Control of sexual activity in goats using photoperiod and male effect

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Abstract

Reproductive seasonality observed in all breeds of goats originating from temperate latitudes and in some breeds from subtropical latitudes, is mainly controlled by changes in photoperiod. Short days stimulate sexual activity, while long days inhibit it. This knowledge has allowed the development of photoperiodic treatments to control sexual activity in goats. In Alpine bucks, seasonality can be prevented by alternations between 1 month of long days and 1 month of short days. In Mexican male goats, sexual behavior can be stimulated during the non-breeding season using only 2.5 months of long days. In females, sexual activity can also be induced during seasonal anoestrus using a sequence of long and short days. Another possibility to stimulate the sexual activity of females is the male effect. Does in seasonal anoestrus can respond to the male effect if an intense sexual activity is previously induced in the stimulus males by a photoperiodic treatment. Indeed, local male goats from subtropical Mexico treated only with artificial long days induce estrous behavior in about 90 % of the females, while control males cause this response in only 35 % of them. These photoperiodic treatments combined to the use of the male effect can improve the out-of-season estrus induction in goats.

Introduction

Reproductive seasonality is observed in all breeds of goats originating from temperate latitudes and in some breeds adapted or originating from subtropical latitudes (Ortavant et al., 1985; Delgadillo et al., 1997). Male goats show dramatic changes in sexual behavior, testicular weight and qualitative and quantitative sperm production (Delgadilllo et al., 1991, 1992, Walkden-Brown et al., 1994ab). Female goats also display marked variations in ovulation and estrous behavior (Chemineau et al., 1992a; Rivera et al., 2003). In temperate latitudes, anoestrus in females and rest season in males, generally occur in spring and summer; on the contrary, in the subtropics, the non-breeding season generally occur in winter and spring. In most of these breeds, the reproductive seasonality is controlled by annual photoperiodic changes (Thiéry et al., 2002; Delgadillo-Sánchez et al., 2003). The knowledge of the mechanisms underlying the effect of photoperiod on reproductive activity has allowed the development of treatments to control the timing of reproduction in goats. This paper describes the photoperiodic control of reproduction and the photoperiodic treatments used to induce the sexual activity of bucks. Then, it analyses the use of these treated males to stimulate the sexual activity of the anovulatory female goats through the male effect.

Photoperiodic control of reproduction

Photoperiod is the main environmental cue controlling the annual reproductive rhythm in breeds of goats and sheep from temperate latitudes and in some local breeds from subtropical latitudes (Lincoln and Short, 1980; Karsch et al., 1984; Aboul-Naga et al., 1992; Delgadillo et al., 2004a). In experimental conditions, short days stimulate reproductive activity whereas long days inhibit it. In Alpine and subtropical Mexican bucks subjected to alternations between 2 or 3 months of short days (short days: 8 or 10 h of light/day for Alpine and Mexican bucks, respectively) and 2 or 3 months of long days (long days: 16 or 14 h of light/day), seasonality of testicular size and testosterone secretion observed in natural conditions are modified. Testicular diameter and plasma testosterone levels increase during short days and decrease during long days (Delgadillo et al., 1991, 2004a). In Alpine and subtropical female goats, seasonality of reproduction observed in natural conditions is also modified by a photoperiodic treatment associating 2.5 or 3 months of artificial long days followed by 3 months of artificial short days (Chemineau et al., 1999; Delgadillo-Sánchez et al., 2003). Ovulations invariably start during short days. However, in goats and sheep, artificial constant short days from the winter solstice do not prevent the end of the breeding season (Lincoln, 1980; Robinson and Karsch 1988; Gebbie et al., 1999). Similarly, artificial constant long days from the summer solstice do not prevent the onset of the breeding season (Robinson and Karsch 1988; Gebbie et al., 1999). These results suggest that the seasonal cycle of reproductive activity in both females and males is driven by an endogenous annual rhythm that is synchronized by photoperiod (Malpaux et al., 1989; Martin et al., 1999; Barrell et al., 2000). The existence of an endogenous reproductive rhythm has been supported by several studies where animals, when exposed to constant short or long days or equinoctial photoperiod, displayed alternations between periods of rest and sexual activity (Howles et al., 1982; Karsch et al., 1989; Martin et al., 1999). The existence of this endogenous cycle prevents the animals to maintain a permanent sexual activity due to the application of a short stimulatory photoperiod, because they become refractory to this daylength. Animals must perceive alternations between long and short days to prevent the establishment of refractoriness (Chemineau et al., 1992b).

Photoperiodic information is conveyed through several neural relays from the retina to the pineal gland, where the light signal is translated into a daily cycle of melatonin secretion: high at night, low during the day (Karsch et al., 1984; Arendt, 1998). The length of the nocturnal secretion of melatonin reflects the duration of the night and it regulates the pulsatile secretion of gonadotropin releasing hormone from the hypothalamus (Malpaux et al., 1999, 2001). In goats, a long duration of melatonin secretion stimulates the LH release which is responsible for the alternating presence or absence of ovulation in the female and sexual activity in the male (Chemineau et al., 1999; Delgadillo et al., 2001).

Control of male sexual activity

As mentioned above, a basic means of controlling reproductions is through the alternations of long and short days. Long days may be provided by extra periods of illumination indoors or outdoors. Short days may be provided by artificial or natural short days indoors or outdoors.

A) Abolition of seasonal variations of reproductive seasonality

In Alpine and Saanen male goats, rapid alternations between long and short days allow to prevent the marked seasonal variations in sexual activity of bucks. In males placed in a light-proof building and subjected to 1 month of long days (16 hours of light/day) and 1 month of short days (8 hours of light/day), testicular weight increased progressively 5 months after the beginning of the study. Then, it remained similar to the maximum level observed in control animals during the natural breeding season for at least 2 years. As a consequence, the total number of spermatozoa per ejaculate and the semen quality, assessed by sperm progressive motility and the percentage of motile sperm, were greater in treated than in control bucks (Delgadillo et al., 1991, 1992; Chemineau et al., 1999; Figure 1). Fertility of deep-frozen semen was in the same range as that obtained normally in the natural sexual season in control animals, but the number of sperm doses usable for artificial insemination was 69 % higher in photoperiodic treated males (Delgadillo et al., 1992). This photoperiodic treatment allows semen collection all year round instead of only during the 6-months breeding season, increasing the stock of semen doses for artificial insemination. The described photoperiodic treatment has been slightly modified and an alternation between 1.5 months of long days and 1.5 months of short days is now used in French national selection program.

B) Induction of sexual activity during the non-breeding season

In local male goats from subtropical Mexico, the sexual activity can be stimulated during the non-breeding season using only artificial long days and natural short days. Indeed, in males maintained in an open pen and submitted to 2.5 months of long days (16 hours of light/day) from 1 November to 15 January, and then exposed back to the natural variations in day length (about 11 hours of light/day), displayed an intense sexual activity from February to April, period of non-breeding season. In long-days treated animals, testosterone concentrations increased dramatically as early as February and peaked in March, reaching levels similar to those observed during the natural breeding season in controls. In these latter animals, plasma testosterone concentrations were minimal between December and May, followed by an increase in June indicating the onset of the breeding season (Figure 2). As a consequence, the sexual behavior of males treated only with artificial long days and assessed by ano-genital sniffing, nudging and mounts, was higher than that of controls when exposed to anovulatory female goats in March (Figure 3; Delgadillo et al., 2002). Interestingly, in another experiment, we observed that maintaining animals in constant long days (16 hours of light/day) from 1 November to 15 June, can induce intense sexual activity of males for at least 4 months (Flores et al., 2002a). Indeed, plasma testosterone levels peaked in March and they remained elevated until June. In addition, sexual behavior was higher in constant long-days treated bucks than in controls when exposed to anovulatory female goats (Flores et al., 2000b). The described photoperiodic treatments allow to induce the sexual activity of subtropical bucks during the non-breeding season. These treatments also can provide sexually active males all year round: those induced by the photoperiodic treatments during the non-breeding season and those naturally active during the breeding season. The efficiency of the photoperiodic treatments described above to abolish reproductive seasonality or to advance the breeding season, is sufficient to make their use in artificial insemination or farm conditions.

Control of female sexual activity by the male effect

In female goats from temperate latitudes and in some from subtropical latitudes, ovulations can be induced alternating long and short days (Chemineau et al., 1999; Delgadillo-Sánchez et al., 2003). However, in subtropical latitudes most local goats are under extensive conditions, graze on native pastures and, at least in subtropical Mexico, most animals remain in precarious open pens making exposure of does to the photoperiodic treatments difficult. In these circumstances, one option to stimulate the sexual activity of anovulatory does is the use of the photoperiod-treated males through the male effect.

The so-called male effect is a technique to stimulate sexual activity in seasonally anovulatory goats and ewes (Walkden-Brown et al., 1999; Rosa and Bryant, 2002). A major limitation of the male effect to induce reproductive activity in the female is that this effect is weak when teasing is performed during mid-seasonal anoestrus, especially in breeds that are strongly seasonal (Restall et al., 1992; Mellado and Hernández, 1996). The male effect is therefore limited to the period just preceding the breeding season (Chemineau, 1987; Walkden-Brown et al., 1999). In Mexican Creole goats, the absence of induction of reproductive activity by the male can be overcome by previously inducing the males into a sexual season condition by a photoperiodic treatment. In fact, in subtropical Mexico, several studies have described the response of female goats to the male effect using photoperiodic treated males (Flores et al., 2000; Véliz et al., 2002; Delgadillo et al., 2004). During the anoestrus period, two control bucks exposed to natural variations of photoperiod and two treated bucks with 2.5 months of artificial long days from 1 November were put in contact with 20 and 19 anovulatory females respectively. All goats maintained with bucks submitted to a photoperiodic treatment showed at least one estrus during the first 11 days following male introduction, whereas only two females kept with control bucks were detected in estrus (Delgadillo et al., 2002; Figure 4). Interestingly, long-days treated males are also able to stimulate the sexual activity of females maintained in extensive conditions (Fitz–Rodríguez et al., unpublished data). After treatment, two males were placed with 20 females in March, remaining with them permanently in pens and during grazing outside. Out of 20 females, 18 displayed an estrous behavior. Fertility was 70% with a prolificacy of 1.7 $\pm$ 0.2. In contrast, only 9 out of the 20 females placed with control males were detected in estrus. Fertility was 25% with a prolificacy of 1.6 $\pm$ 0.2.

These studies indicate that, at least in subtropical Mexican goats, the male effect is an effective method for inducing synchronous cyclic reproductive activity during seasonal anoestrus, but only if fully sexually active bucks are used.

Conclusion

The knowledge of the mechanisms underlying seasonal reproduction and its regulation by photoperiod has led to the development of control methods in goats. In males, alternations between long and short days allow to prevent reproductive seasonality or to stimulate sexual activity during the non-breeding season. These fully sexually active males are able to induce the sexual activity of anoestrous females through the male effect under intensive or extensive conditions, at least in subtropical latitudes. It would be interesting to determine if these photoperiodic treatments can be applied successfully in other temperate or subtropical breeds, and if the males undergoing photoperiodic treatment can stimulate the sexual activity of anoestrous female goats by the male effect regardless of breed and latitude.

Acknowledgments

The author thanks Pascal Poindron for correcting the English manuscript and Dolores López for her kind secretarial assistance.

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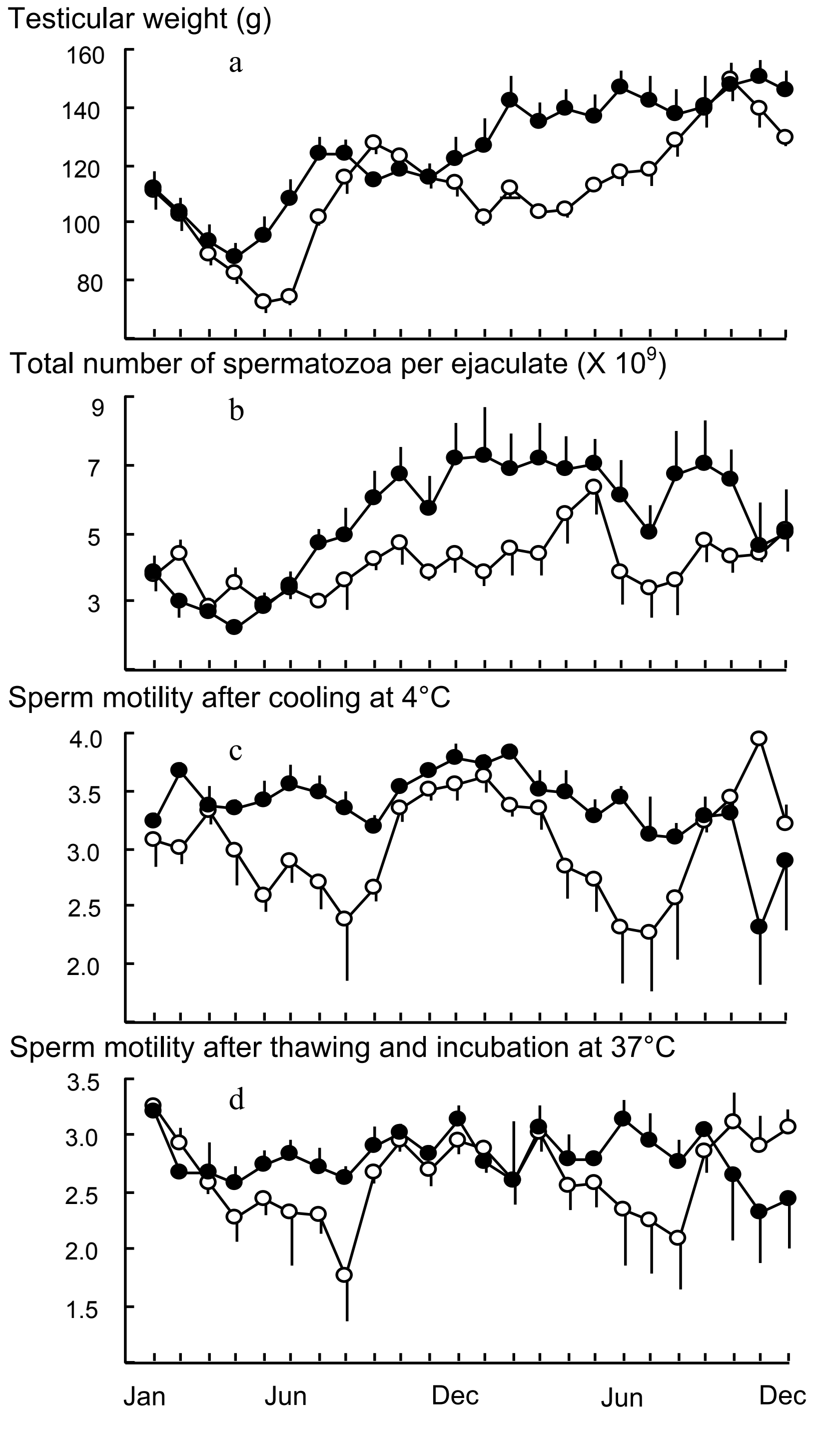

Figure 1. Testicular weight (a; mean ± s.e.m.), total number of spermatozoa per ejaculate (b), sperm motility after cooling at 4°C (c) and after thawing and incubation at 37°C during 5 min (d) from Alpine and Saanen bucks. Control bucks were under natural photoperiod changes (○); treated bucks were subjected to 1 month of long days and 1 month of short days during 2 consecutive years (●). The photoperiodic treatment started with long days (Adapted from Delgadillo et al., 1991, 1992).

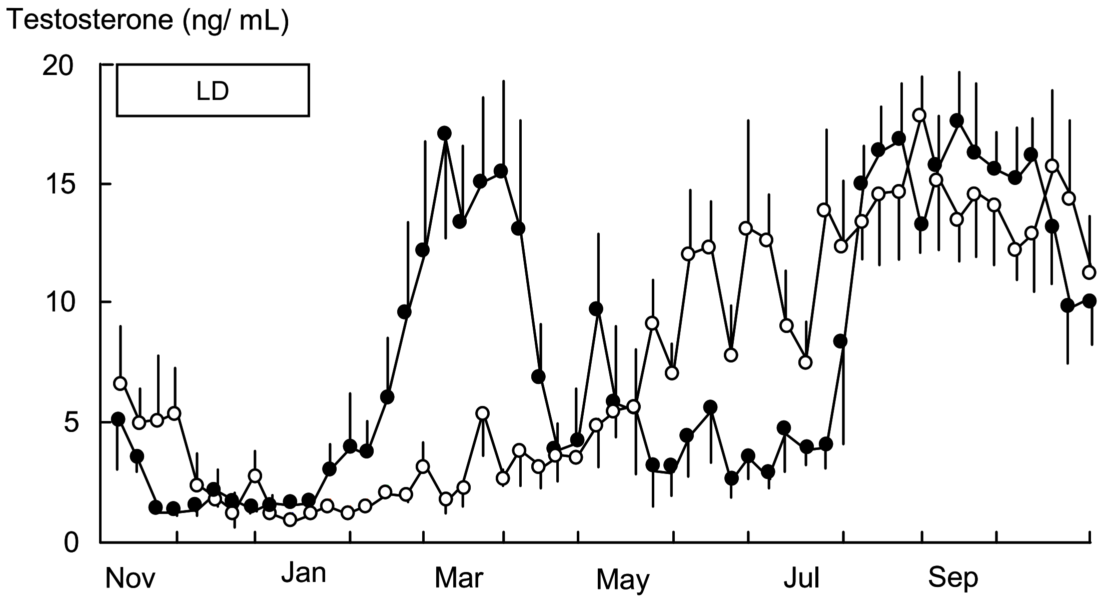

Figure 2. Changes (mean ± s.e.m.) in plasma testosterone concentrations in two groups of male Creole goats from subtropical Mexico subjected to natural changes in daylength (○) or 2.5 months of artificial long days between 1 November and 15 January followed by natural short days (●). Blood samples were taken once a week (Adapted from Delgadillo et al., 2002).

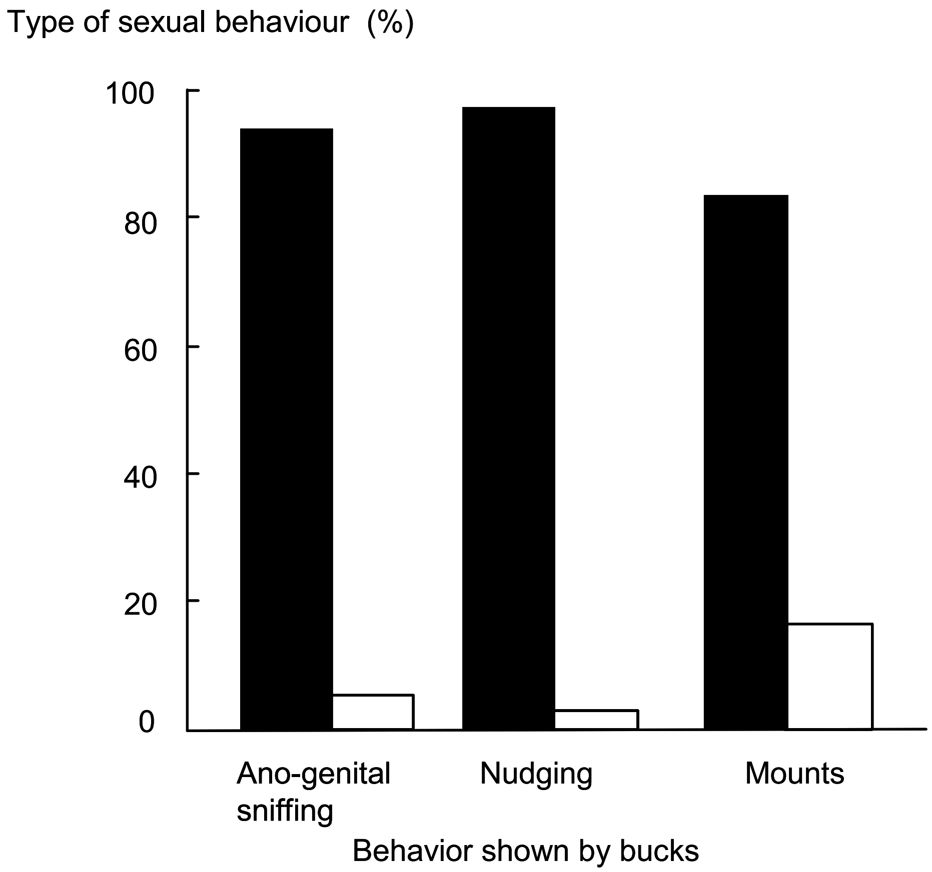

Figure 3. Distribution of each type of behaviour observed between two groups of Creole male goats, expressed as a percentage of the total number of behavioural characteristics. The control group was exposed to natural changes in daylength (□) while the experimental group was subjected to an artificial long-day treatment between 1 November and 15 January, followed by naturally increasing short days (■). Sexual behaviour was recorded for 2 h daily during the first five days of teasing with does (Adapted from Delgadillo et al., 2002).

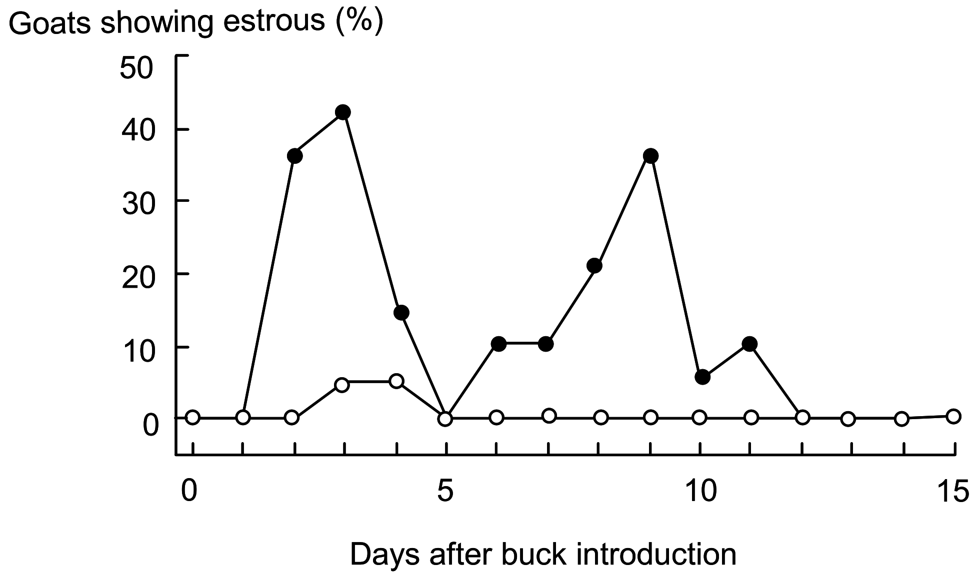

Figure 4. Percentage of anovulatory female goats that displayed oestrous activity after introduction of long-day treated males between 1 November and 15 January followed by naturally increasing short days. Day 0 is day of teasing (Adapted from Delgadillo et al., 2002).