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ANIMAL PRODUCTION

Behavior of buffalo heifers reared in shaded and unshaded pastures during the dry season on Marajó Island, Pará, Brazil

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ABSTRACT. The objective of this research was to evaluate the behavior of twenty buffalo heifers reared during the dry season on Marajó Island, Pará, Brazil. The animals were distributed into two groups, those with shade (WS) and those without shade (WOS). The experimental day was divided into six shifts: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55 a.m.). The WS group was kept in silvipastoral system paddocks, while the WOS group was kept in unshaded paddocks. Climatic data were registered and temperature and humidity index (THI) were calculated. Behavior data such as grazing, rumination, idle time, and other activities (walking, defecating, mounting, drinking water, urinating, eating salt) were evaluated. The results showed that the THI was higher in the WOS group. Grazing time was higher in the WOS group than in the WS group in the intermediate shift ($p < 0.05$), while in the afternoon, evening, and early morning shifts, the WS group spent more time grazing than the WOS group. In the intermediate and early morning shifts, the WS group spent more time ruminating ($p < 0.05$); the WS group ruminated more than the WOS group. The WOS group had more idle time, especially in the evening and early morning shifts ($p < 0.05$), while the WS group had more idle time in the intermediate shift ($p < 0.05$). We conclude that buffaloes graze and ruminate more intensely when they are reared in a shaded system on the island of Marajó.

Keywords: bioclimatology; ethology; heat.

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Introduction

Buffaloes were introduced in Brazil in the late 19th century on the island of Marajó, Pará, where they continued to develop. They reached satisfactory performance indices due to their capacity for adaptation to different environments, especially in areas with low fertility soils and low-quality native pastures, where cows would otherwise not thrive (Damé, Riet-Correa, & Schild, 2013). The economic structure of the Marajó mesoregion is still influenced by activities related to livestock, especially buffalo farming in the natural fields of Marajó Island.

Buffaloes produce beef and milk, and provide labor for farmers. Their ideal “habitat” is the Amazon; three subspecies (*Bubalus bubalis bubalis, B. b. kerebau*, and *B. b. fulvus*), four breeds (Mediterranean, Murrah, Jafarabadi, and Carabao), as well as the Baio type, are found in Brazil. The first four breeds are officially recognized by the Brazilian Association of Buffalo Breeders; the first breed is a marsh buffalo, and the remaining are river buffaloes (Rosa, Ferreira, Avante, Zangirolami Filho, & Martins, 2007). Buffaloes are considered robust and capable of adapting to the most inhospitable environments, yet they are unable to protect themselves from hot weather, especially against direct solar radiation, the main stressor for this species. This inability to cope with heat is due to specific structural features, such as strong melanin concentration in the skin and hair, low number of sweat glands, and extremely thick epidermis, which reduce skin evaporation capacity, and also lead to low hair density and dark skin (Gudev et al., 2007). Buffaloes change their posture to dissipate heat by convection under thermal stress conditions and remain idle for most of the time to reduce movement generated heat. Among other behavioral variations, food intake also changes, with a reduction in rumination affecting animal productivity (Lima et al., 2014). Daily activities are characterized by three basic behaviors: feeding, rumination, and idleness, with the duration and distribution of these behaviors influenced by nutritional characteristics, management, climatic conditions, and animal activity in the group (Pazdiora et al., 2011).

Animals reared in conventional non-wooded pastures are exposed to a high incidence of solar radiation on the skin surface, which may result in thermal discomfort, promoting physiological and behavioral changes (Schütz, Rogers, Poulouin, Cox, & Tucker, 2010). As such, the silvipastoral system may act as an alternative, providing buffaloes with thermal comfort, as tree shade would reduce the incidence of solar rays, resulting in better thermal sensation (Silva et al., 2012). There is little information on the daily behavior of buffaloes as a result of thermal stress in the Amazon.

The objective of this study was to analyze the differences in behavior between buffalo heifers reared in shaded (silvipastoral systems) and unshaded systems on Marajó Island during the dry season. The results of this study will provide information to farmers on how to better manage their animals, increase thermal comfort and improve productivity.

Material and methods

The Committee on Animal Ethics of the Federal Rural University of Amazonia approved this experiment, Protocol No. 054/2015 (CEUA) and 23084.013102/2015-01 (UFRA). All Federal Law 11794/08 requirements were fulfilled (Lei Arouca), respecting COBEA's Ethical Principles on Animal Experimentation.

This experiment was carried out on a rural property in the municipality of Cachoeira do Arari, Marajó Island, Pará, Brazil (00°55′37.8″S and 48°43′48.1″W), in November, the driest month of the year in this region. The study area was chosen based on climatic typology Am (Köppen & Geiger, 1928), which indicated that rainfall during the driest month was below 60 mm, with the mean annual rainfall varying between 2,500 mm and 3,000 mm.

Twenty clinically healthy Murrah heifers (cyclic, non-pregnant, and non-lactating) with mean age of 24 months and mean weight of 267.9 ± 28 kg, were randomly distributed into two groups (WS – with shade, WOS – without shade). The WS group (n = 10) were kept in silvipastoral system paddocks in a *Brachiaria humidicola* pasture shaded by Malay Apple (*Syzygium malaccense*) and Calabash (*Crescentia cujete*) trees. The WOS group (n = 10) was kept in paddocks under the same nutritional management, without access to shade. Both groups were under intensive rotational grazing and had access to water and mineral salt *ad libitum*. Animal behavior was examined over 72 consecutive hours, in special 60-minute forms, divided into twelve periods of five minutes. Animals were washed, dried, and numbered from 1 to 20 with non-toxic white paint on their withers and rump for easy identification.

The visual and direct observation method was used to evaluate animal behavior, with punctual records (Hirata, Iwamoto, Otozu, & Kiyota, 2002) every five minutes using the sampling method (Brscic, Gottardo, Mazzenga, & Cozzi, 2007), where four activity categories were considered (grazing, rumination, idleness and other activities). Grazing was characterized as the time spent on foraging, chewing, and swallowing (Pereira et al., 2005). Rumination was represented by the sum of the periods in which the animal had mandibular movements while lying or standing, without grazing (Baggio et al., 2008). Idleness was the total time spent by animals standing or lying without undertaking any activity (Vizzotto et al., 2015). Other activities were characterized as walking, defecating, mounting, drinking water, urinating, or eating salt. Data were expressed in minutes spent on each activity per shift.

Data on air temperature variables (AT, °C) and relative air humidity (RH, %) were measured using a HOBO® data logger (model U12 - 012 Onset, Brazil), installed in each microclimate's treatment. Wind speed (WSP) was measured using a portable digital anemometer (model TAD – 800 Instrutherm, São Paulo, Brazil). Temperature and humidity index (THI) was calculated according to the formula by Kelly and Bond (1971):

$$\mathrm{THI} = \mathrm{DBT} - 0.55\,(1 - \mathrm{RH})(\mathrm{DBT} - 58)$$

where DBT is dry bulb temperature (air temperature, °C) and RH is relative air humidity (%).

The experimental design was completely randomized. To better analyze the data, six shifts were considered per day: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55

a.m.). Comparison of means (Tukey at 5% probability) was calculated for behavioral and climatic variables using the Statistical Analysis System (SAS, 2004) v. 9.1.2 software to verify the effect of treatment (sun and shade) and shifts (morning, intermediate, afternoon, evening, night, and early morning).

Results and discussion

The THI was higher in the WOS group (Table 1) during most shifts, except during the night and early morning, demonstrating that unshaded environments made the animals feel an extremely uncomfortable thermal sensation. THI values ⩽ 70 indicated a non-stressing environment; values between 71 and 78 a critical environment; values between 79 and 83, a dangerous environment; and values ⩾ 83, an emergency situation (Baêta & Souza, 2010). Thus, in all treatments and shifts, the experimental environment presents thermal discomfort for the animals. The WOS group showed a critical situation even in the early morning shift, when the THI was the lowest. The morning, evening, and early morning shifts were classified as dangerous, with the intermediate and afternoon shifts showing an emergency situation.

The situation was critical in the morning, night, and early morning shifts, and dangerous in the evening for the WOS group. The THI indicated emergency environmental conditions during the intermediate and afternoon shifts, even for the WS group. These results indicate the challenges faced by farmers to keep buffaloes healthy and productive in the Amazon, as the ideal THI for buffalo production should be below 74 (Somparn et al., 2004). Under high temperature and relative humidity conditions, animals dissipate heat and, among other physiological changes, alter their fixed behavioral patterns (e.g. standing and lying times), seeking environments with a milder temperature (Schütz, Cox, & Matthews, 2008; Schütz, Rogers, Cox, & Tucker, 2009) for thermoregulation.

The highest WSP was observed during the evening shift, with the intermediate and afternoon shifts also considered critical. These wind speeds may have contributed in dissipating body heat, since air movement is considered an indispensable factor to improve environmental conditions, as it influences heat loss through the body surface when skin moisture evaporates (Tonello et al., 2012).

There was no difference ($p > 0.05$) in grazing time between treatments (Table 2) in the morning shift, which indicates that shade availability did not influence pasture intake during this shift, possibly because the air temperature was still cool. On the other hand, in the intermediate and night shifts, the WOS group grazed more than the WS group. This possibly occurred because the WS group sheltered under trees to obtain greater thermal comfort during periods of high solar radiation, while the WOS group had no option but to graze. During the afternoon, evening, and early morning shifts, the weather was milder, so the WS group spent more time grazing, most likely to compensate for time spent sheltering during periods of high solar radiation.

There were also differences among shifts between treatments. The WOS group grazed for more time in the morning shift, while the WS group spent most of the time grazing in the morning and afternoon shifts. The shortest grazing time for this group was in the intermediate shift, when the THI was higher (84) and WSP was lower (1.63 m s^{-1}), compared with the afternoon shift (2.13 m s^{-1}), which had the same THI value. As buffaloes have few sweat glands and high melanin concentration in the hair, they are susceptible to heat and direct solar radiation (Damasceno, Viana, Tinôco, Gomes, & Schiassi, 2010). Therefore, buffaloes prefer to graze when the temperature is milder. As such, the WOS group grazed less during the intermediate, afternoon, evening. and early morning shifts.

Table 1. Mean and standard deviation of the mean temperature and humidity index and wind speed in six shifts during the dry season on Marajó Island, Pará.

Shift	Mean Temperature and Humidity index		Wind speed (m s^{-1})
	Without shade	With shade	
Morning	79±1.06 ^{Ac}	78±1.04 ^{Bd}	1.19±1.94 ^{c}
Intermediate	86±0.25 ^{Aa}	84±0.28 ^{Ba}	1.63±0.45 ^{bc}
Afternoon	85±0.40 ^{Aa}	84±0.40 ^{Ba}	2.13±0.55 ^{b}
Evening	80±0.25 ^{Ab}	80±0.23 ^{Bb}	3.28±1.77 ^{a}
Night	79±0.32 ^{Ac}	78±0.28 ^{Bc}	1.45±1.46 ^{bc}
Early morning	76±0.78 ^{Bd}	77±0.42 ^{Ae}	0±0 ^{d}

Means followed by distinct capital letters in the line are different ($p < 0.05$). Means followed by distinct lowercase letters in the column are different ($p < 0.05$). Shifts: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55 a.m.).

Table 2. Mean and standard deviation of the mean grazing time (minutes) for buffaloes in six shifts in environments with and without shade during the dry season on Marajó Island, Pará.

Shift	Treatment	
	Without shade	With shade
Morning	174±31.80 ^{Aa}	159.33±31.23 ^{Aa}
Intermediate	51.33±32.96 ^{Ac}	21.83±19.63 ^{Bc}
Afternoon	63.67±23.85 ^{Bc}	166.5±32.28 ^{Aa}
Evening	51.67±11.77 ^{Bc}	88.67±42.46 ^{Ab}
Night	122.5±25 ^{Ab}	108.83±43.22 ^{Bb}
Early morning	55.0±20.55 ^{Bc}	84.33±61.46 ^{Ab}
Total	518.17	629.49

Means followed by distinct capital letters in the line are different ($p < 0.05$). means followed by distinct lowercase letters in the column are different ($p < 0.05$). shifts: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55 a.m.).

There was no difference ($p > 0.05$) between treatments for ruminating time in the morning and night shifts. However, in the intermediate shift, the WS group spent more time ruminating ($p < 0.05$). This is possibly due to the high THI and temperature during this shift, so the animals sheltered under trees and ruminated the pasture ingested in the previous shift. The WOS group reduced metabolic activities, including rumination, to avoid thermogenesis, with animals preferring to undertake this activity in the cooler periods of the day to compensate for higher internal heat production (Ferreira, Machado Filho, Hotzel, Alves, & Barcellos, 2014).

In the afternoon shift, animals from the WOS group slightly increased rumination ($p < 0.05$), while the WS group reduced this activity, possibly because it was intensified in the previous shift (intermediate). As the THI was reduced in the evening and early morning shifts, the animals in the WS group ruminated for a longer time ($p < 0.05$). In general, the animals in the WOS group ruminated less than the animals in the WS group. This behavior was possibly to avoid increased internal heat production (Ferreira et al., 2014).

Although they did not ruminate much during the experimental period, buffaloes in the WOS group ruminated more during the afternoon shift ($p < 0.05$). Conversely, animals that were in the silvipastoral system (WS group) ruminated more in the intermediate, evening, and early morning shifts ($p < 0.05$). Regarding the idle time (Table 4), there were differences between treatments ($p < 0.05$) in the afternoon, evening, and early morning shifts, when the WOS group had more idle time than the WS group. When exposed to high temperatures, animals stop eating and have more idle time to strategically avoid increasing metabolic heat (Lima et al., 2014). The animals in the WOS group had more idle time during the evening and early morning shifts ($p < 0.05$), while the animals in the WS group had more idle time during the intermediate shift ($p < 0.05$).

However, in general, the WOS group had more idle time than the WS group. This behavior is strategic, since diet can increase thermogenesis through digestion processes and food metabolism, especially when the THI reaches the value of 85 or more, which is common in tropical regions, making the buffaloes more uncomfortable (Ablas, Titto, Pereira, Titto, & Leme, 2007).

Table 5 shows the time spent on “other activities” during the six shifts in both treatments. The buffaloes in the WOS group spent more time on these activities during the intermediate shift ($p < 0.05$), probably increasing water intake, since in this shift, the environment posed extreme thermal discomfort. On the other hand, in the afternoon, evening, night, and early morning shifts, the WS group spent more time on “other activities” than the WOS group ($p < 0.05$).

Table 3. Mean and standard deviation of the mean ruminating time (minutes) for buffaloes in six shifts in environments with and without shade during the dry season on Marajó Island, Pará.

Shift	Treatments	
	Without shade	With shade
Morning	20.67±12.85 ^{Ad}	46.17±36.14 ^{Abc}
Intermediate	65.17±20.74 ^{Bb}	103±39.67 ^{Aa}
Afternoon	83.17±21.27 ^{Aa}	29.17±24.25 ^{Bc}
Evening	34.17±25.12 ^{cbB}	74.33±59.20 ^{Aab}
Night	39±20.53 ^{Ac}	34.67±30.45 ^{Ac}
Early morning	49.33±22.27 ^{Bc}	80.67±65.37 ^{Aa}
Total	291.51	368.01

Means followed by distinct capital letters in the line are different ($p < 0.05$). means followed by distinct lowercase letters in the column are different ($p < 0.05$). shifts: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55 a.m.).

Table 4. Mean and standard deviation of the mean idle time (minutes) for buffaloes in six shifts in environments with and without shade during the dry season on Marajó Island, Pará.

Shifts	Treatment	
	Without shade	With shade
Morning	27.17±18.51 Ad	23.33±17.53 Ac
Intermediate	100.83±32.21 Ab	104.33±33.42 Aa
Afternoon	84.17±26.36 Abc	25.50±16.42 Bc
Evening	154±29.05 Aa	74.67±46.24 Bb
Night	78.17±36.75 Ac	75.67±56.41 Ab
Early morning	134.83±29.72 Aa	63.67±28.74 Bb
Total	579.17	367.17

Means followed by distinct capital letters in the line are different ($p < 0.05$). means followed by distinct lowercase letters in the column are different ($p < 0.05$). shifts: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55 a.m.).

Table 5. Mean and standard deviation of the mean time spent on other activities (minutes) for buffaloes in six shifts in environments with and without shade during the dry season on Marajó Island, Pará.

Shifts	Treatment	
	Without shade	With shade
Morning	18.17±13.42 Aa	11.17±9.16 Ab
Intermediate	22.67±12.64 Aa	10.83±8.91 Bb
Afternoon	9.0±12.27 Bb	18.83±12.15 Aa
Evening	0.17±0.91 Bc	2.33±3.65 Ac
Night	0.33±1.27 Bc	20.83±13.14 Aa
Early morning	0.83±1.89 Bc	11.33±8.19 Ab
Total	51.17	116.15

Means followed by distinct capital letters in the line are different ($p < 0.05$). means followed by distinct lowercase letters in the column are different ($p < 0.05$). shifts: morning (6:00 to 9:55 a.m.), intermediate (10:00 a.m. to 1:55 p.m.), afternoon (2:00 to 5:55 p.m.), evening (6:00 to 9:55 p.m.), night (10:00 p.m. to 1:55 a.m.), and early morning (2:00 to 5:55 a.m.).

In general, the WS group spent more time on "other activities" than the WOS group. These results may have been influenced by increased defecation, since the animals in this group ingested more pasture. In addition, the WOS group strategically had more idle time to reduce internal heat production, thus avoiding thermogenesis and thermal stress because they received more solar radiation and heat from the environment.

Conclusion

We conclude that when buffalo heifers have access to tree shade in a silvipastoral system under the climatic conditions of Marajó Island, they graze, ruminate, and perform other activities more intensely than animals reared in an unshaded system. Thus, planting trees in a pasture is recommended to provide animals with shelter from direct solar radiation, ensuring animal welfare and improved productivity.

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