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The sexual behavior of male goats exposed to long days is as intense as during their breeding season

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ABSTRACT

This study was conducted to determine if the sexual behavior displayed by photo-stimulated bucks is equivalent to that displayed during their natural breeding season. We also studied the individual variability of the sexual behavior of those males between seasons and between tests. Sixteen male goats were rendered sexually active by exposure to 2.5 months of long days from November 1 st onward. The intensity of the sexual behavior of the same bucks was tested during 3 different periods: i) during their natural breeding season, ii) about 60 days after they were submitted to the photoperiodic treatment described previously (Photo-induced sexual season) and iii) during their non-breeding season. For each phase, the sexual behavior of males was recorded on two different days by individually exposing them to an ovariectomized female for 15 min. The following sexual behaviors were recorded: ano-genital sniffing, nudging, mounting attempt, self-urination and flehmen. Males displayed higher occurrences of every component during their photo-induced sexual season in comparison to the non-breeding season ($P \leq 0.001$). In contrast, the occurrences of each component of sexual behavior did not differ between the photo-induced sexual season and the natural breeding season ($P \geq 0.3$). Interestingly, we found high individual variability of the sexual behavior of males between the breeding and photo-induced sexual seasons and also between tests during each season. We conclude that the photoperiodic treatment consisting of 2.5 months of artificially long days enables the induction of sexual behavior equivalent to that of the breeding season of males. Moreover, we illustrated the inter- and intra-season individual variability of the sexual behavior of male goats.

1. Introduction

Male goats from temperate and subtropical latitudes show a reproductive seasonality that hinders out-of-season reproduction (Delgadillo et al., 1991, 1999; Chemineau et al., 1992; Walkden-Brown et al., 1997). In males from subtropical latitudes, the breeding season begins at the onset of summer and ends at the onset of winter (Delgadillo et al., 1999; Walkden-Brown et al., 1994). During the breeding season, plasma concentrations of LH and testosterone in bucks are higher than during sexual rest (Delgadillo and Chemineau, 1992; Delgadillo et al., 1999; Zarazaga et al., 2011). As a consequence, their sexual behavior and odor present similar fluctuations (Rivas-Muñoz et al., 2007; Walkden-Brown et al., 1994, 1997). In this species, photoperiod is the main factor responsible for sexual seasonality. In fact, when male goats were exposed to alternations between 2 or 3 months of short days followed by 2 or 3 months of long days, plasma testosterone concentrations always increased during short days and decreased during long days (Delgadillo and Chemineau, 1992; Delgadillo et al., 2004).

In bucks, photoperiodic treatments based on the succession of a period of artificial long days followed by natural photoperiod enable the induction of sexual activity of males outside of their natural reproductive season (Chasles et al., 2016; Delgadillo et al., 2002; Zarazaga et al., 2011). In Creole bucks from subtropical northern Mexico (26°N), the use of 2.5 months of long days beginning November 1 st followed by a natural photoperiod stimulates testosterone secretion, sexual behavior and increased odor in March and April, during the natural sexual rest (Delgadillo et al., 2002; Ponce et al., 2014; Rivas-Muñoz et al., 2007). In these photo-stimulated males, plasma testosterone concentrations in March

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and April reached levels similar to those observed in untreated bucks during their natural sexual season. Afterwards, concentrations of testosterone decreased progressively at the end of April, and lower concentrations were observed between May and July. Then, an increase occurred at the beginning of August, reaching concentrations similar to those observed in untreated male goats during their natural breeding season (Delgadillo et al., 2002). However, it remains unknown if the sexual behavior displayed by males as a result of the photoperiodic treatment is similar to that observed during their natural sexual season.

The sexual behavior of subtropical male goats has been described in various works and is usually reported as a total number of occurrences, which fails to reflect the variability among animals or individual variability between each observation (Delgadillo et al., 2004; Bedos et al., 2012; Loya-Carrera et al., 2014). More recently, Ponce et al. (2014) and Delgadillo et al. (2015) reported individual values or means ± standard error of the mean of occurrences of different components of sexual behavior, respectively, which enabled to show part of the variability that exists between individuals. However, it does not exist any literature describing the individual variability of sexual behavior in subtropical male goats.

Therefore, the aims of this study were (1) to determine in the same males whether their sexual behavior displayed after the photoperiodic treatment is equivalent to that displayed during their natural breeding season and (2) assess the individual variability of sexual behavior between seasons and tests. Considering the high and similar levels of testosterone observed during their natural and photo-induced sexual season, we hypothesized that the sexual behavior displayed after the photoperiodic treatment would be similar to that displayed during their natural sexual season.

2. Materials and methods

2.1. General management conditions

The experiment was performed using 2–3 year-old local bucks (*Capra hircus*) from the Laguna region in the State of Coahuila, Mexico (latitude, 26°23′N and longitude, 104°47′W; Delgadillo et al., 1999). The local bucks, called "creole", are derived from the Spanish Granadina, Murciana and Malagueña breeds imported to Mexico during the 16th century. During the last 60 years, these animals were crossed with Alpine, Saanen and Anglo-Nubian breeds to improve milk and meat production (Delgadillo et al., 1999). The sexual rest of these males kept under natural photoperiod conditions and isolated from females lasts from January to May (Delgadillo et al., 1999). In the present study, the males were kept together in a shaded open pen (10 × 5 m) at the Centro de Investigación en Reproducción Caprina of the University Antonio Narro located in the Laguna region. Bucks were fed 2 kg of alfalfa hay (18% CP) and 200 g of commercial concentrated feeds (14% CP; 1.7 Mcal/kg) per animal/day, with free access to mineral blocks and water during the study.

2.2. Photoperiodic treatment

Sixteen bucks were subjected to a treatment of artificial long days (16 h of light/8 h of darkness) from November 1 st to January 15th in a shaded open pen. On January 16th, the light treatment was stopped and the bucks were exposed to natural variations of day-length until the end of the study. Artificial light was given from 6:00 h to 8:00 h and from 18:00 h to 22:00 h to extend the natural day (i.e., in order to obtain a total of 16 h of light/d). The open pen had 15 daylight lamps of 68 W of energy each. Light-on and light-off were regulated by an electronic timer and light intensity was at least 300 lx at the level of eyes of the animals (Fig. 1). This photoperiodic treatment has previously been shown to require an additional 45–60 days to produce a stimulatory effect on endocrine and male reproductive activity (Delgadillo et al., 2002). Therefore, the light treatment can stimulate testosterone secretion in March and April and the intensity of odor and sexual behavior of bucks are highly enhanced during these months corresponding normally to the season of sexual rest (Delgadillo et al., 2002; Rivas-Muñoz et al., 2007). All bucks were used previously in other experiments to induce the ovulatory activity of seasonally anestrous females; therefore, they had sexual experience with females before the onset of the current experiment.

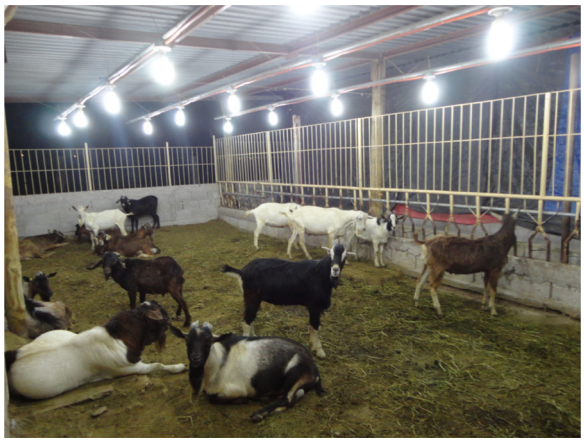

Fig. 1. Shaded open pen where bucks were subjected to a treatment of artificial long days (16 h of light/8 h of darkness) from November 1st to January 15th. On January 16th, the light treatment was stopped and the bucks were exposed to natural variations of day-length until the end of the study. Artificial light was given from 6:00 h to 8:00 h and from 18:00 h to 22:00 h to extend the natural day (i.e., in order to obtain a total of 16 h of light/d). The open pen had 15 daylight lamps of 68 W of energy each. Light-on and light-off were regulated by an electronic timer and light intensity was at least 300 lx at the level of eyes of the animals.

2.3. Sexual behavior observation

The intensity of the sexual behavior of the same bucks was tested during 3 different periods: i) during the breeding season; ii) about 60 days after they were submitted to the photoperiodic treatment described previously (Photo-induced sexual season); and iii) during the non-breeding season. For each phase, males' sexual behavior was recorded on two different days separated by intervals of 9 days on average (Fig. 2). A relatively short interval between the 2 tests was chosen in order to ensure that the males would be in the same physiological state in both tests. On each day, the bucks were taken to one of two testing pens and individually exposed for 15 min to one of eight female goats. The testing pens (3 × 3 m) were located at least 100 m from the housing pen; however, males could not see each other while being tested. The observations started at 8:00 h and all the bucks were observed on the same day. Definitions of specific behaviors were modified from those of Gonzalez et al. (1988) and Hart and Jones (1975). We defined and categorized behaviors as described in Table 1. Mounts, with or without intromission, were not included in the ethogram since the females used for the tests were ovariectomized and therefore could not display estrus. Four observers recorded the sexual behaviors of the bucks for 15 min using preformatted recording sheets. On each date, 2 bucks were observed at the same time by 2 different observers (one in each testing pen). Observers recorded the sexual behavior of different dates in different seasons. The observers were fully trained to record the behavior of the bucks before the experiment and had the same criterion for each behavior. Both male and female were allowed to freely move inside the testing pen. For each test, bucks

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