reported for the 'creole' goat of Venezuela (Gonzales-Stagnaro, 1976) and for the ewe (Prud'hon & Denoy, 1969; Underwood, Shier & Davenport, 1944) in which only a few animals display oestrus at the first ovulation after teasing. The first ovulation occurs within 5 days after the introduction of the male, as in the ewe (Knight, Peterson & Payne, 1978) and in the dairy goat (Ott *et al.*, 1980). It is likely that the physiological mechanisms set in action are identical to those described in the ewe for which introduction of the male provokes an immediate increase in the frequency of LH pulses (Poindron *et al.*, 1980; Martin, Oldham & Lindsay, 1980) leading to a preovulatory LH peak (Oldham *et al.*, 1978). The variation in the interval between teasing and ovulation and the strong relationship between oestrus at the first ovulation after teasing and percentage of non-cyclic females in the flock suggest that these physiological mechanisms could be modified by season or by the 'depth of anoestrus' (Lindsay & Signoret, 1980) of females at introduction of males.

The regularity (whatever the season or the physiological state of females may be) in the duration of the short ovarian cycle after teasing suggests that luteotrophic and luteolytic mechanisms controlling short cycles are well defined and follow a definite pattern. The strong relationship between the proportions of short ovarian cycles and of non-cyclic females in the flock indicates that the latter 'index', based on all the females exposed to the male, could reflect the degree of sexual inactivity of the non-cyclic females before teasing, as suggested by Lindsay & Signoret (1980) for non-cyclic ewes. The strong relationship between the proportion of nulliparous plus suckling females among non-cyclic females supports this hypothesis. It is more difficult to induce ovulation with exogenous hormones in suckling than in non-lactating females (Thimonier, Mauléon, Cognié & Ortavant, 1968). In other goat breeds (Ott *et al.*, 1980) or other species such as the ewe (Oldham & Martin, 1978) a short luteal phase following the first ovulation after teasing also occurs in > 50% of animals. The oestrus that accompanies the second ovulation after teasing and is followed by a normal luteal phase suggests that the hypothalamo-pituitary system may require priming by the small amount of progesterone secreted after the first ovulation (Robinson, 1959; Oldham, Cognié, Poindron & Gayerie, 1980). In contrast to results for the ewe (C. M. Oldham, unpublished), the ovulation rate in these goats was significantly greater at the second ovulation than at the first, and the number of ovulations was similar to that in cyclic females.

The male effect has normally been associated only with non-cyclic females. Our results suggest that the introduction of the male may also influence the cyclic pattern of spontaneously ovulating animals. Some of the high oestrous activity on the first day of introduction of the male may be explained by the fact that some females in oestrus the previous day may have been marked by males. This could certainly not be the case on Day 2. Therefore, it appears that the presence of males may have induced rapid luteolysis and early ovulation in the females which would normally have ovulated several days later. This hypothesis is consistent with the small number of females in oestrus on Days 5–8 because they probably ovulated on Days 1–4. In November 1980, when accurate measurements of plasma progesterone concentrations were made the day before introduction of males, goats becoming oestrous within 5 days after exposure to the male had much lower progesterone values than did those becoming oestrous later. This suggests that this level of progesterone may not be sufficient to block the secretion of LH after introduction of the male (see Poindron *et al.*, 1980), and the subsequent secretion of oestrogens may thus induce rapid luteolysis and oestrus. This shortening of the length of the oestrous cycle has already been observed in rodents (review of Signoret, 1980). However, the present results need to be confirmed because the records before introduction of males are not sufficiently precise to permit definition of the exact stage of the oestrous cycle for each female and I cannot be sure that for some unknown reason the cycles were not previously synchronized.

The high proportion of short cycles, also observed by Y. Cognié (personal communication) for non-breeding females, indicates that ovarian activity of 'creole' nanny goats is irregular, but these observations were made mostly on females which did not conceive at the first oestrus and our sample may have been less fertile than normal.

However, use of the male effect will result in 80% fertility in 'creole' goats regardless of season or physiological state. This contrasts markedly with the variable sporadic activity of the animals if the male effect is not used. Prolificacy, although always above 1.61 kids/goat, seems to be more sensitive. However, the conditions under which our observations were made do not allow us to distinguish which of several factors, such as cyclicity of females, physiological state or season of mating, may be important in improving prolificacy.

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