

Article

Behavior Patterns of Colombian Creole Bulls Romosinuano and Costeño Con Cuernos

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Abstract

The objective of this study was to characterize the sexual behavior and reproductive performance of Colombian Creole bulls from the Romosinuano (ROM) and Costeño con Cuernos (CCC) breeds, to support their strategic use in tropical production systems and sire selection programs. A standardized sexual behavior test, including nine behavioral indicators, was conducted over a 15 min observation period to assess libido and service capacity. Significant differences ($p < 0.05$) were found between the breeds in terms of the frequency of urination and mounting behaviors. ROM bulls exhibited a more uniform and rapid behavioral response, while CCC bulls showed greater individual variability and a broader behavioral repertoire, with courtship behaviors—such as smelling, the Flehmen reflex, and butting—strongly associated with ejaculation events. Libido scores were high in both breeds, with 80.35% of bulls rated as very good to excellent. CCC bulls also achieved mounts more frequently within the first five minutes of exposure. Additionally, bull age was inversely associated with mounting time ($p < 0.05$), suggesting that maturity and sexual experience influence behavioral efficiency. These findings represent the first quantitative assessment of sexual behavior in CCC bulls and provide comparative insights with ROM bulls, highlighting the functional reproductive potential of Colombian Creole bulls under low-input tropical conditions.

Keywords: adaptation; libido; selection; service capacity



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1. Introduction

Reproductive behavior is critical for the productivity and sustainability of livestock systems. In cattle, factors such as breed, bull experience [1], and adaptation to specific environmental conditions [2] produce behavioral changes that directly impact reproductive efficiency and the final economic utility of the systems, including Creole-based systems [3].

Creole cattle, descendants of bovines introduced to the Americas during Iberian colonization, are renowned for their exceptional adaptability, shaped by natural selection in challenging environments [4]. These cattle exhibit outstanding reproductive traits, including high fertility, ease of calving, and longevity, even under limited resource availability and low management conditions [5].

The selection processes and adaptation have also conferred advantages on Creole cattle, such as enhanced resistance to diseases and thermal stress. These traits result in superior

reproductive performance under adverse conditions when compared to commercial taurine and zebu breeds [6]. In fact, commercial breeds like Holstein, which are highly productive in intensive systems, often reduce that reproductive efficiency due to challenges in tropical environments characterized by extreme heat [7]. Crossbreeding commercial breeds with Creole cattle has improved reproductive performance [8]. This highlights the importance of Creole breeds as valuable components of sustainable livestock systems.

Despite the recognized reproductive advantages of Creole breeds, studies on their sexual behavior are limited. Evaluating the functional reproductive fitness of bulls should include assessments of physical conformation, clinical health, semen quality, and sexual behavior—primarily defined by libido and service capacity (SC). Previous studies have shown that libido is not associated with semen characteristics, scrotal circumference, or serum testosterone levels [9–12]. Although the heritability of libido remains poorly understood, it is highly correlated with SC, with an estimated heritability of 0.59 [13]. This suggests that sires with low libido may still be selected, potentially reducing reproductive success in the herd if they also exhibit low service capacity.

The most recent genetic evaluations for libido in cattle have integrated multiple fertility-related genetic markers and reproductive traits rather than targeting libido alone. They rely on genomic data and comprehensive reproductive phenotyping to select animals with better reproductive performance, including libido, as a functional component of fertility [14].

The use of non-adapted individuals may result in reduced performance, particularly in regions where environmental factors directly affect animal behavior. Conversely, if well-adapted cattle are not consistently and properly evaluated, their true advantages may be overlooked, potentially leading to misinterpretations of the effectiveness of Creole breeds. This could reinforce the misconception that their performance limitations are inherent rather than a consequence of suboptimal management practices [15].

Evaluating sexual behavior has become a critical complement to andrological examinations for selecting bulls with strong reproductive potential, particularly in natural mating systems. Such evaluations contribute to improved calving rates, increased production of high-quality meat and/or milk, sustainable growth of the livestock sector, and faster returns on investment. Accordingly, the aim of this study was to characterize the sexual behavior of Colombian Creole bulls from the Romosinuano (ROM) and Costeño con Cuernos (CCC) breeds. This research presents the first documented assessment of the reproductive behavior of Colombian Creole bulls and offers practical criteria for identifying high-potential sires in the field, supporting their integration into sustainable production systems.

2. Materials and Methods

2.1. Location and Sire Population Evaluated

A total of 46 bulls from the Romosinuano (ROM, $n = 39$) and Costeño con Cuernos (CCC, $n = 7$) breeds, belonging to the Genetic Improvement Herds (PMG) and Germplasm Bank (BGA), were evaluated. Both herds are maintained at the Centro de Investigación Turipaná of the Corporación Colombiana de Investigación Agropecuaria, AGROSAVIA (<https://www.agrosavia.co> (accessed on 10 June 2025)), located in the Sinú River valley in Km 13 vía Montería-Cereté, Córdoba, at a latitude of 8°50'15.2" N and longitude of 75°47'33.9" W, with an altitude of 14 m above sea level. The region experiences an average annual temperature of 28 °C, relative humidity ranging from 79% to 87%, and an average annual precipitation of 1400 mm. Both the PMG and BGA herds are managed under a rotational grazing system based on *Megathyrus maximus* pastures.

The BGA operates as a closed nucleus, where reproductive management follows a circular mating scheme to minimize inbreeding. The evaluated bulls had an average age of

5.40 ± 0.94 years for the CCC breed and 4.792 ± 1.451 years for the ROM breed. All bulls had participated in at least one breeding season and were confirmed to be reproductively competent based on comprehensive physical, clinical, and semen quality examinations.

2.2. Evaluation of Sexual Behavior

The evaluation encompassed sexual interest (libido) and the service capacity of the bulls (SC). Each bull was placed in a pen of approximately 500 m² with two non-restrained cows in estrus. Bull evaluation was performed for 15 min in the morning. The frequency of sexual behaviors was recorded, including smelling, Flehmen reflex, butting, urination, courtship, protrusion, erection, mounting, and ejaculation. Libido was assessed using an ordinal scale from 0 to 10 [16], with modifications applied to scores ranging from 7 to 10 (Table 1).

Table 1. Description of the scoring system for libido classification.

Classification	Score *	Sexual Behavior Description
Questionable	0	The bull shows no sexual interest in the cow(s); apathetic.
	1	Identification of the cow in estrus (smelling and Flehmen reflex).
	2	Smelling, Flehmen reflex, and continuous accompaniment.
Good	3	Attempted mounting without jumping, accompanied by vocalizations, moving, and masturbation.
	4	Mount attempt without jumping, with penis exhibition.
	5	Mount attempt with jumping and penis exhibition.
	6	Two or more mount attempts by jumping and penis exhibition.
	7	Mount with protrusion, erection, penis exhibition, and ejaculation.
Excellent	8	Mount with complete service.
	9	Two complete services.
	10	More than two complete services performed consecutively with persistence.

* Adapted from [16].

During the same period, the number of services performed by each bull was recorded to assess service capacity (SC), adapted from the VART methodology [17] SC was classified as follows: Superior SC: A complete service achieved within 5 min; High SC: A complete service achieved within 10 min; Acceptable SC: A service achieved within 15 min; and Not Suitable SC: No service achieved by the end of the evaluation period.

2.3. Statistical Analysis

Descriptive statistics and frequency tables were initially computed to summarize the number of events for each of nine sexual behaviors exhibited during the evaluation. Because of the discrete and ordinal categories of data, the Kruskal-Wallis test was employed to determine the differences between breeds in the frequency of observed behaviors.

Subsequently, multiple correspondence analysis (MCA) was conducted to identify patterns or significant relationships within the data [18], particularly those associated with behavior and breed. Confidence intervals of 95% were included. Behavioral variables were analyzed using the Clustofvar algorithm [19] to classify variables with similar behaviors into homogeneous groups. Finally, breed differences in bull service capacity were evaluated

using an χ^2 -test, and linear regression was performed to establish the relationship between the time for service and bull age.

Data processing, descriptive statistics, non-parametric multivariate analyses, and linear regressions were performed using the statistical software R version 4.4.1 [20].

3. Results

Table 2 summarizes the descriptive statistics for the scores obtained for each evaluated reproductive behavior. Significant differences ($p < 0.05$) were observed between the ROM and CCC genetic groups for the behaviors of urination and mounting. Figure 1 illustrates the distribution of the number of times bulls of each breed exhibited this behavior. In particular, the behaviors of butting, urination, courting, and ejaculation were less frequently observed in both breeds. Except for urination and mounting, the remaining behaviors showed similar patterns of occurrence in both breeds. The CCC breed tends to respond immediately to the presence of a female in estrus.

Table 2. Descriptive statistics of reproductive behaviors by breed and their comparison using the Kruskal-Wallis test.

Behavior	CCC				ROM				Kruskal-Wallis	p-Value
	Min	Median	Mean $\pm$ SD	Max	Min	Median	Mean $\pm$ SD	Max		
Smelling	0	2.5	2.4 $\pm$ 1.71	5	1	3	3.21 $\pm$ 1.57	7	1.314	0.252
Flehmen reflex	0	2	2.5 $\pm$ 1.96	7	1	3	3.4 $\pm$ 1.92	8	2.224	0.136
Bunting	0	0	0.3 $\pm$ 0.48	1	0	0	0.26 $\pm$ 0.49	2	0.154	0.694
Urination	0	1	1.2 $\pm$ 1.14	3	0	0	0.4 $\pm$ 0.85	4	7.464	0.006
Courtship	0	0.5	0.5 $\pm$ 0.53	1	0	0	0.4 $\pm$ 0.61	2	0.553	0.457
Protrusion	1	3.5	3.6 $\pm$ 2.22	8	0	3	2.96 $\pm$ 1.79	8	0.605	0.437
Erection	1	2.5	3.3 $\pm$ 3.02	10	0	2	2.66 $\pm$ 1.72	7	0.004	0.949
Mounting	2	3.5	3.9 $\pm$ 2.38	9	0	2	2.32 $\pm$ 1.82	7	4.37	0.037
Ejaculation	0	0.5	0.6 $\pm$ 0.7	2	0	1	0.62 $\pm$ 0.68	3	0.007	0.932

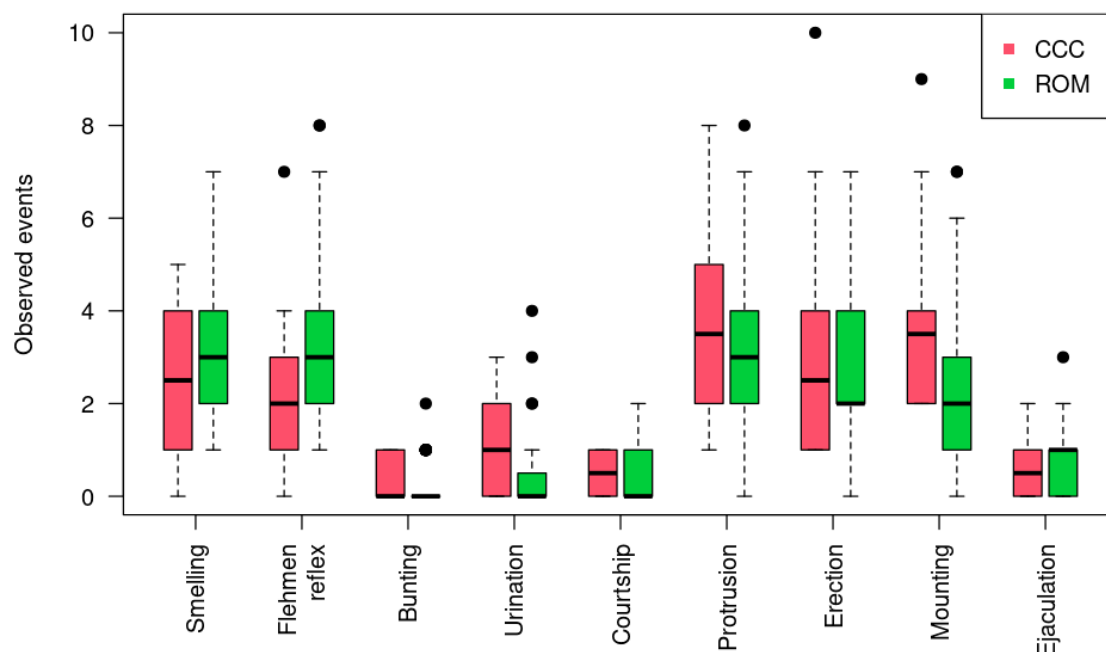


Figure 1. Distribution of the number of events for the nine evaluated behaviors in the CCC (red) and ROM (green) breeds. Dots indicate individuals with observed events that fall outside the expected range.

The distribution of the number of events observed for certain behaviors (Table 1), such as the Flehmen reflex or protrusion, showed variability within individuals. To assess whether there were underlying behavioral patterns among individuals, a Multiple Correspondence Analysis (MCA) was conducted, which included the nine behaviors evaluated (Figure 2).

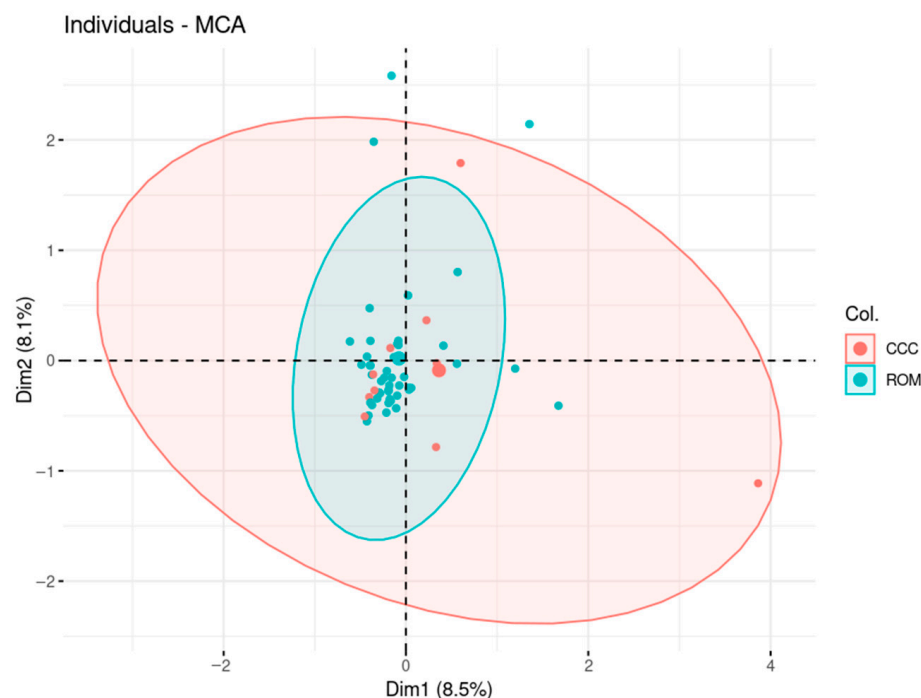


Figure 2. Multiple correspondence analysis of nine reproductive behaviors in CCC and ROM Creole cattle.

The ROM individuals (cyan) tend to cluster more closely together, suggesting less variability in their behaviors. Conversely, the CCC individuals (red) display a wider spread and variability (Table 1). In fact, the confidence interval for the CCC overlaps that estimated for ROM. Despite the evident overlap, their confidence ellipses suggest a partial separation, especially along Dim1, which is mainly influenced by erection, urination, mounting, and flehmen.

The first two dimensions capture 16.6% of the variation in the events observed for the nine behaviors and revealed outstanding bulls for both populations, but particularly in the CCC breed. Most ROM bulls were clustered near the origin, reflecting consistent behavior and characteristics across the variables analyzed.

Therefore, to identify patterns in the number of events by breed, a clustering-based method on variables was performed (Figure 3). The clustering patterns of the behaviors revealed that ROM animals displayed a consistent and rapid mounting behavior. In contrast, CCC animals demonstrated mounting behavior closely associated with urination, protrusions, and erections. Among CCC bulls, behaviors such as smelling, the Flehmen reflex, and courting were strongly linked to ejaculation, suggesting that effective courting is crucial for reproductive success.

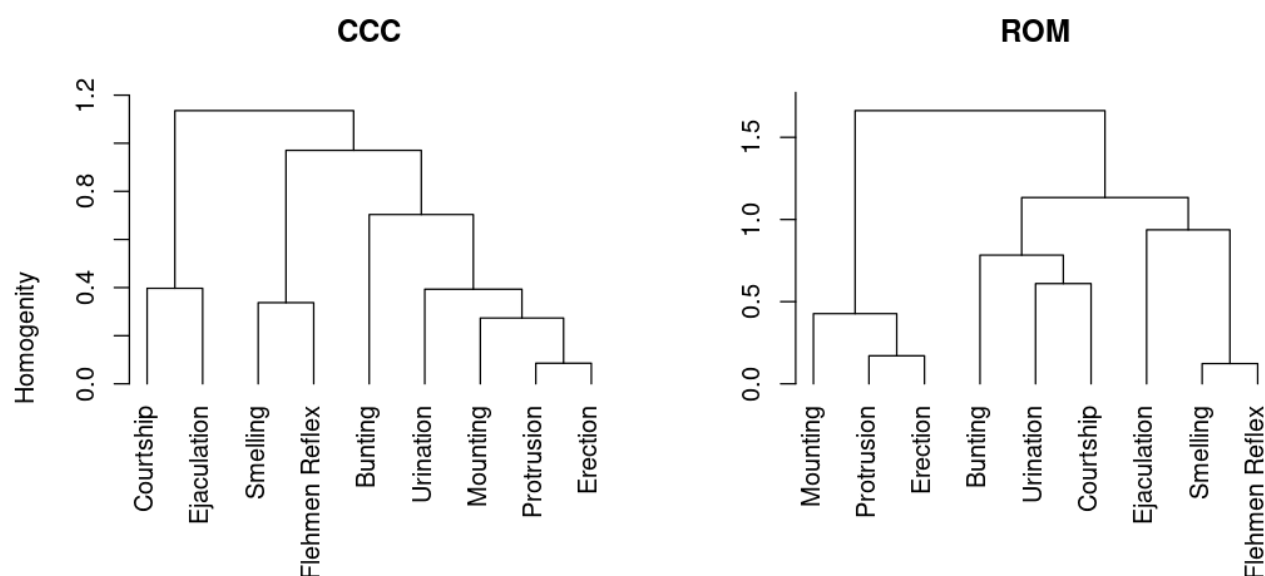


Figure 3. Hierarchical clustering analysis of the relationships among the nine evaluated sexual behaviors for each breed.

Libido and Service Capacity

Regarding libido, bull scores ranged from 4 to 9, with 80.35% achieving scores of 7 or higher, which were classified as very good or excellent. No statistically significant differences were observed between the breeds ($p > 0.05$). However, 85.71% of CCC bulls and 65.21% of ROM bulls achieved very good or excellent scores. Service capacity (SC) was evaluated based on the time required by bulls to achieve mounts. Overall, 50.87% of trials resulted in a mount within 5 min, 10.52% within 10 min, 21.05% within 15 min, and 17.56% of trials did not result in mounting.

In the CCC breed, 71.42% of bulls achieved mounting within the first 5 min, compared to 44.68% of ROM bulls. Conversely, 14.28% of CCC bulls and 19.14% of ROM bulls failed to achieve a mount within the 15 min trial period. While no statistically significant differences ($p > 0.05$) in SC were found between breeds, caution should be exercised in interpreting these results due to unequal sample sizes (CCC: $n = 7$, ROM: $n = 39$). In addition to assessing reproductive behaviors, the time required for bulls to achieve the first, second, and third mounts was quantified (Table 3).

Table 3. Time (in seconds) required by bulls to achieve first, second, and third mounts.

	First Mount	Second Mount	Third Mount
All bulls	114.41 ± 112.88	226.32 ± 152.99	296.56 ± 149.34
CCC	101.11 ± 122.90	226.56 ± 163.15	283.20 ± 161.67
ROM	119.20 ± 111.33	226.19 ± 152.49	302.64 ± 151.23

Younger bulls required more time to achieve mounting ($p < 0.05$), likely due to inexperience. For the first and second mounts, it was observed that each additional year of age reduced the time to mount by -26.95 s and -38.97 s, respectively (Figure 4).

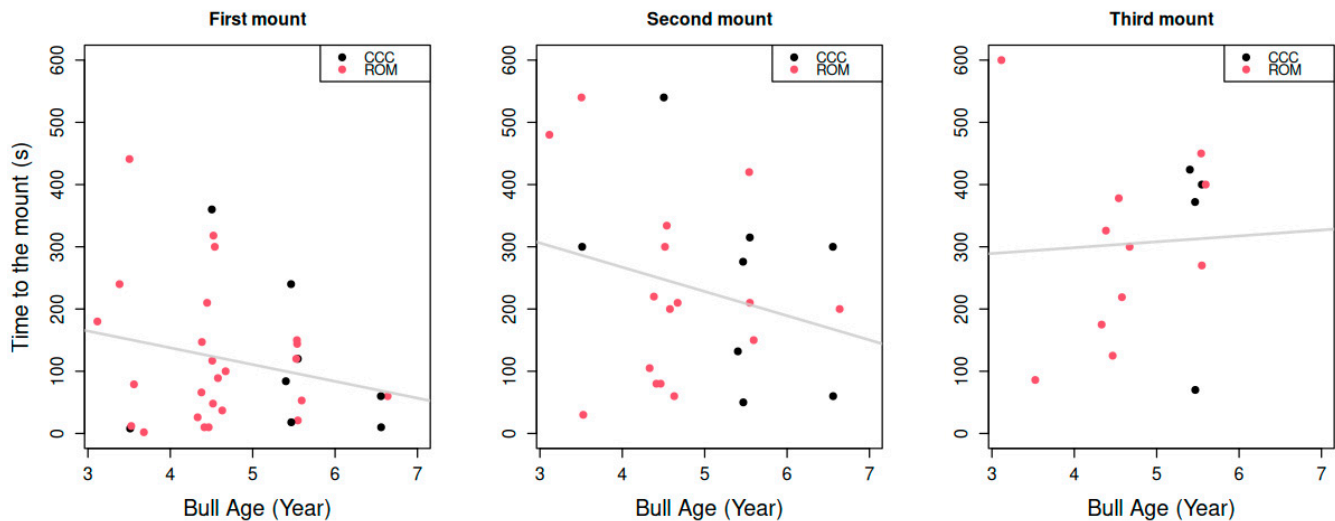


Figure 4. Time in seconds to the first, second, and third mounts according to the age of the sire.

4. Discussion

Several studies have highlighted the reproductive capacity of Creole cattle in both males and females. Similarly, anatomical and physiological evaluations have revealed that Creole cattle exhibit characteristics comparable to those of commercial breeds. However, the true value of Creole cattle lies in their remarkable adaptability, which provides a distinct advantage over other breeds selected for production under challenging environmental conditions. Adaptation is a critical component of overall efficiency, and establishing behavioral patterns is essential for achieving optimal reproductive outcomes.

The Romosinuano (ROM) and Costeño con Cuernos (CCC) breeds are valuable genetic resources in the Caribbean region of Colombia. While ROM has been introduced in other countries and plays a significant role in tropical production systems [21], CCC remains primarily localized, contributing to dual-purpose systems within Colombia [22], where natural mating using bulls is a common herd management practice. Evaluating the behavioral traits of these breeds can enhance the functional selection criteria for breeding bulls and promote more sustainable livestock production.

Despite their potential, there is limited scientific information regarding the reproductive and behavioral traits of Colombian Creole breeds—especially CCC. Describing these traits can contribute to a more effective use of these genetic resources, which may currently be undervalued. This information is particularly relevant for small- and medium-scale producers operating under low-input or environmentally constrained conditions, where adaptability and fertility are critical for productivity.

The Colombian cattle population is predominantly composed of Zebu breeds such as Brahman, which have historically displaced Creole cattle due to their higher growth rates and adaptability. However, national calving rates remain below 55.1% [23], which is notably lower than the reported rates for CCC (70% [24]) and ROM (>80% [25]).

Despite their physiological adaptation to tropical environments, the reproductive behavior of Zebu breeds like Brahman is highly influenced by environmental factors in Colombia. Libido and service capacity in Brahman bulls decrease significantly during periods of intense rainfall and tend to increase during transitional seasons, suggesting a marked sensitivity to climatic variation in the country [26].

Bos indicus bulls generally exhibit lower libido than *Bos taurus* bulls. For example, Zebu bulls raised under tropical conditions are typically categorized as having questionable to good libido [27–29]. In this study, 80.35% of *Bos taurus* ROM and CCC bulls were

classified as having very good to excellent libido, with the remaining bulls rated as having good libido.

This study presents the first objective assessment of libido scores in Costeño con Cuernos (CCC) bulls. While field observations have previously indicated that CCC bulls may serve more than 25 females and achieve pregnancy rates above 70% during the breeding season [24], the standardized evaluation conducted in this study provides a quantitative basis for characterizing reproductive behavior in this Creole population.

A study evaluating the libido of ROM bulls between 12 and 20 months of age reported progressive improvements in libido scores over time, with an earlier onset of puberty than Brahman bulls and reproductive traits comparable to those of Angus bulls [30]. Additionally, assessments of ROM bulls under tropical conditions in Florida (USA) positioned the breed at an intermediate level: superior to Brahman and Nellore $\times$ Brahman bulls, but not reaching the libido scores observed in Angus bulls [31]. The authors emphasized early puberty and tropical adaptation of ROM as key traits for reproductive efficiency under heat stress, recommending their use in tropical beef systems without compromising resilience.

Our findings showed that ROM and CCC bulls initiated reproductive behaviors in less than 15 min. This contrasts with *Bos indicus* bulls, for which standard libido tests often require extended observation periods to adequately capture sexual behavior [26]. Therefore, the immediate and spontaneous response observed in Creole bulls may represent a functional advantage in natural mating systems, enabling more efficient reproductive evaluations and potentially improving herd fertility under tropical conditions.

Sexual behaviors such as smelling, Flehmen reflex, butting, courtship, protrusion, erection, and ejaculation showed no significant differences between ROM and CCC bulls. However, CCC bulls were more frequent in mounting and urination behaviors, which are indicative of mating periods, territorial marking, or chemical communication with females. These behaviors enhance interactions in extensive or rotational grazing systems.

Moreover, a close link was observed between initial interaction behaviors (courtship and smelling) and those related to the final success of the reproductive process (ejaculation) in CCC bulls. This highlights the importance of preparation and communication with females before mating to ensure reproductive success.

Studies have shown that smelling or licking the body and vulva, followed by the Flehmen reflex, are key physiological signals used by Nelore bulls to identify a female's reproductive state [32]. Similarly, others have described that [33,34] smelling the perineal region and exhibiting the Flehmen reflex were also prevalent behaviors in the Guzará breed [35], indicating similarities in the initial behaviors for recognizing females in estrus.

The ROM and CCC herds are maintained in the same area; therefore, environmental conditions impact both groups similarly. Adaptation to tropical environments is essential for reproductive success. Stress factors induce metabolic and endocrine changes, potentially altering behavior temporarily and even across generations [36]. Additionally, behavior can be influenced by social, hormonal, nutritional, individual, age-related, and genetic factors [37,38].

For example, the inexperience of younger bulls can result in sexual behaviors that hinder reproductive efficiency [39]. Mating times (Table 3) may reflect the interaction behaviors between young bulls and cows [40], leading to greater variability in the timing of the first and second mounts compared to more experienced bulls (Figure 4).

In other creole breeds, such as Limonero from Venezuela, bulls do not require estrogenized females to exhibit sexual behaviors. A study showed that [41] females in estrus were not necessary to stimulate sexual responses in Criollo Limonero bulls; immobilizing females was sufficient to elicit attraction. Similarly, another study reported that Mexican

Criollo Lechero Tropical bulls were characterized by high libido and good seminal quality regardless of age, indicating their potential use in breeding programs [42].

Although it is not possible to generalize these behavioral measurements, the observed trends suggest that environmental stressors may reduce the sexual responsiveness of taurine and zebuine breeds to a lesser extent. In this context, Creole bulls may offer advantages under limited environmental conditions, potentially contributing to improved reproductive performance [43]. Although Creole cattle typically do not exhibit the growth performance of specialized breeds, their consistent reproductive behavior under suboptimal conditions may result in favorable pregnancy rates, which can translate into improved weaning success or milk yield per unit area.

This study represents an initial step toward the development of new indicators of reproductive capacity in Colombian Creole cattle. To date, research on the reproduction of Creole cattle has primarily focused on either genetic evaluations of reproductive traits [25] or seminal quality studies [44–46]. Furthermore, production systems based on Creole genetic resources, alongside commercial cattle herds in the country, incorporate bulls [47]. Behavioral evaluations provide valuable insights for selecting effective bulls to ensure the reproductive sustainability of herds.

5. Conclusions

This study provides a comprehensive evaluation of sexual behavior and reproductive performance in Colombian Creole bulls of the Romosinuano (ROM) and Costeño con Cuernos (CCC) breeds under natural mating conditions. ROM bulls exhibited a more uniform and rapid behavioral response, whereas CCC bulls showed greater individual variability and a broader behavioral repertoire, with courtship behaviors that were strongly associated with ejaculation. These findings suggest that CCC bulls may rely more on a sequential courtship strategy, while ROM bulls display a more direct approach, highlighting the potential advantages of breed-specific reproductive strategies in tropical environments.

In terms of libido and service capacity (SC), 80.35% of all bulls achieved very good to excellent libido scores. CCC bulls achieved mounts more frequently within the first five minutes of exposure to estrous females, underscoring their prompt sexual responsiveness. Additionally, age was inversely associated with time to mount, emphasizing the role of maturity and experience in enhancing reproductive efficiency.

This study presents the first objective characterization of sexual behavior in CCC bulls and offers valuable comparative insights into the ROM breed. Overall, the results underscore the adaptive potential and functional reproductive efficiency of Colombian Creole bulls, supporting their strategic inclusion in breeding programs aimed at improving fertility under environmentally constrained conditions.

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Institutional Review Board Statement: The animals used in this study were handled and treated under qualified veterinary supervision following the animal experimentation rules described in

the International Guiding Principles for Veterinary Research Involving Animals. This study was approved by the Ethics, Bioethics, and Scientific Integrity Committee of the Corporación Colombiana de Investigación Agropecuaria Agrosavia, under Act N.2; date of approval: 6 October 2021.

Informed Consent Statement: This study did not involve human participants.

Data Availability Statement: Data for this study is available from the corresponding author upon request.

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Conflicts of Interest: The authors William Orlando Burgos-Paz, Jorge Armando Mejía-Lúquez and Erly Luisana Carrascal-Triana were employed by Corporación Colombiana de Investigación Agropecuaria—AGROSAVIA. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Glossary

Smelling:	Investigating the female with the nose to detect estrus-related olfactory cues.
Flehmen reflex:	Curling of the upper lip to transfer pheromones to the vomeronasal organ.
Butting:	Gentle pushing of the female with the head, often as part of courtship.
Urination:	Act of urinating, which may occur during sexual courtship.
Courtship:	Pre-mounting behaviors aimed at stimulating the female.
Protrusion:	Visible extension of the penis from the sheath.
Erection:	Physiological hardening of the penis in preparation for copulation.
Mounting:	The act of climbing onto the female for copulation
Ejaculation:	Release of semen during copulation.
Libido:	The bull's level of sexual interest and motivation.
Service ability:	The bull's capacity to complete mounts with ejaculation efficiently within a defined observation period.

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