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What Do Cattle Prefer in a Tropical Climate: Water Immersion or Artificial Shade?

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Abstract: Animal performance is affected by high air temperature and it is known that shade reduces the absorption of radiant temperature, and water for immersion facilitates heat loss. This study intends to find preferences of resources that contribute for the well-being of cattle and how they alterdaily behaviour. During summer, six Caracu and six Red Angus bulls were submitted to two different treatments: availability of artificial shade and water for immersion and availability of water for immersion. The categories observed were: positions (in the sun, under the shade, in the water), posture (standing, lying down) and activities (grazing, ruminating, leisure). The behavioural patterns were recorded using the focal sampling method every 15 minutes (from 6:00 a.m. to 6:00 p.m.). When shade and water for immersion coexists, cattle in this study prefer shade to avoid solar radiation. Both breeds had remained more time grazing, followed by ruminating in the Caracu breed, and by resting in the Red Angus breed. The Caracu breed had presented clear preference for the shade resource, but that fact was not always observed in the Red Angus breed. In hot climates, resources for defence against heat load, as shade and water for immersion improve the well-being of cattle.

Key words: Animal welfare, behaviour, grazing, Caracu, Red Angus.

1. Introduction

In Brazil, one of the main factors that affect animals' performance is high temperature, which is felt through the year. High temperature often causes heat stress and therefore one of the most important adaptative aspects for cattle is heat tolerance [1]. Only recently, focus on interaction of cattle with the environment has received attention, for example, issues related to finding shade and other ways of cattle to reduce environmental thermal discomfort.

Müller [2] states that negative interference on the metabolism and production by climate causes an imbalance in the elements that influence an animal's health. The animal then responds physiologically, initially through the nervous system and later through the arch hypothalamus, pituitary, and adrenal cortex. This specific response is generically called stress. In the tropics, heat stress due to heat causes drastic changes in the biological functions of animals and it is a major factor limiting the production of cattle [3]. The response to climatic stress situations can vary from animal to animal, since heat stress is dependent on temperature gradients that exist between the animals and the environment, and is resistance to heat flow types [4]. In heat stress situations, one of the first responses recorded in most domestic animals is a decrease in food consumption [5-8].

Since the animal is nothing more than an open thermodynamic system, it is constantly exchanging energy and matter with the environment. With increasing temperature, the ability to dissipate sensitive heat decreases as the thermal gradient

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between the animals' body and their surroundings decreases. These heat losses are independent of the thermal gradient and are mainly dependent on gradients of vapour pressure. To manage the heat, the animal promotes the process of fluid evaporation, which consists of heat exchange that occurs when a fluid turns from liquid to gas by taking advantage of the latent heat of vaporization that is involved in the process. In animals, this occurs through the respiratory tract and skin surface.

Activities of animals seeking a better adjustment to their environment are called adaptive behaviours [9]. Thermoregulatory behaviour such as lower food consumption and changes in attitudes and activities are carried out to promote heat loss and prevent heat accumulation [5]. When animals lay down in a hot environment, they increase the contact with the floor facilitating a greater heat exchange. One of the most important adaptive behaviour in a hot environment is to seek shade: a continuous exposure of cattle to summer heat in the absence of shade results in significant hyperthermia and impairs growth and general health [10]. Several studies have shown the benefits of shade, which reduces the radiant temperature that animals are exposed to, allowing a greater comfort, which is then reflected in the production of these animals [8, 11-14].

Under high temperatures, animals act according to the influence of the exchange of heat between their bodies and the environment toward reducing the acquisition of heat. An example of such an act is shade seeking. According to Tapki et al. [15], in summer, the incident solar radiation at the hottest hours of the day may become a strong source of stress that reduces the production of cows. In the absence of trees, animals utilize the minimal shade available such as the shadow of fences, walls, plants or any other object, preferably trying to protect their heads.

Another situation for heat reduction is water immersion, which facilitates heat loss by conduction and convection. According to Ford [16] shade and water bath (immersion) provide similar conditions for thermoregulation. In water, cattle tend to remain standing, with feet and lower members in the water for long periods, and all animals often adopt the same strategy of thermoregulation [17]. The water not only increases heat dissipation from the skin of the animal by conduction and convection but also provides endogenous heat dissipation through the effect of evaporation on the wet skin.

Therefore, by providing better conditions for animals, breeders and technicians can guarantee or improve their production. The purpose of this study was to analyze the behaviour of two breeds of *Bos taurus* with different thermoregulatory characteristics subjected to different environmental situations: with and without the availability of shade but always with the availability of water for immersion.

2. Materials and Methods

The experiment took place at the Biometeorology and Ethology Laboratory of the Faculty of Animal Science and Food Engineering at the University of São Paulo (FZEA-USP), located at 21º80′00″ S and 47º25′42″ W and 634 m above the sea level. The experiment was conducted with six bulls, each of the Caracu and Red Angus breeds, between 20-30 months of age and an average live weight of 527 kg. Behaviour observations were made on experimental pasture paddocks, each measuring 0.33 ha and predominantly covered with Brachiaria decumbens and with a water trough (Fig. 1). Each paddock was designed to study the effects of one of the following treatments: (1) artificial shade and water for immersion (SW) and (2) water for immersion (W). Artificial shade was made with a sheet of polyethylene mesh with 80% filtration of solar radiation, measuring 6 m × 10 m (60 m2) and providing shade for all animals at the same time (10 m2 for each animal). Water was advantageously diverted from a stream near the parks to two pools in these paddocks for water immersion. Each pool was 5 m wide, 10 m long and 1 m deep.

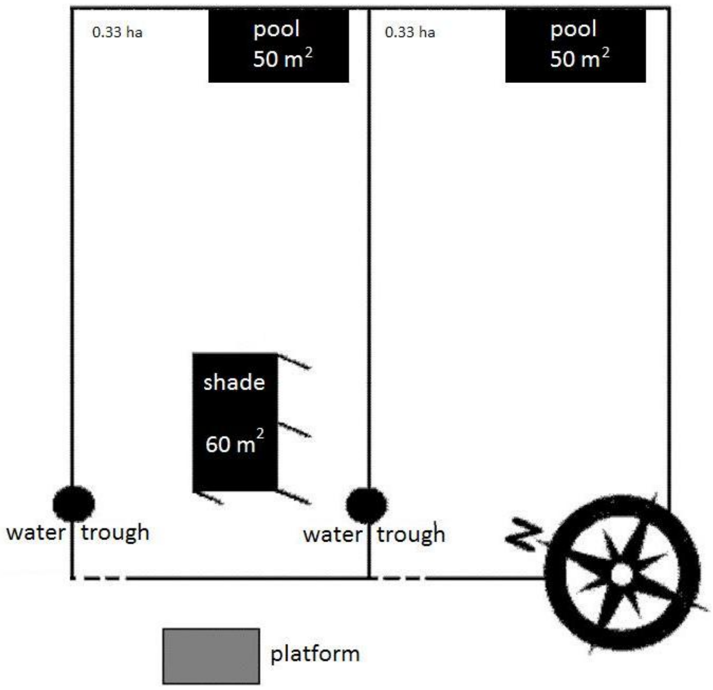

Fig. 1 Detail of experimental site (not to scale).

The behaviour of the animals was recorded over 12 h (from 6:00 a.m. to 6:00 p.m.) every 15 min, through instant and continuous collection of data using the focal sampling method [18], by one trained observer positioned on an elevated platform (10 m) 2 m from the beginning of the paddocks. Continuous behaviours were subdivided into: (1) position (sun, shade and water), (2) posture (standing or lying) and (3) activity (grazing, ruminating and idling). These records specified the animals involved and the time of occurrence. During eight sunny days, each treatment group was observed for 4 d for 12 h per day.

During the experiment, weather variables such as relative humidity, black globe temperatures (in the sun and shady areas) and air temperature were recorded on an hourly basis from 6:00 a.m. to 6:00 p.m.

Data were analyzed using the repeated measures ANOVA procedures of GML (SAS Institute, Inc., Cary, NC) with positions and activities as the dependent variables and treatments as the independent variable modelled as a fixed effect. When significant differences were revealed by the ANOVA procedure through least square means, a Tukey-Kramer multiple comparison test was performed at $P \leq 0.05$.

3. Results and Discussion

3.1 Weather and Environmental Measures/Climatic Conditions

The Biometeorology and Ethology Laboratory of FZEA-USP is situated in a region where the climate is characterized as humid subtropical, with the rainy season from October to March. The annual average temperature is 23 ºC and the average annual rainfall is 1,303 mm.

The maximum temperature was 37 ºC during the study period of March and April.

3.2 Behaviour Preferences

The exposure to the sun, shade and water taken by the animals in both the treatments were different, which made them to exhibit different behaviours. Squires (1981) and Daly (1984) cited by Blackshaw et al. [19] stated that when cattle have access to shade they remain there during the hottest hours of the day, leaving it only when looking for water or at the end of the day. This was observed in the case of the Caracu breed, which preferred shade (19.39%) instead of water (0.51%). The Angus animals also preferred shade instead of water; however, they spent a considerable time in the water (13.83%). This option to remain in the water had an influence on the activities of the animals. An animal standing in the sun or in the shade, has the ability to graze, which is unlikely to occur in water.

Grazing was the most frequent activity for both races in both the treatments (Table 2). In the SW treatment, Angus spent as much time idling (41.27%) as that of grazing (41.72%), which can be understood as an immediate response to heat stress, thereby reducing the consumption of food [5, 19, 20]. The difference in grazing periods between the two treatments for the Angus animals was evident. This fact was expected as the reduction in food intake is directly related to the reduction of heat gain by digestion and muscular activity as an immediate response to heat stress [19].

Comparing the two treatments for the Caracu animals in both phases, the number of grazing animals decreases after the typical morning graze. However, the decreases occurred earlier and were more regular in the SW treatment than in the W treatment (between 1:00 p.m. and 2:45 p.m. is the most representative period for this). Grazing activity was the most common behaviour in the two treatments, even though it was more intense in the treatment where shade and water coexist (61.73%). In the W treatment there were actually moments where grazing was almost or totally lacking. Ruminating and leisure activities had an equal distribution between the treatments, though ruminating was higher in the W treatment (22.45%) because of the decreased percentages of grazing.

A decrease in the percentage of animals that were grazing was observed for the Angus breed since the morning until the hottest hours of the day, followed by a later increase. In the W treatment, the decrease was more marked but more irregular until 1:00 p.m. when there was no animal grazing. However, after this interruption a larger number of animals returned to grazing.

Probably in the SW treatment, Caracu and Angus had periods of grazing followed by periods of rumination since they had access to shade. This hypothesis is also valid for Caracu in the W treatment. However, in the same treatment for the Angus animals, the rumination periods were not so many (7.65%) and frequent, probably due to the lack of shade. In these cases, the animals chose to graze and/or rest even during the hottest hours. This justification is consistent with Curtis' [21], which states that it is possible that animals will act differently in order to influence the exchange of heat between their bodies and the environment. In addition, Blackshaw et al. [19], argue that the patterns of grazing may be influenced by the existence of shades.

For the Angus breed, the fact that shade was available on the SW treatment may be one reason for

Table 1 Climatic measurements during the experiment.

Treatment	SW (Shade and water)		W (Only water)	
Breed	Caracu	Angus	Caracu	Angus
Temperature (ºC)				
Minimum	21	14.6	20	18.5
Maximum	36	35.5	37	32
Average Minimum	21.9	16.8	21.5	19.3
Average Maximum	33.7	33.8	34.3	29
Relative humidity (%)				
Minimum	47	57	40	53
Maximum	84	100	91	100
Average Minimum	46	52.5	45.5	66.5
Average Maximum	81	94	87.5	99

Table 2 Least square means (percentage of observations), pooled standard errors (SEM), and probability values of behaviours for Caracu and Angus breeds in each treatment (SW, W).

Variable	Mean		SEM		*P*-value	
Breed	Caracu	Angus	Caracu	Angus	Caracu	Angus
Sun						
SW	80.1	57.03	2.5	5.16	< 0.0001	0.0007
W	93.87	77.38	1.45	2.49		
Water						
SW	0.51	13.83	0.28	1.64	0.0004	0.004
W	5.78	22.62	1.42	2.49		
Grazing						
SW	61.73	41.72	2.73	4.11	0.8077	0.1186
W	60.54	51.36	4.04	4.54		
Ruminating						
SW	19.73	16.33	2.18	2.18	0.4715	0.0033
W	22.45	7.65	3.06	1.86		
Idling						
SW	16.33	41.27	2	3.34	1	0.8109
W	16.33	39.96	2.46	4.28		
Sun Grazing						
SW	94.91	81.77	2.17	4.62	0.4882	0.3054
W	92	88.43	3.57	4.51		
Sun Ruminating						
SW	35.88	26.41	5.8	5.79	< 0.0001	0.2367
W	71.2	37.07	6.16	6.82		
Water Ruminating						
SW	0	9.32	0	3.46	0.0608	0.0407
W	2.27	1.7	1.44	1.21		
Sun Idling						
SW	37.24	42.03	5.98	6.14	0.0448	0.5374
W	55.35	37.05	6.59	5.19		
Water Idling						
SW	1.94	25.95	1.19	3.26	0.0151	0.0006
W	9.66	48.66	3.27	5.52		

the differences observed in the values of grazing (41.72% in SW and 51.36% in W) and rumination (16.33% in SW and 7.65% in W). As they seek shade more often and spend there more time, the food intake was reduced, a fact quite common in *Bos taurus* [22].

A higher incidence of grazing in the early hours of the day and at late afternoon was observed for both breeds. This fact agrees with other findings that confirm this trend in cattle regardless of their origin [23-25].

Significant differences in time spent ruminating in the sun for Caracu between treatments (35.88% in SW and 71.2% in W) were observed. In turn, the Angus ruminated preferably in the shade (64.27%) but also used the water for a considerable period of time (9.32%).

Comparing the treatments according to breed, it was observed that the behaviour of Caracu was significantly different, this may be because the animals in the treatment SW had the option of shade and used it as a protection against the heat, especially during the hottest hours of the day. In the treatment W, they appealed to water (5.78%) but were in the sun where they remained ruminating most of the time

(93.87%). In this case, it may be possible that the few times they used the water were sufficient to reduce the heat stress to which they were subjected.

In the case of Angus, there were no significant differences in sun rumination between the two treatments (26.41% in SW and 37.07% in W). However, there is also a preference for the use of shade.

In relation to the use of the water, there were significant differences in treatments for both breeds. When water for immersion was the only resource, the utilization time by both breeds significantly increased. In treatment SW, Caracu rarely used the water to rest (1.94%) preferring once again the shade. The Angus also preferred the shade, but the time that they spent in the water was much higher at 25.95%. In treatment W, the situation was quite similar, verifying that the Angus rested preferably in water (48.66%), while the Caracu rested only 9.66% of the time in the water. Such differences can be justified by the fact that the exchange of heat conduction that occurs between the animal and the water is faster than the exchange by convection and sweating that occurs when the animal is in the shade.

After analyzing the behaviour of the Caracu and Angus breeds for the different treatments, it appears that the Caracu has preference for the shade, using water only for short periods and/or in situations of a more pronounced heat stress, or if that is the only recourse. On the other hand, the Angus behaved differently as it resorted to water immersion when thermal discomfort was felt, choosing to dissipate metabolic and acquired heat by convection and endogenous heat loss due the effect of evaporation of water that remains on the skin [25, 26]. These differences between breeds can be explained by their origin. Although the Caracu breed is a descendant of European and African breeds (*Bos taurus*), it behaves similar to the *Bos indicus*, indicating a superior heat tolerance. In spite of European descent, the fact that they have suffered a prolonged process of acclimatization to the tropics, has led to a progressive tolerance to heat.

The fact that the animals were taken as one (of a breed) may have influenced the results, since each individual is an individual and there may be patterns of behaviour quite different within a group of animals. The reduced number of observations may have influenced the entire comparative analysis of the ethogram, which may explain the low number of significant differences that were found.

4. Conclusion

The use of water for immersion although not regarded as a typical behaviour of animals can serve as an alternative to shadow as a means of heat dissipation. However, this resource is passed over by the breeds in the study when the resource of shade coexists. Animals of different breeds and different husbandry while dealing with increase in radiant temperatures exhibit different behaviours.

In warm climates, resources that allow animals to defend themselves against the heat positively contribute to their welfare.

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