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Abstract: The aim of this study was to evaluate the intensity of the annual sexual behavior (SB) of Boer bucks under tropical conditions in southern Mexico. For one year, 16 extensively grazing males were evaluated for SB individually with estrogenized goats. From the beginning of the experiment and every 30 days, body weight (BW), body condition (BC), testicular circumference (TC), odor intensity (OI) and SB (nudging, ano-genital sniffing, flehmen, mounting attempts, mounts with intromission, and self-urination) were recorded. The bucks showed a more intense SB during the months of November to May than during the months of June to October ($p < 0.05$). Greater frequency was found for nudging, ano-genital sniffing, mounting attempts, and self-urination in the months of November to May ($p < 0.001$). BW was lower during the months of January to August than in the months of September to December ($p < 0.05$). On the other hand, TC increased from October to December ($p < 0.05$). Similarly, the OI in males varied over time (time effect; $p < 0.001$). In fact, an increased odor was found from October to December. The conclusions were that breed male goats from the tropics of Guerrero have a more intense SB during the months of November to May, which corresponds to the time of the year when forage availability is the greatest.

Keywords: annual sexual response; body weight; odor intensity; testicular circumference; vocalizations; sexual rest

1. Introduction

The bucks originating or adapted from temperate and subtropical regions show reproductive seasonality that decreases sexual behavior (SB) [1,2]. In the Mexican subtropics of northern Mexico, bucks have sexual rest during the months of January to May (winter-spring), while the period of reproductive activity occurs from May to

December (spring-autumn) [3]. During the period of reproductive seasonality, there is a decrease in sexual behavior (SB), testicular circumference (TC), odor intensity (OI), vocalizations, testosterone

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secretion, and sperm quality [4,5]; these variables increase during the reproductive season, together with a more intense SB [5].

On the other hand, some goat breeds from subtropical and tropical regions show variations in their SB [6]. Indeed, male goats from tropical regions show sexual activity throughout the year. However, some factors such as forage availability, environmental temperatures, and socio-sexual relations, among other factors, modify this behavior [6–8].

In bucks, testosterone secretion is important to heighten their high sexual libido and good sperm quality [9,10]. Testosterone stimulates the preoptic area and medial region of the hypothalamic amygdala, which is important for endocrine activity and essential for the deployment of SB in male goats [11]. A determining factor to evaluate SB in males is exposure to a female in estrus, a moment in which some factors such as pheromones and sexual attractiveness intervene [12–14].

It has been proven that females who show signs of estrus, improve their response when exposed to the male effect [15]. However, the behavior of females with signs of estrus can induce both appetite and consumption behaviors in male sheep and goats [14,16]. In fact, proprioceptive behavior can initiate and maintain sexual interactions between two females, thus increasing sexual motivation in males to mate with them [16–19].

Therefore, the aim of the present study was to assess the intensity of SB in Boer males throughout the year under tropical conditions southern Mexico.

2. Materials and Methods

2.1. General

The study was carried out in a period from January 1 to December 31, 2019, in the municipality of Cuajinicuilapa, Guerrero, Mexico. The region belongs to the Costa Chica region of this state and it is located in the Mexican tropical region between parallels 16° 18' 58'' and 16° 35' 46'' north latitude; meridians 98° 21' 04'' and 98° 43' 44'' west longitude. The climate is warm and dry with annual average temperatures of 34°C, and rains occur during the summer months showing precipitations of 1,300 mm [20]. All the experimental procedures in the experimental units that were used in the present study strictly adhered to the standards for the ethical use, care and well-being of research animals [21].

2.2. Animals and Treatments

Sexual behavior (SB) was evaluated in 16 adult Boer bucks with an average age of 3.5 years, a body weight (BW) of 96.38 ± 3.43 kg, and a body condition (BC) of 3.5 ± 0.45 points (on scale from 1 to 4 points).

2.3. Management and Measuring of Males

Goat production in the region is for subsistence purposes. Extensive grazing takes place in the morning (08:00 h) and in the afternoon (19:00 h) they are locked in open goat sheds that have drinking fountains. The animals do not receive neither any supplemental nutrition nor zootechnical management; except for internal deworming once a year (Ivermectin; Baymec®, 200 μg kg-1 PV; Bayer-Animal Health).

Before starting with the experiment, all males from both groups were measured for body weight (BW), body condition (BC), testicular circumference (TC), neck odor and the SB. Then, on January 1, 2019 these same measurements were taken from all males. Since the beginning of the experiment and every 30 days, BW, BC, TC, odor intensity (OI) and SB from 10-15 cm at the base of the horns were recorded. These measurements were always made by previously trained people and with the same evaluation criteria. Animals were weighed with an electronic hanging scale (Rhino-Model: BAC-300) with a capacity of 300 kg and an accuracy of 100 g. BC was evaluated by palpation of the spinous and lateral processes of the lumbar vertebrae, to detect fat and musculature in this region of the spinal column. A score of 1 (thin) to 4 (fat) was assigned with increments between units of 0.5. OI was evaluated by smelling the dorsal part of the neck, 10-15 cm posterior to the base of the horns. The 0-

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to-3-point scale described by Walkden-Brown et al. [22] was used, with the following values: 0 (neutral or equal odor to females), 1 (light sexual odor), 2 (moderate sexual odor) and 3 (intense sexual odor). Finally, TC was measured using a centimeter graded tape measure.

2.4. Observation of Sexual Behavior

Male goats were evaluated for SB for one year. These activities were performed every 30 days for thirty minutes per male (0:700 to 11:00 h). Males were exposed to females with signs of estrus. SB was evaluated in males with 2 females using one female for every 4 males and from a different herd. SB evaluations were carried out by one person per male and recorded the following variables: nudging, ano-genital sniffing, flehmen, mounting attempts, mounts with intromission, and self-urination [23] (Table 1). For estrogenization of the female goats that were used to evaluate the male SB, a short synchronization protocol described by García y González et al. [24] was used.

Table 1. Etogram of the Sexual Behavior of Bucks Exposed to Female Goats Artificially Induced to Estrus.

Behavior	Description
Nudging	Lateral approach of the male flexing his front leg against the female with short, staccato kicks, these may be accompanied by licks and low vocalizations.
Ano-genital sniffing	Smells focalized in the perineal area of the female (> 3 s).
Mounting attempts	The male tries to jump with his front legs and upper back on another goat. There may or may not be pelvic movements, usually interrupted by female flight.
Mounting without intromission	The male places his front legs and upper back on another goat. Associated with pelvic movements and erection, but without penetration; usually interrupted by female flight.
Mounting with intromission	The male attaches his front legs and the upper part of the back to another goat. Known as true riding or with service, characterized by pelvic movements and the movement known as kidney blow: when the tip of the glands makes contact with the vulvar mucosa, a strong push is accompanied by penetration and ejaculation.
Flehmen	Rearward tilt of the upper lip that exposes the dental ridge, usually with the head raised and the neck extended. This occurs after smelling the perineal area, his urine, or that of the female to facilitate the arrival of olfactory signals to the vomeronasal organ.
Vocalizations	It's the emission of low sounds characteristic of the male during contact with the female.
Self-urination	The male urinates his own face, mouth and beard as the erect penis protrudes.

The definitions were modified from those reported by Hart and Jones (1975) and Bedos et al. (2016).

2.5. Food and Accommodation

Male goats were only fed the usual grass and plants that they consumed during the grazing period, along with products derived from agricultural activities and seasonal fruits: corn, sorghum,

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mango, orange, and watermelon, among others. The animals did not receive any nutritional supplementation and were housed in open pens, enclosed using cyclonic mesh, wooden posts, and galvanized sheet roofs (width 6 m, length 14 m, and ceiling height 3.5 m). The pens had drinking fountains supplied with clean and fresh water that was commonly washed every 3 days. Additionally, more than 100 m away from the management pens, there was a wooden pen to expose females in estrus to males. This is where SB was evaluated.

2.6. Statistical Analysis

Data was analyzed under a completely randomized design with a 95% confidence interval. The total number of nudging and ano-genital sniffing was compared with a one-way of variance analysis (ANOVA) with repeated measurements over time (time of year) followed by post-hoc Bonferroni tests to compare two by two. Sexual behavior, mounting attempts, flehmen, and self-urination was compared with the Friedman test for non-parametric statistics. Subsequently, the Wilcoxon test was used to compare two by two. The data obtained from the BW and TC readings was analyzed with an ANOVA considering two factors (group x time). BC, as well as OI, was compared using a non-parametric Mann-Whitney U test. All statistical analysis was conducted using the statistical program for Windows SYSTAT 13 [25].

3. Results

3.1. Sexual Behavior

The SB displayed by the bucks was more intense during the period from November to May ($p < 0.001$), compared to the months of June to October ($p > 0.180$). This shows a significant difference between seasons (summer-fall vs spring-winter) for nudging, ano-genital sniffing, mounting attempts, and self-urination ($p < 0.001$). The frequency of mounts without intromission, mounts with intromission, flehmen, and vocalizations was similar in all seasons of the year ($p > 0.05$) (Figure 1).

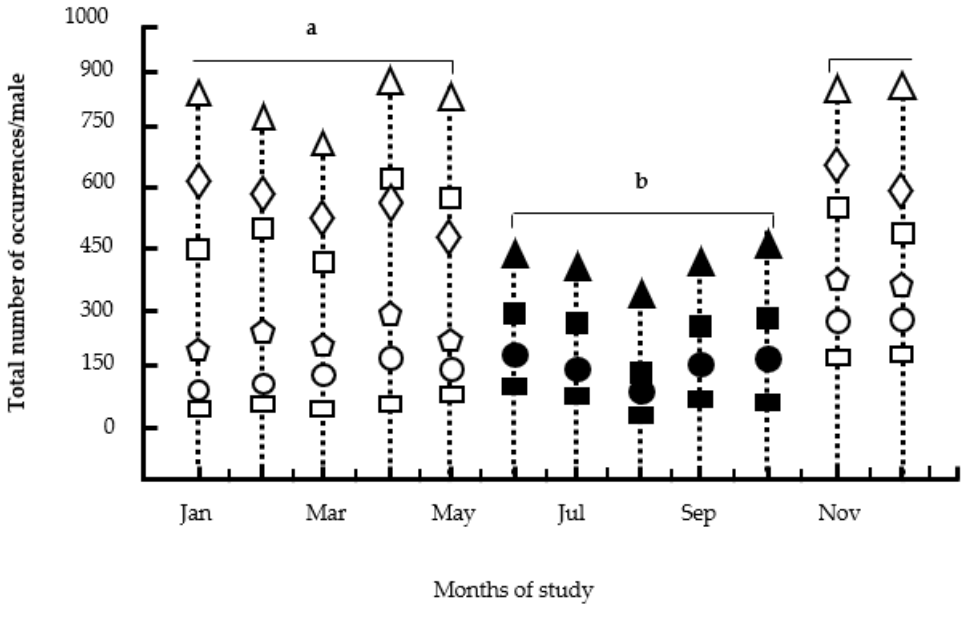

Figure 1. Sexual behavior (SB) of male goats is displayed throughout the year. The unfilled geometric figures indicate the variables with the highest SB (November to May; spring - winter) (nudging ⬠, ano-genital sniffing ◎, flehmen ◊, mounting attempts ○, mounting with intromission ▭ and self-urination ⬭). On the other hand, the figures with filling indicate the variables with the lower SB (June to October; summer - autumn) (nudging ▲, ano-genital sniffing ■, mounting attempts ● and self-urination ▬). Literals $^{a, b}$ in the geometric figures describe a significant difference ($p < 0.001$).

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3.2. Body Weight and Condition

The BW of males was different between seasons (summer-fall vs spring-winter) throughout the assessed time ($p < 0.001$). On the other hand, body weight (BW) was lower during the months of January to August than in the months of September to December ($p < 0.05$). BC was similar among the group of males throughout the year ($p > 0.05$). However, there was no effect recorded of the group or of the time-by-group interaction ($p > 0.05$) (Figure 2).

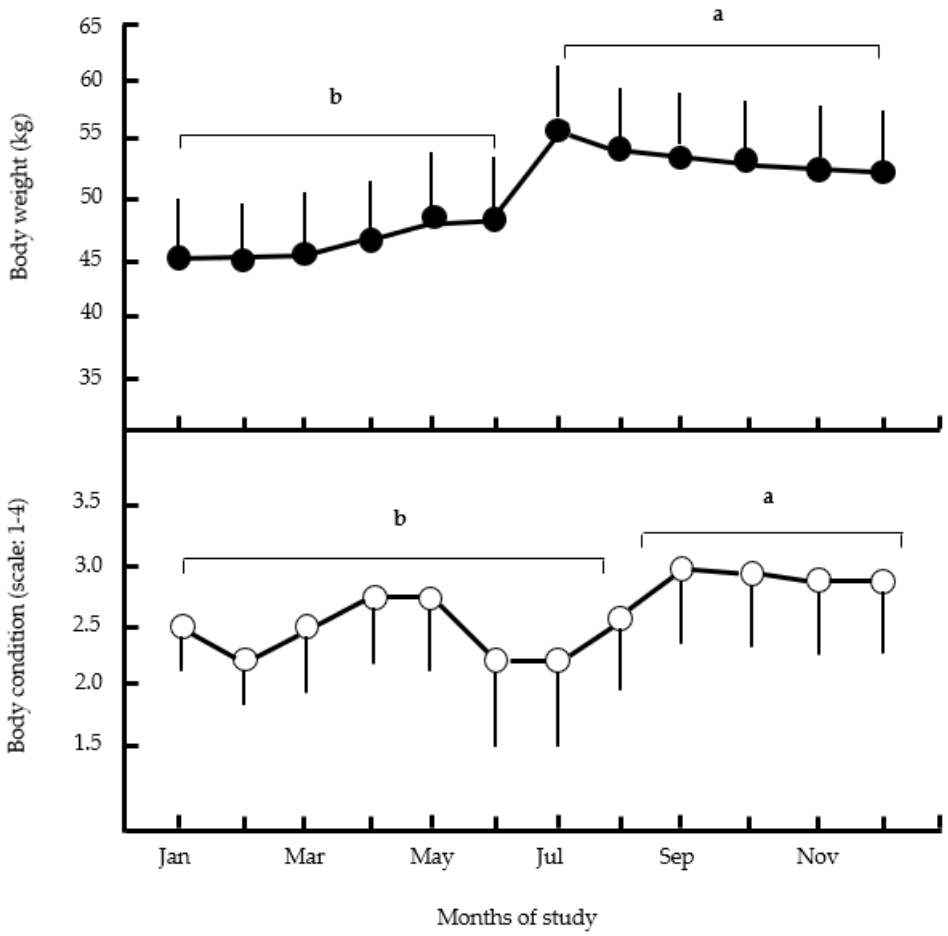

Figure 2. The top of the figure indicates body weight whereas body condition is illustrated in the bottom graph (scale: 1-4) (months from January to August), [a,b] for the circle indicates a significant difference ($p < 0.001$).

3.3. Testicular Circumference and Odor Intensity

The TC of the males varied throughout the study, with a significant difference due to the seasonal effect ($p < 0.001$). In fact, a time x group interaction was found ($p < 0.001$). In males, TC increased from October to December ($p < 0.05$). Similarly, OI of the males varied over time (time effect; $p < 0.001$). In fact, an increased odor was found from October to December (Figure 3).

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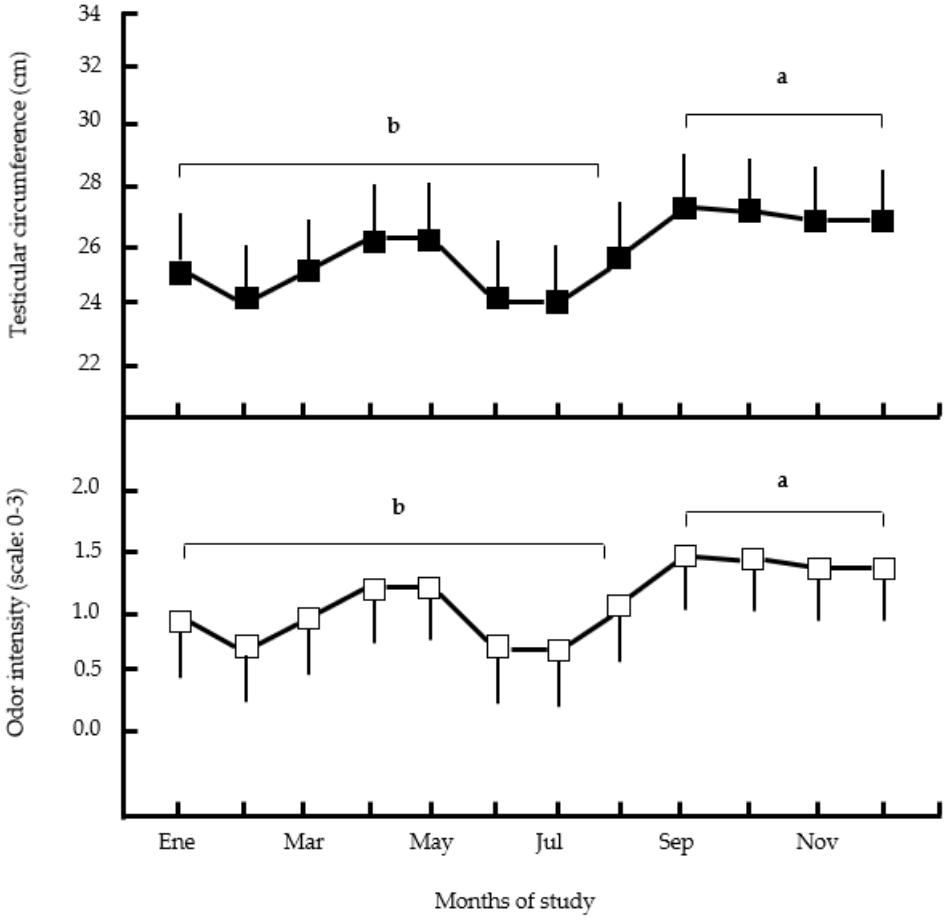

Figure 3. The top of the figure indicates scrotal circumference (cm) and the bottom figure shows odor intensity (scale: 0-3) (months from October to December), [a,b] for the square indicates a significant difference ($p < 0.001$).

4. Discussion

4.1. Sexual Behavior

Previous studies indicate that male sheep and goats from temperate and subtropical regions express a marked period of sexual rest modulated by the photoperiod, where SB decreases: nudging, ano-genital sniffing, mounting attempts, self-urination, mounting with and without intromission, flehmen and vocalizations [3,9]. This phenomenon is observed in goats of the Mexican subtropics that show sexual rest during the months of January to May (photoperiod effect) [4]. In contrast, in the Australian subtropics, sexual rest is attributed to other modulators such as nutrition, temperatures, and environmental humidity [26,27].

In the present study, the intense SB shown by the male goats from the tropic of Guerrero during the months of November to May is likely due to nutrition, since during those months the males recovered after the rainy season when the forage availability is higher. In this regard, some authors point out that the nutritional level influences testicular mass, testosterone production, and body weight; as a consequence of SB deployment [22,27].

Consistent with these results, González-Reyna et al. [28] in the Mexican tropics, male Pelibuey sheep found a decrease in SB during the months of January to May. Contrary to this, some literature mentions that male sheep and goats from tropical regions display a SB throughout the entire year [8,29]. This phenomenon is explained in male sheep and goats from tropical regions of the world where the decrease in SB is not due to the photoperiod, but rather modulated by other factors; such as nutrition, high environmental temperatures, relative humidity, rainfall, among others [8,14,29,30].

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This is understandable since reproductive seasonality is a natural selection strategy for the survival of the offspring, justified in temperate regions by inclement weather. However, in subtropical and particularly tropical conditions the conditions are different, observing this effect when some environmental factors change and directly affect the reproduction of the species. Little availability of forage during the dry season, high temperatures and environmental humidity, socio-sexual relations, among others are factors that modulate reproduction.

4.2. Body Weight and Condition

Some research work carried out in temperate and subtropical regions in goats shows that BW increases in them when they experience intense SB [3,31]. The present study was conducted with Boer bucks in tropical conditions, and it was found that the animals experienced an increase in weight and BC during the months of the year when the availability of forage increased. This has been proven in some studies carried out in sheep and goats under similar study conditions [6,8,32].

The aforementioned is a logical result, since the increase in weight and BC of these males is due to the fact that they will start with the reproductive season and these animals need body reserves that will be used during the mating season.

4.3. Testicular Circumference and Odor Intensity

In the present study, a decrease in TC and OI was found in the months of October to December indicative of low forage availability and low SB. Some studies carried out in male goats from temperate and subtropical regions show that during the period of sexual rest, SB, TC, OI, vocalizations, testosterone secretion, and sperm quality decrease [3,5]. However, in the tropics, goats decrease these variables but without considering a period of sexual rest. But rather, their intensity and quality simply decrease [22,28,33].

In the present study, TC and OI, that are directly related to sperm quality and testosterone secretion were evaluated; the hormone responsible for males having high sexual libido and intense SB. In effect, male goats from the Mexican subtropics that were photo-stimulated during the period of sexual rest increased their TC, OI, vocalizations, sperm quality, and testosterone secretion [3,4,34,35]. In this regard, Rivas-Muñoz et al. [34] reported that the photo-stimulated goats increase the scrotal circumference and the OI; this same behavior occurs in male goats treated with exogenous testosterone during sexual rest [37]. The increase in TC is due to an increase in the secretion of prolactin, which during this period is secreted in greater quantity, also OI is indicative of the secretion of testosterone and consequently the deployment of an intense SB.

5. Conclusions

The present study describes for the first time the seasonal variations of the SB in bucks of the Boer breed in the tropical conditions of Guerrero. Males have a higher SB, TC, and OI during the months of November to May which corresponds to the summer and autumn seasons. On the other hand, BW and BC presented higher values during the months of November to May. These findings show that the time of year influenced this to happen since the SB, TC, OI, BW and BC were higher during the months in which there is greater availability of forage as a consequence of the rainy season. However, it does not mean that this can occur in all herds as mentioned by Chemineau and Xandé [7] based on the SB displayed by Creole goats from the tropics of Guadalupe Island.

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