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Characterization of the climatic environment for feedlot-finished cattle in the semi-arid region

Caracterização do ambiente climático para bovinos terminados em confinamento na região semiárida

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Highlights

Deciduous trees made it allows the formation of a microclimate due to the roots.
The position of the trough under the sun exposes cattle to thermal stress conditions.
Feeding frequency occurred during the day and night thermal comfort.

Abstract

On rural properties in the semi-arid region, deciduous trees are used in feedlot systems, since their leaves act as barriers against solar radiation, favor ventilation, provide shade and reduce air temperature. However, during the cattle finishing phase, coinciding with the dry period, these trees lose their leaves. Therefore, the objective of this research is to characterize the deciduous vegetation offered as shade to cattle in the finishing phase, during the dry period, in the semi-arid region. For that reason, data collection was carried out on a private property and specialized in cattle breeding, located in the municipality of Janaúba (MG), during the months from August to October. In this study, two environments were characterized: one under full sun and another one under natural shade, by means of the evaluation of climatic variables, besides physiological and behavioral parameters of 31 zebu-type beef cattle. The animals were managed in a single corral, where they were exposed to an integrated space under full sun and shade (deciduous trees – environment 2), and the trough was in the environment (environment 1) under full sun. Furthermore, a completely randomized design was adopted with two environments

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and four assessment periods (morning, afternoon, night, and dawn), with five repetitions (weeks under assessment). The results showed that deciduous trees used as shade for beef cattle in the feedlot system did not prevent the passage of radiant thermal load due to the absence of foliage. Even so, a suitable microclimate was formed for the animals due to evapotranspiration carried out by the roots, which reduced the soil temperature, and consequently, the animals' respiratory rate. Finally, it was found that the highest frequency of animals feeding occurred during the day, under unfavorable climatic conditions, since the trough was under the sun, while rumination and idleness occurred at night, under comfortable conditions in the corral space, where the deciduous trees were.
Key words: Ambience. Beef cattle farming. Deciduous trees. Native vegetation.

Resumo

Nas propriedades rurais da região semiárida, árvores caducifólias são utilizadas nos sistemas de confinamento, haja vista que as folhas dessa espécie atuam como barreiras contra a radiação solar, favorecem a ventilação, proporcionam sombra e reduzem a Tar; no entanto, durante a fase de terminação dos bovinos, coincidente com o período de seca, essas árvores perdem as suas folhas. Em função disso, o objetivo desta pesquisa consiste em caracterizar a vegetação caducifólia ofertada como sombreamento para bovinos na fase de terminação, durante o período de seca, na região semiárida. Para tanto, a coleta de dados foi realizada em uma propriedade privada e especializada na criação de bovinos, localizada no município de Janaúba (MG), durante os meses de agosto a outubro. No ambiente em questão, foram caracterizados dois ambientes: um a pleno sol e outro à sombra natural, por meio da avaliação de variáveis climáticas, além de parâmetros fisiológicos e comportamentais de 31 bovinos de corte anelorados. Os animais foram manejados em um único curral, onde foram expostos a um espaço integrado a pleno sol e sombra (árvores caducifólias – ambiente 2), e o cocho estava localizado no ambiente (ambiente 1) a pleno sol. Ademais, adotou-se o delineamento inteiramente casualizado com dois ambientes e quatro períodos de avaliação (manhã, tarde, noite e madrugada), com cinco repetições (semanas em avaliação). Os resultados mostraram que as árvores caducifólias utilizadas como sombreamento para os bovinos de corte no sistema de confinamento não impediram a passagem da CTR devido à ausência de folhagem; mesmo assim, houve formação de microclima adequado para os animais em razão da evapotranspiração realizada pelas raízes que reduziram a temperatura do solo, e consequentemente, a FR dos animais. Por fim, constatou-se que a maior frequência de animais se alimentando ocorreu no período diurno, sob condições climáticas desfavoráveis, uma vez que o cocho estava sob o sol, enquanto a ruminação e o ócio ocorreram no período noturno, sob condições de conforto no espaço do curral, onde estavam as árvores caducifólias.
Palavras-chave: Ambiência. Árvores caducifólias. Bovinocultura de corte. Vegetação nativa.

Introduction

Brazil produced 8.91 million tons of beef in 2023, a record for the sector (Centro de Estudos Avançados em Economia [CEPEA, 2024]; Siqueira, 2024). The weight of animals has increased in response to the investments made by many livestock farmers for improving breeding, pastures, supplementation, and health. The increase in average productivity has also been favored by animals in feedlots, generally slaughtered at around 20 at sign. This positive growth meets the global demand expected by the who, which says that by 2030 Brazil needs to increase its food production by up to 35%.

One of the world's largest beef producers, Brazil has seen a significant increase in the use of intensive production systems to meet growing demand (Pereira et al., 2024). These systems aim to optimize production, maximizing efficiency and reducing costs (Sousa & Baptista, 2023). The finishing phase covers a period of 80 to 120 days in Brazil, confined animals receive diets with greater energy density to maximize carcass gain (F. N. G. Ferreira, 2015).

Due to the short time available for finishing and the rusticity and adaptation of zebu animals (Bos taurus indicus) (Lima et al., 2020), which represent around 80% of the animals slaughtered in Brazil, few confinement facilities have natural shading. However, in addition to nutrition and health management, the thermal comfort provided by the facilities is known to significantly contribute to improving the performance and well-being of animals (Ferro et al., 2016; R. C. Santos et al., 2023; Brown-Brandl et al., 2006).

To increase meat production, Brazilian livestock farmers adopt strategies such as genetic crossings, nutritional enrichment, and environmental modifications natural shading (Lal, 2020). Some properties choose to use the shade cloth, which, according to Ferro et al. (2016), is an alternative that can be quickly installed, enabling replacement, changing location, and not impeding corral management.

The scientific literature presents positive results in improving the microclimate of the farming environment when natural shading is used (Baêta & Souza, 2010; R. C. Santos et al., 2020a) adopting the use of tree species, some of which are considered native (Pio et al., 2023).

Tropical forests are complex ecosystems, and the caatinga vegetation displays diverse phytophysiognomies, with wide floristic and structural diversity. In this context, the species that make up the arboreal habitat play a crucial role in microclimate development (C. H. S. de Oliveira et al., 2023).

Planting native species is a primary and lower-cost modification for the farmer, as it allows to build the corral around the existing vegetation (England et al., 2020). Factors such as tree crown diameter and senescence must be taken into consideration (Feitoza et al., 2022).

Thus, the objective of the present study was to characterize the climatic environment formed by deciduous trees for raising beef cattle finished in confinement in the semi-arid region.

Material and Methods

All procedures with animals were approved by CEUA/Unimontes (protocol number 019/2023).

Experimental site and period

The study was conducted on private property in the municipality of Janaúba, state of Minas Gerais, Brazil, from August to October 2023, specifically during the dry season. According to Köppen and Geiger (1928), the climate in Janaúba is BSh and Aw, respectively, with well-defined summer rains and dry periods in the winter. Average annual rainfall varies from 800 mm to 1,200 mm, with an average annual temperature of 24-28 °C. The climate is tropical mesothermal, almost megathermal, due to the altitude, sub-humid and semiarid, with uneven rainfall, causing long periods of drought (Köppen & Geiger, 1928). As for phytophysiognomies, this municipality is located in the Cerrado/Caatinga transition domain (Borges et al., 2021), with a predominance of deciduous vegetation (W. B. dos Santos et al., 2020b).

The experimental period comprised 48 days. The corral is 5,031.00 m², with 2,730.00 m² in full sun and 2,301.00 m² in shaded area (Figure 1). The corral has a single trough (12 meters) and a drinking fountain (capacity of 600 liters) both in the unshaded space.

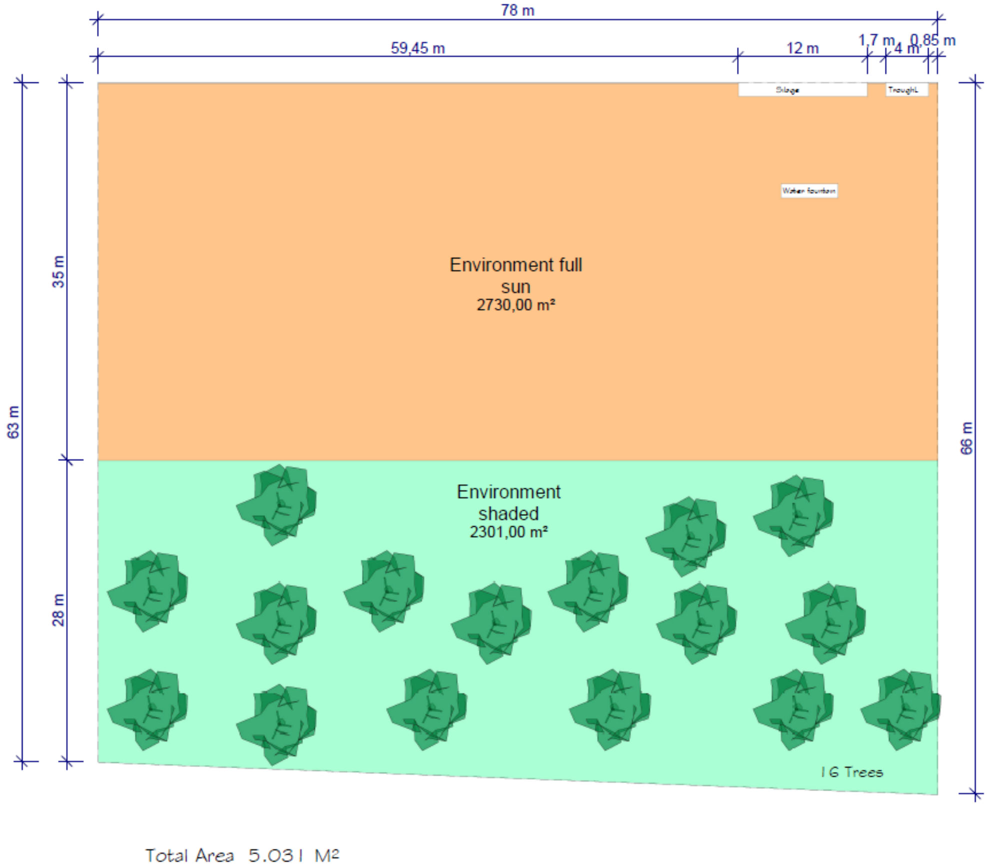

Figure 1. Floor plan showing the characterization of the evaluated corral.

Experimental design and characterization of the climatic environment

Thirty-one Zebu cattle, intact, with an average body weight of 367.23 ± 19 kg and age of ± 24 months, were housed in a single 0.5ha corral. At this location, the animals were exposed to two conditions (environments): 1 - 0.27ha of space without shading (full sun) and 2 - 0.23ha with shading composed of native deciduous trees. The plant composition is formed by trees ranging in height from 3.7m to 14m and with a trunk circumference of 0.12m to 12.2m. The tree characterization is presented in Table 1.

Table 1
Arboreal characterization of plants located in the shaded space

Environment	Number	Scientific name	Common name	Origin	Habit
1	18	Bursera simaruba	Gumbo-limbo	Native	Tree
2	3	Enterolobium cyclocarpum	Elephant-ear tree	Native	Tree

Mean values followed by different lowercase letters in the row and uppercase letters in the column differ by Tukey's test ($p<0.05$).

The climatic environment was characterized for 48 days to verify the development of a microclimate in the evaluated environments. Two groups of RHT-10 dataloggers, Instrutherm, were installed at the site; one group was installed in a space without shade and another group was installed under the trees inside the corral. Each group was composed of a sensor positioned inside the black globe to obtain the black globe temperature, and another sensor was used to obtain air temperature, relative air humidity, and dew point temperature. Wind speed was measured using a portable, digital anemometer. The sensors were fixed at the average height of the animals, ±1.70m. Using the values of the environmental variables collected, the Radiant Heat Load Index (RHL) was calculated (J. L. Oliveira & Esmay, 1982). This calculation is used to characterize radiation emission in an environment.

$$RHL = s\,(MRT)4 \quad \text{eq. 1}$$

Where:

RHL = radiant heat load, in $W.\ m^{-2}$; and

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:

$$MRT = 100\sqrt[4]{2.51x\sqrt{vx(bgt-dpt)+\left(\frac{bgt}{100}\right)4}} \qquad \text{eq. 2}$$

Where:

MRT = Mean Radiant Temperature, in K;

V = wind speed, in m/s;

Bgt = Black globe temperature (°C); and

Dpt = Dew point temperature (of air), in K.

The black globe temperature and humidity index (BGTH) was calculated according to Buffington et al. (1981) using the following mathematical model:

BGTH = BGT + 0.36 x dpt + 41.5 eq. 3

where:

Dpt = Dew point temperature (°C); and

Bgt = Black globe temperature (°C).

To assess the climatic environment throughout the day, collection times were grouped into 4 periods:

- Morning period: 6am to 11:55am;
- Afternoon period: 12am to 5:55pm;
- Night period: 6pm to 11:55pm;
- Early morning period: 12pm to 5:55am.

Animals and food

The thirty-one Zebu cattle were weighed on a digital scale, individually identified using an ear tag, and dewormed with 15% albendazole sulfoxide (Agebendazol®, União Química, Embu Guaçu, São Paulo, Brazil) as recommended by the manufacturer.

The diet was offered daily allowing 5% leftovers of the amount of dry matter supplied. The diet was the same for all animals during the experimental period, maintaining the roughage: concentrate ratio of 80:20 in the total dry matter of the diet. The diet was supplied to the animals twice a day, at 8am and 3pm in a complete diet system (total mixed ration), using a total mixing wagon, with a total capacity of 1,200 kg. The bulky basis of the diets was BRS capiaçu grass silage (*Pennisetum purpureum* Schum). The concentrate for nutritional adjustment was formulated with ground corn (1-2mm), soybean meal, mineral mixture with additives and vitamins. The diets were formulated based on BR Corte (2016) for an average daily weight gain of 1.5 kg/day.

Samples of ingredients, diets, and leftovers were analyzed for dry matter (DM; method 967.03), ash (method 942.05), crude protein (CP; method 981.10), according to INCT-Ciência Animal recommendations (Detmann et al., 2021). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents were determined as described by Detmann et al. (2021). The analysis showed the composition of the diet offered was 42.4% DM; 9.41% ash; 13.5% CP; 54.54% NDF, and, 32.57% ADF.

Physiological parameters

Respiratory rate 1

The respiratory rate (RR) of the animals was measured at the following times: 6am, 9am, 12pm, 3pm, 6pm, 9pm, 12pm and 3am, every 15 days, totaling five collections. RR was measured by visual observation of flank movement for 15 seconds and then multiplied by four to obtain movements per minute (Brown-Brandl et al., 2006).

Body surface temperature 2

To determine the Body Surface Temperature (BST), photographic records were taken of the left flank of the animals, at the following times: 6am, 9am, 12pm, 3pm, 6pm, 9pm, 12pm and 3am, every 15 days, totaling five collections. Photographic records were taken using a FLIR Infrared Thermographic Camera.

Assessment of ingestive behavior

Every five minutes, for 24 hours, the frequency (%) of animals that performed feeding, rumination, and idleness was evaluated (Gonçalves, 2020). Collections began at 6am and ended at 05:55am. The observations took place on-site and were carried out by trained students. After data collection, they were grouped into four periods:

- Morning period: 06:00h to 11:55h;
- Afternoon period: 12:00h to 17:55h;
- Night period: 18:00h to 23:55h;
- Early morning period: 00:00 to 05:55h

Statistical analysis

A completely randomized design was used in a factorial arrangement with two environments (Sun and Shade), four evaluation periods (morning, afternoon, night, and early morning), and five replications. Each week was considered an experimental unit in the model.

Principal component analysis (PCA) was used to achieve a better understanding of the nature of the relationship between the studied variables and the independent variables.

The statistical model follows:

$$Y_{ij} = \mu + T_i + P_j + T_i \times P_j + e_{ijk}$$

Where:

Y_{ij} = the observation referring to treatment “i”, within repetition “j”;

μ = constant associated with all observations;

T_i = effect of treatment “i”, with “i” = 1 and 2;

P_j = effect of period “j” with “j” = 1, 2, 3, and 4;

$T_i \times P_j$ – Interaction effect

e_{ijk} = experimental error associated with all observations (Y_{ij}), independent, which by hypothesis has a normal distribution with zero mean and variance δ^2.

Treatment means, when significant by the F-test, were grouped using the Scott-Knott test (Jelihovschi et al., 2014) ($P<0.05$).

For this analysis, 12 studied characteristics were considered. Based on the correlation matrix between the characteristics, the data were submitted to PCA, in which the variables were standardized to mean equal to zero and variance equal to one (Table 2).

Table 2
Principal Component Analysis for climatic variables and indices, ground temperature, physiological parameters, and ingestive behavior recorded as a function of environments and periods throughout the experimental period

Item	Eigenvectors	% Variance
1	96.443	80.369
2	210.107	17.509
3	0.254628	21.219

Results

In the analysis of the climatic environment to verify the development of a difference in microclimate for the evaluated environments, a difference ($P<0.05$) was found only for air temperature and wind speed. There was no ($P>0.05$) development of microclimate based on the evaluation of radiant heat load (RHL) values, with an average of $404.8 W.m^{-2}$ in the sun and $407.8 W.m^{-2}$ in the shaded area, and black globe temperature and humidity index with 75.1 in the sun and 74.9 in the shaded area (Table 2).

Over the days, the lowest values of air temperature (At), black globe temperature (bgt), BGTH, and RHL ($P<0.05$) were observed in the morning; this is, inversely, proportional to the reduction in relative humidity (RH), whose highest values were observed at night (night and early morning).

Although there was no difference ($P>0.05$) in the body surface temperature (BST) of the animals depending on the environments, the animals positioned in the sun had an 85% higher respiratory rate than animals in the shade (Table 3).

Table 3
Climatic variables and indices, ground temperature, physiological parameters, and ingestive behavior according to the environments and periods throughout the experimental period

Item	Sun	Shaded	SEM	Morning	Afternoon	Night	Early morning	SEM	Treat	Per	Treat x Per
Air temperature, °C	27.6 A	26.9 B	0.24	28.8 B	30.9 A	25.9 C	23.4 D	0.34	0.03	0.00	0.72
Relative humidity, %	55.1	55.2	1.08	56.5 B	42.6 D	54.0 C	67.0 A	1.55	0.96	0.00	0.98
Wind speed, $m.s^{-1}$	3.50 B	5.1 A	0.32	5.30	4.40	3.40	4.20	0.46	0.03	0.06	0.81
Black globe temperature, °C	27.1	26.8	0.28	29.9 B	31.9 A	24.5 C	21.6 D	0.40	0.48	0.00	0.98
Radiant heat load, $W.m^{-2}$	404.8	407.8	3.33	434.1 B	446.8 A	382.5 C	363.0 D	4.78	0.52	0.00	0.57
BGTH	75.1	74.9	0.29	78.4 B	80.3 A	72.0 C	69.3 D	0.42	0.59	0.00	0.97
Ground temperature, °C	32.14 A	24.83 B	0.70	35.19 B	40.65 A	20.03 C	20.5 C	0.96	<0.01	<0.01	0.99
PHYSIOLOGICAL PARAMETERS											
Respiratory rate, $mov.min^{-1}$	102.97 A	87.82 B	2.66	107.2 A	107.0 A	86.08 B	84.75 B	5.09	<0.01	<0.01	0.06
Body surface temperature, °C	31.62	31.01	0.44	33.51 A	33.28 A	30.06 B	27.61 C	0.58	0.33	<0.01	1.00
INGESTIVE BEHAVIOR											
Feeding (%)	-	-	-	21.4 b	28.2 a	14.7 c	0.9 d	0.82	-	0.00	-
Ruminating (%)	-	-	-	19.9 c	17.1 d	29.9 b	43.2 a	0.72	-	0.00	-
Idling (%)	-	-	-	58.6 a	54.6 b	55.4 b	56.9 b	0.78	-	0.02	-

The highest values of BST and RR were found during the day (morning and afternoon) when the highest values of At, bgt, and RHL were registered, in addition to being the period in which the animals were dedicated to feeding in the trough. It is worth noting that the trough was placed under the sun. During thermal comfort times (night period), the animals remained ruminating.

Based on the responses of the climatic indices and physiological parameters, we decided on a multivariate analysis of the data; the Cluster analysis (Figure 2) indicated the development of a microclimate between the two environments in the corral. This is confirmed by the results of the principal component analysis (Figure 3) due to the higher correlation between the RR and the RHL of the sun and shaded environments, that is, the lower the RHL in the shade, the lower the BST, and the higher the At and the ground temperature in the sun, the greater the RR.

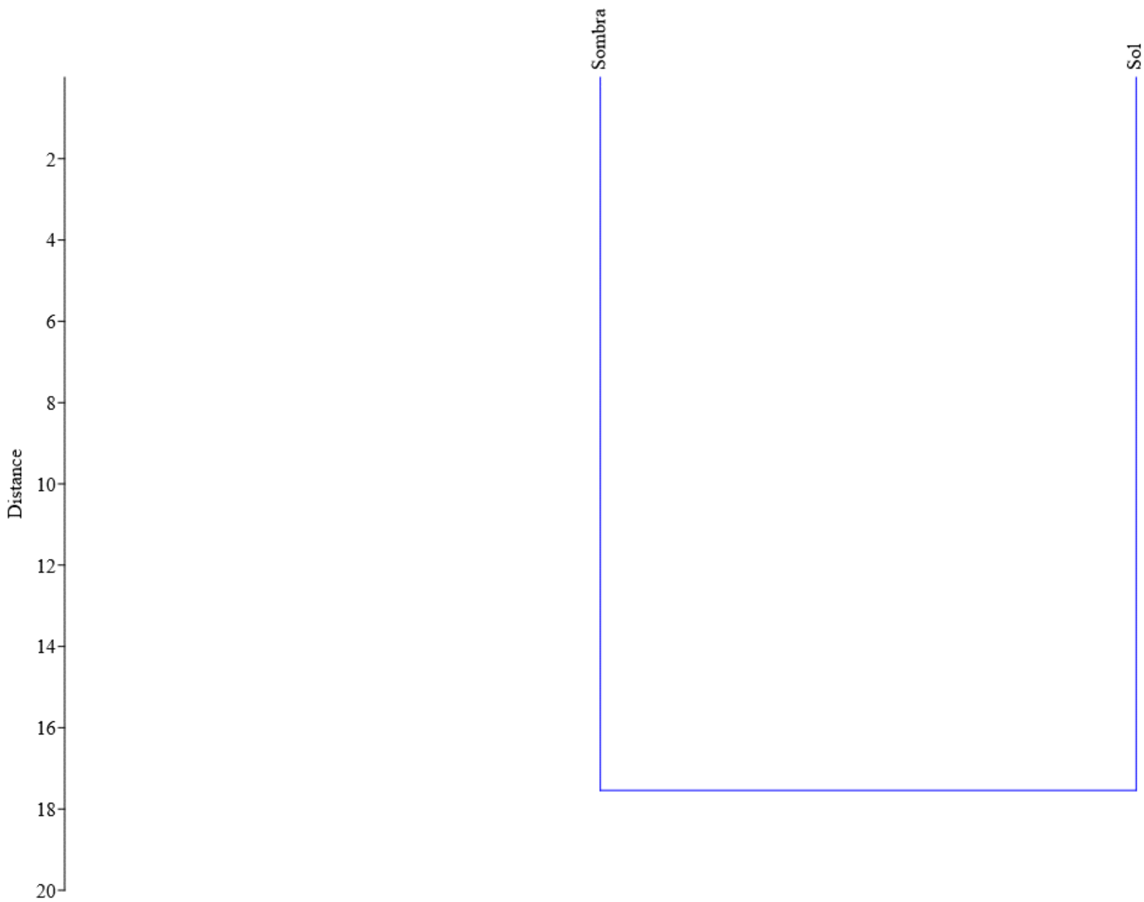

Figure 2. Dendrogram of the climatic variables and indices recorded in the corral evaluated according to the environments throughout the experimental period.

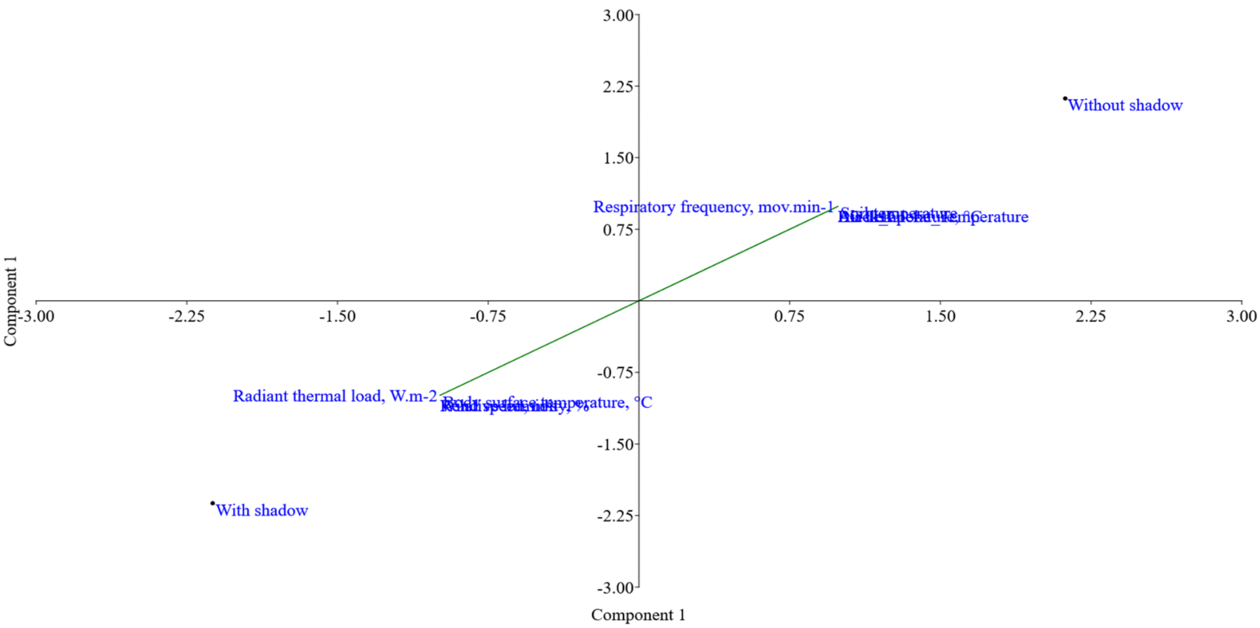

Figure 3. Schematic representation of the principal components depending on the sun and shaded environments.
Caption. Air Temperature, Relative humidity, Wind speed, Radiant thermal load, Black_Globe_Temperature, Black globe-temperature-humidity index (BGTHI), Body surface temperature, Respiratory frequency, Soil temperature

RHL, Bgt, BGTH, and higher feeding frequency presented the highest weighting coefficient within PC1, with greater impacts on the explained variance of 80.3%. In PC2, wind speed, RH, and frequency of animals in idle showed a variance of 17.5% (Table 4). RHL, ground temperature, BGTH, and Bgt showed a positive correlation between the morning and afternoon periods and a negative correlation with RH. At and the frequency of feeding animals showed a positive relationship with the afternoon period. RH and the frequency of animals ruminating and idling showed a positive correlation with the early morning period. Among the physiological parameters, RR showed the highest positive correlation with the morning period.

Table 4
Principal component analysis of climatic variables and indices, ground temperature, physiological parameters, and ingestive behavior according to environments and periods throughout the experimental period

Item	PC 1	PC 2	PC 3
Air temperature, °C	0.31915	-0.090915	0.034261
Relative humidity, %	-0.26469	0.39261	0.042719
Wind speed, $m.s^{-1}$	0.18208	0.55685	0.33607
Radiant heat load, $W.m^{-2}$	0.32136	0.034473	0.077051
BGT	0.32188	-0.011179	0.044351
BGTH	0.32166	0.016819	0.078835
Body surface temperature, °C	0.31521	0.060349	-0.36588
Respiratory rate, $mov.min^{-1}$	0.30663	0.20778	0.099162
Ground temperature, °C	0.30896	0.067001	0.5241
Feeding	0.31035	-0.15443	-0.28703
Ruminating	-0.31416	0.059772	0.39952
Idling	-0.027036	0.66873	-0.45777

Discussion

Based on these components, the absence of leaves on the trees allowed solar radiation to pass through the trees (P>0.05); however, in the Cluster analysis, there was a difference between the treatments that can be explained by the difference between ground temperature (P<0.05) and wind speed (P<0.05), which were lower in the shaded environment. In the analysis of treatments in Figure 3, the radiation heat load incident on the animals was lower in the shaded environment.

Radiant heat load (RHL) is the total radiation received by a body from the entire space surrounding it. This definition does not encompass the net exchange of radiation between the body and its surrounding environment, but it does include radiation incident on the body (Bond & Kelly, 1955). Solar radiation is the main source of environmental heat absorbed by animals. To obtain values for the total radiation received by animals in a given location, it is necessary to consider the absolute air temperature, wind speed, and the black globe temperature, which is a receptor used to quantify all the radiant radiation absorbed by a body, quantified and expressed in degrees Celsius (Baêta & Souza, 2010). H. C. Ferreira et al. (2021), evaluating beef cattle in different farming environments, found that animals managed in an environment without shade reduced food intake during the day to reduce the production of metabolic heat, increased respiratory rate to dissipate heat absorbed by the skin, and among the treatments studied, these showed the lowest production.

When trees are used in a beef cattle feedlot system, the tree canopy is expected to reduce infrared radiation by up to 60%; evapotranspiration from plants should contribute to lowering the temperature and trees should be prevented from making natural ventilation difficult (Baêta & Souza, 2010). The introduction of trees into the confinement system enhances animal welfare by providing shade and shelter to cattle (Pereira et al., 2024). During the period of this work, spring and dry period, the trees were without their leaves, thus allowing the passage of all solar radiation, i.e., there were no shadows; however, the radiation heat load incident on animals was apparently lower in the shaded environment due to the positive correlation with wind speed (P<0.05).

Another important characteristic of deciduous trees is their roots, which are long and deep, increasing the storage of water and nutrients during the dry period, and thus keeping the plant alive (Andrade et al., 2012). A positive correlation was observed between air temperature and soil temperature, which did not have vegetation to have roots and carry out evapotranspiration, or absorption of radiation for photosynthesis, so all radiation incident on the soil was reflected back into the environment, increasing the animals' respiratory rate. The ground temperature was lower in the shaded area due to the long and deep roots, through evapotranspiration reflected in the positive correlation with body surface temperature, and association with wind speed, which helped in the development of microclimates depending on the treatments.

In the exploratory analysis carried out to understand the ingestive behavior of beef cattle that had free access to both treatments, it can be seen in Figure 4 that RHL, ground temperature, BGTH, and Bgt showed a positive correlation in the connection between the morning and afternoon. This is because during the daytime these variables and climate indices tend to present higher values than the night shift. The fact that the trough was located in a space under the sun, associated with the times at which food was offered, exposed the animals to climatic conditions under the sun, and consequently to an increase in respiratory rate, especially in the late morning and early afternoon. The average RR values observed were higher than 80 mov.min^{-1} (H. C. Ferreira et al., 2021), values considered as the maximum limit of the comfort range, thus confirming that the values recorded while the animals were in the sun, or, the values recorded during the daytime indicate the animals were exposed to a discomfort microclimate.

Even under unfavorable climate conditions (positive correlation with air temperature and black globe temperature), the highest frequency of beef cattle feeding was recorded in the afternoon, after 3pm. In evaluating the scale of the order of priority for production animals, Klein (2014) describes that before being able to reproduce and produce, the animal has to survive, which is why it prioritizes the maintenance of its basal metabolism through food, in search of staying alive. Thus, confirming the behavior observed in this experiment.

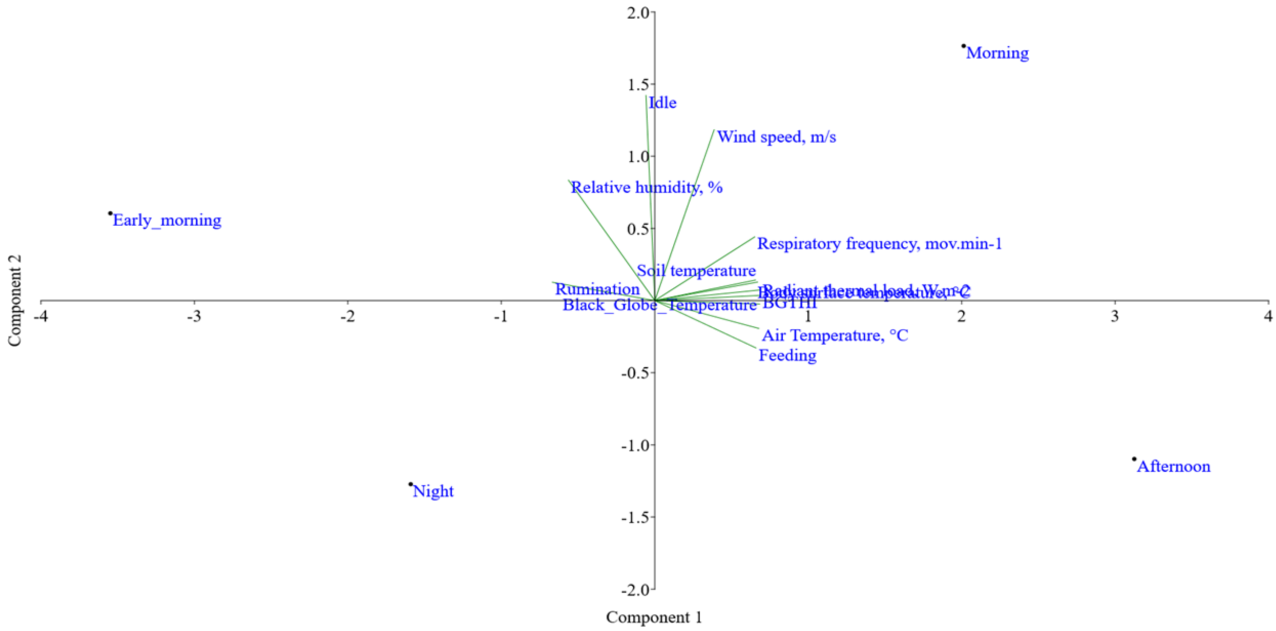

Figure 4. Schematic representation of the principal components as a function of the periods evaluated.
Caption. Air Temperature, Relative humidity, Wind speed, Radiant thermal load, Black_Globe_Temperature, Black globe-temperature-humidity index (BGTHI), Body surface temperature, Respiratory frequency, Soil temperature, Feeding, Rumination, Idle

Gonçalves (2020) evaluated the ingestive behavior of beef cattle subjected to different farming environments and found that in the sunny environment, the RHL was 446.7 W.m-2, and in the shaded environment with trees, it was 416.4 W.m^{-2}. Under the sun, the frequency of beef cattle feeding was 15.4% and 13.8% in the morning and afternoon, respectively; and for animals in the corral with shade provided by trees and leaves, the values were 37.6% and 31% in the morning and afternoon, respectively; thus showing the efficiency of trees in promoting an improvement in the microclimate, thermal comfort, and conditions for an increased frequency of animals going to the trough when the weather condition is unfavorable.

RH and the frequency of ruminating and idling animals showed a positive correlation in the early morning period when the relationship was negative with radiant heat load, air temperature, and black globe temperature. The higher frequency of animals performing rumination and idleness in the early morning (BGTH < 74) represents an important characteristic of Zebu cattle, which is adaptability, confirmed by feeding during the day and ruminating and idling in periods when the environmental condition is comfortable (BGTH < 74). At night, rumination and idleness were observed with the animals lying down when the soil temperature was approximately 20°C (Table 2), and in the shaded area (PC 2).

Conclusion

The trees allowed the development of a suitable microclimate for finishing cattle and because of the presence of tree roots (a source of water storage) and air movement, they reduced the ground temperature. The microclimate developed in the tree environment made it possible to reduce the animals' respiratory rate, and, at night, it provided thermal comfort for the animals that ruminated and remained idle in that location. The highest frequency of animals feeding was observed during the day, under unfavorable weather conditions because of the location of the trough.

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