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EVALUATION OF THE THERMAL ENVIRONMENT FOR RAISING DAIRY COWS IN A PASTURE MILK PRODUCTION SYSTEM

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Joyce Cavalcante de Brito[1], Patricia de Azevedo Castelo Branco Vale[2], Welington Gonzaga do Vale[3], Lígia Maria Gomes Barreto[4], Valdir Ribeiro Junior[5], Juliana Paula Felipe de Oliveira[6], Suelange Oliveira Cruz[7] and Adriano Henrique do Nascimento Rangel[8]

ABSTRACT

The production of milk on pasture is subject to several challenges, one of them being the thermal environment to which the cows are subjected, which can be a determining factor in the quantity and quality of milk produced. Thus, the present study aimed to evaluate the thermal environment of Holstein cows, producing milk on pasture, analyzing the Temperature and Humidity Index (UTI) and the Respiratory Rate (RR). During the experimental months, Tmax (ºC) of 40º was observed, characterizing a high value in the thermal aspect for dairy cows. As for the UTI, an average value of 72 was observed, considering the thermal environment of rearing as comfortable for the cows. During the experimental period, dairy cows were, most of the time, in conditions of mild to moderate heat stress, since the UTI and RF values observed, when compared with those in the literature consulted, suggest such a situation. However, when considering RH during the

[1] Animal Scientist
Institution: Federal University of Sergipe
Address: Nossa Senhora da Glória, Sergipe, Brazil
E-mail: joycecavalcante15@academico.ufs.br
[2] PhD in Animal Science
Institution: Federal University of Sergipe
Address: Nossa Senhora da Glória, Sergipe, Brazil
Email: pacbvale@academico.ufs.br
[3] PhD in Plant Production
Institution: Federal University of Sergipe
Address: São Cristóvão, Sergipe, Brazil
Email: valewg@gmail.com
[4] PhD in Animal Science
Institution: Federal University of Sergipe
Address: Nossa Senhora da Glória, Sergipe, Brazil
E-mail: ligiamgbarreto@academico.ufs.br
[5] PhD in Animal Science
Institution: Federal University of Sergipe
Address: Nossa Senhora da Gloria, Sergipe, Brazil
E-mail: valribjunior@academico.ufs.br
[6] PhD in Animal Science
Institution: Federal University of Sergipe
Address: Nossa Senhora da Gloria, Sergipe, Brazil
[7] PhD student in Animal Science
Institution: Federal University of Bahia
Address: Salvador, Bahia, Brazil
Email: suelange26@gmail.com
[8] PhD in Animal Science
Institution: Federal University of Rio Grande do Norte
Address: Natal, Rio Grande do Norte, Brazil
E-mail: adrianohrangel@yahoo.com.br

evaluation period, several peaks were observed, between 80 and 90, which warn that some days there may have been excessive humidity coinciding with a higher temperature, generating heat stress because the latent mechanisms of heat dissipation, such as sweating and evaporation, are not efficient, which can be understood by the observed RF values. most of them are above the value considered normal, therefore RR present in the graph at high peaks of 80 to 100 mov.min-1, and this interval is classified as high heat stress. In view of the above, it is necessary to adopt strategies to mitigate the heat stress of cows, especially those with high production, since there is a direct influence between increased FR and reduced milk production.

Keywords: Thermal comfort. Heat stress. Physiological parameters.

INTRODUCTION

When it comes to milk production, Brazil stands out among the largest milk producers in the world, having reached, in 2022, according to the Brazilian Institute of Geography and Statics (IBGE) the production of 34.6 billion liters of milk, placing the country third in the ranking of the world's largest milk producer (IBGE, 2023). These data show the country's productive capacity, even in the face of economic or environmental difficulties that are faced by breeders. In view of this, national dairy farming stands out as a growing breeding that is part of food security, especially in the country's internal sphere.

Brazil has about two thirds of its territory located in the tropical belt of the planet, where the climate is Bsh according to the Koppen classification, characterized by the predominance of high temperatures, high incidence of radiation and low air humidity. (Dias e Silva, et al 2012). This fact contributes to the difficulties in raising on pasture, as dairy cows are particularly sensitive to heat stress due to their more specialized productive function and their high efficiency in the use of feed (Baccari, 1989, cited by Moura, 2010).

In this context, society demands and values products that come from practices that guarantee the rights of animals and that they express their freedoms. Welfare has a direct correlation with efficient production, because if the animal is well managed and does not have health problems, it can express its productive potential.

Broom (1986) defined Animal Welfare (BEA) as the state that an animal presents in relation to its attempts to deal with the environment in which it lives. In this sense, well-being can directly affect the animal's physiological reactions, having negative or positive effects, because from the moment the animal leaves the thermal comfort zone to try to maintain its homeothermy, there is caloric expenditure, both to lose or maintain body heat. If the animals are kept in thermoneutral environments, the energy expenditure for the animal's maintenance is constant and minimal, and the energy retention of the diet is maximum (TOSETTO, 2014)

It is known that heat stress is a strictly environmental component, so it should be defined only in terms of the environment. In pasture farming, animals are in their natural environment and are subject to changes in temperature and humidity throughout the day, especially in Brazil, as it is a tropical country, it shares high temperatures lasting all year round, and animals are often exposed to heat stress. This occurs when the sum of external forces acting on a homeothermic animal changes the body temperature from the resting state and this causes physiological, metabolic, cellular and molecular tensions (FERREIRA et al, 2017).

However, there is thermoneutrality that refers to the optimal environmental temperature for the animal, which maintains its homeothermy, without spending energy to maintain its comfort. In environments where the weather conditions are adverse to ideal, the animals activate their thermoregulatory system to maintain their body temperature. Reproductive functions, productive performance, and physiological parameters are negatively affected in environmental conditions outside the thermo-neutrality zone (Tosetto, 2014). And, with milk production, it would be no different. According to Souza et al. (2021), milk production is closely linked to keeping the animal in the thermoneutral zone, that is, where the animal does not suffer stress from cold or heat.

When homeothermy is not achieved, the animal is in the temperature ranges considered critical, which are the upper critical temperature, with consequent heat stress and lower critical temperature, being subjected to cold stress. According to Azevedo and Alves (2009, apud Nãs, 1989), the comfort temperature for cattle breeds is in the range of 13 ºC to 18 ºC and, for lactating cows, temperatures between 4 ºC and 24 ºC are recommended, and these limits may be restricted from 7 ºC to 21 ºC, due to relative humidity and solar radiation.

In view of this, several studies in the area of welfare always seek to identify whether the environment and facilities are offering comfort to animals (Alves, 2014) and for this purpose, indices are used that measure thermal comfort such as the Temperature and Humidity Index (UTI), Black Globe Temperature and Humidity Index (ITGU), as well as physiological variables such as respiratory rate (RR) and rectal temperature (RT), These data are used to modify and improve the place where the animals are present, with alternatives to minimize heat stress.

As a rule, the first visible sign of animals subjected to heat stress is an increase in respiratory rate, although this is the third in the sequence of thermoregulation mechanisms. The first mechanism is vasodilation and the second, sweating, this physiological mechanism promotes heat loss through evaporative means. Respiratory rate (RR) depends mainly on the time of day, the ambient temperature and the level of animal production (MARTELLO, 2002).

For Silanikove (2000) cited by Dalcin, 2013, RF values of 40 to 60, 60 to 80 and 80 to 120 mov/min characterize respectively low, medium and high stress for ruminants, and above 200 mov/min the stress is classified as severe.

According to Ferreira (2017), rectal temperature is a physiological parameter that indicates thermal balance and can be measured to indicate adaptability to hot environments. When the rectal temperature increases, the animal stores heat that is not dissipated, that is, the thermoregulation mechanisms are insufficient to maintain homeothermy and, as a consequence, there may be the manifestation of deleterious effects of heat stress (BACCARI JÚNIOR, 2001 cited by FERREIRA, 2017).

Martello (2004) reports that the average rectal temperature for cattle over one year of age is 38.5 ± 1.5 ºC. This temperature is maintained through careful regulation of the balance between the formation of heat and its release by the body. The rectal temperature varies throughout the day and usually has the highest degrees in the afternoon than in the morning.

The temperature and humidity index (UTI), which relates temperature and relative humidity of the air, is the most used by researchers to evaluate heat stress (MARTELLO, 2004). It was initially developed for humans by Thom (1958), and then began to be used for animals, mainly cattle (FERREIRA, 2017).

Armstrong (1994) classified heat stress according to the variation of UTI as mild or mild (72 to 78), moderate (79 to 88) and severe (89 to 98). UTI below 72 would characterize a heat-stress-free environment.

Thus, the present study aimed to evaluate the thermal environment of Holstein cows, producing milk on pasture, analyzing the Temperature and Humidity Index (UTI) and the Respiratory Rate (RR).

MATERIAL AND METHODS

The present research was developed at the Leite Verde Agropecuaria Farm, located in the municipality of Jaborandi - BA, Rodovia Mambaí - Cocos Km 35, place of mandatory supervised internship, the farm breeds Kiwicross animals on pasture derived from the crosses of the Holstein Friesian Holstein breeds with Jersey. The trial period was from August to December 2023.

It has 11 irrigation pivots with an area of 56 hectares each, subdivided into 24 paddocks with an area of 4.6 ha, with a capacity for 600 animals, adopting the rotational system with daily pasture management, measurement of grass entry and exit height, as well as fertilization and soil correction.

The farm is a reference in pasture raising with its milk, which has a differential for the flavor added to its 4.2% fat, with a total volume of 12 million liters of milk produced, an average production of 37 thousand liters/day, with an average of 16 liters/cow/day.

Respiratory rate (RR, mov/min.) was assessed at 8 a.m. and 2 p.m., after the respective morning and afternoon milking on three alternate days of each week (Monday, Wednesday, and Friday), during the months of August to December 2023. RR was measured by counting the number of respiratory movements on the flank of the animals for a period of 30 seconds, multiplying the values found by two to obtain the number of respiratory movements/minute.

The data for calculating the Temperature and Humidity Index, ITU, were provided by the farm, since it has a meteorological station, located in a central position to the paddocks where the cows stay. Thus, every hour this station recorded dry bulb temperature (Tbs) and relative humidity (RH), in addition to other climatic parameters, with only the two mentioned being important to generate the UTI. For this calculation, climatic data between 8 and 4 p.m., on the same day of the RF evaluation, were used, totaling 15 days of evaluation, 3 each month, totaling 120 observations of each variable evaluated in the experimental period.

The temperature and humidity index (THI) was calculated for each hour of data recording, using the following formula, cited by Kelly & Bond (1971):

UTI = TBs – 0.55 (1 – your) (TBs – 58)

where UTI = temperature and humidity index, admensional; TBs = dry bulb temperature in degrees Fahrenheit; RH = relative humidity expressed in decimal value.

The data were uploaded and processed using the pandas library (version 3.6). Descriptive statistics were calculated using the numpy library (version 1.24.0) for exploratory data analysis. The graphs were created using the matplotlib.pyplot library (version 3.9.10) for visualization of the data and patterns. All data analysis was performed using Python programming language (version 3.9.13), in the Visual Studio Code (VSCode) environment (version: 1.86.2), a popular IDE for software development, providing an intuitive interface and advanced features for programming in Python.

RESULTS AND DISCUSSION

Table 1 presents the data for the experimental period, from 3 collections per month, from August to December 2023, totaling 15 periods analyzed, with 8 repetitions per period. A higher standard deviation (SD, %) was observed for the variables RH (10.91) and RF (15.89), indicating high variation in these values, which may lead to heat stress in the animals.

Table 1. Descriptive statistics for the variables Respiratory rate (RR), Maximum, average and minimum temperatures (Tmax; Tmed; Tmin), Relative Humidity (RH) and Temperature and Humidity Index maximum, medium and minimum (ITU Max; ITU Med; ITU Min), in the 15 RF evaluation periods, between August and December.

	Sample number	average	SD1 (%)	Min	Max
Tmax (°C)	120.0	33.92	2.61	26.00	40.00
Tmed (°C)	120.0	25.04	2.52	15.00	34.00
Tmin(°C)	120.0	17.81	2.54	11.00	23.00
RH (%)	120.0	60.08	10.91	45.00	88.00

ITU	120.0	72.84	3.45	58.81	84.29
FR (mov/min)	120.0	85.75	15.89	57.00	123.00

[1] Standard Deviation

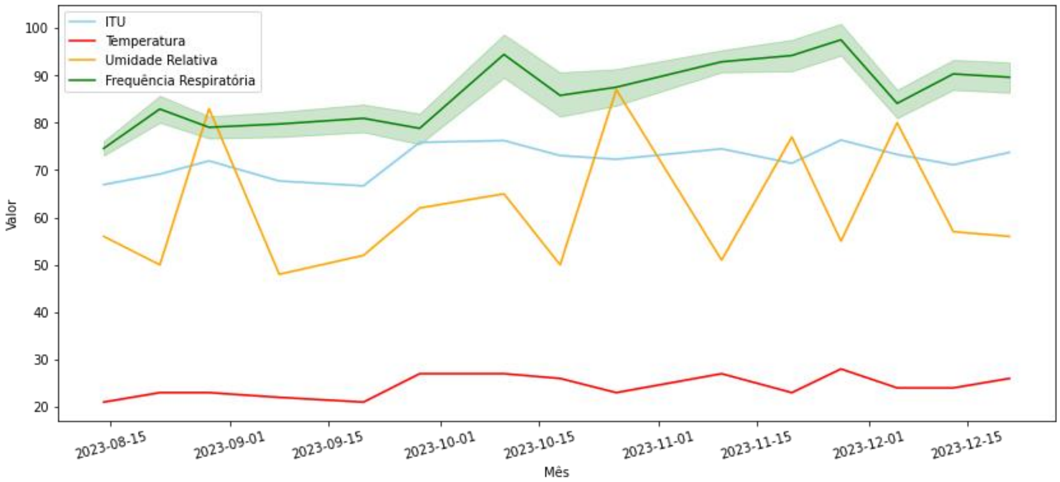
During the experimental months, Tmax (ºC) of 40º was observed, characterizing a high value in the thermal item for dairy cows, which according to Huber's (1990) classification the ideal values are between 4ºC and 26ºC, where values above those mentioned can impair the productive capacity of the animals, since body temperature increases due to the failures of the heat regulating mechanisms.

The maximum values of RF observed, 123 mov/min, were probably a consequence of the significant temperature increases, particularly in the maximum values. The average temperature remained outside the thermoneutral zone for dairy cows, according to Huber (1990), since the average value observed was 33.92ºC. As it is a tropical region, this is the temperature range that predominates most of the year, with high temperatures and humidity, causing stress to the animals, since they try to adapt to this adverse situation. The Tmin of 26ºC was within the expected range since these temperatures occur in the cold months, understanding August as one of those months with low temperatures for the region in question.

As for the UTI, an average value of 72 was observed, considering the thermal environment of rearing as comfortable for the cows, according to the classification of Armstrong (1994), with UTI below 72, environment without heat stress; 72 to 78, mild or mild stress; moderate, from 79 to 88 and severe stress when UTI between 89 and 98. The average for the maximum value observed in the experimental period, 84.29, points to a challenging thermal environment for the animals, characterizing the heat stress in moderate.

Graph 1 shows the behavior of the data referring to UTI, TºC, RH, and RF, according to the dates of the evaluations, revealing an UTI between 60 and 80, i.e., classifying the thermal condition of pivot 2 between ideal and moderate thermal stress.

Graph 1: UTI, T (ºC), RH (%) and RF (mov.min-1) observed on the collection days, distributed between the months of August and December 2023.

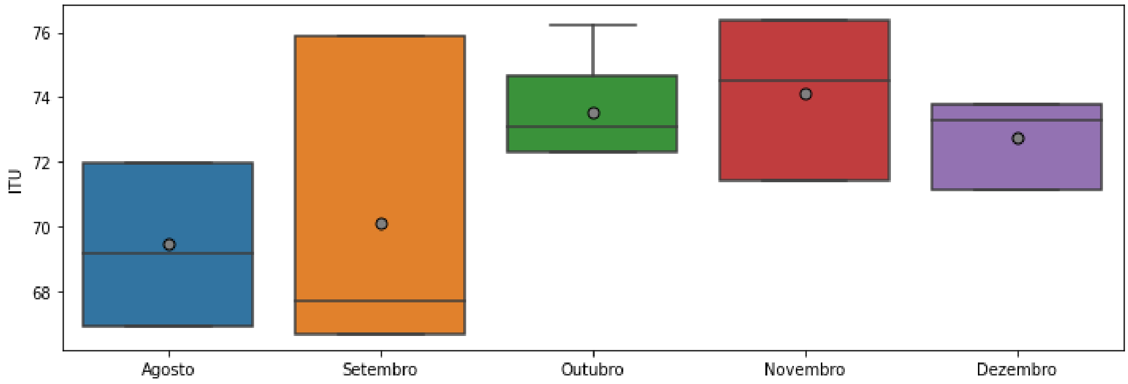


However, when considering RH during the evaluation period, several peaks were observed, between 80 and 90, which warn that some days there may have been excessive humidity coinciding with a higher temperature, generating heat stress because the latent mechanisms of heat dissipation, such as sweating and evaporation, are not efficient, which can be understood by the observed RF values. most of them are above the value considered normal, therefore RR present on the graph at high peaks of 80 to 100 mov.min-1, and this interval is classified by high heat stress (Silanikove, 2000 cited by Dalcin, 2013).

RH oscillations from 50 to approximately 90 at some times were accompanied by high values for RR, above 70, with the temperature also above the recommended for high-production dairy cows, between 20 and 30ºC, translating into an average UTI value between 65 and 75. This occurred due to the factors of climate and environment affecting the animal and directly impacting the change in the physiology of thermoregulation, since it needs to donate energy to maintain thermal balance through latent or sensitive heat dissipation mechanisms, directly interfering in its production. To mitigate these consequences, primary or secondary measures are needed to mitigate the impact of the environment, such as the use of trees and shade meshes as shade, ventilation and sprinkling for body cooling.

The UTI values and their variations over the experimental period are shown in Graph 2, with the month of August presenting the best UTI value (60 to 75), a condition of thermal comfort.

Graph 2: UTI values referring to the days of evaluation of the respiratory rate (RR) of cows housed in pivot 2, during the months of August to December 2023.

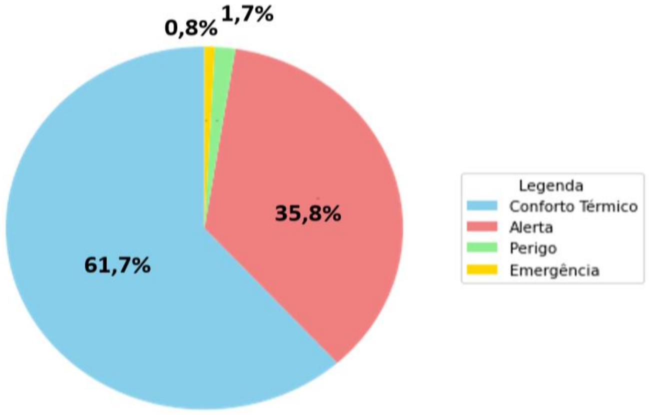


The highest variations in UTI were observed in September, with a comfortable range up to 70, but also values indicating mild heat stress for cows, as it ranged from 64 to 76. In the months of October and December, the variation in UTI values was the smallest, and most of the time the cows were in comfort or, at most, in mild stress. In November, the trend observed was similar to September. This can be partially explained because in these two months it was most necessary to turn on the irrigation of the pivots, which considerably increased the RH, causing changes in the UTI values, with values close to 80.

UTI values above 72 can trigger changes in behavioral and physiological parameters, characterizing heat stress, reflecting on the performance and reproduction of cows (Martello et al, 2004).

To better understand how the thermal environment would be classified in terms of the thermal comfort of the cows, Pivot 2 was stratified according to the frequency of occurrence of the environmental classification intervals, according to the ITU, according to the classification of Armstrong (1994).

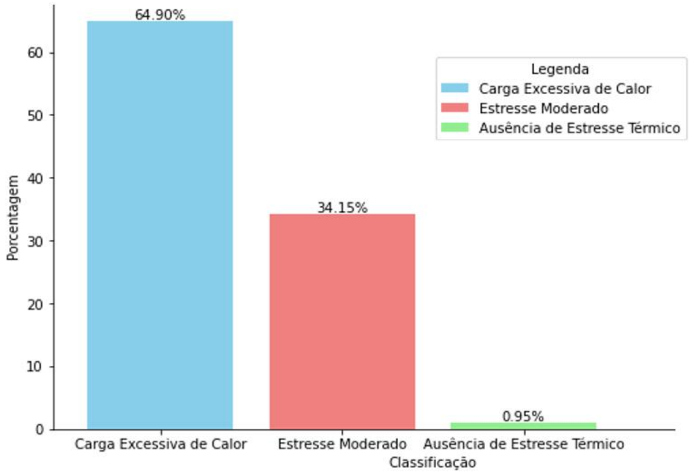
Graph 3: Thermal characterization of Pivot 2, based on the determination of the ITU in the months of August to December 2023.



Thus, it was observed that in 61.7% of the time the cows were in thermal comfort, although the values of RH, TºC, RF put the cows in a moderate state of heat; and 35.8% indicate that they were on alert, that is, using heat dissipation mechanisms to try to maintain homeothermy; and 1.7% in danger, representing an animal already in critical condition that can no longer control its temperature.

However, when it comes to the evaluation of RF, the results were quite different, when it came to characterizing the cows' breeding environment, as can be seen in graph 4.

Graph 4: Thermal characterization of Pivot 2, based on the evaluation of the FR of the cows, in the months of August to December 2023.



It was observed that in 64.90% of the experimental period, the cows were subjected to excessive heat load, 34.15% with moderate stress and less than 1% with absence of stress.

When there is an increase in respiration per minute, it is understood that that animal is trying to lose heat and maintain homeothermy, usually sweating, rapid flank movement and exposed tongue are signs of latent heat dissipation mechanisms, actions that show critical state and indicate the condition of heat stress. In view of this fact, graph 4 highlights that the month of October had a great variation in values (65 to 120), characterizing high heat stress, and it is noted that the following month, November, also has high frequencies (70 to 119) as well as December (65 to 115), since values between 80 and 120 mov.min-1, an interval classified as high heat stress (Silanikove, 2000 cited by Dalcin, 2013).

In a study conducted by Baccari Jr. et al. (1995), these authors observed an average respiratory rate of 68 movements per minute in Holstein cows, when the UTI was 79, with a thermal environment classified as moderate stress, but the RR was still maintained adequate for dairy cows, that is, not harming their milk production in the short term. Aguiar et al. (1996) observed a reduction in milk production from Holstein cows by 3.6 and 4.5% when the UTI was 72.3 and 74.4, respectively.

Silva et. al. (2002) observed RF equal to 75.8 in environmental conditions of UTI equal to 78.2, placing these animals in moderate heat stress. Thus, Holstein cows need to activate, with more intensity than crossbred cows, their thermoregulatory mechanism in order to dissipate excess body heat through the respiratory tract, due to their lower adaptability to the adverse conditions of hot climates.

Thus, an isolated parameter cannot translate the real thermal sensation of the animal, and these data can often be confronted, as observed in graphs 3 and 4.

CONCLUSION

During the experimental period, dairy cows were, most of the time, in conditions of mild to moderate heat stress, since the UTI and RF values observed, when compared with those in the literature consulted, suggest such a situation.

It is necessary to adopt strategies to mitigate the heat stress of cows, especially those with high production, since there is a direct influence between increased RF and reduced milk production.

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