Differences in water consumption and temperament of young Nelore and Canchim bulls raised on tropical pastures revealed by electronic monitoring

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Abstract

Electronic animal monitoring devices have been tested to increase the productivity and sustainability of agricultural and food systems. For this reason, the study aimed to evaluate traits related to the use of water resources and the expression of temperament of young bulls of two breeds raised in tropical pastures using precision instruments. The experiment was conducted in São Carlos, Brazil, over 152 days. Sixteen bulls of the Nelore (NEL, *Bos indicus*; n=8) and Canchim (CAN, 5/8 Charolais x 3/8 Zebu; n=8) breeds were used (13.7±1.5 months; 283.0±31.6 kg BW). The animals were housed in pasture-based production systems and had ad libitum access to electronic water fountains that were continuously monitored. Temperament assessment took place in a management corral using accelerometers to measure the intensity and frequency of the animals' movements. Mean values were compared using the t-test and Mann-Whitney test, and correlation was calculated using Pearson's test (RStudio, $P<0.05$). The frequency of daily visits to the water fountain was 7.4% lower in the Canchim animals. However, these animals had a higher daily water intake (NEL: 15.1±8.8 vs. CAN: 20.9±10.2 L/day; $P<0.05$). Nelore animals had a more reactive temperament (NEL: 1,296 vs. CAN: 1,056; $P<0.05$). There was a significant correlation between reactivity and daily water intake. The electronic recording thus made it possible to determine a substantial influence of genotype on the pattern of water intake and temperament of the animals, information that can be very useful for the management of pasture-based production systems.

Keywords: precision livestock farming, natural resources, beef cattle, water intake, reactivity, sustainability

Introduction

Raising cattle on pasture in tropical regions is a challenging activity, as heat stress is considered a limiting factor in achieving high productivity, as well as having an impact on animal health (Romanello et al., 2023). Currently, the use of sensors and electronic devices to obtain data in real-time has the potential to be applied to the calculation of indicators, which can be applied to increase the productivity and sustainability of farms (Vaintrub et al., 2021). There are, for example, sensors that generate information based

on the interaction between animals and equipment, which can provide details of behavior during water intake. This monitoring is essential because using natural resources, such as water, is one of the most critical points in agri-food production systems. Thus, the development and use of technological innovations can identify essential information on factors that influence animal water intake, such as breed, category, and physiological condition, as well as abiotic factors, such as climatic variables in the production area.

In addition to physiological responses, behavioral mechanisms are used by animals to regulate their body temperature. For this reason, some attitudes can be used as indirect indicators of heat stress. Cattle raised in warm environments tend to alter their behavior to reduce endogenous heat generation (Barreto et al., 2022) and minimize the risk of heat stress. Among the behavioral aspects of the most significant zootechnical interest in cattle is the expression of temperament.

Temperaments' evaluation is essential in production systems, as this characteristic is related to the animal's performance, welfare, and, ultimately, meat quality (Sant'Ana et al., 2013; Moura et al., 2021). As such, temperament is essential for herd management and the economic return on livestock. The expression of cattle temperament may be affected by genetic and environmental factors. Studies report that breed influences the temperament of beef cattle. Animals of the *Bos taurus* subspecies show less behavioral reactivity and less intense reactions during routine handling than *Bos indicus* animals. For this reason, *Bos indicus* animals tend to show more pronounced physiological responses to stressful situations (Ceballos et al., 2016; Braga et al., 2018). In this context, cattle temperament assessments can be carried out using subjective and objective methods for visual observation techniques or electronic devices (Maffei et al., 2006).

In this respect, to comply with the animal welfare requirements currently demanded by consumers (CNI, 2020), it is essential to know the interactions between animals and the environment in which they are raised. Additional information makes it possible to monitor the animals' productive responses and comfort, supervise the use of natural resources, and, if necessary, direct the implementation of measures to improve the functioning and condition of production systems. Therefore, the objective of this study was to evaluate behavioral characteristics related to the use of water resources and the expression of temperament in young bulls of two breeds raised in a tropical pasture production system, based on the use of precision instrumentation.

Material and Methods

Bioethics

The research was approved by the Ethics Committee for the Use of Experimental Animals of Embrapa Pecuária Sudeste (CEUA Certificate PRT02/2023).

Experimental site and period

The experiment was carried out at Embrapa Pecuária Sudeste, São Carlos-SP, Brazil (21°57'42"S, 47°50'28"W, 860m) between October 2023 and February 2024, totaling 152 days. The local climate type is Cwa, tropical altitude, according to Köppen-Geiger (Kottek et al., 2006). During the experimental period, the maximum air temperature ranged from 18.60 to 31.50ºC. The average relative humidity ranged from 70.1 to 81.7%. The average monthly rainfall was 142.42 mm. The daily solar radiation average was 21. 80 MJ/m^2/day (Embrapa, 2024).

Animals

Sixteen young bulls of the Nelore (NEL, *Bos indicus*; n=8) and Canchim (CAN, 5/8 Charolais x 3/8 Zebu; n=8) breeds were used, aged 13.7±1.5 months and 283,0±31,6 kg BW. The animals were allocated to a pasture-based production system (12 ha) cultivated with *Urochloa Brizantha* grass (cv Piatã). Animals were managed under equal health and nutritional conditions, with ad libitum access to mineral supplementation. All animals were individually identified with subcutaneous microchips and RFID ear tags.

Monitoring water intake

Access to the water fountains was *ad libitum* and monitored uninterruptedly by four electronic devices installed in the pastures (AF 1000, Intergado Ltda., Brazil). The drinkers had presence sensors for individual animal identification when accessing the platform. When an animal inserts its head into the equipment, the hardware automatically read the RFID identification button (Figure 1). The animal was allowed to drink water freely in an amount and for a time to be determined by itself. After drinking, the animal spontaneously left the platform without restriction on how many times each animal used it.

The variables of interest were the frequency of the animal's visits to the water fountain (visits/day), water intake time (min/day), and individual water intake (L/day), which was calculated based on the difference between the reservoir's weights at the beginning and end of the visit. After each visit to the water fountain, the respective data was transmitted to acquisition centers near the equipment. The data packets were automatically compiled and sent to the management platform using wireless technology.

Figure 1: (A) Illustrative photograph of young bull water intake from an individual electronic water fountain installed in a pasture-based production system at Embrapa Pecuária Sudeste, São Carlos-SP, Brazil. (B) Detail of the animal getting close to the electronic water fountain and individual identification using RFID technology.

Temperament evaluation

Temperament evaluations were carried out individually, in a management pen (|Figure 2), at 90-day intervals. This was done using an electronic device attached to the scale, fitted with an accelerometer, which quantifies the intensity and frequency of the animals' movements over 20 seconds. The electronic device (Utility Model Patent - No DEINPI/MG 001088)) recorded the result of each animal's assessment on a numerical scale ranging from 1 to 99.999.

During the temperament evaluation, the animal was not physically restrained, directly contacted, or subjected to any other simultaneous procedure. The individual results were categorized into three reactivity classes, with the class with the highest score indicating more aggressive animals (adapted from Maffei et al., 2006). For example, animals in Class 1 (reactivity from 0 to 1000 points) are considered more docile than animals in Class 3 (reactivity >2000 points).

Figure 2: (A) Electronic evaluation of the temperament of experimental animals in a management environment. (B) Screenshot of the software used to evaluate the frequency and intensity of cattle movements.

Statistical analyses

The data were tested for normality of the residuals using the Shapiro-Wilk test. Multiple comparisons between the mean values of the breeds were performed using the t-test. Comparisons of mean temperament scores between breeds were performed using the Mann-Whitney test. The linear correlation coefficients were calculated using the Pearson correlation test. All statistical analyses were performed using RStudio. A significance level of 5% ($P<0.05$) was used for all analyses. The correlation coefficients were considered to be high ($r > 0.68$), moderate ($0.36 < r < 0.67$), or low ($r < 0.35$) according to the estimated values (Taylor, 1990).

Results and Discussion

Water intake

The data indicates that the Nelore animals searched the water fountains more often than the Canchim animals (Table 1). In comparison, the frequency of daily visits to the water fountains was 7.4% lower for Canchim animals. Although they went to the drinker less often, the Canchim animals had higher daily water intake (NEL: 15.1±8.8 vs. CAN:

20.9±10.2 L/day; P<0.05), with an intake of 5.8 L/day more than Nelore animals. This difference suggests a behavioral adaptation in Canchim animals, resulting in fewer visits to the water fountains without compromising their daily water intake. Our results for Zebu animals align with those published by Zannetti et al. (2019), who indicated a predicted average water intake of 16.7 L/day for Nelore cattle raised in tropical conditions.

Similarly, our results for composite animals indicate daily water intake very similar to the 20.7 L/day recorded for Charolais x Romosinuano (Bos taurus adapted to the tropics) animals (Brew et al., 2011). As the Canchim is also a heat-tolerant breed (ABCCAN, 2017), the water intake of continental, British or composite taurine breeds will be lower the more adapted the breed is to the tropics. In this context, animals' water intake from crossing the Charolais x Angus breeds, which are less adapted to the heat, reaches 42.8 L/day (Brew et al., 2011). However, it is essential to emphasize that direct comparisons between different studies can show differences in water intake patterns depending on the rearing system, especially when confinement is used, unlike the pasture rearing system adopted in this study.

Daily water intake time did not differ significantly between breeds (P>0.05). However, the Water intake rate and the volume of water intake per visit were influenced by breed, with Nelore animals showing a lower water intake rate (-14.5%) and lower water intake per visit (-2.6 L) compared to Canchim animals. Higher water intake aims to maintain electrolyte balance and meet water replacement needs. Part of the water ingested is used to compensate for the fluid used in insensible heat loss, such as sweating, an essential mechanism for maintaining body temperature in cattle (Pereira et al., 2019). These results highlight the importance of considering the specific characteristics of each breed when planning the water supply to meet daily requirements and fulfill one of the five animal freedoms, which advocates those animals be raised thirst-free (FAWAC, 2009).

Table 1: Mean values (± standard deviation) of the variables relating to the drinking behavior exhibited by young bulls of the Nelore (n=8) and Canchim (n=8) breeds raised in pasture-based production systems

Variables*	NEL	CAN	P-value	Average
Daily visits	2,9±1,3	2,7±1,2	<0,05	2,8±0,1
Water intake (L/day)	15,1±8,8	20,9±10,2	<0,05	18,1±0,4
Water intake time (min/day)	5,8±19,0	6,8±20,7	>0,05	6,3±0,1
Water intake rate (L/min)	4,1±2,4	4,8±2,9	<0,05	4,4±0,1
Water intake per visit (L/visit)	5,6±3,4	8,2±4,0	<0,05	6,8±0,2

*The variables were calculated considering a total of 5.687 daily visits

In addition, the results of this study provided unprecedented information on the water intake behavior of beef cattle raised on tropical pastures, regardless of the breed evaluated. Electronic technology revealed that young bulls went to the water fountain two to three times a day. Over a day, they consumed an average of 18.1 liters of water and spent just over 6 minutes daily drinking. The average water intake flow by the young bulls was 4.4 liters per minute, and the amount of water ingested during each visit to the water trough was 6.8 liters.

Studying the correlations between the variables derived from electronic monitoring of water intake is crucial for improving management strategies and providing valuable insights into water management efficiency in grazing cattle (Figure 3).

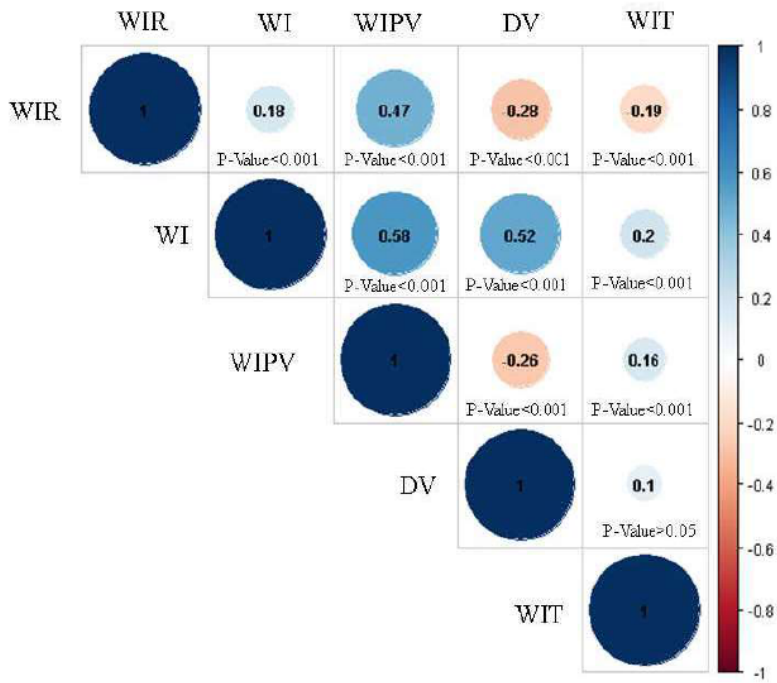

Figure 3: Linear correlation coefficients between variables from electronic monitoring of water intake of young bulls reared in a tropical pasture-based production system (WIR: Water intake rate; WI: Water Intake; WIPV: Water intake per visit; DV: Daily visits; WIT: Water intake time)

Statistical analysis showed that water intake rate was positively correlated with consumption (0.18) and water intake per visit (0.47). In other words, animals that consumed water quickly and with greater avidity consumed more water at each visit to the drinker and, ultimately, had greater daily water intake. Conversely, avidity during consumption was negatively related to the time spent on water intake (-0.19) and the number of daily visits to the water trough (-0.28).
Water intake had a positive correlation of moderate magnitude for water intake per visit (0.58) and daily visits (0.52) and a positive correlation of low magnitude for water intake time (0.20). Thus, animals that consumed more water tended to visit the troughs more often and consumed more water each time they went to the trough. There was a positive but low correlation (0.1) between the daily visits to the water fountains and the total drinking time. Hence, animals that visited the water fountain more often on the same day tended to spend more time drinking.

Temperament

Figure 4 shows the results obtained in the temperament evaluations. A different distribution was observed between the breeds in the ranking established. Many Canchim animals were found in Classes 1 and 2, which concentrate animals with a more docile temperament. Class 3, on the other hand, concentrated more animals of the Nelore breed. By definition, animals with higher reactivity scores are considered more aggressive (Maffei et al., 2006; Marcondes et al., 2023).

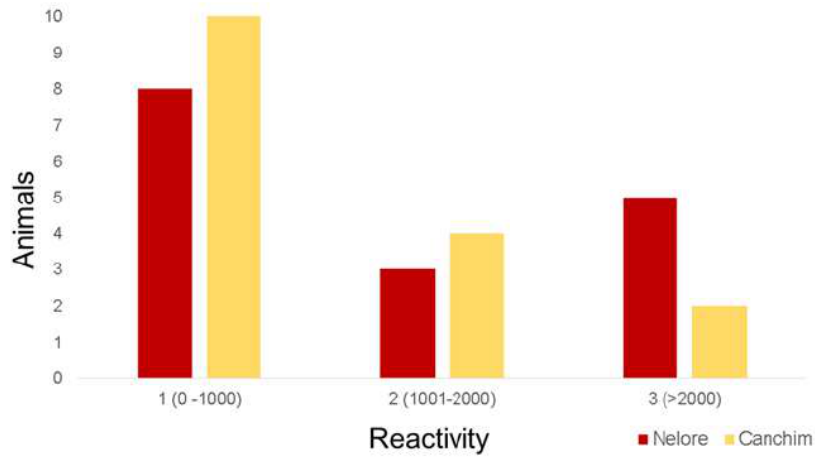

Figure 4: Frequency of Nelore and Canchim animals classified according to the reactivity score determined with an electronic device

The temperament analysis showed significant variation between breeds and individuals, with substantial averages for reactivity ($P<0.05$). Canchim animals had an average reactivity score of 1,056, with a minimum of 277 and a maximum of 3,365 points. Nelore bulls had an average reactivity of 1,296, with a minimum of 299 and a maximum of 3,212 points. As the animals were contemporaries, raised together, and subjected to the same management from birth, their different genetics can partly explain these differences. *Bos indicus* animals generally have a more reactive temperament than *Bos taurus* animals. Our results differ from those published by other authors, who found an average reactivity of 3,255 for Canchim cattle (Marcondes et al., 2023) and 534 for Nelore animals (Maffei et al., 2006).

A positive correlation was found when analyzing the correlation between reactivity and daily water intake ($r = 0.19$). Although the correlation is low, this suggests that the more reactive the young bulls reared on pasture, the more water was consumed by the animals. From this, we could infer that more reactive animals might be exposed to greater stress due to environmental, social, or genetic factors. Consequently, they have a higher metabolic rate and a greater need for water replacement to maintain their basal balance. However, this approach needs further investigation. In any case, there is evidence that the relationship between temperament analysis and water intake highlights the importance of considering not only environmental aspects but also the individual behavioral characteristics of cattle when planning water management aimed at animal welfare in livestock production.

Conclusions

Young Canchim bulls had a higher daily water intake, drinking time, drinking rate, and fewer visits to water fountains than Nelore animals. In turn, Nelore animals had a more reactive temperament than Canchim animals. It was observed that the more reactive young bulls reared on pasture were, the higher their water consumption was. Both groups of phenotypic traits were efficiently recorded by electronic monitoring. Therefore, the temperament analysis in relation to water intake underlines the importance of considering

the individual environmental and behavioral aspects of cattle when planning water management for animal welfare in livestock production.

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