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SIMPLE PHYSIOLOGICAL INDICATORS OF ½ SANTA INÊS × ½ DORPER CROSSBRED SHEEP RAISED IN THE MUNICIPALITY OF MIRADOR, MARANHÃO, BRAZIL

Ângela Maria Barros Moura
Universidade Estadual do Piauí (UESPI), Piauí, PI, Brazil,
https://orcid.org/0000-0002-8185-4424

Laylson da Silva Borges
Instituto Federal de Roraima, Roraima, RR, Brazil,
https://orcid.org/0000-0002-0976-8935
Corresponding author: laylson.borges@ifrr.edu.br

Antônia Leidiana Moreira
Universidade Estadual do Piauí (UESPI), Piauí, PI, Brazil,
https://orcid.org/0000-0001-5432-4818

Marlei Rosa dos Santos
Universidade Estadual do Piauí (UESPI), Piauí, PI, Brazil,
https://orcid.org/0000-0001-8251-618X

Tadeu Barbosa Martins Silva
Universidade Estadual do Piauí (UESPI), Piauí, PI, Brazil,
https://orcid.org/0000-0003-4256-0682

Miguel Arcanjo Moreira Filho
Universidade Federal do Piauí (UFPI), Piauí, PI, Brazil,
https://orcid.org/0000-0002-0137-2637

Jandson Vieira Costa
Centro Universitário FACID Wyden (UniFacid), Teresina - PI, Brazil,
https://orcid.org/0000-0003-3448-670X

Flávio Carvalho de Aquino
Universidade Federal do Piauí (UFPI), Piauí, PI, Brazil,
https://orcid.org/0000-0002-8447-2712

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Abstract

In this study we aimed to evaluate the influence of environmental differences caused by day shifts on the physiological indicators of crossbred ½ Santa Inês × ½ Dorper sheep raised in a semi-intensive system. For this, 12 animals with an average weight of 35.00 ± 5.00 kg were allocated in a completely randomized design, with two treatments (morning shift and afternoon shift) and six replicates per treatment. The environmental variables (temperature (°C) and relative humidity (%)) were collected using a digital thermo-hygrometer. The black globe temperature and humidity index was calculated using temperature values of the black globe thermometer and dew point. The following physiological indicators were measured in the animals: respiratory rate (mov/min); heart rate (beats/min); rectal temperature (°C); and surface temperature (°C). In the morning shift, the average values of air temperature and relative humidity were 31.71°C and 88.66%, respectively. In the afternoon, the average air temperature was 33.91°C, while the relative humidity was 62.66%. The highest mean globe temperature and humidity index was observed in the afternoon shift (87.75). The physiological indicators showed the highest mean values in the afternoon shift: respiratory rate 73.72 mov/min; heart rate 81.27 beats/min; rectal temperature 39.98°C; surface temperature 34.76°C. The crossbred ½ Santa Inês × ½ Dorper sheep reared in a semi-intensive system showed signs of thermal discomfort.

Keyword animal welfare, animal bioclimatology, heat stress, little ruminants.

INDICADORES FISIOLÓGICOS SIMPLES DE OVINOS MESTIÇOS 1/2 SANTA INÊS X 1/2 DORPER CRIADOS NO MUNICÍPIO DE MIRADOR, MARANHÃO, BRASIL

Resumo

Objetivou-se com esta pesquisa avaliar a influência das diferenças ambientais proporcionadas pelos turnos do dia sobre os indicadores fisiológicos de ovinos mestiços ½ Santa Inês × ½ Dorper criados em sistema semi-intensivo. Para isso, foram utilizados 12 animais, com peso médio de 35,00 ± 5,00 Kg, alocados em delineamento inteiramente casualizado, com dois tratamentos (turno manhã e turno tarde) e seis repetições por tratamento. As variáveis ambientais, temperatura (°C) e umidade relativa do ar (%), foram coletadas com o uso de um termo-higrômetro digital. O índice de temperatura de globo negro e umidade foi calculado usando os valores da temperatura do termômetro de globo negro e do ponto de orvalho. Os indicadores fisiológicos mensurados nos animais foram às frequências, respiratória (mov./min.) e cardíaca (bat./min.), a temperatura retal (°C) e a temperatura superficial (°C). As médias para temperatura do ar foram, respectivamente, 31,71°C e 33,91°C para os turnos manhã e tarde, enquanto que a umidade relativa do ar foi de 88,66% e 62,66%, nessa mesma ordem. A média para o índice de temperatura de globo e umidade foi superior no turno tarde, com valor igual a 87,75. Os indicadores fisiológicos apresentaram maiores médias para o turno tarde, apresentando valores de 73,72 mov./min., 81,27 bat./min., 39,98°C e 34,76°C para frequência respiratória, frequência cardíaca, temperatura retal e temperatura superficial, respectivamente. Os ovinos mestiços ½ Santa Inês x ½ Dorper criados em sistema semi-intensivo apresentaram sinais de desconforto término.

Palavra-chave bem-estar animal, bioclimatologia animal, estresse térmico, pequenos ruminantes.

INTRODUCTION

Sheep farming is an activity practiced in practically all regions of Brazil, where it is developed mostly for meat production. The country has a total herd of 20.6 million sheep, most of which are in the northeast region, where 14.5 million are farmed according to data from the Brazilian Institute of Geography and Statistics (IBGE, 2020). The production of these animals is of fundamental importance for the socioeconomic development of this region and has been regarded as a sustainable source with excellent possibilities of economic profitability (BORGES et al., 2019; SENA et al., 2021).

Because it is a hot and dry region, the Brazilian northeast is characterized by a high incidence of solar radiation and high temperatures during practically all months of the year. This culminates in an extra load of heat to the animals that induces thermal stress, which causes production to decline (BORGES et al., 2020).

Among the most exploited breeds in this region, Santa Inês stands out due to attributes such as remarkable body size, growth rate, adaptability, and reproductive capacity. However, one of the obstacles to the sale of animals of this breed is the quality of their carcasses (LISBOA NETO et al., 2020). On the other hand, Dorper sheep have good maternal ability, high growth rates, and muscularity, all of which work together to generate high-quality carcasses (REZENDE et al., 2020).

To render the production process more efficient, many producers have adopted crossbreeding in an effort to exploit heterosis and complementarity. For instance, Santa Inês and Dorper are crossed in aiming at progenies with better carcass quality and meat production ability without prejudice to the animals' hardiness (TORRES et al., 2017).

Studies involving animals from these crosses are scarce, especially addressing the impact environmental variations occurring in different periods of the day can have on the physiological parameters of these animals. The environmental conditions to which animals are subjected are known to have a direct influence on the production indices of their rearing systems. Therefore, the choice of breeds or genetic groups to be exploited cannot be based only on weight gain and carcass yield potentials, but also on the adaptability of the animals (SENA et al., 2021); otherwise,

the decision-making processes within the production system may be subject to errors.

In view of this scenario, the present study was undertaken to examine the influence of environmental differences between periods of the day on the physiological parameters of ½ Santa Inês × ½ Dorper crossbred sheep raised in a semi-intensive system.

MATERIAL AND METHODS

This study was carried out after approval by the Ethics Committee on Animal Use of the State University of Piauí (CEUA/UESPI) (approval no. 0482/2020). The experiment was developed on Sossego farm, located in the municipality of Mirador, Maranhão, Brazil (6°21′43″ S and 44°20′56″ W, 223 m above sea level). The municipality has a tropical climate with a dry season, classified as an Aw type by the Köppen system. Throughout the year, the climate in the municipality is hot, with temperatures ranging from 22 to 36 °C; 43.5% relative humidity; and average precipitation of 38.2%.

The study involved twelve Santa Inês × ½ Dorper crossbred sheep (six males and six females) aged 3.0 years and with a mean weight of 35.00 ± 5.00 kg. The rearing system used on the farm is semi-intensive, with feed supplied in the trough (a mixture of soybean meal and corn meal), access to *Panicum maximum* cv. Masai pasture areas, and water *ad libitum*. During the experimental period, the feed was supplied in the morning, around 10h30, and in the afternoon, around 16h30.

The experiment was laid out in a completely randomized design with two treatments: one corresponding to the morning period (considered from 09h00 to 10h00) and the other to the afternoon period (from 15h00 to 16h00), i.e. the times that precede the supply of supplementary feed to the animals. Six replicates were used per treatment (three male and three female animals). The experiment was carried out from January to February 2021, and a pre-experimental period of six days was used so that the animals could adapt to management procedures referring to the measurements of physiological indicators. The statistical model of the adopted design is represented by the following formula:

$$Y_{ij} = \mu + t_i + e_{ij},$$

where Y_{ij} is the observed value in the experimental unit that received treatment i in replicate j; μ is the general effect of the mean inherent to the entire

experimental unit; t_i is the effect of treatment i; and e_{ij} is the random error in experimental unit i in replicate j.

Before the beginning of the experimental period, the animals were evaluated visually for clinical signs of health aspects. This step involved determining the color of the conjunctival mucosa, following the FAMACHA© method; body condition score; and body weight at adulthood, which was measured using a dial-type scale of 0 to 120 kg.

The following physiological indicators were measured in the animals: respiratory rate (mov./min), heart rate (beats/min), rectal temperature (ºC), and surface temperature (ºC). Respiratory rate, expressed in movements per minute, was obtained by directly observing the movements of the left flank. Heart rate, in beats per minute, was counted using a clinical stethoscope that was positioned on the left side of the animal's thorax. Rectal temperature, in degrees Celsius, was measured with a clinical veterinary thermometer that was inserted into the animal's rectum, for a minimum period of two minutes, at a depth of six centimeters. Surface temperature, in degrees Celsius, was determined using an infrared thermometer, with an accuracy of ± 2 ºC, at a distance of 10 cm, on the skin of the animals in three different places, namely, neck, rib cage, and flank, and the average was calculated (OLIVEIRA et al., 2011).

The environmental variables (temperature (ºC) and relative humidity (%)) were recorded daily during the experimental period through readings taken 30 min after the beginning of the collections in the morning and afternoon periods. Air temperature, relative humidity, and dew point (T_{dp}) were recorded using a digital thermo-hygrometer. The temperature of the black globe thermometer (T_g) was also recorded, using a globe with a diameter of approximately 150 mm, painted matte black on the outside, that was installed at an average height of the animals' body. Based on the values of T_g and T_{dp}, the black globe humidity index (BGHI) was calculated by applying the formula proposed by Borges and Rocha (2018) and Borges et al. (2020):

$$BHGI = T_g + 0.36 \cdot T_{dp} + 41.5,$$

where T_g and T_{dp} are black globe thermometer temperature and dew point, respectively.

Environmental variables and physiological indicators data were subjected to

analysis of variance and their assumptions were checked using R Studio software version 3.6, followed by Tukey's test at 5% probability. Additionally, Pearson's correlation coefficients were calculated between the environmental variables and the physiological indicators of the animals.

RESULTS AND DISCUSSION

The means of the environmental variables of temperature and relative humidity and BGHI differed significantly (P<0.05) between the periods of the day (Table 1).

Table 1. Means of environmental variables and black globe humidity index (BGHI) in different periods of the day in the municipality of Mirador, Maranhão, Brazil.

Period of day	Environmental variables and bioclimatic index		
	AT (°C)	RH (%)	BGHI
Morning	31.71[b]	88.66[a]	86.51[b]
Afternoon	33.91[a]	62.66[b]	87.75[a]

AT: air temperature; RH: relative humidity.

Air temperature showed a thermal amplitude of 2.2 °C between the limits of the studied periods, with 6.48% higher values occurring in the afternoon (33.91 °C). This result is probably due to the greater incidence of solar radiation observed at that time of the day. As expected, the opposite behavior was observed for relative humidity, which dropped 29.32% in the afternoon period (62.66%) compared with the morning (88.66%), given the increase in air temperature and higher incidence of solar radiation.

The air temperature means found in both periods are outside the thermal comfort zone established for sheep. It is noteworthy that the air temperature in the afternoon period approached the critical effective temperature for these animals, which, according to Souza et al. (2015), is above 34 °C. This denotes a possible situation of thermal discomfort for the animals, which in turn may lead to a decrease in the production rates of the rearing system. These high air temperature means are even more worrisome when accompanied by low relative humidity, as observed in the afternoon period, since heat losses through evaporation become difficult.

In line with this statement, Borges et al. (2018) investigated the thermal comfort of Santa Inês sheep and highlighted that climatic conditions in which the air temperature and relative humidity exceed the thermal comfort zone of the animals

make heat dissipation difficult and increase body temperature. In this situation the animals must make use of physiological and behavioral measures to maintain homeothermy, which culminates in a decline in production performance.

Pulido-Rodriguez et al. (2021) evaluated the thermoregulatory responses of Santa Inês sheep and their crosses with the Dorper breed in the municipality of Pirassununga, São Paulo. The authors inferred that these animals showed similar tolerance to heat despite displaying different dynamics of thermogenesis and thermolysis, as evidenced by the maintenance of rectal temperatures within physiological limits even when they were subjected to intense solar radiation.

The BGHI values were higher in the afternoon, averaging 87.75, which is likely a reflection of the influence of the higher air temperature in that period of the day (33.91 °C). This BGHI value characterizes a possible emergency situation for the animals. Agreeing with this statement, the means found for the physiological indicators of the ½ Santa Inês × ½ Dorper crossbred sheep were outside the thermal comfort zone established for sheep (Table 2).

Table 2. Means of physiological indicators of ½ Santa Inês × ½ Dorper crossbred sheep raised in a semi-intensive system.

Period of the day	Physiological indicator			
	RR (mov./min)	HR (beats/min)	ST (°C)	RT (°C)
Morning	65.83[b]	74.03[b]	33.47[b]	39.45[b]
Tarde	73.72[a]	81.27[a]	34.76[a]	39.98[a]

RR: respiratory rate; HR: heart rate; ST: surface temperature; RT: rectal temperature. Means followed by different letters in the column differ statistically by Tukey's test at 5% probability.

All physiological indicators evaluated showed significant differences, with superiority detected in the afternoon period. Respiratory rate rose 10.70% in the afternoon (73.72 mov./min) relative to the morning (65.83 mov./min), demonstrating that the animals had to increase their respiratory movements to dissipate heat to the environment insensibly through respiration. An increase in animals' respiratory rate is indicative of thermal discomfort, which can directly interfere with their ethology, since, in situations of thermal discomfort, animals tend to reduce their feed intake and increase water intake to reduce endogenous heat production.

Pantoja et al. (2017) evaluated the thermal comfort of Santa Inês and Dorper sheep in an exhibition during an agricultural fair and found mean respiratory rates and surface temperatures of 88.07 mov./min and 37.68 °C in the Dorper and 94.96 mov./min and 32.80 °C in the Santa Inês sheep, respectively. The aforementioned

authors reported that the studied animals exhibited physiological parameters outside their thermoneutrality zone. However, it can be inferred that the Santa Inês sheep expressed greater tolerance to the environmental conditions of the agricultural exhibit.

The heart rate of the animals followed the same rhythm as respiratory rate, increasing by 8.90% in the afternoon (81.27 beats/min) compared with the morning period (74.03 beats/min). Heart rate is known to physiologically increase in situations of thermal stress induced by high ambient temperatures, as was observed in both periods of the day. This increase prompts peripheral veins and capillaries to vasodilate in an attempt of the animal to exchange heat with the environment and maintain its body within the thermoneutrality zone.

The surface temperature of the animals was higher in the afternoon period, averaging 34.76 ºC. The thermal gradient—difference in temperature between the environment and the surface temperature of the animals—at this time of day is 0.85 °C, which makes the process of heat dissipation difficult, causing heat increment and increasing surface temperature. It is important to note that the higher air temperature at that time of day (Table 1), coupled with the hair color of the studied animals, which was predominantly black, may have favored the increase in surface temperature due to greater absorptivity and lower reflectivity of solar radiation.

It is also important to highlight that the use of the infrared thermography technique to measure surface temperature in production animals can provide important information without the need for physical contact with them. In addition, it can also be used as an indicator of thermal stress in animals (MCMANUS et al., 2016). According to Cruz Júnior et al. (2015), this technique can be employed to adequately assess temperature gradients in sheep and identify breeds or crossbreeding strategies that are more or less heat tolerant.

As regards the animals' rectal temperature, the average for this physiological indicator was higher in the afternoon period (39.98 °C). This was an expected finding, since, in this period, the air temperature (33 .91 °C) and the surface temperature (34.76 °C) of the animals were also higher. The average rectal temperature of the animals found in the afternoon is outside the standards (between 38.5 and 39.5 °C) considered normal for sheep according to Eustáquio et al. (2011).

The correlations between the physiological indicators of the animals, environmental variables, and BGHI (Table 3) show the relationships between air

Table 3. Pearson's correlation coefficient between the environmental variables, black globe humidity index, and physiological indicators of ½ Santa Inês × ½ Dorper crossbred sheep raised in a semi-intensive system.

	AT	**RH**	**BGHI**	**HR**	**RR**	**RT**	**ST**
AT	1	-0.12	0.80*	-0.09	-0.04	0.29*	0.33*
RH		1	-0.16	-0.37	-0.40	-0.18	0.33
BGHI			1	0.01	0.05	0.26	0.17
HR				1	0.72*	-0.14	-0.32
RR					1	-0.03	-0.26
RT						1	0.21
ST							1

AT: air temperature; RH: relative humidity; BGHI: black globe humidity index; HR: heart rate; RR: respiratory rate; RT: rectal temperature; ST: surface temperature. *Significant at 5% probability.

temperature and their rectal (r = 0.29) and surface (r = 0.33) temperatures. This means that during the day, when the air temperature is higher, there is possibly an increase in the thermal storage of heat, which consequently stimulates an increase in the surface and rectal temperature of the animals.

Heart rate and respiratory rate showed a positive and significant correlation (r = 0.72), denoting the reaction of the animal organism to the accumulation of additional heat provided by the high air temperature. This increase in respiratory rate can lead to several undesirable effects, including a decrease in the alkaline reserve of the animals' blood, since the large amount of expired air results in a low concentration of carbon dioxide in the blood, evidencing respiratory alkalosis and disturbing the compensatory system that prevents changes in blood acidity (NEVES et al., 2021). Additionally, the high rate of respiratory movements implies great muscle activity in the animal, consequently increasing its heat production and inducing a true vicious circle as well as excessive work on the lungs and heart.

Air temperature and BGHI showed a positive and significant correlation (r = 0.80), which indicates that an increase in ambient temperature will probably result in an increase in BGHI. It should be noted that BGHI is calculated considering the temperature of the black globe thermometer, so an increase in ambient temperature will trigger an increase in BGHI and, consequently, at some point in the day, situations of thermal stress in the animals, especially at times of peak solar radiation.

Overall, the physiological indicators evaluated and the direction of the correlations indicate a situation of thermal discomfort for the animals. In this respect, Polli et al. (2020) highlighted the need for management practices such as pasture afforestation around the sheepfold or the use of artificial shade structures, such as

shade cloths, to improve animal welfare in the face of adverse weather conditions.

CONCLUSIONS

The ½ Santa Inês × ½ Dorper Crossbred sheep raised in the municipality of Mirador, Maranhão, Brazil, showed signs of thermal discomfort, especially during the afternoon. Therefore, adequate environmental management measures must be adopted during this period of the day to allow these animals to express their maximum productive potential.

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