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# HEAT TOLERANCE IN NATURALISED CATTLE IN BRAZIL: PHYSICAL FACTORS

TOLERÂNCIA AO CALOR EM GADO NATURALIZADO NO BRASIL: FATORES FÍSICOS

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## ADDITIONAL KEYWORDS

Bioclimatology. Heat stress. Physiological responses. Bovine. Conservation.

## PALAVRAS CHAVE ADICIONAIS

Bioclimatologia. Bovino. Conservação. Estresse térmica. Respostas fisiológicas.

## SUMMARY

The objective of this study was to evaluate the heat resistance in different breeds of naturalised cattle, at two different times of day with different temperatures and humidity. The experiment took place at Sucupira farm of Embrapa/Cenargen in Brasília-DF. A total of 52 animals were used, 11 Curraleiro, 11 Crioulo Lageano, eight Nelore, eight Pantaneiro, six Junqueira, four Holstein and four Mocho Nacional including both males and females. The measurements were taken at 08:00 and 14:00 after the animals had been exposed to the sun for 6 hours. The procedure was repeated 3 times. The data collected included heart rate (HR), rectal temperature (RT) and respiratory rate (RR). Blood was also collected as well as sweating rate and the length and number of hairs per cm<sup>2</sup>. Breed influenced ( $p < 0.001$ ) the heat response. The Nelore breed had the best response (HR= 66.06, RR= 32.71, RT= 39.36 and sweating= 215.22), followed by the Junqueira (HR= 76.71 RR= 33.05 RT= 38.75 Sweating= 247.14), which although had high heart rate maintained the other parameters at a low level. The Pantaneira

presented the lowest variation between morning and afternoon measurements (HR= -1.61, RR= -0.28, RT= +0.19, Sweating= +20.65). The Mocho Nacional and Holstein were the least adapted with high means (Mocho Nacional: HR= 71.44, RR= 42.38, RT= 39.25, Sweating= 323.22; Holstein: HR= 69.34, RR= 39.57, RT= 39.37, Sweating= 269.13). The Holstein had a greater number of hairs per cm<sup>2</sup> although its sweating rate was not the highest. The results enable the differentiation between breeds with higher and lower heat resistance in the conditions of the experiment.

## RESUMO

O objetivo deste estudo foi de avaliar a resistência ao calor em raças diferentes de gado naturalizado, em duas horas no dia com diferentes temperaturas e umidade. O experimento foi realizado na Fazenda Sucupira da Embrapa/Cenargen em Brasília-DF. Um total de 52 animais foi usado, 11 Curraleiro, 11 Crioulo Lageano, oito

Nelore, oito Pantaneiro, seis Junqueira, four Holstein e quatro Mocho Nacional incluindo machos e fêmeas. As medidas foram tomadas às 08:00 e 14:00 depois de exposição ao sol para seis horas. O procedimento foi repetido três vezes. Os dados coletados incluíram taxa cardíaca (TC), temperatura retal (TR) e taxa respiratório (BR). Sangue foi coletado, bem como taxa de sudorese e o número e comprimento de pêlos por cm<sup>2</sup>. Raça influenciou ( $p < 0,001$ ) a resposta ao calor. Nelore mostrou a melhor resposta (TC= 66,06, BR= 32,71, TR= 39,36 e sudação= 215,22), seguida por Junqueira (TC= 76,71 BR= 33,05 TR= 38,75 Sudação= 247,14), que embora teve uma taxa cardíaca alta, manteve os outros parâmetros num nível baixo. A Pantaneira mostrou a variação mais baixa entre de manhã de de tarde (TC= -1.61, BR= -0.28, TR= +0.19, Sudação= +20.65). Mocho Nacional e Holandesa foram as menos adaptadas com médias altas (Mocho Nacional: BC= 71,44, BR= 42,38, TR= 39,25, Sudação= 323,22; Holandesa: BC= 69,34, BR= 39,57, TR= 39,7, Sudação= 269,13). A Holandesa teve o maior números de pêlos por cm<sup>2</sup> embora sua taxa de sudação não foi a mais alta. Os resultados permitem a diferenciação entre raças para características de tolerância ao calor nas condições do experimento.

#### INTRODUCTION

Bioclimatology is a part of the science of ecology and involves the study of geography, meteorology, physiology, etiology and pathology (Baccari, 1998), relative to the influence of climate on animal development. The tropics have the hottest climates on the planet (McDowell, 1975) and animal production is affected by the environment (Baccari, 1998). Muller (1989) stated that climatic factors, such as temperature, relative humidity, wind speed and solar radiation, may cause

stress. These factors interact causing greater or lesser degrees of stress thereby affecting growth, milk production, reproductive success etc. The present work aimed to investigate the effect of heat stress on naturalised breeds of cattle in Brazil and compare their responses with breeds used in commercial production systems.

#### MATERIAL AND METHODS

The experiment took place at Sucupira Farm of Embrapa/Cenargen in Brasilia-DF. A total of 52 animals were used, 11 Curraleiro, 11 Crioulo Lageano, 8 Nelore, 8 Pantaneira, 6 Junqueira, 4 Holstein and 4 Mocho Nacional including both males and females. The measurements were taken at 08:00 and 14:00 after the animals had been exposed to the sun for 6 hours. The procedure was repeated 3 times. The data collected included heart rate (HR), rectal temperature (RT) and respiratory rate (RR). Sweating rate (S) was calculated using filter paper soaked with  $\text{CoCl}_2$  and dried. Three disks were then put on shaved skin of the animals and the time (t) to turn colour measured. This was then converted using  $S = 38446,6 \times t$  ( $\text{g} \cdot \text{m}^2 \cdot \text{h}^{-1}$  Schleger and Turner, 1965). The length and number of hairs per cm<sup>2</sup> were also measured.

Data were analyzed using GLM, CORR and PRINCOMP procedures of SAS (Statistical Analysis System, 1999). Fixed effects included in the model were breed, sex, day and time as well as animal within breed as a random effect. Distance matrix was constructed using the Tocher method (Cruz, 1997).

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**Table I.** Summary of variance analysis of physiological parameters in naturalised cattle breeds. (Resumo de análise de variância de parâmetros fisiológico em raças de gado naturalizado).

	HR	RR	RT	Sweating
Breed	4249.16***	1430.97**	8.18*	68777.52 <sup>ns</sup>
Time of day	13.70 <sup>ns</sup>	256.92*	2.89*	5444.45 <sup>ns</sup>
Time*Breed	451.72 <sup>ns</sup>	101.46 <sup>ns</sup>	3.95 <sup>ns</sup>	32863.62 <sup>ns</sup>
Animal (breed)	23500.82***	9050.34***	26.77 <sup>ns</sup>	343510.29 <sup>ns</sup>
R <sup>2</sup>	0.53	0.48	0.28	0.52
Cv	15.55	22.43	1.90	265.13
Mean	72.82	36.02	39.19	40.44

‡p<0.10; \*p<0.05; \*\*p<0.01; \*\*\*p<0.001; HR= Heart rate; RR= respiratory rate; RT= rectal.

### RESULTS AND DISCUSSION

Breed was a significant source of variation for all traits except sweating rate (**tables I, II and III**). Time of day also influenced respiratory rate and rectal temperature but not heart rate. Animal within breed was also a significant source of variation for all traits except sweating rate. No significant interaction between breed and time was noticed. The temperature

at 7 in the morning was 24°C + during the experimental period, and over 32°C in the afternoon. The Nelore were less affected by the environment, followed by Junqueira and Pantaneira with the Holstein and Mocho Nacional being the most affected by the temperature. The main physiological responses to heat stress in cattle is water loss via respiration and increased rectal temperature (Dukes, 1996; Baccari, 1998), which accounts for the increase

**Table II.** Summary of variance analysis for size measures in naturalised cattle breeds. (Resumo da análise de variância para medidas de tamanho em raças de gado naturalizadas).

	Cannon bone	Body length	Thoracic circumference	Height	Number of hairs/cm <sup>2</sup>	Hair length
Breed	603.31***	14184.58***	23114.91***	18938.96***	613362.66***	568.42***
Animal (breed)	882.18***	32745.56***	30643.21***	10101.76***	4161294.893***	926.28***
R <sup>2</sup>	0.70	0.67	0.96	0.89	0.96	0.99
Cv	7.71	6.63	1.54	2.87	8.29	0.47
Mean	20.14	143.55	177.50	128.71	316.77	7.76

\*\*\*p<0.001.

**Table III.** Means per breed of physical and physiological traits in naturalised cattle breeds. (Médias por raças de características físicas e fisiológicas em raças de gado naturalizadas).

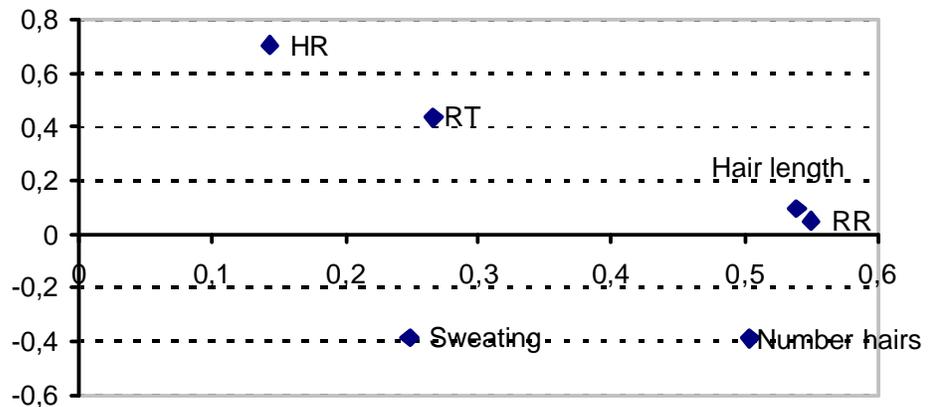
Breed	HR	RR	RT	cannon bone length (cm)	body length (cm)	thoracic circumf. (cm)	height (cm)	length of hairs (mm)	number of hairs/cm <sup>2</sup>	sweating rate (g/cm <sup>2</sup> /h)
CL	69.65 <sup>a</sup>	37.44 <sup>ab</sup>	39.18 <sup>ab</sup>	20.75 <sup>c</sup>	151.50 <sup>c</sup>	182.10 <sup>f</sup>	129.50 <sup>b</sup>	9.22 <sup>f</sup>	321.75 <sup>c</sup>	264.35
Curraleira	76.27 <sup>b</sup>	35.00 <sup>a</sup>	39.22 <sup>ab</sup>	17.81 <sup>a</sup>	133.27 <sup>a</sup>	164.72 <sup>a</sup>	114.27 <sup>a</sup>	7.11 <sup>c</sup>	289.31 <sup>b</sup>	287.41
Holandesa	69.34 <sup>a</sup>	39.57 <sup>b</sup>	39.37 <sup>b</sup>	21.46 <sup>c</sup>	150.50 <sup>bc</sup>	180.16 <sup>ab</sup>	135.60 <sup>d</sup>	8.73 <sup>e</sup>	408.06 <sup>e</sup>	269.13
Junqueira	76.71 <sup>b</sup>	33.05 <sup>a</sup>	38.75 <sup>a</sup>	21.40 <sup>c</sup>	142.22 <sup>b</sup>	178.69 <sup>cd</sup>	133.86 <sup>c</sup>	5.45 <sup>b</sup>	241.54 <sup>a</sup>	247.14
MN	71.44 <sup>a</sup>	42.38 <sup>b</sup>	39.25 <sup>ab</sup>	20.33 <sup>bc</sup>	150.33 <sup>bc</sup>	191.33 <sup>b</sup>	129.66 <sup>bc</sup>	5.16 <sup>a</sup>	350.00 <sup>d</sup>	323.22
Nelore	66.06 <sup>a</sup>	32.71 <sup>a</sup>	39.36 <sup>b</sup>	21.44 <sup>c</sup>	137.77 <sup>ab</sup>	170.55 <sup>b</sup>	137.00 <sup>d</sup>	7.32 <sup>d</sup>	358.00 <sup>d</sup>	215.22
Pantaneira	76.63 <sup>b</sup>	35.91 <sup>ab</sup>	39.23 <sup>ab</sup>	19.31 <sup>b</sup>	148.37 <sup>bc</sup>	189.37 <sup>a</sup>	129.75 <sup>bc</sup>	9.93 <sup>a</sup>	297.00 <sup>b</sup>	261.07

CL=Crioulo Lageano; MN=Mocho Nacional; HR= Heart rate; RR= respiratory rate; RT= rectal temperature; <sup>a,b</sup>different letters in the same column indicates significant difference (p<0.05).

in respiratory rate with increase in temperature. The increase in rectal temperature is probably due to the increase in climatic temperature. Heart rate changed depending on the time of day but not significantly. This trait is

related to circulatory changes caused by increased body temperature.

The Pantaneira cattle showed least variation in physiological measures, followed by the Crioulo Lageano and Holstein showed the highest. Kellaway



**Figure 1.** First two autovectors for traits in naturalised cattle in Brazil. (Primeiros dois autovetores de características em gado naturalizado no Brasil).

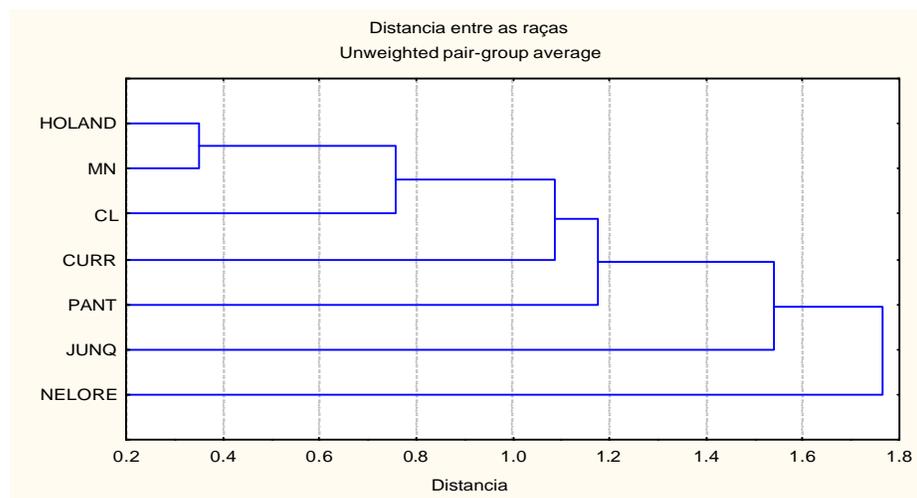
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and Colditz (1975) verified that rectal temperatures and respiratory rates in pure Holstein *B. taurus* were higher than in crossbred Holstein-Zebu and their water consumption was greater under stressful conditions.

Sweating rate was highest in Mocho Nacional and lowest in Nelore. Although the Hostein had high sweating rates, they were not the highest, possibly showing a less efficient sweating system or fewer glands. Carvalho et al. (1995) confirmed that the Nelore (*Bos indicus*) breed had glands with a larger diameter than (*Bos taurus*), breeds, thereby causing a more efficient control of physiological parameters. The shape of the gland in zebus (saculiform), is also different from that of European breeds (enovelated) which also affects the adaptation to heat.

The first two autovectors accounted for almost 50 p. 100 of the total variation

(**figure 1**). The first component showed that an increase in one trait is accompanied by an increase in the others. A higher heart and respiratory rate is accompanied by higher sweating rate, and a higher number and length of hairs. The second component shows animals where an increase in heart rate and rectal temperature are accompanied by lower sweating and less hairs. This confirms results found by Frisch (1998) where animals with higher hair density are less tolerant to hat stress. The cluster analysis (Cruz, 1996) showed Pantaneira, Curraleira and Crioulo Lageano (*Bos taurus ibericus*) grouped together (**figure 2**) while Holstein (*Bos taurus taurus*) and Mocho Nacional (*Bos taurus aquitanicus*) are in another group and Junqueira (*Bos taurus ibericus*) and Nelore (*Bos indicus*) in a further group. This may indicate crossbreeding



**Figure 2.** Distances between breeds using Tocher method. (Distancias entre as raças usando o método de Tocher).

between these two breeds.

examination of these breeds needs to be carried out, especially at lower temperatures.

#### CONCLUSION

The Nelore was considered the best adapted and Holstein worst of the breeds examined. Of the naturalised breeds the Junqueira maintained the lowest means of the traits and the Pantaneira showed least variation, these being considered the best adapted, while the Mocho Nacional was the worst adapted. Further

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