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Effect of time of day and type of shading on the physiological responses of crossbred calves in tropical environment

Efeito da hora do dia e tipo de sombreamento sobre as respostas fisiológicas de bezerros mestiços em ambiente tropical

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Abstract Many studies report the relationship between adverse environmental conditions and damage yield, especially in dairy cows. However, studies about the effects of environment on young animals, especially calves of mixed breed are rare. Were studied the effects of day time and type of shading on physiological responses of crossbred calves in a tropical environment. Twenty-four ½ Holstein and WDB (without defined breed) calves were identified in two nursery facilities; one provided with natural shading and the other provided with artificial shading by fiber cement tile. In both facilities, air temperature, wind speed, and black globe temperature were recorded between 7 am to 4 pm to calculate the radiant thermal load. Physiological responses (rectal temperature and respiratory rates) were measured in the morning and in the afternoon. The natural shade provided less thermal comfort because of higher radiant thermal load, especially in the afternoon. The crossbred calves showed higher rectal temperature and respiratory rate than WDB calves in both periods of day and in both nursery facilities, with the highest values recorded under natural shade. Calves of different genotypes respond differently in hot environments, should be to test in future research another types of trees to verify their thermal quality.

Keywords *Bos taurus*, nursery facility, physiological responses, thermal environment

Resumo Muitos estudos relatam a relação entre as condições ambientais adversas e danos aos rendimentos, especialmente em vacas leiteiras. No entanto, os estudos sobre os efeitos do ambiente sobre os animais jovens, especialmente bezerros mestiços são raros. Foram estudados os efeitos da hora do dia e tipo de sombreamento sobre as respostas fisiológicas de bezerros mestiços em um ambiente tropical. Vinte e quatro bezerros ½ Holandês e 24 SPRD (sem padrão de raça definida) foram distribuídos em dois tipos de bezerreiro, um com sombreamento natural e outro com sombreamento artificial promovido por telha de fibrocimento. Em ambas as instalações, a temperatura do ar, velocidade do vento e temperatura de globo negro foram registradas das 7 às 16 horas para compor o calculo da carga térmica radiante. As respostas fisiológicas (temperatura retal e frequência respiratória) foram aferidas na parte da manhã e na parte da tarde. O sombreamento natural forneceu menor conforto térmico, por apresentar temperatura e carga térmica radiante mais elevada, principalmente no período da tarde. Os bezerros ½ Holandês apresentaram temperatura retal e frequência respiratória mais alta que os SPRD nos dois horários e em ambas as instalações, sendo que no bezerreiro com sombreamento natural ocorreram as maiores médias. Bezerros de diferentes genótipos respondem de forma diferente em ambientes quentes, tornando necessária a realização de estudos nesta mesma linha para testar outros tipos de árvores com o intuito de verificar a qualidade térmica das mesmas.

Palavras-chave ambiente térmico, bezerreiro, *Bos taurus*, respostas fisiológicas

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Introduction

In beef holding, the renewal of herd is a very important practice for the reduction of mortality of calves (Pereira 2007). In Brazil, providing a favorable environment for the animals to express their full genetic potential is a challenge due the high temperatures and high levels of solar radiation. Indeed, the control of environmental conditions is practically impossible in a natural environment. Thermal requirements vary with the stage of development of the animals, and protecting the young animals from adverse environmental conditions is essential during breast-feeding time (Cunha et al 2007a).

According to Ferreira et al (2006), bovine susceptibility to thermal stress increases as relative humidity and ambient temperature exceed the thermal comfort zone, which increases the body temperature and causes adverse effects. In addition, solar radiation is another factor affecting the animals located in regions near the Equator line. In this context, understanding the process of thermal balance in these animals may be useful to improve the handling and building of animal shelters (Da Silva et al 2002).

Heat stress changes the homeothermy and can be quantified by measurements of physiological variables such as rectal temperature, respiratory rate, and hormone concentrations. Respiratory rate is a sensitive response to heat similar as how body temperature changes in response to increased outside temperature and relative humidity (Bianca 1963). Since rectal temperature is a physiological response that changes with significant delay, its elevation depends on excessive heat gain from the environment.

Many studies report that adverse environmental conditions damage yield, especially in dairy cows. However, studies about effects of environment on young animals, especially calves of mixed breed are rare. Although few studies have been conducted to assess the physiological responses of dairy calves in different types of facilities (Cunha et al 2007ab; Campos et al 2002), no study about the physiological responses of crossbred calves provided with natural shade to hot environments was found in the literature. Therefore, the effect of day time and type of shading on physiological responses of crossbred calves in tropical environment forms a background of this paper.

Materials and Methods

The study was conducted in 2008 on the Nazaré Farm located in Maranguape town, Ceará, Brazil. The farm is located at an altitude of 68.6 m, latitude 3°53′27″ and longitude 34°41′08″, and characterized by hot and humid tropical climate. Twenty-four ½ Holstein calves and 24 calves without defined breed (WDB aged between 10 and 60 days were distributed in equal numbers in two types of shelters:

(a) Natural shading was provided by carob trees (*Prosopis juliflora*) with an average height of the canopy of 5 m; in a delimited area of 5 m^2 per animal; containing troughs for supplying roughage and concentrate and water *ad libitum.* The animals were restrained by ropes with 2 m in length to avoid contact between them.

(b) Under artificial shading, the animal shelter was made of wood with concrete floor, tile cement coverage, ridge height of 2.5 m, and collective drinking and feeding troughs. The area available per animal was 2 m^2. However, the cover corresponds to only half the total area, resulting in a shading area of 1 m^2 per animal.

Rectal temperature (R_T, °C) was measured with a digital thermometer (SALVTERM) coupled to a temperature sensor (PT-100) that was inserted (10 cm) into the rectum of animals. Respiratory rate (R_R, breaths/min) was measured by observing the flank movements of the animals. R_T, R_R and environmental data were measured for two periods of the day: morning (7 am) and evening (4 pm). Air temperature (A_T, °C) was measured with a digital thermo-hygrometer (model HT-300; Instrutherm). Black globe temperature (B_{GT}, °C) was measured using a temperature sensor (model SK-100) introduced into a black globe (hollow sphere of copper plate, 0.15 m in diameter, and painted matte black). Mean radiant temperature (M_{RT}, K) and radiant heat load (R_{HL}, $W.m^{-2}$) were estimated by the equations described by Da Silva et al (2010).

The data were analyzed by the method of least squares for dates not balanced and analysis of variance was performed using the General Linear Models of Statistical Analysis System - SAS® (SAS 1999).

Results and Discussion

The analysis of variance for A_T showed significant effect of day time ($F=33.93$; $P<0.0001$) and shelter type ($F=4.05$; $P=0.0479$). The sampling day and interaction between day time × shelter type had no significant effect. For R_{HL}, the analysis of variance revealed significant effect of day time ($F=19.11$; $P<0.0001$), shelter type ($F=16.89$; $P=0.0001$) and sampling day ($F=5.23$; $P=0.001$). The interaction between day time × shelter type had no significant effect.

The dairy changes on averages of A_T and R_{HL} during the study are presented in Figure 1. The lower means for A_T (25.22 °C) and R_{HL} (490.91 $W.m^2$) were observed at 7 pm. The higher averages for A_T (31.65 °C) and R_{HL} (535.05 $W.m^{-2}$) were recorded at 1 pm. These findings

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indicate that R_{HL} is highest at noon, when shadow is essential in order to reduce the thermal discomfort.

A_T and R_{HL} were higher in the afternoon (30.95 °C and 528.38 W.m^{-2}, respectively) than in the morning (28.36 °C and 512.99 W.m^{-2}, respectively). A_T and R_{HL} for calves under natural shade were higher (30.10 °C and 527.92 W.m^{-2}, respectively) than for calves under artificial shade (29.21 °C and 513.25 W.m^{-2}, respectively).

Trees usually provide greater efficiency in provision of shade as compared with artificial shelters due to the cooling caused by the evaporation of moisture from the leafs (Hahn, 1993). However, the efficiency of natural shade over artificial shade is also related to the tree type. Isolated trees may be less efficient than artificial shelters, which, as observed in this study, were more efficient in reducing A_T and R_{HL}. The tree *Prosopis juliflora* had very dense canopy, which facilitated the passage of direct solar radiation, resulting in an increase in R_{HL} and consequently A_T.

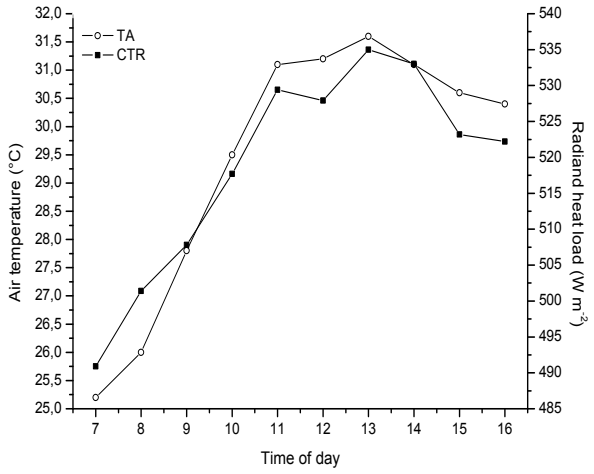

Figure 1 Dairy variation on averages of air temperature (A_T) and mean radiant temperature (R_{HL}) observed during the study.

Figures 2 and 3 show the comparison between mean values of A_T and R_{HL} under different shelters. The results of this study agree with Abreu et al. (2001) when it comes to shading provided by the tree, where the highest average happens in the afternoon for the two variables. The same relationship was found with artificial shelters.

The analysis of variance for R_R show significant effect of the genetic group (F=103.08; P<0.0001), day time (F=16.95; P<0.0001) and shelter type (F=91.21; P<0.0001). The collection day, the interaction between hour × genetic group and the interaction between genetic group × shelter type had no significant effect. The average R_R for ½ Holstein calves was higher than for WDB calves (50.0 and 34.58 breaths/min, respectively). The mean R_T was higher in the afternoon than in the morning hours (45.41 and 39.17 breaths/min, respectively). Calves housed under natural shade showed higher R_R than calves under artificial shade (61.79 and 44.01 breaths/min, respectively).

The comparison of means of R_R for the fixed effects time of day and shelter type was performed independently of the genetic groups. The R_R of ½Holstein calves (Figure 4) was higher than the R_R of WDB calves in the morning and in the afternoon. Because the animals are from Europe, they are less adapted to hot environments. The increase in R_R is an attempt to dissipate the excess of body heat (evaporative respiratory) to maintain homeothermy. The average R_R of ½Holstein calves remained above 45 breaths/min in the two periods of day studied. For other hand, the average R_R of WDB calves did not exceed 40 breaths/min in the afternoon period.

The analysis of variance for R_T show significant effect of the genetic group (F=12.03; P=0.0006), day time (F=35.98; P<0.0001) and shelter type (F=21.86; P<0.0001). The collection day, interaction between hour × genetic group and interaction between genetic group × shelter type had no significant effect for T_R. The average R_T of ½ Holstein calves was higher than the R_T of WDB calves (39.40 and 39.08 °C, respectively). The afternoon period had higher mean R_T than morning period (39.52 and 38.95 °C, respectively).

Calves housed under natural shade showed higher R_T than calves under artificial shade (39.85 and 39.42 °C, respectively). The comparison of means R_T for fixed effects (day time and shelter type) was independently performed of the genetic groups.

The ½ Holstein calves under the tree shade had higher average R_T in the afternoon (Figure 5); being outside of normal limits (38.0–39.3 °C) proposed by Dukes (1996). The WDB calves had average R_T lower than ½ Holstein calves in the two periods. The possible explanation is that animals of European origin are less adapted to environments with intense solar radiation and high air temperature than animals with greater proportion of Zebu genes. Thus, ½ Holstein calves have difficult to dissipate the excess of body heat, causing the increase in R_T.

In the morning, there was no significant difference between the genetic groups (P<0.05) for rectal temperature. The observed increase in R_T in the afternoon in both genotypes (Figure 5), as was also observed by Cunha et al (2007a), was due to the increase in R_{HL} and A_T (Figure 1) caused a major input of thermal energy received by the animals at this time.

When R_T was compared between calves in different shelter types regardless of day time, the

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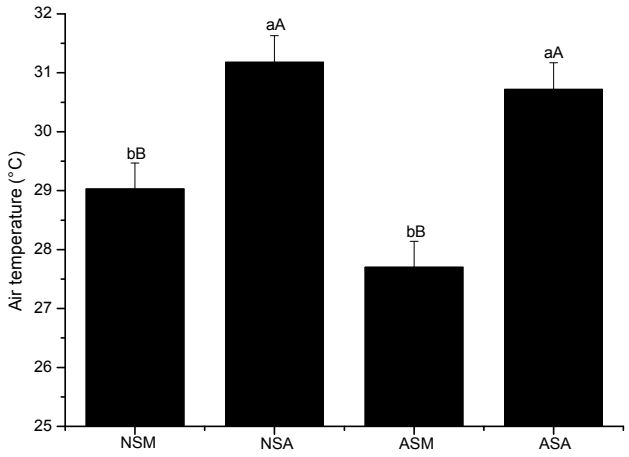

Figure 2 Averages of air temperature under natural shelters in the morning (NSM) and in the afternoon (NSA), and under artificial shelters at the same times (ASM and ASA).

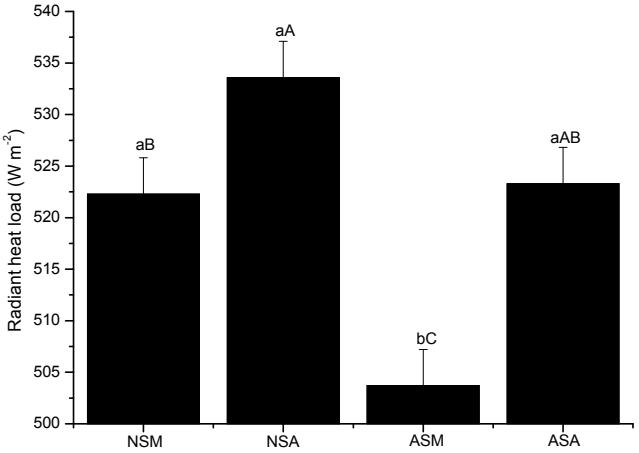

Figure 3 Averages of radiant heat load under natural shelters in the morning (NSM) and in the afternoon (NSA), and under artificial shelters at the same times (ASM and ASA).

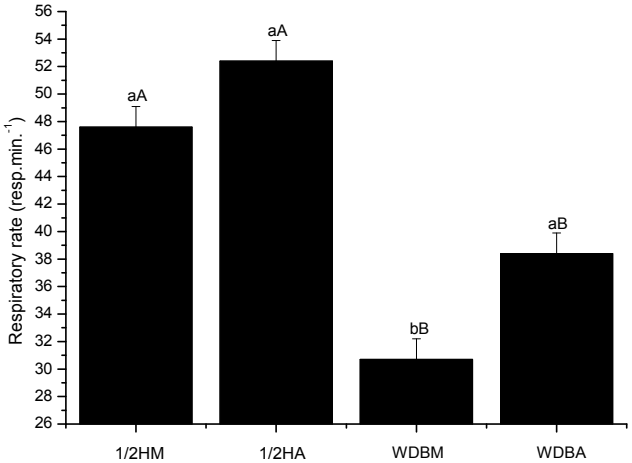

Figure 4 Averages of respiratory rate for ½ Holstein calves and crossbreds in the morning (½HM and WDBM, respectively) and afternoon (½HA and WDBA, respectively) independent of shelter type.

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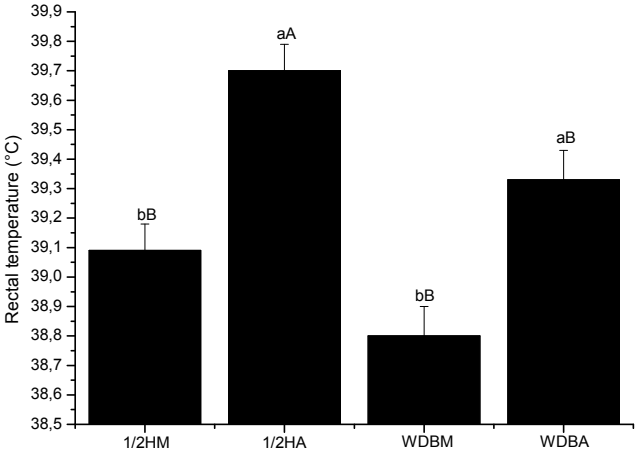

Figure 5 Averages of rectal temperature for ½ Holstein and crossbred calves in the morning (½HM and WDBM, respectively) and in the afternoon (½HA and WDBA, respectively), independent of shelter type.

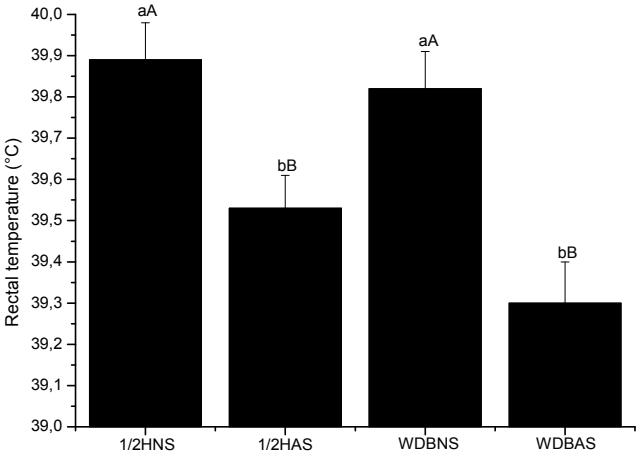

Figure 6 Averages of rectal temperature for ½ Holstein calves and crossbred calves housed in shelters with natural shade (½HNS and WDBNS, respectively) and artificial shade (½HAS and WDBAS, respectively).

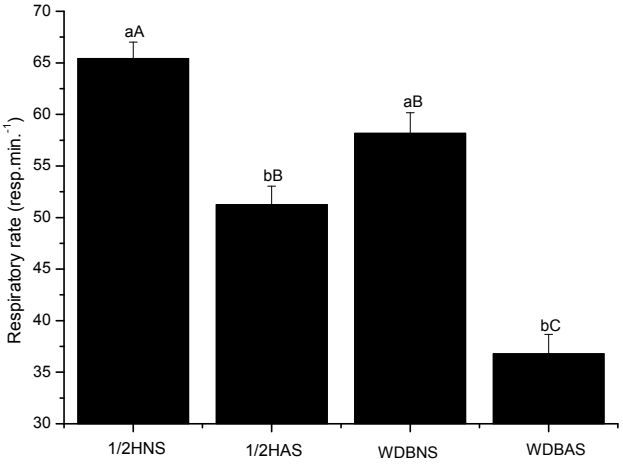

Figure 7 Averages of respiratory rate for ½ Holstein calves and crossbred calves housed in shelters with natural shade (½HNS and WDBNS, respectively) and artificial shade (½HAS and WDBAS, respectively).

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highest average was observed for animals in shelters with natural shade (Figure 6), which showed no statistical difference between the genetic groups. In this type of installation, a failure to maintain R_T within the normal limits is seen in animals (Dukes, 1996), but for the ½ Holstein the average R_T was around 39.5 °C.

According to Schmidt-Nielsen (2002), animals in a hot environment receive excessive amount of heat which elevates their body temperature. Without any other sensible heat transfer mechanism, the animals lose heat by evaporation through the skin (sweating), breathing as well as by raising the respiratory rate. Therefore, the R_R was higher for genetic groups housed in shelters with natural shade (Figure 7).

However, the ½ Holstein had higher average R_R than WDB calves ($P<0.05$) in this facility. The same result was recorded in artificial shelters ($P<0.05$), where ½ Holstein calves (15 breaths/min) showed an average R_R higher than WDB calves.

Cunha et al. (2007a), studying calves at different facilities (coverage, mobile shelter and exposed to direct solar radiation), found no significant difference between R_R for different installations in the morning and in the afternoon, except to animals exposed to direct solar radiation in the afternoon. However, the experiment of Cunha et al. (2007a) was conducted in the state of Rio de Janeiro, Brazil, where radiation levels differ from those found in the region in the present study. The state of Ceará, Brazil, is located near of the equator line, being characterized by high levels of radiation which is responsible by the higher average temperature.

Interestingly, ½ Holstein calves presented high R_T and R_R under both types of shelters and during the two periods of day, suggesting that these animals had an ineffective mechanism of thermoregulation. In contrast, WDB calves showed better adaptive characteristics, avoiding the activate of their respiratory evaporative mechanism even when the R_T raised to 39.0 °C in the afternoon.

Conclusions

Calves of different genotypes respond differently in hot environments. In the afternoon, the ½ Holstein calves had higher body temperatures and respiratory rate than WDB calves. The facilities provided by artificial shading were more effective than that provided by trees. Thus, the microclimate provided by different trees and their effects over the animal thermoregulation should be studied.

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