ENVIRONMENTAL COMFORT IN CONSTRUCTIONS FOR SINDI AND GUZERA CALVES IN THE AGRESTE REGION OF THE STATE OF PARAIBA, BRAZIL[1]

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ABSTRACT: The objective of this study was to evaluate the quality of air, bioclimatic indexes of facilities and physiological indices of Guzera and Sindhi calves, reared in climatic conditions of Agreste. The study was conducted at the experimental station of Alagoinha, PB, Brazil, using 16 calves of Sindi and Guzerá races. The average concentration of oxygen (20.85%), ammonia (1.99 ppm), carbon monoxide (<0.01 ppm), methane (0.13 ppm) and hydrogen sulfide (<0.01) within facilities, were within the limits established by the Brazilian and international standards, for both animals and workers. The bioclimatic index of temperature and humidity and the temperature of the black globe and humidity index were within the thermal comfort zone for cattle in most of the experimental period, the mean values of respiratory frequency (26.0 min mov^{-1}) and skin temperature (32.3 °C) were higher in the hottest time of the day (1 pm) and rectal temperature (39.3 ^{o}C) in the late afternoon (5 pm), but remained within normal ranges for the studied races. The races have good adaptability to climatic conditions in the region of the Paraibano Agreste, Brazil.

KEYWORDS: environment, cattle, adaptability, physiological responses.

CONFORTO AMBIENTAL EM INSTALAÇÕES PARA BEZERROS SANDI E GUZERÁ NO AGRESTE PARAIBANO

RESUMO: Este trabalho teve o objetivo de avaliar a qualidade do ar, os índices bioclimáticos das instalações e os índices fisiológicos de bezerros Sindi e Guzerá, criados nas condições climáticas do Agreste Paraibano. O estudo foi realizado na estação experimental de Alagoinha - PB, utilizando-se de 16 bezerros das raças Sindi e Guzerá. A concentração média de oxigênio (20,85%), amônia (1,99 ppm), monóxido de carbono (<0,01 ppm), metano (0,13 ppm) e gás sulfídrico (<0,01) no interior das instalações ficaram dentro dos limites estabelecidos pelas normas brasileiras e internacionais, tanto para os animais como para os trabalhadores. Os índices bioclimáticos; índice de temperatura e umidade, e índice de temperatura do globo negro e umidade, estiveram dentro da zona de conforto térmico para bovinos na maior parte do período experimental. Os valores médios de frequência respiratória (26,0 mov min^{-1}) e temperatura da pele (32,3 ^{o}C) foram mais elevados no horário mais quente do dia (13h00), e a temperatura retal (39,3 ^{o}C), no final da tarde (17h00), mas mantiveram-se dentro da normalidade para as raças em estudo. As raças apresentam boa adaptabilidade às condições climáticas da região do Agreste Paraibano.

PALAVRAS-CHAVE: ambiência, bovinos, adaptabilidade, respostas fisiológicas.

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INTRODUCTION

The dramatic population growth of countries in tropical and subtropical areas, as in the case of Brazil, combined, in some regions, with the overall inefficiency of food production, exacerbates the problem of malnutrition of the population, which has led to demand by races with greater productive potential for these regions (AZEVEDO et al., 2008). Among the cattle breeds with the highest degree of adaptation to the semi-arid region are the zebu; and the Sindi and the Guzera breeds have stood out for presenting dual purpose (milk and meat), high feeding efficiency and reproductive early and productive performance, besides having high levels of pigmentation in the epidermis, which offers greater protection against ultraviolet radiation.

Regarding the limits of permissible gases BAETA & SOUZA (2010) state that there must be limits to the exposure of cattle to them, where the concentration of ammonia (NH_3) and methane (CH_4) should be below 10 ppm and not exceed 25 ppm, carbon monoxide (CO) less than 10 ppm and not exceed 50 ppm and carbon dioxide (CO_2) less than 3,000 ppm and not exceed 5,000 ppm.. The unhealthy work environment has been a constant concern, and the NR 15 - Regulatory Norm #15 (1996), recommended for individuals with 8 hours of work, the limit of 20 ppm of NH_3 and H_2S, 29 ppm CO and 3900 ppm of CO_2.

Two-thirds of Brazil are located in the tropical zone of the planet where predominates high air temperatures and high solar radiation (TURKISH et al., 2006; RIBEIRO et al., 2008), and high temperatures in the Northeast occur during most the year (AZEVEDO et al., 2008). According to KAWABATA et al. (2005) in tropical countries like Brazil, the effects of temperature and humidity are often limiting the development, production and reproduction of animals, due to thermal stress, acting as a limiting factor for maximum efficiency production and may interfere with reproductive rates and the production of meat and milk (MARTELLO et al., 2004; TURCO et al., 2006).

The thermal comfort indexes were developed to characterize and quantify the production areas, appropriate to the different animal species, presenting in a single variable, both the factors that characterize the thermal environment, and the stress provided. Among these indexes, there is the index of temperature and humidity and black globe temperature and humidity index (SOUZA et al., 2002; SILVA et al., 2007). BAETA & SOUZA (2010) and SILVA (2000) reported that for Indian cattle, the thermal comfort zone should be between 10 and 27 °C, relative humidity between 50 and 70%. According to DUKES (2006), under thermoneutrality the rectal temperature of calves up to one year is 38.5 +1.5 °C and the normal number of respiratory movements is in average 18 to 28 mov min^{-1}.

The skin protects the body from heat and cold, and its temperature depends mainly on the environmental conditions, such as: temperature, relative humidity and air velocity, the physiological conditions, such as vascularization, sweat evaporation and its composition (RIBEIRO et al. 2008; FAÇANHA et al., 2010). Animals use various mechanisms to maintain homeothermy, such as peripheral vasodilatation and redirect blood flow to the body surface, increasing the surface temperature of the animal, facilitating the dissipation of heat by non-evaporative mechanisms (conduction, convection and radiation). The effectiveness of these mechanisms depends on the thermal gradient between the animal's body and the environment and the higher the gradient, the greater the heat dissipation, since the animal's skin has a tendency to lose more heat to the cooler air (SANTOS et al., 2006; BAÊTA & SOUZA, 2010).

Therefore, the aim in the present study was to evaluate the quality of the air and bioclimatic indexes within the premises and physiological indexes such as Guzera and Sindhi calves reared in climatic conditions of the Paraiba Agreste.

MATERIAL AND METHODS

The experiment was conducted at the Experimental Station Alagoinha, belonging to the State Company for Agricultural Research of Paraiba SA - EMEPA, located in the Agreste Greater Region

in the municipality of Alagoinha, PB. The station is located in the geographic coordinates 6° 57' 00" S and 35º 32' 42" W. Gr, at an altitude of 154 m. The climate according to Köppen classification is an As type (hot and humid) with rain from fall to winter.

It was used 16 weaned calves, Sindhi and Guzera breeds, with initial average weight of 179.0 ± 14, ± 209.0 kg and 21 kg respectively. The experiment was conducted between the months of July to September, totalizing 73 days, 13 and 60 adaptive data collection. During the adaptation period the animals were vaccinated, wormed and given organic modifier (vitamin and mineral). The animals were randomly distributed and confined in stalls, each with two animals of the same breed. The typology of facilities are the following dimensions: north-south aisle of masonry with 2.0 m wide, 11.5 m long, 13.5 m wide, ceiling height of 3.25 m, 1.5 m border divided into eight bays individual with an area of 14.5 m^2, concrete floor, feeder and drinker with masonry, covered with ceramic tiles.

The diet fed to the animals consisted of Napier grass and concentrate based on corn bran, soybean meal, wheat bran, urea and mineral supplement. The diet was formulated based on NRC (1996) to meet the requirements of growing calves with average daily gain of 0.5 kg day^{-1}. The animals received food twice a day at 7am and at 1pm, each animal received, in average, 16 kg of elephant grass and 2.5 kg of concentrate per day. The amount of feed supplied daily was adjusted according to the consumption of the previous day so that there remains around 20% of the total supplied to ensure the voluntary consumption.

In the experiment, the measured concentrations of: oxygen (O_2), ammonia (NH_3), methane (CH_4), carbon monoxide (CO) and hydrogen sulfide (H_2S), within the premises, by means of portable equipment (PHD5) Biosystems brand, precision 0.1. The records were taken at 10am, 2pm and 6pm, twice a week, and the gas detector was placed first at the height of the animal's head (1 m) and then at the height of center of mass of calves (1.5 m). The collection levels was performed using the STEL (Time Weighted Average), corresponding to the average level of exposure to toxic gas at an interval of 15 min.

The bioclimatic variables within the premises were collected every hour, using HOBO®H8 data logger from Onset brand with a precision of 0.5 °C, with four sensors, which collected the following variables: dry bulb temperature, wet bulb temperature and black globe temperature. The air velocity was collected using a portable digital anemometer, LM 8000 Lutron, to 0.1 m s^{-1}. With the environmental variables used to calculate the relative humidity, the rate of temperature and humidity index and black globe temperature and humidity.

The physiological variables analyzed were rectal temperature (RT), respiratory rate (RR) and skin temperature (ST), collected twice a week at three different times at 7am, 1pm and 5pm. To obtain the respiratory rate and skin temperature, measurements were made at the place where the animals were confined, while for rectal temperature the calves were taken to the Bret, for containment and after resting, collected the rectal temperature.

RT was collected by introducing a veterinary thermometer with range of up to 44 °C and 0.1 °C precision directly in the rectum of the animal, at a depth of 3.5 cm for 2 min, the RR was performed by visual observation of the flank of the animal by counting the number of movements for 15 s, the result was multiplied by 4 to obtain the respiratory rate (mov min^{-1}). TP was measured with an infrared digital thermometer, Model Raystphc, accurate to ± 0.5 °C, Raytec brand, in the head, legs and dorsal region, at an approximate distance of 50 cm. With data, it was calculated the arithmetic average of ST.

The data were subjected to analysis of variance and, when necessary, the measures were compared by Tukey test at 5% probability by the statistical program ASSISTAT 7.5. For data evaluation it was used the delineation of completely randomized block with eight replications in a split plot with genotype in the main plots and time in the subplots, as the following statistical model:

$$Yijk = \mu + gi + Ɛij + tk + gtik + \varepsilon ijk \quad (1)$$

In which,

μ - general constant;
gi - genotype;
εij - error in the plot;
tk - time;
gtik - interaction g x t, and
Ɛejk - error in the subplots.

RESULTS AND DISCUSSIONS

The average concentration of gases within the premises were not significantly different (P>0.05) between the hours surveyed, who were an average of 20.85% for oxygen, ammonia 1.99 ppm, 0.13 ppm methane and below 0.01 for carbon monoxide and hydrogen sulfide, all below the recommendations of the NR-15 (1996) and the recommendations of BAÊTA & SOUZA (2010), mentioning that the hydrogen sulfide and ammonia are the gases that most affect the health of animals and workers, and recommended maximum concentrations of 10 and 25 ppm, respectively.

These low values of concentration of gases can be explained by the architectural design of the facilities, which were open, as is common in northeastern Brazil and the management, where the stalls were cleaned daily, thus avoiding the accumulation of waste, which in its biological degradation produces ammonia, hydrogen sulfide, methane and carbon dioxide, but also by natural ventilation, an average of 2.9 m s^{-1}, constantly contributing to the renewal of air.

The average values of air temperature (AT), relative humidity (RH), air velocity (VV), temperature and humidity index (THI) and globe temperature index and humidity (GTIH) are presented in Table 3, where it is observed that the average value of AT was 25.3 °C and, taking as basis the recommendations BAÊTA & SOUZA (2010), can be considered within the zone of thermal comfort for young cattle. KABAWATA et al. (2005) in studies with various types of hutches, mentioning a average temperature of 23.0 ºC, but during the morning (11am) and afternoon (2pm), found maximum values of 32.1 and 34.9 °C respectively, therefore much higher than to those of this research, and these higher values are attributed to roofing materials analyzed. SOUZA et al. (2007) in studies with Sindh breed females, with 18 months of age in semi-arid Paraiba, reported that, during the winter, the average temperature was 26.3 and 38.2 °C in the morning and afternoon, respectively, therefore higher than the values of this study.

It is observed that low temperature range occurred at room temperature, both in the morning (1.0 ºC) as the afternoon (0.5 ºC), which may contribute to the maintenance of thermal comfort of the animals, and this low amplitude can be justified by the period in which the research was performed, late winter and early spring, but also by the location of the facility, which is near the equator, which provides low-temperature range in temperature throughout the year, and these are most evident when comparing the nighttime to the daytime.

The RH showed values of 68.1% in the morning, and 66.9% in the afternoon, according to SILVA (2000) may be within the comfort zone for calves, which is from 50 to 70%. The lowest values in the afternoon may be associated with increased ambient temperature and radiant heat load in this period. The RH has great influence on the well-being and productivity of the animal, especially high values associated with high air temperatures (BAÊTA & SOUZA, 2010). KABAWATA et al. (2005) researching different coverage types hutches, found mean values of RH (68.2%) similar to this research and considered non-stressful to the animals. SOUZA et al. (2007), in studies with female Sindhi, mentioning in the rainy season, RH values in the morning of 71% and in the afternoon of 64%, so close to the present study.

TABLE 1. Average values of air temperature (AT), relative humidity (RH), wind speed (WS), temperature and humidity index (THI) and rates of globe temperature and humidity (RGTH)

	Period of the Day				
	Morning		Afternoon		
	Average	Amplitude	Average	Amplitude	General Average
AT (°C)	25.1	24.6 - 25.6	25.6	25.3 - 25.8	25.3
RH (%)	68.1	54.0 - 82.2	66.9	54.8 - 79.0	67.5
WS (m s^{-1})	2.4	1.8 - 2.9	2.9	2.2 - 3.5	2.6
THI	73.1	72.4 - 73.8	73.4	72.0 - 74.8	73.3
RGTH	73.6	72.6 - 74.5	74.0	72.5 - 75.6	73.8

Unlike ambient temperature RH had a wider reach, which was 28.1 and 24.2% for the morning and afternoon, respectively. High amplitudes in the RH associated with AT levels can interfere with the metabolism of animals, as they have to adjust physiologically to maintain their homeothermy, either to conserve or dissipate heat. For this, energy expenditure occurs, resulting in reduced efficiency of production (ESMAY & DIXON, 1986), however very high humidity can affect the health of animals under heat stress (JOHNSON & McGLONE, 2007).

In the morning, the average speed of the air ranged from 1.9 to 2.9 m s^{-1}, and in the afternoon, 2.2 and 3.5 m s^{-1}, respectively, can be considered within the limits for young calves and influenced positively in the comfort of the animals, also collaborating in the dissipation of heat and gases. These values were similar to those cited by FAÇANHA et al. (2010), in a study with dairy cattle in semi-arid state of Ceara, with the highest average in September and March (3.0 and 2.8 m s^{-1}, respectively), reported that, they were considered beneficial for the convective heat loss mechanism, relieving the sensation of heat imposed by higher temperatures. It is observed that there was a higher wind speed (2.9 m s^{-1}) and greater range in the afternoon (1.3 m s^{-1}), which may be beneficial for the control of body temperature by means of the effect of convection, as occurs in tropical higher temperatures and relative humidity lower in the afternoon (KABAVATA et al., 2005; SOUZA et al., 2007; FAÇANHA et al., 2010).

The average values of THI in the morning was 73.1; 73.4 in the afternoon, and RGTH were 73.59 and 74.06 in the morning and afternoon, respectively. The representativeness of these values, at certain times of the day remained in a situation of alert (range from 74 to 78), as quotes from SOUZA et al. (2002). TURCO et al. (2006) in studies with climatic zoning for dairy cows mentioning reduction in milk production with the elevation of the THI, with production losses of up to 4.5 liters of milk per cow daily.

The values found in the morning were higher than those reported by KAWABATA et al. (2005), and in the afternoon the situation had reversed itself, where they mention minimum and maximum values, among several hutch of 83.01 (covered with tiles of cement and cellulose shadow) and 85.60 (covered with cement asbestos in the sun), respectively. These values were lower than those cited by SOUZA et al. (2007), in studies in the semiarid region of Paraiba, in both dry and rainy season, a fact justified by the region where the experiments were carried out, that even being in the state of Paraiba, this study was carried out in the Agreste and the other on the sertão of Paraíba. It is observed that there was little variation in the amplitude of the THI and RGTH, which can be justified by the small variation in temperature and good air velocity.

Table 4 presents the average values of rectal temperature (RT), respiratory rate (RR) and skin temperature (ST), where it is observed that there was no significant difference (P> 0.05, Tukey) between breeds to all physiological indexes, but there was no difference between the times.

TABLE 4. Average values of rectal temperature, respiratory rate and skin temperature of Guzera and Sindhi calves at different times.

	Schedules		
	7am	1pm	5pm
	Rectal Temperature (ºC)		
Breeds			
Sindhi	38.6 C	39.1 B	39.3 A
Guzera	38.8 C	39.2 B	39.3 A
Average	38.7	39.2	39.3
	Respiratory Rate (mov min^{-1})		
Breeds			
Sindhi	23.1 C	27.0 A	24.4 B
Guzera	22.8 C	25.1 A	24.2 B
Average	22.9	26.0	24.3
	Skin Temperature (ºC)		
Breeds			
Sindhi	29.2 C	32.5 A	24.0 B
Guzera	29.2 C	32.2A	24.1 B
Average	29.2	32.4	24.3

Medium line followed by different capital letters differ by Tukey test ($p<0,05$).

Although the values of RGTH and THI were considered as alert situations, the races had RT values within the normal range quoted by DUKES (2006), in which the calves showed no signs of discomfort for the installation conditions. These values were similar to average values (38.0 °C) cited in a study conducted with cattle, by FERREIRA et al. (2006). In the morning, values were lower than those quoted by KAWABATA et al. (2005), in research with hutches, where the afternoon values were similar to those of the authors, who had different covers for the present experiment.

Although there was no significant difference between breeds, it is observed that the RT at 1pm had values higher than of those at 7am and the value at 5pm was higher than other times. These data are consistent with the studies of SOUZA et al. (2007), with females of Sindhi breed, as well as AZEVEDO et al. (2008), that in studies with the hard-foot breed, in northeastern Brazil, which describe the RT obtained in the morning, undergo distinct effect of environmental variables in relation to those obtained in the afternoon, indicating that there was a delayed effect of climatic variables on the rectal temperature, which has led the animals to have a rectal temperature higher at the end of the day.

It is noticed that the two breeds studied did not fit into the classification of alert, they did not present symptoms of discomfort before the environmental conditions, showing its adaptation to the climate of the region and that more research is needed to determine the thermal comfort zone for the various breeds adapted / naturalized Brazilian semi-arid climate.

As for the RF, it is observed that there was no significant difference ($P>0.05$) between breeds, but there was between the times, with elevation from 7am to 1pm, with decline at 5pm. These facts may be associated with raising the temperature, the THI and the RGHI in the hottest times of the day, where animals use panting as a way of dissipation of body heat. It appears that the RF was within the optimum values cited by DUKES (2006), not reaching critical values, indicative of good primary physiological response to thermal conditions in the region. SOUZA et al. (2007), also reported that the Sindhi cattle in both rainy and dry season in the semiarid region of Paraíba, kept respiratory frequency within the normal range for the species. KABAWATA el al. (2005) cite average RF values higher than those of the present experiment (average of 52.3 mov min^{-1}), in hutches.

AZEVEDO et al. (2008), in studies with the hard-foot breed, under thermal stress in the dry season, with young males (1.6 years), received animals RF from 26.4 and 28.0 mov min^{-1}, in the morning and afternoon period, respectively, similar to the present study, also demonstrating the adaptability of the animals from zebu breeds have for the tropics.

It is verifies that the highest ST was at 1pm, with strong decline at 5pm, due to the fact that the animal is at an environment with higher temperature and radiant thermal load, its organism elevates the ST, with raise in blood flow of the central nucleon to the animal's surface, and, consequently, heat flow rate elevated, resulting in high superficial temperatures (SOUZA et al., 2007). BAÊTA & SOUZA (2010) quote that in the hottest hours of the day it occurs a peripheral vasodilatation, as a response to the elevation of environment's temperature, with a consequent increase in blood flow to the skin surface, and that this heat can flow from the body surface of the animal to the environment. FAÇANHA et al. (2010) in studies with Dutch cows with different genetic groups in semi-arid region, quote the average surface temperature of the haircoat of 35.0 + 0.1 °C, which can be justified by the high air temperature, rate of temperature black globe humidity and intense radiant heat load recorded during the experimental phases, where the temperature of the coat increased with the increase of the mean radiant temperature.

According BAETA & SOUZA (2010) with higher evaporative losses, a large amount of heat is removed by vaporization of the skin, so that the blood that circulates through the body surface becomes cooler. In the early evening, with the decline of temperature and solar radiation, there was a reduction in skin temperature. MARTELLO et al. (2004) found values of skin temperature between 31.6 and 34.7 °C and found that animals were not suffering from heat stress and SOUZA et al. (2007) in the dry season, mention that the skin temperature of cattle of Sindhi breed, were 19.1 and 31.8 °C in the morning and afternoon, respectively, similar to the time at 7am and 1pm.

It can be seen that the gradients of Rt-St were lower at 1pm and the highest recorded at 5pm and this can be explained by the increase of air temperature and radiant heat load at 1pm, and the consequent decrease at the end of days. The existence of gradient between the animal surface and the environment is an important factor for heat dissipation by non-evaporative mechanisms, such as conduction, convection and radiation (SANTOS et al., 2006).

As to the gradient between the Rt and St, it is observed that this was the highest at 7am, decreasing at 1pm and increasing again at 5pm. This difference between rectal and the superficial temperature are essential for the maintenance of homeothermy, since the animals tend to perform peripheral vasodilatation, as a way of losing heat to the environment and this mechanism raises the surface temperature, reducing this gradient during hot hours of the days.

TABLE 5. Averages of thermal gradients (St-At) and (Rt-St) as a function of the interaction between Guzera and Sindhi calves and times.

	(St-At ^{o}C)			(Rt-St ^{o}C)		
Breeds	7am	1pm	5pm	7am	1pm	5pm
Sindhi	6.0B	5.5C	7.3A	9.4A	6.6C	7.8B
Guzera	6.0B	5.2C	6.9A	9.6A	6.9C	8.2B
C.V.%		6.35			4.37	

Average line followed by different capital letters differ by Tukey ($p<0.05$)

SANTOS et al. (2006) in studies with Santa Inez sheeps, Morada Nova and their crosses, in semiarid region of Paraíba, quote gradients between the Rt and St in the morning and afternoon shifts of 8.8 and 7.4 °C, respectively, and between the At and St, even in these times of 10.5 and 3.8 °C, respectively, following the same trend of this experiment. These thermal gradients were analyzed at all times, higher than those reported by RIBEIRO et al. (2008), that in studies with indigenous goats in semi-arid Paraiba, quote average thermal gradients between Rt-Ts of 5.1 °C and between St-At of 5.4 °C, demonstrating the difference between species and between surveyed areas.

CONCLUSION

Under conditions that the experiment was realized, it is concluded that the amounts of gases generated in the premises were within the ideal conditions, depending on the use and management of natural ventilation. Respiratory rate and rectal temperature, although they were higher in the warmer hours of the day, remained within the normal limits of thermal comfort for calves. The breeds have good adaptability to climatic conditions of the Agreste region of the State of Paraíba.

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