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Behavioral, productive, reproductive and thermoregulatory performance of lactating ¾ and ⅞ Holstein/Gir cows

Desempenho comportamental, produtivo, reprodutivo e termorregulador de vacas em lactação ¾ e ⅞ Holandês/Gir

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Highlights

Cows with the higher European genetic composition showed higher respiratory rates.
Rumination occurred at the lower temperatures of the day: dawn and dusk.
Rectal temperature was similar between ¾ and ⅞ Holstein/Gir cows.

Abstract

The aim of this study was to examine the behavioral, productive, reproductive and thermoregulatory performance of ¾ and ⅞ Holstein/Gir (HG) dairy cows to identify which genetic composition suffers the least heat stress. A completely randomized design was adopted involving 20 multiparous, lactating crossbred cows from a dairy farm located in the municipality of Turvânia - GO, Brazil. During the experimental period, data on behavioral, productive, reproductive and thermoregulatory traits were collected every 15 days. Bioestat (5.0) statistical software was used for statistical analysis. The mean temperature-humidity index, ambient temperature and relative humidity obtained throughout the experimental period were 74.45, 30.51 ºC and 63.64%, respectively. In terms of reproductive performance, there was a significant difference ($p < 0.05$) between the genetic compositions for the time from calving to first service, with a longer period shown by the animals with greater Holstein breed genetic composition. Service period and calving interval differed significantly ($p < 0.05$) during the experimental period between the genetic compositions.

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A significant difference ($p < 0.05$) was also detected between the compositions for respiratory rate, with higher values observed in the animals with higher European genetic composition. Benezra thermal comfort index also differed significantly ($p < 0.05$), with the ⅞ HG animals showing a higher value. Lactating cows with a ⅞ HG genetic composition achieved better results in milk production, whereas those with ¾ HG genetic composition showed superiority in milk fat composition and reproductive and thermoregulatory performance, indicating greater adaptation to the climatic conditions of the region.
Key words: Ambience. Dairy production. Thermotolerance.

Resumo

Objetivou-se avaliar o desempenho comportamental, produtivo, reprodutivo e termorregulador de vacas leiteiras ¾ e ⅞ Holandês/Gir (HG), com intuito de identificar qual composição genética sofre menor estresse térmico pelo calor. Foi utilizado um delineamento inteiramente casualizados com 20 vacas mestiças, em lactação, multíparas, pertencentes à propriedade leiteira localizada no município de Turvânia, GO. Durante o período experimental, a cada 15 dias foram coletados dados das características comportamentais, produtivas, reprodutivas e termorreguladoras. Para a realização das análises estatísticas foi utilizado o programa estatístico Bioestat (5.0). Os valores médios obtidos durante todo o período experimental para índice de temperatura e umidade, temperatura ambiente e umidade relativa do ar foram 74,45, 30,51ºC e 63,64%, respectivamente. Quanto ao desempenho reprodutivo, houve diferença significativa ($p < 0,05$) entre as composições genéticas para o intervalo do parto ao primeiro serviço, observando valor maior para os animais com maior composição genética da raça Holandesa. Para as características período de serviço e intervalo de parto foram constatadas diferenças significativas ($p < 0,05$) durante o período experimental entre as composições genéticas. Foi encontrado diferença significativa ($p < 0,05$) entre as composições na característica de frequência respiratória, observando-se maior frequência para os animais com maior composição genética europeia. Foi observado diferença significativa ($p < 0,05$) na característica índice de conforto de Benezra, onde foi encontrado maior valor para a composição genética ⅞ HG. As vacas em lactação com composição genética ⅞ HG obtiveram melhores resultados na produção de leite, mas em contrapartida a composição genética ¾ HG mostraram superioridade na composição de gordura do leite e no desempenho reprodutivo e termorregulador, evidenciando maior adaptação as condições climáticas da região.
Palavras-chave: Ambiência. Produção Leiteira. Termotolerância.

Introduction

Brazil is located in tropical regions, which are characterized by high temperatures. In dairy cattle farming, the climate has a great influence on production performance. In this respect, cases of heat stress can cause an imbalance in homeostasis as well as physiological and behavioral changes, in an effort to adjust body temperature.

Environmental conditions can reduce milk production and increase the physiological activities of thermoregulation, which is triggered by reduced feed intake; low thyroid functionality; and the energy being used to maintain body temperature in place of production. The more intense the thermal stress, the greater the chances of reductions occurring in the feeding behavior, which will ultimately cause a deficit in production, as nutrients are diverted to maintain body temperature (Rodrigues, Souza, & Pereira, 2010).

Because cattle are homeothermic animals, their temperature must be within their thermal comfort zone. When subjected to thermal stress, these animals may exhibit behavioral, thermoregulatory, reproductive and productive changes (I. C. Ferreira, Martins, Fonseca & Cumpa, 2017).

Under stress conditions, alterations can occur in the feeding, rumination, rest and sleep behaviors as well as in other activities such as body care, play, locomotion and anomalous actions. Rodrigues et al. (2010) observed that in the hotter times of the day, animals sought some type of shelter and continued the activities of rumination and rest; that is, they reduced their feeding activity according to the environment, which gave an opportunity for other activities such as anomalous behaviors to be performed.

In an effort to minimize the risks of thermal stress, animals activate some thermoregulatory mechanisms to ensure their homeostasis. According to Rezende, Munhoz, Nascimento and Guimarães (2015), animals in thermal stress conditions exhibit physiological changes such as vasodilation, increased transpiration rate and increased respiratory rate.

In adult cattle, body temperature can vary according to breed, age, sex and physiological status, with values considered normal ranging from 37.5 to 39.0 °C (I. C. Ferreira et al., 2017).

Santos et al. (2018) reported that hair morphology is a factor that interferes with the dissipation of body heat. Façanha, Silva, Maia, Guilhermino and Vasconcelos (2010) described that the numerical density, length, sheath thickness and color of hair in cattle directly affect the thermal exchanges of sensitive (convection and radiation) and latent (cutaneous evaporation) heat with the environment.

Stress is directly related to milk production, as the animal is not in its comfort zone and will thus not fully express its genetic potential, reducing the levels of fat, protein and even the amount of milk. An animal under thermal stress will use its energy to maintain body temperature, diverting from the main focus of the activity-milk. Rodrigues et al. (2010) stated that high ambient temperatures can reduce about 0.54% and 0.44% of fat and protein, respectively.

When it comes to reproduction, heat stress can influence the levels of gonadal hormones, compromising the reproduction cycle of an animal and causing changes such as decreased fertility, low estrus detection rates and lower conception rates. Schüller, Burfeind and Heuwieser (2014) demonstrated in their studies that conception rate decreased from 31% to 12% when the animals were subjected to heat stress.

According to Prata et al. (2014), to reduce the effects of thermal stress, farmers should choose breeds or crossbreeds more adapted to the tropical climate. European breeds (Holstein) are more productive in a favorable environment, whereas zebu breeds (Gir) are more adapted to the tropical climate conditions, and their crossing provides good productive and reproductive traits due to the adaptability to the tropical environment.

Therefore, the present study proposes to examine the behavioral, productive, reproductive and thermoregulatory performance of ¾ and ⅞ HG dairy cows as well as to identify which genetic composition suffers the least thermal stress, which will facilitate the choice of higher-yielding animals adapted to the climate of the region.

Material and Methods

The study was conducted between August 2018 and July 2019 on a dairy farm in the municipality of Turvânia - GO, Brazil (16º36′29″ S, 50º7′25″ W, 603 m altitude). According to the Köppen classification, the climate of the region is a tropical Aw type, with dry (May to October) and rainy (November to April) seasons (DB-City, 2018). The experiment was approved by the State University of Goiás (approval no. 3663).

During the dry season, the cows were grazed in 24 rotated irrigated paddocks of mombasa grass, adopting one day of occupation and 24 days of rest. The cows received a supplementary diet based on maize silage (dry matter: 31%; crude protein (CP]: 7.2%) and concentrate supplementation (CP: 22%; moisture [max]: 120.00 g; ether extract [min.]: 25.0 g; fibrous matter [max]: 35.0 g; mineral matter [max.]: 80.0 g; calcium [max.]: 13.0 g; phosphorus [min.]: 4,500.00 mg; and total digestible nutrients [min.]: 720.00 g). In the rainy season, the cows were rotated across the same paddocks, where they received concentrate supplementation with 22% CP. Mineral salt was freely available throughout the year, and all animals had free access to drinking water and natural shade.

Twenty multiparous, lactating crossbred cows with similar ages, with an average body weight of 500 ± 26 kg and an average daily milk yield of 17 ± 1.9 kg, were used. The animals were divided equally into two genetic groups (¾ Holstein + ¼ Gir; and ⅞ Holstein + ⅛ Gir) and distributed in a completely randomized design where each animal constituted a replicate.

The cows were milked twice daily, at 05h00 and 15h00, by the mechanical, bucket-type milking method. During the experimental period, data on behavioral, productive, reproductive and thermoregulatory traits were collected at every 15 days.

Environmental assessments were carried out fortnightly, on three occasion throughout the day (08h00, 13h00 and 17h00), in the paddocks. Two psychrometers were used to measure the relative humidity of the air, dry bulb temperature (DBT) and wet-bulb temperature (WBT), which were later used to determine the temperature-humidity index (THI) by the following equation: THI = DBT + 0.36 × WBT + 41.5 (Thom, 1958).

The behavioral assessment of the animals lasted 12 h, at 15-min intervals. The procedure followed the methodology proposed by Santana et al. (2014), starting at 06h00 and ending at 18h00. Feeding, rumination, rest and sleep behaviors and 'other activities' were observed; the latter included social, body 'care, play, locomotion and anomalous behaviors, as shown in the ethogram (Table 1).

Table 1
Ethogram with the behaviors to be observed

Behavioral category	Description
Feeding	Animais observados no momento do ato de alimentar.
Rumination	Process in which the swallowed feed returns to the mouth for a new breaking of particles through movements promoted by chewing.
Rest and sleep	Animal lying, resting, or sleeping while possibly performing another activity such as rumination.
Other activities	Performing any activity other than those described, comprising social, body-care, playful, anomalous and locomotion behaviors
Social	Socially interacting with other animals.
Body care	Self-cleaning, cleaning others, urination, defecation, and rubbing.
Playful	Playful behavior, such as jumping.
Anomalous	Related to stereotypies; anomalous behavior self-directed or directed towards the environment or another animal, such as sodomy, lignophagia, and geophagia.
Movement	Moving (walking or running).

Feeding, rumination, rest and sleep behaviors and ‘other activities’ were measured in minutes, whereas the other behaviors were expressed as a percentage within the time (min) expended on other activities.

Behavior was assessed visually by four trained evaluators that were divided into pairs and positioned strategically so as not to disturb the animals. To measure the time expended on each activity, digital stopwatches were used.

Productive performance was determined based on the measurement of test-day milk yield, to check the productive capacity of each genetic group, as well as collection of milk for laboratory analysis to determine its chemical composition. The milk of each animal was weighed on a digital scale, during the morning and afternoon milking, to determine daily milk production per cow. After weighing, a 40-mL sample of milk cow^{-1} was taken (60% in the morning and 40% in the afternoon) for an individual analysis (cow^{-1}) of fat, protein, lactose and somatic cell count (SCC) levels.

The vials in which the samples were stored contained a tablet of the preservative bronopol at a concentration of 8 mg of active ingredient for each 40 mL of sample. After collection, the flasks were identified and immediately homogenized to dissolve the tablet.

Immediately after collection, the samples were placed in cooler boxes containing recyclable ice in an amount sufficient to maintain the internal temperature of the box at a maximum of 7 ºC until they arrived at the laboratory, which was accredited by the Ministry of Agriculture, Livestock and Supply. According to Dias (2012), the period between collection and arrival of samples at the laboratory should not exceed 96 h and the temperature should not exceed 10 ºC, so as not to compromise the quality of the sample.

The following reproductive traits were evaluated, in accordance with the methodology proposed by Guimarães et al. (2002): time from calving to first service (days), number of doses per pregnancy, service period (days) and calving interval (days).

Thermoregulatory performance was composed of rectal temperature (RT, ºC); respiratory rate (RR, movements min-1); surface temperature (ºC); Benezra thermal comfort index (BTCI); number, length and thickness of hairs; and color of the epidermis.

Rectal temperature was measured at the time of milking by a digital thermometer that was inserted in the rectum of the animal for an average time of three minutes. Respiratory rate and surface temperature were evaluated at 08h00, 13h00 and 17h00, in a way that would not influence animal behavior. Respiratory rate was recorded by counting the movements of the flank in one minute.

Animal surface temperature was measured using an infrared thermometer, which was positioned at a distance of five meters from the cows. This variable was measured in the region below the eyes, chest, neck side, ribs, flank, rump and udder, whose values were used to calculate an average.

The RT and RR values were used to calculate the BTCI, a highly reliable technique to measure heat tolerance, with the objective of identifying or comparing more adapted breeds and lines as well as understanding the physiological changes involved in thermolysis. The index was obtained by the following formula: BTCI = RT/38.33 + RR/23 (Benezra, 1954). In the obtained results, values close to two (2.0) represent a high degree of adaptability to the environment, whereas higher values may represent a lesser degree of adaptability.

The number, length and thickness of the hairs, as well as the color of the epidermis, were measured in the middle region of the thigh, after the measurement of RT. Next, a sample of hairs was taken from the same region as that used to measure hair thickness, using adapted electrician pliers to determine the density (n cm-²), and the length and thickness of the ten largest hairs (mm) using a caliper. The color of the epidermis was determined by a direct visual assessment through a comparison with a printed pattern, following the methodology proposed by R. G. Silva (2000).

The experiment was laid out in a completely randomized design with two treatments and ten replicates. Analysis of variance and Tukey's mean comparison test at 5% were performed for the environmental variables and the behavioral, productive, reproductive and thermoregulatory traits of ¾ and ⅞ HG dairy cows. Bioestat (5.0) statistical software was used for statistical analysis.

Results and Discussion

The THI, air temperature and relative humidity means obtained throughout the experimental period were 74.45 ± 1.24, 30.51ºC ± 2.75 and 63.64 ± 3.98%, respectively. Ferro et al. (2019) evaluated animals subjected to similar conditions and found respective THI, air temperature and relative humidity values of 79.15, 30.77 °C and 46.95%. The average temperature of the experiment is within the maximum value of 35 ºC required for zebu dairy cows and above the 27 ºC considered the maximum for lactating cows of European origin (Pires, Castro, Oliveira, & Paciullo, 2010).

Based on the average THI, the environment was characterized as in a state of alert for lactating cows, according to the Livestock Weather and Safety Index presented by Xiong, Green and Gates (2015). By this system, the environment can be classified as in a normal (THI ≤ 74), alert (75 ≤ THI ≤ 78), danger (79 ≤ THI ≤ 83) and emergency (THI ≥ 84) situation. When the environment is on alert, animals initiate some behavioral and physiological changes to maintain homeothermy, which was observed in this study.

In the analysis of behavioral performance, there were significant differences for the durations of feeding, rumination, rest and other activities between the genetic groups (Table 2). The ¾ HG cows showed the following percentages relative to the 720-min evaluation time for the respective activities: 24.68, 29.94, 64.20 and 11.11%. The ⅞ HG animals, in turn, showed respective percentages of 26.62, 27.70, 63.04 and 10.33%.

Table 2
Feeding, rumination, rest and other activities performed by lactating ¾ HG and ⅞ HG cows

Behavior (min)	Genetic composition		p[1]	CV%[2]	SD[3]
	¾ H + ¼ G	⅞ H + ⅛ G			
Feeding	177.78[a]	191.67[a]	0.3035	26.57	49.09
Rumination	215.56[a]	199.44[a]	0.2649	25.36	52.63
Rest	462.22[a]	453.89[a]	0.5809	11.82	54.13
Other activities	80.00 [a]	74.44[a]	0.5437	42.55	32.86

[1] Probability value of the F test of analysis of variance; [2] Coefficient of variation; [3] Standard deviation.

The percentages found in this experiment were similar to those observed by Pinheiro et al. (2011), who evaluated crossbred cows in confinement for 24 h and described 22.92% for feeding, 36.5% for rumination and 40.6% for rest or idleness. The ¾ and ⅞ HG cows had a long rest time, which may be directly related to their adaptive state to tropical climates; i.e., in some periods of the day, the animal was static so as to minimize energy expenditure. In addition, the animals reduced their feed intake in an attempt to decrease body heat production through caloric increment and the animals sought more favorable environments for heat exchange, such as shades and humid environments.

Oliveira et al. (2016) observed similar results in crossbred cows, which expended 19%, 34%, and 47% of their time feeding, ruminating and resting, respectively. Rumination is important because it is related to the quantity and quality of feed consumed, especially in terms of the NDF present, particle size and roughage:concentrate ratio of the diet.

Mendes et al. (2013) evaluated the feeding behavior of dairy cows grazing on Brachiaria brizantha and obtained results different from those found in this study. In their experiment, the cows expended 40.7, 36.24 and 23.05% of their time feeding, ruminating and performing other activities, respectively.

In the present study, the animals ruminated at the coolest times of the day-dawn and dusk-and, in most cases lying down (over 80% in both genetic groups). If possible, the cows would do it in the shade, which is in agreement with Broom and Fraser (2010), who stated that animals seek shade to perform rumination and better control their body temperature.

Within the other behavioral activities, the ¾ HG cows dedicated 17.26%, 30.53%, 0%, 0% and 52.21% of their time to social, body care, playful, anomalous and locomotion behaviors, respectively. The ⅞ HG animals, in turn, expended 25.76%, 18.94%, 0%, 0% and 55.30% of their time doing the respective activities, and no statistical difference was detected between the same behaviors for the genetic groups. Ferro et al. (2019) described similar values in an observation of the other behavioral activities of ½ and ¾ HG animals.

Mendes et al. (2013) found that ½ HG dairy cows devoted 23.05% of their total observed time to other activities, almost twice as much as in the present study. This variation may be due to the comfort encountered by the animal in the environment, which can increase social interactions, body care, locomotion and playful behaviors. These are observed when the animal is totally at ease in the environment in which it is inserted.

According to Broom and Fraser (2010), social behavior is understood as the interaction between two or more individuals. Body care includes self-cleaning, cleaning others, defecation, urination and thermoregulation. Playful behavior is characterized by frolic actions, and anomalous activities are those that differ from the expected behavioral pattern of the species.

In the evaluation of productive performance, there was a significant difference regarding the production of milk and fat between the ¾ HG and ⅞ HG genetic groups (Table 3). The amount of milk produced was higher for ⅞ HG animals (20.96 kg), which can be explained by their greater Holstein genetic composition, a breed specialized in milk production, when compared with the ¾ HG cows, which produced 19.97 kg. A higher fat content was observed in the milk of the ¾ HG genetic group (3.61%), which can be explained by the greater adaptation of these animals to the climate that leads them to consume a larger amount of forage, which in turn increases milk fat production.

Table 3
Production and composition of milk from ¾ HG and ⅞ HG cows

Productive trait	Genetic composition		p[2]	CV%[3]	SD[4]
	¾ H + ¼ G	⅞ H + ⅛ G			
Milk production (kg)	19.97[b]	20.96[a]	< 0.05	21.60	4.42
Fat (%)	3.61[a]	3.48[b]	< 0.05	18.32	0.65
Protein (%)	3.49[a]	3.35[a]	0.092	10.07	0.34
Lactose (%)	4.47[a]	4.56[a]	0.128	7.29	0.33
SCC (x 1000 SC mL^{-1})	90.43[a]	91.24[a]	0.087	13.71	12.46

[1] Variables followed by different letters in the same row differ at the 5% significance level by Tukey's test [2] Probability value of the F test of analysis of variance; [3] Coefficient of variation; [4] Standard deviation.

Ferro et al. (2019), observed similar results for milk production and fat percentage (19.73 kg and 3.52% in ¾ HG animals) in the same conditions as in this experiment.

Protein and lactose levels showed no significant difference between the ¾ and ⅞ HG compositions. Ferro et al. (2019) found different protein levels, but no differences in the lactose concentrations of milk from ½ and ¾ HG animals.

The SCC values did not differ significantly between the genetic groups, which can be explained by the environment and management that were exactly the same for the two groups. Both genetic compositions showed low SCC values, indicating a healthy mammary gland, with low indications of mastitis.

Vargas et al. (2014) found a negative correlation between SCC and lactose, with higher SCC translating into decreased lactose values. This reduction occurs because the lactose from the mammary gland is lost to the blood due to the permeability of the membrane that separates the milk from blood. The obtained percentages in their study indicated that at SCC (x 1000 cells mL^{-1}) lower than 200, there was 4.43% lactose in milk, and at SCC from 400 to 500, the milk lactose content was 4.36%. As a comparison, in the present study, the ¾ HG cows had a SCC of 90.43 (x 1000 cells mL^{-1}) and 4.47% lactose, whereas the ⅞ HG cows showed a SCC of 91.24 (x 1000 cells mL^{-1}) and 4.56% lactose in their milk.

Both genetic groups evaluated in this study are within the parameters for chilled raw milk proposed by Normative Instruction no. 76, of November 26, 2018, by the Ministry of Agriculture, Livestock and Supply (MAPA), which establishes minimum fat, protein and lactose contents of 3.0%, 2.9%, 4.3%, respectively, and a maximum SCC of 500,000 cells/mL (Instrução Normativa, 2018).

In the evaluation of reproductive performance (Table 4), a significant difference was detected between the genetic compositions for the time from calving to first service, with longer periods observed in the animals with greater Holstein genetic composition. According to Gonsalves (2012), this variable makes it possible to evaluate the resumption of ovarian activity and can be an indicator of nutritional efficiency and estrus detection, with the ideal time being 45 days and an acceptable period up to 60 days.

Table 4
Time from calving to first service (TCFS, days), number of doses per pregnancy (NDP), service period (SP, days) and calving interval (CI) (days) of ¾ and ⅞ HG dairy cows

Behavior	Genetic composition		p[1]	CV%[2]	SD[3]
	¾ H + ¼ G	⅞ H + ⅛ G			
TCFS	54.97[b]	66.54[a]	< 0.05	17.23	10.47
NDP	2.90[a]	3.10[a]	0.091	8.00	0.24
SP	90.47[b]	157.98[a]	< 0.05	15.27	18.97
CI	418.93[b]	432.87[a]	< 0.05	11.44	48.73

¹ Probability value of the F test of analysis of variance; ² Coefficient of variation; ³ Standard deviation.

There was no significant difference between the compositions for number of doses per pregnancy. This parameter is mainly used to evaluate cow fertility and the efficiency of the reproduction process. The results found were considered acceptable according to A. M. Ferreira (2012), since a maximum of three doses should be used to obtain a pregnancy.

Significant differences were found during the experimental period between the genetic compositions for service period and calving interval, with the animals with ½ Holstein genetic composition showing lower indices (90.47 and 418.93) than the ⅞ HG cows (157.98 and 432.87, respectively). Silveira et al. (2018) found service periods ranging from 126.8 to 152.95 days in Holstein-Gir crossbred cows. Balancin et al. (2014) described shorter calving intervals for the ¾ and ⅞ HG genetic compositions (396.66 and 403.96 days, respectively). However, for service period, these authors described higher values for the ¾ HG cows (117.18 days) and shorter periods for the ⅞ HG animals (123.39 days). There were significant differences between the genetic groups, which was explained by the low heterosis.

In the evaluation of thermoregulatory performance, no significant difference was observed for number of hairs (Table 5), whose results were 509,952 and 563,050 for the ¾ and ⅞ HG cows, respectively. These values are higher than those described by Ferro et al. (2019) for ¾ HG animals (469.14) and lower than those found by Cruz, Monteiro, Guimarães, Antunes and Nascimento (2016) in ⅞ HG animals (1589.79). The number of hairs per square centimeter is important for the protection of the epidermis layer. Nevertheless, in dairy cattle, a high density can provide thermal insulation, making it difficult for the animal to exchange heat with the environment (R. G. Silva, Guilhermino, & Morais, 2010).

Table 5
Number of hairs (NH), hair length (HL), hair thickness (HT), surface temperature (ST), respiratory rate (RR), rectal temperature (RT) and Benezra Thermal Comfort Index (BTCI) in ¾ HG and ⅞ HG cows

Thermoregulatory trait	Genetic composition[1]		p[2]	CV%[3]	SD[4]
	¾ H + ¼ G	⅞ H + ⅛ G			
NH	509.952[a]	563.050[a]	0.5129	34.44	184.757
HL (cm)	1.082[b]	1.230[a]	0.0409	19.12	0.221
HT (mm)	0.098[a]	0.096[a]	0.5352	5.15	0.005
ST (ºC)	32.507[a]	32.300[a]	0.6334	6.70	2.172
RR (mov. min^{-1})	49.910[b]	56.000[a]	0.0457	8.10	4.291
RT (ºC)	38.364[a]	38.305[a]	0.7715	1.50	0.576
BTCI	3.164[b]	3.434[a]	0.0471	14.94	0.493

[1] Variables followed by different letters in the same row differ at the 5% significance level by Tukey's test [2]Probability value of the F test of analysis of variance; [3] Coefficient of variation; [4] Standard deviation.

Hair length differed significantly between the genetic groups, with higher values observed in the animals with greater Holstein breed genetic composition. The hair length measured in the ¾ HG animals was similar to the 1.01 cm described by Cruz et al. (2016). These authors found, however, lower values in the ⅞ HG cows (0.85 cm), which may be due to European genetics being more evident in the ⅞ HG animals and their predisposition to having longer hairs due to their taurine origin.

Hair thickness, on the other hand, did not differ significantly between the two genetic groups throughout the experiment. The ¾ HG animals showed a lower value in comparison to the average 0.14 mm described by Ferro et al. (2019). As stated by Façanha et al. (2010), hair thickness helps the animals exchange heat and can vary according to the time of year, as it will determine the extension of contact surface between the environment and the epidermis.

There was no significant difference for surface temperature. Both genetic compositions exhibited similar values (32.507 and 32.300 ºC for ¾ and 7/8 HG, respectively), as the animals were under the same environmental conditions and had access to sunlight interceptors and natural shading. The average surface temperatures measured in the present study were higher than the 30.64 in ¾ HG animals and 30.97 ºC in ⅞ HG animals (average: 20.25 °C) reported by Cruz et al. (2016). However, there were no signs of stress for this trait.

Respiratory rate differed significantly between the genetic groups, with higher values observed in the animals with greater European genetic composition. Nonetheless, there were no alarming levels of stress for this trait, since the ¾ and ⅞ HG cows showed RR of 49.91 and 56.00 mov. min^{-1}, respectively. Both values are considered normal according to I. C. Ferreira et al. (2017), who mentioned the ideal range as being between 18 and 60 mov. min^{-1}.

There was no significant difference between the genetic compositions for RT, with both groups exhibiting values close to 38.3 ºC. These values are similar to the average 38.77 and 38.98 ºC described by Cruz et al. (2016) in ¾ HG and ⅞ HG animals, respectively. Ferro et al. (2019) found a similar RT value, 38.56 ºC, in ¾ HG animals under similar conditions. Rectal temperatures between 38 and 39.0 are considered physiologically normal for dairy cattle, and outside these normal conditions, performance can be compromised (N. M. Silva, 2019).

The Benezra thermal comfort index differed significantly, with higher values found in the ⅞ HG animals as compared with the ½ HG cows (3.434 and 3.164, respectively). This result demonstrates the lesser adaptability to the environment of the former group, since, according to Daltro et al. (2017) animals with BTCI close to 2.0 are considered more adapted to the environment. In their experiment, pure Holstein animals showed the highest BTCI values, followed by ¾ HG and ½ HG.

According to Balancin et al. (2014), animals with greater Holstein genetic composition may have superior performance. In contrast, better reproductive and thermoregulatory indices can be observed in animals with higher heterosis and easier adaptation, which is in line with the superiority shown by the ¾ HG cows in this experiment.

Conclusion

Lactating cows with ⅞ HG genetic composition obtained better results in milk production. In contrast, the ¾ HG group was superior for milk fat composition and reproductive and thermoregulatory performance, which indicates greater adaptation to the climatic conditions of the region.

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