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Heterogeneous genetic cows of three genetic groups in feedlot system in the state of Pernambuco, Brazil

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ABSTRACT. The behavior of 15 Girolando cows from three genetic groups (1/2, 5/8 and 3/4 HG) in feedlots was evaluated. Experimental design was completely randomized with 3 treatment (genetic groups) and 5 replicates. The animals were evaluated by the variables: food, rumination, rest, locomotion, water intake, demand and time in the shade, and other activities. Group 5/8 HG spent more time feeding (267.88 min.) than groups 3/4 HG (245.55 min.) and 1/2 HG (259.55 min.). Idle standing time was higher (204.66 min.) for 3/4 HG when compared to the other groups. There was no statistical difference for the duration of rest in the shade. Solar radiation and THI were the factors which most influenced the animals' behavior. Results show that the genetic groups 5/8 and 3/4 HG had a higher sensitivity to heat than 1/2 HG.

Keywords: dairy cattle, stress, ethology.

Comportamento de vacas Girolando de três grupos genéticos em sistema de confinamento no Estado de Pernambuco, Brasil

RESUMO. Avaliou-se o comportamento de 15 vacas da raça Girolando, de três grupos genéticos (1/2, 5/8 e 3/4 HG) em confinamento. O delineamento utilizado foi o inteiramente casualizado, sendo 3 tratamentos (grupo genético) com 5 repetições. Os animais foram avaliados pelas variáveis: alimentação, ruminação, ócio, locomoção, ingestão de água, procura e permanência na sombra, e outras atividades. O grupo 5/8 HG apresentou maior tempo de alimentação (267,88 min.) que os grupos 3/4 HG (245,55 min.) e 1/2 HG (259,55 min.). O tempo de ócio em pé foi maior (204,66 min.) para os animais 3/4 HG em relação aos demais grupos. Não houve diferença estatística para o tempo de permanência na sombra. A radiação solar e o ITU foram os elementos que mais influenciaram o comportamento dos animais. Os animais dos grupos genéticos 5/8 e 3/4 HG apresentaram maior sensibilidade ao calor que o 1/2 HG.

Palavras-chave: bovinocultura de leite, estresse, etologia.

Introduction

The low adaptation to Brazil's climate by dairy cattle hailing from temperate climates and introduced in the country has made it mandatory for producers to promote crossbreeding of these races with zebu breeds. Such crossbreeding has been normally adopted in tropical and subtropical regions as an alternative to minimize the negative effects that the regions' climate has on the animals.

The most frequent crossbreeding occurs between Dutch and Gir breeds (McMANUS et al., 2008), giving origin to the Girolando breed. Taking advantage of the rusticity of the Gir breed and from the dairy production of the Dutch breed, Girolando cows are currently the main source of milk production in Brazil with approximately 80% of dairy cattle in the country. However, these animals are also under heat stress especially when their genetic composition is composed of high European blood percentage

Since decrease in food intake, increase in water intake, reduction of pasturing activities and shade seeking are immediate responses to stress by heat (SILANIKOVE, 2000), an analysis of animal behavior contributes towards an improvement of the production system since stress may be evaluated by such activities.

Current research had been undertaken to evaluate behavior responses to stress by heat in Girolando breed cows from three genetic groups, bred in feedlots, in the state of Pernambuco, Brazil.

Material and methods

Experiment was undertaken on the Fazenda Avimalta in the municipality of Paudalho, between

January and April 2010. The municipality lies in the southern Mata micro-region of the state of Pernambuco, Brazil, at an altitude of 70 m, with As' climate featuring a humid tropical climate with dry summers.

Fifteen milking Girolando cows were used in the experiment, comprising five animals from each genetic group (1/2, 5/8 and 3/4 HxG), average body weight 530.46 kg and average daily production 12 kg. Animals received vaccine and anthelmintics doses. The animals were placed in 700 m^2 land lots comprising 208 m^2 of natural shade from the tree species *Mangifera indica* (mango tree), *Ficus benjamina* (fícus tree), *Eugenia jambolana* (jambul) and *Prosopis juliflora* (algarrobo). The land lot contained a 15m-long trough covered with fiber-cement tile roofing and placed on a cement floor. Salt containers and water troughs with mechanical floaters were available. The entire complex was surrounded by an electric hedge.

Complete diet, provided twice a day (6 and 15h) after milking, comprised 20 kg of forage palm, 5 kg of malt residue, 3 kg concentrate and triturated grass given *ad libitum*. Table 1 gives the bromatological analysis of feed according to methodology by Silva and Queiroz (2002).

Table 1. Bromatological composition of ingredients in experimental feed.

Ingredients	DM (%)							
	DM	OM	CP	EE	MM	NDF	ADF	TCH
Elephant Grass	37.1	91.5	10.9	6.6	8.5	83.0	38.9	74.0
Forage cactus	12.4	89.3	2.2	6.0	10.7	31.5	15.6	81.1
Malt residue	23.8	96.1	24.6	12.0	3.9	58.66	20.0	60.22
Concentrate	88.4	93.4	17.1	8.5	6.6	18.5	4.2	67.7

DM = Dry matter, OM = Organic matter, CP = Crude protein, EE = Ethereal extract, MM = Mineral matter, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, TCH = Total carbohydrates.

Behavior of cows was evaluated during 9 weeks with weekly reports during two consecutive days and a 10-day adaptation period with the presence of researchers. Reports were taken only during the day, from 6 to 18h. Animals were removed from the experimental land lot twice a day, at 4 and 14h for mechanical milking. Animals returned from the afternoon milking session at 15h and since no activity report was made between 14 and 15h, total daily report was restricted to 11 hours.

Animals were identified by a silvery synthetic paint on the dorsal and lateral regions and by morphological characteristics of each animal such as type of horns and hide. Binoculars were employed for better visualization of the group. Reports on behavior standards was undertaken every 10 min by scanning by 3 evaluators who observed and registered the following behavior variables: feed (FED), locomotion (LOC), rumination while resting (RUML), rumination while standing (RUMS), idle while resting (IL), idle standing (IS), other activities (OA), time duration in the shade and time drinking water.

The entire environment was monitored during the experimental period by an automatic meteorological station established on the site and programmed to register hourly data on temperature (Ts), global solar radiation (Qg), relative humidity (RH), wind speed (WS) and rainfall (RF). Data were stored in a data logger on the station and transferred weekly to a computer. Black globe temperatures in the sun and in the shade (BGT) and (BGTs) were obtained by two black globe thermometers respectively installed near the meteorological station and in the shade where animals used to spend most of the time. Temperatures were used to calculate radiant thermal load (RTL) and radiant thermal load in the shade (RTLs) in W m^{-2}, and index of black globe temperature and humidity in the sun and in the shade (BGHI and BGHIs) respectively. RTL was calculated by formula according to Esmay (1969):

$$RTL = \sigma . (MRT)^4$$

where:

$\sigma = 5.67 \times 10^{-8}$ (W/m^{-2} K^{-1});

MRT = mean radiant temperature (K).

where:

$$MRT = 100\ \{2{,}51 \times \sqrt{ws}\ (BGT - Ts) + \\ +(BGT/100)^4\}^{0{,}25}$$

where:

WS = wind speed (m s^{-1});

BGT = black globe temperature (K);

Ts = dry bulb temperature (K).

THI (temperature humidity index) was calculated by equation following Kelly and Bond (1971).

where:

$ITH = Ts - 0{,}55 * (1 - RH) * (Ts - 58)$; *Ts* is the temperature in (°F) and *RH* air relative humidity in decimals. IGTH was determined according to formula by Buffington et al. (1981):

$$BGHI = BGT + (0.36TD) + 41.5$$

where:

BGT is the black globe temperature (°C) and TD is the temperature of dew (°C).

Experimental design was entirely randomized, with three genetic groups (1/2, 5/8 and 3/4 HxG) as treatments and five repetitions.

Variables were feeding duration, rumination, idleness, locomotion, other activities and rest in the shade. Averages underwent variance analysis and were compared by Tukey's test at 5%. Duration of water intake was described statistically. Pearson's correlation between behavior and meteorological data and thermal comfort index were also taken. Statistical package SAEG 8.1 (SAEG, 2003) was used for analyses.

Results and discussion

Table 2 provides data on mean environmental variables registered during the experimental period (6 to 18h) and their respective amplitudes. Average wind speed (WS) was 3.2 m s^{-1}, above the interval between 1.3 and 1.9 m s^{-1}, according to McDowel (1972). Minimum and maximum temperatures were 23.8 and 31.9°C, respectively. When average and amplitude of ITH were taken into account, the cows of the three genetic groups underwent heat stress. This fact is foregrounded by estimates of critical rates (80, 77 and 75 for animals of the genetic groups 1/2, 3/4 and 7/8 HZ, respectively) described by Azevedo et al. (2005).

Table 2. Averages and amplitudes of environmental variables and confort indexes during the experimental period (6 to 18h).

Variables	Average	Amplitude
Ts (°C)	28.8	±10.8
Tmin (°C)	23.8	±2.2
Tmax (°C)	31.9	±0.4
RH (%)	69	±44
WS (m s^{-1})	3.2	±3.9
BGT (°C)	35.2	±25
BGTs (°C)	29.3	±12
RTL (W m^{-2})	639.7	±757.8
RTLs (W m^{-2})	484.2	±318.8
THI	79.1	±11.2
BGHI	84.8	±25.3
BGHIs	78.9	±13.2

Temperature (Ts), minimum temperature (Tmin), maximum temperature (Tmax), relative humidity (RH), wind speed (WS), black globe temperature (BGT), black globe temperature in the shade (BGTs), radiant thermal load (RTL), radiant thermal load in the shade (RTLs),temperature humidity index (THI), black globe humidity index (BGHI), black globe humidity index in the shade (BGHIs).

Figure 1 shows that there was an increase in ITH from 74 at 6h to 81 at 11h, with duration on this band till 15h, with a gradual decrease to 77 at 18h.

Table 3 shows that animals of group 5/8 HG spent more time in feeding ($p < 0.05$) when compared to the time spent by group 3/4 HG, although the latter did not differ from the 1/2 HG group. Since the diet was the same and no competitiveness existed in the trough area, the above result may be due to the type of shade provided by the rooftop covering (fiber-cement tiles). In fact, some animals of group 3/4 stopped feeding and sought the shade of the trees in the land lot where they were idle, standing, during a short period of time and returned to the feed trough to feed. It does not seem that this fact provided any unfavorable conditions. In fact, other groups had the same behavior since the latter had a higher proportion of zebu blood in their genetic composition.

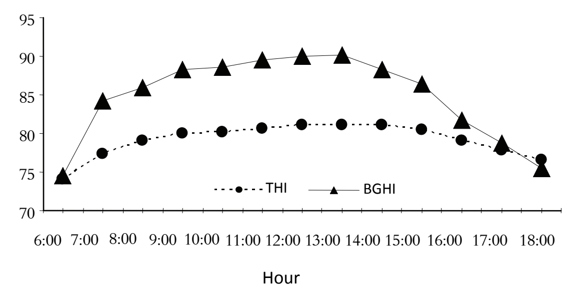

Figure 1. Daily average variation of THI and BGHI.

Table 3. Averages of day behavior activities in minutes of three genetic groups of Girolando cows in feedlots.

Activity	GG			CV (%)
	1/2	5/8	3/4	
FED	259.55ab	267.88a	245.55b	6.1
LOC	10.22a	8.00a	6.88a	11.4
RUML	61.33a	68.66a	64.88a	20.8
RUMS	52.55a	61.22a	40.33a	35.2
IL	79.11a	67.55a	85.00a	21.0
IS	181.11b	174.88b	204.66a	9.5
OA	16.11a	11.77a	12.66a	30.0

Averages followed by the same letter on the same row do not differ among themselves by Tukey's test ($p < 0.05$); GG = genetic group; FED = feeding; LOC = locomotion; RUMS = rumination while standing; RUML = rumination while resting; IS = idle while standing; IL = idleness while resting; OA = other activities; CV = coefficient of variation.

Low feed time duration of group 1/2 HG compared to that of 5/8 HG is due to a greater percentage of Gir blood in the former, with less feed intake. This is one of the adaptive characteristics of the zebu breed which is more heat-bearing due to a lower production of metabolic heat.

More time was spent in idleness while standing ($p < 0.01$) by 3/4 HG animals when compared to the others. This is due to a low feeding duration time by the group since preference is given to idleness while standing than to feeding time. Probably the cows heat regulated themselves by the strong wind (3.2 m s^{-1}) registered in the land lot.

There was no significant difference ($p > 0.05$) among treatments for locomotion (LOC), rumination while resting (RUML), rumination while standing (RUMS), idleness while resting (IL) and other activities (OA).

Confined cattle in feedlot search for food mainly during two periods: early in the morning and late in the afternoon. Figure 2 shows that during current trial feed peaks were verified in the morning between 6 and 7h (90.9 and 92.3%); however, feed peaks in the afternoon occurred at 15h (91.2%). This is probably due to the fact that animals in stables are stimulated to search for food during the instances of supply. Two small rumination peaks may be observed at 9h (42.8%) and 10h (24.5%) and a more intense one at 17h (87%). According to Broom and Fraser (2007), most rumination occurs during the night during 6 to 8h per day. Souza et al. (2007) evaluated the day ingestion behavior of crossbreed steers (1/4 Beefalo 1/4 Nelore) within the pasture system and reported low rumination percentage (8.97%). In fact, animals spend the day period for feeding and 20.69% ruminate during the night period.

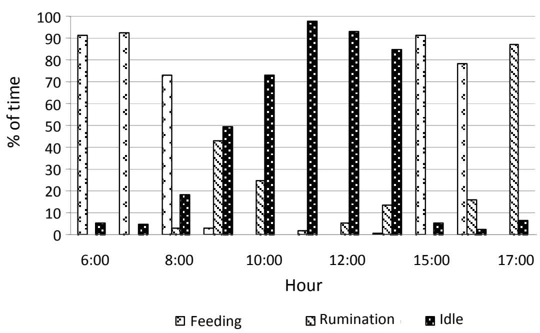

Figure 2. Distribution of behavior activities of Girolando cows in feedlot system.

Van Soest (1994) reports that rumination occurs during the night period even though it may occur around noon. Idleness activities showed a gradual increase between 8h and 11h (18, 49.2, 73.1 and 97.5%) with slight decrease to 92.8 and 85%) respectively at 12 and 13h. This fact shows that increase in comfort indexes decreases the animals' activities. The interval between 9 and 13h revealed that rumination activity had an inverse relation to idleness: rumination decreases in proportion to an increase in idleness. In fact, several studies have shown that idleness is more intense during the hottest period of the day in which the animals substitute feed intake activities and rumination with idleness so that the production of metabolic heat could be reduced.

The great number of tree species in the land lot in which the animals were confined and the gregarious mode of cattle herds did not favor great differences for shade-seeking among the groups (Figure 3). In fact, all the groups remained in the shade at the same time and returned to feeding at the specific time.

Time duration in the trough shade during feeding time was not calculated so that reports would not be overestimated.

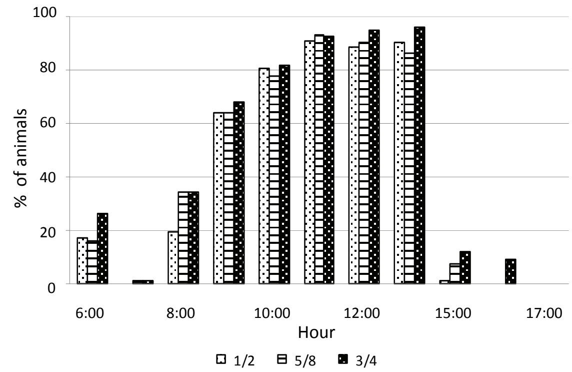

Figure 3. Percentage of the three genetic groups of cows in the shade within the feedlot system.

Table 4 shows a slight trend in 3/4 HG animals to spend more time in the shade, although no statistical difference was reported for this activity among the groups.

Table 4. Mean time (min.) in the shade spent by Girolando cows in feedlot system.

GG			CV (%)
1/2	5/8	3/4	
400.51 a	433.23 a	470.33 a	11.9

Averages followed by the same letter on the row did not differ by Tukey's test ($p < 0.05$); GG = genetic group; CV = coefficient of variation.

Shade of the fícus (*Ficus benjamina*) and jambul (*Eugenia jambolana*) trees were the most sought for by the animals, which may be due to their great protection from solar rays. In fact, they cause a 24.3% decrease of radiant thermal load when compared to the non-shaded area. Studies by Schütz et al. (2009) and Tucker et al. (2008) reported that cattle prefer shade that would supply protection against the sun rays. Trees actually provide effective protection against incident solar radiation and make the environment more humid and comfortable. Through forestry, more pronounced short wave radiation is warded off and problems caused by surface reflections are avoided (SILVA, 1998). Tucker et al. (2008) also found a positive relationship between solar radiation and shade use.

According to Damasceno et al. (1999), water intake mainly occurs during the first morning hours and late afternoon. However, environmental conditions may have important effects on this behavior. In current study the periods with more water intake occurred at 6 and at 7h (Figure 4). Animals of the 3/4 genetic group spent more time in water intake. This activity reveals a greater necessity to replace water loss by evaporation mechanisms of heat regulation and identifies the animals as less tolerant to heat stress.

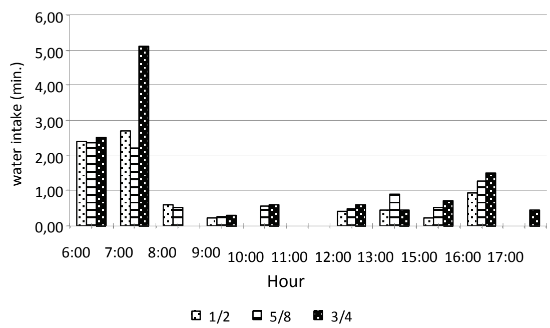

Figure 4. Time spent in water intake by cows in feedlot.

Portugal et al. (2000) report that frequency in water intake may be also due to the type of diet and to water taken with the diet. The water needed for the animal's vital functions comes from three sources, or rather, the animal's internal metabolism, feed intake and water intake. The last two are the most important (NRC, 2001).

Diet supplied to animals maintained their water balance since it contained forage palm and malt residues which are water-rich feed.

Foregrounded on the greatness of coefficients of correlations in Table 5, solar radiation and temperature were the climate factors that most affected the animals' behavior. In fact, they supplied a negative association ($p < 0.01$) of medium greatness with feeding time and a positive association with idle time while standing. This fact suggested that animals decreased feeding activities to stay idle while standing when both factors increased.

A positive correlation ($p < 0.01$) existed between solar radiation and rumination time while standing. Animals decrease their feeding and resting time as behavior responses to an increase in heat load (OVERTON et al., 2002; TUCKER et al., 2008; ZAHNER et al., 2004).

According to Ansell (1981), cattle stand to maximize the body surface area exposed to the environment and increase air flow around the body for the dissipation of heat by convection. Rumination while standing, idleness while resting and standing have a positive correlation ($p < 0.01$) with Ts and BGT.

THI represents the index of thermal comfort with the highest correlation with evaluated activities, or rather, correlated negatively ($p < 0.01$) with feed and locomotion activities and positively with idleness and rumination while standing. Animals, in fact, tended to adjust themselves to thermal environment by changing their position, as registered by Pough et al. (1993).

Table 5. Pearson's coefficients of correlation between behavior activities of Girolando cows and climate variables and indexes of thermal comfort.

CV	Behavior activities						
	FED	LOC	RUML	RUMS	IL	IS	OA
T	-0. 4974**	-0. 3774**	-	0. 4274**	0. 3792**	0. 3798**	-
BGT	-0. 4156**	-0. 2004*	-	0. 3726**	0. 2778**	0. 3763**	-
RTL	-0. 3923**	-0. 2323*	-	0. 3246**	0. 2819**	0. 3877**	-
THI	-0. 4899**	-0. 3677**	-	0. 4456**	0. 3473**	0. 3868**	-
BGHI	-0. 4151**	-0. 1989*	-	0. 3784**	0. 2728**	0. 3818**	-
RAD	-0. 5106**	-0. 3058**	-	0. 4348**	0. 3057**	0. 5387**	-

** = Significant at 1% probability ($p < 0.01$); * = Significant at 5% probability ($p < 0.05$). CV = climate variables; TS = Temperature (°C); BGT = Black global temperature (°C); RTL = radiant thermal load (W m^{-2}); THI = temperature humidity index; BGHI = black globe humidity index; RAD = solar radiation (W m^{-2}); FED = feed; LOC = locomotion; RUMS = rumination while standing; RUML = rumination while resting; IS = idle while standing; IL = idleness while resting; OA = other activities.

Conclusion

Animals of group 3/4 HG spent less time feeding and more time in idleness and spent more time drinking water. Such behavior is linked to thermal stress.

Solar radiation and air temperature caused the highest behavior alterations reported in current study, especially on feeding behavior.

Results therefore show that Girolando cows of the genetic group 1/2 HG had the best tolerance rate to heat than the genetic groups 5/8 and 3/4 HG.

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