Acta Scientiarum
http://periodicos.uem.br/ojs
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v47i1.71117

Ingestive behavior of Nellore cattle confined during the growing phase in different shading strategies

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ABSTRACT. The study evaluated different shading strategies on the ingestive behavior of confined Nellore cattle during the growing phase. The experiment was conducted in the semi-arid region of Minas Gerais, Brazil, with 225 Nellore cattle (10 months old, 240 kg body weight). A completely randomized design was used with three treatments: no shading (full sun), natural shading (trees), and artificial shading, with 75 animals per group. Climatic variables were recorded, and feeding, ruminating, and idling behaviors were observed every 15 minutes for 24 hours. The full-sun environment was the most uncomfortable, with the highest air temperatures recorded between 12:00 a.m. and 2:50 p.m. Animals under natural shading showed higher feeding frequency, improved feeding efficiency, and greater daily weight gain, resulting in higher final weights. A significant difference ($p < 0.05$) in air temperature was found among treatments, with the highest value under full sun (29.3°C). Relative humidity and air velocity did not differ significantly. Natural shading improved the environment, leading to better zootechnical performance. The study concluded that providing natural shade for confined Nellore cattle improved ingestive behavior, increased feeding frequency and efficiency, and enhanced weight gain. This strategy is recommended for better cattle management and welfare in semi-arid regions.

Keyword: Animal welfare; beef cattle; feed, feedlot; shading; thermal comfort.

Received on January 27, 2024.
Accepted on August 21, 2024

Introduction

Brazil has the largest commercial cattle herd in the world, with 215 million animals, utilizing 167 million hectares of native and/or cultivated forage plants as the main nutrient source for the animals (Instituto Brasileiro de Geografia e Estatística [IBGE], 2018). However, due to climatic changes throughout the year, forage production is inconsistent, resulting in the slaughter of older animals (over 42 months of age) with low carcass weights (below 270 kg), often without minimum finishing (3 mm of subcutaneous fat) (Benatti et al., 2017; Sampaio et al., 2017).

The bovine rearing or growth phase, known as the interval between weaning and finishing, is considered one of the main challenges leading to delayed slaughter due to its long duration (over 24 months) (Barbero et al., 2017). In Central Brazil, calves are weaned between April and June, a transitional period marking the end of the climatic season (autumn) and the beginning of winter. Consequently, tropical grasses deferred during the summer have low nutritional value in the winter, which coincides with the animals' upward growth phase due to muscle deposition (Delevatti et al., 2019; Sampaio et al., 2017).

Despite higher production costs in pasture systems, confinement in pens remains the only viable alternative to enhance performance and shorten rearing time. This approach also facilitates general management activities, such as feeding, weighing, and deworming, which influence the subsequent finishing phase (Roth et al., 2017).

However, most containment structures in Brazil lack natural or artificial shading systems, which can affect animal welfare and, consequently, performance, particularly in semi-arid regions where solar radiation and air temperatures remain high year-round. Therefore, the strategic use of natural (trees) or artificial shade is an important tool, not only to improve animal performance but also to provide thermal comfort and improve the quality of life for farm animals. This is especially important when aiming to produce young, heavy, and well-finished animals (Oliveira et al., 2021).

The initial phase of confinement during the rearing or finishing stages is critical due to several factors, including the animals' history (coming from different acquisition sources), adaptation to management practices (weighing, vaccination, deworming), diets (with higher energy density), and social interaction within the group (dominance or sodomy). These factors can influence both the ingestive and social behavior of the animals, as well as their performance. In Brazil, there are gaps in knowledge regarding the behavior and performance of Zebu cattle (Nellore), which form the genetic basis of beef cattle, under different shading conditions in feedlot structures.

Given the above, the objective of this study was to evaluate the ingestive behavior and zootechnical performance of Nellore cattle subjected to different shading strategies in feedlots during the rearing phase.

Material and methods

Ethics committee

The project was evaluated and approved by the Ethics Committee on Experimentation and Animal Welfare of the State University of Montes Claros (UNIMONTES) — process No. 185/2019.

Experiment location, experimental design, management, and diet

The study was conducted on a farm representative of beef cattle breeding in the semi-arid region of Minas Gerais, located at geographic coordinates 15°01'02.3"S latitude and 44°03'48.3"W longitude. According to the Köppen-Geiger classification, the region's climate is Aw, characterized as a tropical savanna with a distinct dry season for most of the year. The average annual precipitation is 947 mm, and the average annual temperature is 26.3°C, with a maximum average of 30.9°C and a minimum average of 17.5°C.

Two hundred and twenty-five post-weaning Nellore cattle, uncastrated, with an average body weight (BW) of 240 ± 11 kg and 10 months of age, were used to assess nutrient intake, ingestive behavior, and performance. The experimental design was completely randomized, with three shading strategies for the pens: no shading (full sun), natural shading with trees, and artificial shading with man-made covers. Each treatment group consisted of seventy-five animals.

In the pen with natural shading, *Prosopis juliflora* (Sw) DC trees had been planted in a linear arrangement, five meters apart, on one side of the pen. In the pen with artificial shading, a polyethylene shade screen with 70% light interception was installed, covering 30% of the total pen area (16 m^2 per animal). All pens were equipped with sprinklers programmed to release water periodically.

The experiment was conducted during the initial breeding period, lasting 15 days, with four days of interleaved data collection to monitor the adaptation process of the animals to the new environment and feeding system, as they were transitioning from extensive to confined management. The experimental period occurred in May, with the first nine days dedicated to the animals' adaptation to the management and diet, and the last six days reserved for data collection and sampling.

At the start of the experiment, the animals were weighed using a digital scale, individually identified with ear tags, and dewormed with albendazole sulfoxide 15% (Albendazole®, UniãoQuímica, Embu Guaçu, São Paulo, Brazil). The diet, measured in kilograms of dry matter per day, was set at 2% of the initial body weight, with 5% leftovers allowed based on the dry matter provided. The same diet was used across all treatments and experimental periods, with a roughage-to-concentrate ratio of 90:10 in the total dry matter.

The diet was provided four times daily, at 7:30 a.m., 11:00 a.m., 2:00 p.m., and 5:00 p.m., using a complete diet system with a total mixing wagon (capacity of 6.1 m^3, Rotormix Express 3142, with an on-board electronic scale, Kuhn do Brasil, Passo Fundo, Rio Grande do Sul, Brazil). The bulk of the diet consisted of brachiaria silage (*Urochloa ruziziensis* (Hoschst. Ex A. Rich) R.D. Webster cv. Ruziziensis), which was weighed and mixed daily with the concentrate (Table 1). The animals were housed in collective pens measuring 1,200 m^2, equipped with feeding troughs (40 cm per animal) and drinking fountains (16 m^2 per animal).

Characterization of the climatic environment

In each treatment, the air temperature (°C), relative humidity (%), dew point temperature (°C), and black globe temperature (°C) were obtained through the use of two RHT 10 data loggers of continuous reading, scheduled to perform the collection every 10 minutes, for 24 hours. With these data, the black globe temperature and humidity index (BGTHI) proposed by Buffington et al. (1981) were obtained with the following expression:

$$BGTHI = Dpt + 0{,}36 \times Bgt + 41{,}5 \quad (1)$$

where:
Dpt = Dew point temperature (°C)
Bgt= Black globe temperature (°C)

Air velocity was measured using a portable and digital anemometer to calculate the Radiant Thermal Load (RTL) that affects animals (Esmay, 1982). This calculation is a subsidy to characterize the emission of radiation in an environment.

$$RTL = s\,(TRM)^4 \quad (2)$$

in which:
RTL = thermal radiation load, on W. m^{-2}
S = Stefan-Boltzmann constant ($5{,}67 \times 10^{-8} W.m^{-2}K^{-4}$)

The mean radiant temperature (MRT) was obtained according to the equation:

$$MRT = 100\sqrt[4]{2{,}51x\sqrt{vx(tgn - tbs)} + \left(\frac{tgn}{100}\right)^4} \quad (3)$$

where:
MRT = mean radiant temperature, in K;
V = wind speed, in m s^{-1}
Dpt = Dew point temperature (°C);
Dbt = Dry bulb (air) temperature, in K

Behavioral parameters

For the assessment of behavioral parameters, the animals first underwent a 3-day adaptation period to allow the observer to acclimate. Behavioral measurements were conducted over a period of 6 days, with continuous 24-hour observations aligned with the same time segments used for climatic data collection. The frequency of animals feeding at the trough, ruminating, or idling was recorded every 10 minutes (Mezzalira et al., 2011).

Bromatological characterization

The feedstuffs were analyzed for dry matter (DM; method 967.03), ash (method 942.05), crude protein (CP; method 981.10), and ether extract (EE; method 920.39), following the recommendations of Association of Official Analytical Chemists (AOAC International, 1990). The neutral detergent fiber content, corrected for ash and protein (using thermostable alpha-amylase without sodium sulfite) (NDFap; Mertens 2002; Licitra et al., 1996), and acid detergent fiber (ADF) were determined according to Van Soest (1994). Lignin was measured by treating the acid detergent fiber residue with 72% sulfuric acid (Silva & Queiroz, 2002). The non-fibrous carbohydrate (NFC) content was calculated as proposed by Detmann et al. (2012): NFC (g kg^{-1}) = 100 - ash - EE - NDFap - CP (Table 1).

Table 1. Chemical composition of ingredients and diet used during the experimental period.

Item (g kg^{-1} DM)[1]	Silage of Ruzizienses [2]	Concentrate [3]	Diet [4]
Dry matter (DM)	305.4	918.0	375.5
Organic matter	926.8	921.4	899.3
Crude protein	62.3	386.7	91.8
Ether extract	17.0	20.6	17.4
Non-fibrous carbohydrates	148.5	300.0	163.2
Neutral detergent fiber	763.2	100.0	696.9
Lignin	85.0	45.6	81.06
Total digestible nutrients *	472.0	596.3	484
Potential digestibility of DM	655.0	887.1	678.0

[1] Grams per kilogram - neutral detergent fiber (NDF); * NRC (2001). [2] *Brachiaria ruziziensis* cv. *Ruzizienses* harvested at 150 days after planting. [3] Ingredients: Ground corn 37%, soybean meal 30%, livestock urea 8%, white salt 15%, limestone 2%, mineral salt 8% (maximum calcium (230 g kg^{-1}); phosphorus (160 g kg^{-1}); magnesium (15 g kg^{-1}); sulfur (70 g kg^{-1}); sodium (0 g kg^{-1}); copper (2,340 mg kg^{-1}); manganese (1,800 mg kg^{-1}); zinc (8,660 mg kg^{-1}); iodine (173 mg kg^{-1}); cobalt (138 mg kg^{-1}); selenium (45 mg kg^{-1}); fluorine (max) (2,656 mg kg^{-1}), and sodium monensin (3,200 mg kg^{-1}). [4] Diet used during the experiment (i.e., diet composed of 90% silage from *Ruzizienses* and 10% concentrate from dry matter).

Statistical analysis

The diagnoses related to the homogeneity and normality of the residuals were examined but were not associated with the variables studied here. The data were analyzed using the PROC GLM procedure from SAS (SAS Institute Inc., Cary, NC, USA). The model considered treatment as a 'fixed effect' and the animal as a 'random effect.' Results were reported as least square means. The sun, artificial shade, and natural shade treatments were compared using the SNK test (Student-Newman-Keuls). Significant differences were declared at a 5% probability level.

Results

Characterization of the thermal environment

There was no interaction between the mean descriptive values of the climatic variables' behavior throughout the day across the three treatments evaluated (sun, artificial shade, and natural shade), as shown in Table 2. However, a significant difference ($p < 0.05$) was observed in air temperature among the treatments, with the highest value recorded in the full sun treatment (29.3°C).

Table 2. Average values of climatic variables as a function of the evaluated treatments.

Treatments	Air temperature (°C)	RH (%)	Dpt (°C)	Air speed (m s^{-1})
Sun	29.3 a	56.3 ns	18.7 a	1.1 ns
Artificial shade	28.0 b	58.7 ns	18.7 a	1.3 ns
Natural	28.2 b	56.3 ns	18.0 b	1.1 ns
Hours				
00:00 – 02:50	23.4 f	69.0 b	17.0 d	0.2 b
03:00 – 05:50	22.0 f	74.3 a	17.2 d	0.0 b
06:00 – 08:50	28.1 d	60.6 c	19.4 b	1.7 a
09:00 – 11:50	34.4 b	46.3 d	21.0 a	1.4 a
12:00 – 14:50	36.4 a	38.4 e	19.6 b	2.1 a
15:00 – 17:50	32.4 c	43.2 d	18.0 c	2.1 a
18:00 – 20:50	26.2 e	60.7 c	18.0 c	1.5 a
21:00 – 23:50	25.0 e	64.4 c	17.7 c	0.5 b
00:00 – 02:50	23.4 f	69.0 b	17.0 d	0.2 b
CV (%)	8.0	12.2	3.8	107.4

Means followed by distinct lower case letters in the column differ by the SNK test at 5% probability. ns = Not significant. CV- Coefficient variation. RH = Relative humidity; Dpt = Dew point temperature.

In the analysis of temperature throughout the day, it was found that between 09:00 a.m. and 5:50 p.m., the values remained high, with the highest being recorded between 12:00 p.m. and 2:50 p.m. (36.4°C). During this same period, the lowest average relative humidity was observed (38.4%).

There were no significant differences ($p > 0.05$) among treatments for the climatic variables relative humidity (RH) and air velocity in the environments analyzed — full sun, artificial shade, and natural shade — with average RH values ranging between 56.3 and 58.7%, and air velocity between 1.1 and 1.3 m s^{-1}. The highest RH values were recorded at night.

However, a significant difference ($p < 0.05$) was found in the dew point temperature between treatments, with the lowest value recorded in the natural shade environment (18.0°C).

An interaction ($p < 0.05$) was observed between treatments and climatic indices during the evaluation periods. The black globe temperature (BGT) was higher in the corral under full sun, between 09:00 a.m. and 2:50 p.m. (39.8 and 42.3°C, respectively). A reduction in BGT was found in the artificial and natural shade environments, with temperatures 6.2 and 7.7°C lower, respectively, when compared to the full sun environment during the 12:00 p.m. period (Table 3).

In this study, the highest BGTHI value was recorded in the corral with shade and in the corral under full sun, in the morning and afternoon, between 09:00 a.m. and 2:50 p.m., and in natural shade in the morning and afternoon between 09:00 a.m. and 5:50 p.m. At 09:00 a.m. and 2:50 p.m., the highest values of BGTHI recorded in the corral, in full sun, were 6.3 and 7.9 points higher than in the artificial and natural shade corrals

In this study, the lowest BGTHI values were recorded at 09:00 a.m. and 2:50 p.m. in the environment with trees. Additionally, there was no significant difference between the natural and artificial shade environments ($p > 0.05$). The Radiant Thermal Load (RTL) reached its highest incidence of solar radiation in the afternoon, between 12:00 p.m. and 2:50 p.m., under full sun and artificial shade (447.3 and 498.6 W m^{-2}, respectively).

Characterization of ingestive behavior

There was a difference ($p < 0.05$) in the behavioral parameters, depending on the treatments evaluated. The frequency of animal feeding in the trough was higher in the environment of natural shade (27.5%), when compared to the corral with artificial shade (22.8%).

Table 3. Mean values of the climatic indices according to the shading strategies and evaluated time intervals.

Hours	Bgt (°C)			BGTHI			RTL (W.m^{-2})		
	Artificial shade	Natural	Sun	Artificial shade	Natural	Sun	Artificial shade	Natural	Sun
00:00–02:50	23.7 Ad	24.0 Ac	23.3 Ad	71,0 Ad	71,6 Ac	71,0 Ad	388,8 Ad	390,3 Ad	386,3 Ad
03:00–05:50	22.4 Ad	22.7 Ac	22.0 Ad	70,0 Ad	70,3 Ac	69,6 Ad	382,0 Ad	383,5 Ad	380,1 Ad
06:00–08:50	27.8 Ac	25.1 Ac	28.8 Ac	76,4 Ac	73,4 Ab	77,5 Ac	412,0 Ac	391,3 Bd	418,7 Ac
09:00–11:50	33.6 Ba	34.0 Ba	39.8 Ab	82,7 Ba	82,7 Ba	89,0 Aa	443,1 Ba	446,8 Bb	481,8 Ab
12:00–14:50	34.6 Ba	35.0 Ba	42.3 Aa	83,2 Ba	83,1 Ba	91,1 Aa	447,3 Ba	452,0 Bb	498,6 Aa
15:00–17:50	30.2 Bb	35.7 Aa	37.7 Ab	78,3 Bb	83,4 Aa	85,8 Ab	421,3 Bb	413,6 Ac	404,5 Ab
18:00–20:50	25.5 Ac	28.8 Ab	26.8 Ac	73,5 Ac	75,8 Ab	74,7 Ac	397,7 Ad	397,6 Ad	395,1 Ac
21:00–23:50	25.2 Ac	25.4 Ac	25.0 Ad	73,1 Ac	73,2 Ab	72,8 Ad	396,5 Ad	463,3 Aa	474,0 Ad
CV (%)	8.7			3.4			3.5		

Means followed by distinct capital letters on the line and lower case letters in the column differ from each other by the SNK test, at 5% probability. CV - Coefficient variation. Legend: = Bgt - black globe temperature, BGTHI - black globe temperature and humidity index, RTL = Radiant Thermal Load.

In the rumination activity (Table 4), it was verified that there was no difference ($p > 0.05$) between the treatments in the evaluated periods. However, there was a difference for the frequency of idleness in animals ($p < 0.05$), which was higher for cattle housed in the corral with full sun.

Table 4. Mean values of the percentage (%) of the frequency of animals feeding in the trough, ruminating, and idling, according to the evaluated treatments.

Treatments	Feeding in the trough	Rumination	Idle	BGTHI
Artificial shade	22.8 b	19.7 a	37.9 b	76.1 b
Natural	27.5 a	19.6 a	37.5 b	76.7 b
Sun	24.3 ab	18.2 a	54.2 a	79.0 a
CV (%)	30.0	27.5	23.7	3.4

Means followed by distinct lower-case letters in the column differ by the SNK test at 5% probability. CV - Coefficient variation, BGTHI - black globe temperature and humidity index

The study examined the percentage of animals engaged in different activities (feeding, ruminating, idling, seeking shade, and displaying agonistic behaviors) over various time periods (Table 5). The highest concentration of animals feeding occurred between 6:00 a.m. and 8:50 a.m. (44.8%) and from 3:00 p.m. to 5:50 p.m. (46.3%). Between 9:00 a.m. and 2:45 p.m., there was a reduction in time spent at the trough (around 35%). Agonistic behaviors varied considerably throughout the day, intensifying during periods of increased activity and competition for resources, such as food and shade. These interactions are essential for understanding the social dynamics and competitive behavior of animals under different environmental conditions (Table 5).

Table 5. The mean values of the percentage (%) of animals feeding in the trough, ruminating, idle, positioned in the shade and performing agonistic reactions according to the periods evaluated.

Hours	Feeding in the trough	Ruminating	Idle			Positioned in the shade		Agonistic reactions
			Natural	Artificial shade	Sun	Natural	Artificial shade	
00:00–02:50	8.7 d	25.0 b	44.0 Ba	61.4 Aa	68.2 Aa	17.6 Aa	6.4 Bd	0.4 b
03:00–05:50	1.0 e	33.5 a	40.8 Ba	59.2 Aa	63.6 Aa	17.3 Aa	5.4 Bd	3.4 a
06:00–08:50	44.8 a	8.6 d	36.7 Aa	35.0 Ac	43.6 Ab	4.0 Bb	10.6 Ac	3.2 a
09:00–11:50	34.2 b	12.9 c	33.8 Ba	17.8 Cd	52.3 Ab	10.8 Bb	31.7 Ab	4.0 a
12:00–14:50	32.6 b	15.0 c	25.6 Ba	8.7 Cd	51.1 Ab	22.7 Ba	40.6 Aa	2.7 a
15:00–17:50	46.3 a	4.1 e	32.8 ABa	28.6 Bc	47.6 Ab	7.7 Bb	18.2 Ac	4.5 a
18:00–20:50	17.5 c	22.8 b	47.1 ABa	43.1 Bb	59.3 Aa	5.8 Bb	14.1 Ac	3.1 a
21:00–23:50	14.3 c	31.5 a	39.0 Aa	49.3 Ab	48.2 Ab	14.4 Aa	3.4 Bd	2.5 a
CV (%)	30.0	27.5	23.7			67.5		75.2

The means followed by distinct lower case letters in the column and distinct upper case letters in the row differ by the SNK test at 5% probability. CV - Coefficient variation, Probability Values (p) - Treatment (p = 0.02); Period (p = 0.02); Treatment x Period interaction (p = 0.99).

At night, the lowest values of trough activity were observed, and between 3:00 a.m. and 5:50 a.m., the percentage of animals at the trough reached 0%. On the other hand, Table 5 showed a significant interaction

($p < 0.05$) between the frequency of idleness in the evaluated treatments. It was observed that between 9:00 a.m. and 3:00 p.m., the frequency of animals idling was higher for those housed in the pen under full sun. During the same period, animals under natural shading and artificial shade reduced their idleness frequency to feed and/or ruminate.

There was a reduction in idleness as the time for feed distribution at the trough approached (7:00 a.m.), and animals showed higher feed intake during this period compared to the early morning hours.

Discussion

The elevation in air temperature observed in the full sun environment is justified by the greater incidence of solar radiation. In contrast, the situations in the naturally shaded and artificially shaded environments change, as cattle have shading strategies to reduce solar exposure.

Thus, animals in the corral without shading were exposed to temperatures above the thermoneutral zone set for Zebu animals, which is up to 29°C according to Müller and Botha (1993) and Müller (1989). The increase in air temperature over the longest day, between 12:00 p.m. and 2:50 p.m., is explained by the greater incidence of solar radiation during that period—a routine situation in almost all national territories in the tropical zone.

According to Cardoso et al. (2015), in tropical regions, the average air temperature is above 20°C, and the maximum temperature is above 30°C for much of the year, often reaching values between 35 and 38°C. The climatic conditions of the tropics, particularly those observed in the semi-arid region, suggest working with animals that are tolerant to high temperatures.

The verified values of relative humidity (RH) did not differ between treatments, as all treatments had sprinklers programmed to activate at various times of the day and were within the range considered ideal for cattle, between 40 and 70% (Ferreira, 2005).

Air velocity is important for characterizing convective exchanges in the environment, which facilitates heat exchange between the skin and the environment through convection and evaporation, especially during the day when the air temperature is high.

The lower dew point value observed in the environment with natural shade is due to the shading provided by trees. The dew point is used to represent the amount of water vapor in the air or dry gas, making it a good indicator of the moisture content in an air parcel, regardless of air temperature. The trees in this environment absorb solar radiation and use it in photosynthesis, producing energy and water. The amount of water vapor influenced the reduction in the air temperature of this microclimate.

Thermal comfort indices are occasionally employed to gauge the stress or comfort levels of animals in their environment by analyzing information from multiple climatic variables (Table 3).

The black globe temperature in the corral exposed to full sun, from 9:00 a.m. to 2:50 p.m., was higher due to the absence of a physical barrier provided by trees and shade, thus, all the solar radiation and air temperature were absorbed by the black globe.

Regarding the sun treatment, the reductions in black globe temperature (Bgt) of 6.2 and 7.7°C were found in this study in the environments with artificial and natural shades, respectively. Similar results were obtained by Chiquitelli Neto et al. (2015), who used polypropylene mesh of "artificial shade" type with 80% solar radiation blockage and achieved a Bgt reduction of 6.5°C with an area of 4.5 m^2 of shade per animal. Arcaro et al. (2005) conducted a study in the Piracicaba region of Brazil, which demonstrated similar results. By providing 5.0 m^2 of shade per animal, the study recorded a significant reduction of 6.4°C in Bgt. The region is characterized by a tropical climate with hot, humid summers and mild, dry winters.

The association of air temperature, black globe temperature, air speed, and relative humidity identifies the thermal comfort condition of an environment through BGTHI. Buffington et al. (1981) suggest a classification where BGTHI values up to 74 indicate comfortable environmental conditions for cattle. Values from 74 to 78 signal a warning, while those from 79 to 84 represent a danger sign. Values exceeding 84 are considered an emergency situation for cattle.

According to Junior et al. (2018), an environment where the BGTHI exceeds 78 is harmful to livestock. In this experiment, values confirming that animals exposed to the sun experienced a more critical environment were found. The highest BGTHI values were recorded in the corral with shade and in the corral exposed to full sun. These measurements were taken in the morning and afternoon, from 9:00 a.m. to 2:50 p.m., as well as in natural shade from 9:00 a.m. to 5:50 p.m.

The peak BGTHI values were influenced by the black globe temperature and were associated with the highest solar radiation levels, as indicated by the RTL. The greatest solar radiation incidence was observed in the afternoon, between 12:00 p.m. and 2:50 p.m., in both the sun and artificial shade environments, with readings of 447.3 and 498.6 W/m², respectively.

Baêta and Souza (2010) indicated that natural shade provides greater environmental comfort compared to artificial shade (artificial shade canvas, ceramic tile, asbestos, galvanized metal). For Furtado et al. (2003), the RTL was defined based on solar radiation values, with the highest values found around 12:00 p.m. when the sun was perpendicular to the local horizon. Silva (2000) suggests that RTL measures the thermal exchanges by radiation between the animal and its environment. Therefore, in tropical regions, lower RTL values are preferred.

Diniz et al. (2017) recorded RTL values ranging from 405.5 to 480.7 W/m² in the semi-arid region of Minas Gerais during November and December. In this study, RTL values ranged from 380.1 to 498.6 W/m² in the corral under full sun, higher than those recorded by Diniz et al. (2017). These values were also higher than those found by Moreira et al. (2017), who evaluated RTL in the semi-arid region of Minas Gerais during two periods of the year—February to March (summer) and August (winter)—and recorded mean RTL values of 548.65 and 467.35 W/m², respectively.

Silva (2008) observed that the shade from tree canopies could reduce the heat load on animals by 26% compared to treatment in full sun. In intertropical zones, reducing solar radiation levels is essential. Numerous studies have proven that the simple existence of shade guarantees favorable changes and positive outcomes for animal development (Silva, 2000).

The increase in the frequency of feed intake was recorded in the environment with natural shading, as indicated by the BGTHI value, which was enhanced by the dew point temperature that provided better comfort conditions.

The BGTHI values between the environments with shade and natural shade were similar ($p > 0.05$); however, the portion of moisture present in the environment provided a better thermal sensation (Table 4).

According to Edwards-Callaway et al. (2021), the availability of natural shade should be prioritized for animals raised in warm climates to promote their well-being and productivity. Sousa et al. (2007) notes that afforestation contributes to a decrease in air temperature. In tropical conditions, the temperature under the canopy of trees is about 2 to 4.8°C lower than in full sun. In this study, the air temperature was 1.1°C lower.

Regarding the frequency of greater idleness in animals, cattle housed in a corral under full sun influence tend to increase leisure activity as the animals are under heat stress conditions. This is contrary to the activities of rumination and feeding, which tend to decrease when cattle are experiencing heat stress (Pereira et al., 2018), a condition verified in this study where leisure activity was higher in the environment where the average BGTHI was 79.

As per the analysis of afforestation, during the periods evaluated throughout the day, the highest concentration of animal feeding was during food placement in the trough between 7:30 a.m. and 5:00 p.m., and the air temperature was below 32°C. During the period of reduced trough activity (9:00 a.m. to 2:45 p.m.), the BGTHI values were high, reaching emergency conditions (91). In contrast, the frequency of rumination was higher during periods when BGTHI was lower than 74 (Buffington et al., 1981) and the lowest RTL values were recorded.

Based on the data presented in Tables 4 and 5, it is believed that animals accommodated in the corral under full sun showed similar behavior to animals in the corral with shade during the night.

According to Chiquitelli Neto et al. (2015), in the absence of shade, the need for stress reduction may be greater than the nutritional needs, leading animals to reduce feed intake, with predictable consequences on their productive performance. It was also found that with regard to the provision of shading, animals accommodated in the corral with shade sought more shading compared to animals under natural shade.

The microclimate formed by the trees makes the environment more pleasant for the animals, while the shade functions only as an apparatus to prevent direct solar radiation on the animals.

Conclusion

The microclimate formed by the trees in the natural shading corral made the environment more suitable for raising cattle. Animals accommodated in the corral with natural shading showed a higher frequency of feeding at the trough and achieved the body balance necessary for the adaptation period, even before the other treatments were evaluated.

Acknowledgements

The Minas Gerais State Research Support Foundation (GT: 37300351/2021), Coordination for the Improvement of Higher Education Personnel (CAPES; financing code 001); National Council for Scientific and Technological Development (CNPq) and State University of Montes Claros.

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