ORIGINAL ARTICLE

# Behavioral and physiological responses of crossbred Holstein-Zebu cows and their interaction with the milker in two milking systems

Hugo Pereira Santos ▪ Auriclécia Lopes de Oliveira Aiura ▪
Guilherme Alfredo Magalhães Gonçalves ▪ Felipe Shindy Aiura ▪
Mariany Ferreira ▪ Isabel Cristina de Santana Alves ▪ Bruna Fernanda Carvalho Cunha

**HP Santos ▪ ALO Aiura** (Corresponding author) **▪ GAM Gonçalves ▪ FS Aiura ▪ M Ferreira ▪ ICS Alves ▪ BFC Cunha**
Department of Agricultural Sciences, Universidade Estadual de Montes Claros (UNIMONTES), Montes Claros, MG, Brazil.

email: auriclecia.aiura@unimontes.br

Received: August 05, 2018 ▪ Revised: August 21, 2018 ▪ Accepted: August 21, 2018

**Abstract** The aim of this study was to evaluate the behavioral and physiological responses of dairy cows and their interaction with the milker in two types of milking systems. The experiment was conducted in two farms, in the Coração de Jesus city, Brazil, where the surface temperature (TS, °C), rectal temperature (TR, °C), respiratory rate (RR, breaths.min$^{-1}$) and heart rate (HR, beats.min$^{-1}$) of 44 crossbred cows during the morning shift on twelve days of data collection at each farm. It was monitored the meteorological variables: the black globe temperature (TGN, °C), air temperature (TAR, °C), relative humidity (RH, %) and wind speed (V, m.s$^{-1}$). Observations about human behavior, negative patterns (tapping, yelling, and pushing) and positive patterns (talking, groping, and naming) were made without people being aware of their nature. The behavioral data observed in the animals were: vocalization (VOC), defecation (DEF), micturition (MIC) and movement (MOV) and milking time (TOR) was also recorded. The physiological variables were significant among farms, except heart rate. The talking, naming, pushing and shouting actions were not significant, only groping and hitting. The behavior occurrences VOC, MIC, and MOV of cows were low. The TO presented a positive correlation ($P < 0.01$) with TS, TR, and HR and negative correlation ($P < 0.01$) with RR. Under the conditions of this experiment, the type of milking system influenced the physiological responses. The milking system of type "bucket at the bottom" provided greater contact between the milker and the cow, leading to a greater negative interaction reflected by the defecation behavior.

**Keywords**: animal welfare, thermal environment, human-animal interaction

## Introduction

The Brazilian cattle herd is composed of approximately 218 million head, 9% of which are milked cows, which in the year 2016 produced 33.62 billion liters of milk, where the Minas Gerais state show the largest milked cows number and remains the main Brazilian milk producer, representing 26.7% of the national production (IBGE 2017). Most of the milk produced comes from the herd of crossbred Holstein-Zebu cows. These cows are adapted to tropical climate regions, due to the Zebu's rusticity, together with the high productivity of the European breed (Azevedo et al 2011, Miranda and Freitas 2009, Monteiro et al 2007).

Milking within the dairy farm represents the expected action of the productive process. This action is specific to each farm, showing variation from the infrastructure to the way the milker deals with the cow during milking (Rosa et al 2001). The influence of environmental factors has a direct impact on animal production, causing changes in the physiological mechanism of the animals such as body temperature elevation, panting, accelerated heart rate and sweating rate (Pinheiro et al 2015).

A widely explored concept in dairy cattle, and in other production systems, is that in the welfare absence, the animal does not produce according to its potential. For example, the heat stress, according to Bilby et al (2009), significantly reduces milk yield, thus causing large reproductive losses and, causing a significant economic impact on dairy farmers.

The concern about animal welfare has increased over time, since the milk withdrawal depends on a neurohormonal reflex such as calf suckling, entering the milking parlor, ceilings cleaning, among others. This stimulates the oxytocin release, which binds myoepithelial cells causing them to contract the alveoli and ducts resulting in milk ejection (Cunninghan 2008). However, the milk ejection can be inhibited by several stress causative factors, and can influence the animal behavior.

doi.org/10.31893/2318-1265jabb.v7n1p1-5

Therefore, the provision of better conditions to animals and a tranquility in the milking shed may allow high productivity, however, little is known about what type of milking systems provides this condition and the best the milker-animal interaction in the milking. Thus, the objective was to evaluate the behavioral and physiological responses of dairy cows and their interaction with the milker in two types of milking.

## Materials and Methods

The experiment was conducted on two farms, farm A (Fazenda Almécegas) and farm B (Fazenda Brota D'água), in the Coração de Jesus city, north of Minas Gerais state, Brazil (altitude of 778 m, South Latitude 16º27'52" and West Longitude 44º17'23"). The climate type of this region, according to Köppen classification, is Aw, with annual average temperature of 22ºC, dry and mild winters and rainy summers with high temperatures, with annual average rainfall of 1,146 mm.

A total of 44 crossbred cows (Holstein-Zebu) were evaluated during the morning shift, being 21 cows from Fazenda A and 23 cows from Fazenda B. Twelve days of evaluations were carried out at each farm, where the first two days being used to adapt the animals to the measurements. The animals were numbered with red paint in the croup area to identify these during the measurements of variables physiological performed in the milking room.

It was monitored the meteorological variables: the black globe temperature (TGN, ºC), air temperature (TAR, ºC), relative humidity (RH, %) and wind speed (V, $m.s^{-1}$) of the environment where the animals were, at the beginning and end of the measurements. The meteorological variables were used to calculate the radiant heat load (RHL, $W.m^{-2}$) and the Wet-Bulb Globe Temperature Index (WBGT). The RHL was calculated according to Silva (2000):

$$RHL = \sigma(MRT)^4 \text{, } W.m^{-2}$$

Where $\sigma = 5.67051 \times 10^{-8}$ $W.m^{-2}.K^{-4}$ is the Stefan-Boltzman constant and MRT is the mean radiant temperature, obtained by the equation:

$$M_{RT} = \left[ \frac{h_G\,(T_{GN} - T_{AR}) + \varepsilon_G \sigma T_{GN}^4}{\varepsilon_G \sigma} \right]^{1/4} \text{, K}$$

Where: $\varepsilon_G = 0.95$ is the globe emissivity, $T_{GN}$ is the black globe temperature (K) and $h_G$ is the convection coefficient of the black globe:

$$h_G = \frac{kN_U}{d_G} \quad \text{, } (W.m^{-2}.K^{-1})$$

Where: $d_G$ is the black globe diameter (m), $N_u$ is the Nusselt number and k is the air thermal conductivity ($W.m^{-1}.\ K^{-1}$).

The Wet-Bulb Globe Temperature Index (WBGT) (Buffington et al 1981) obtained by the following equation:

$$WBGT = T_{GN} + 0.36\ T_{PO} + 41.5$$

Where: $T_{GN}$ = black globe temperature (°C) and $T_{PO}$ = dew point temperature (°C):

$$T_{PO} = 273.15 \times [\ 0.971452 - 0.057904 \times l_n\ P_p\{t_a\}]^{-1} - 273.15$$

The physiological parameters were measured daily during the whole experimental period, in the morning shift at milking time. The heart rate (HR, $beats.min^{-1}$) was obtained by counting the heart beats with the aid of a stethoscope positioned between the third and fourth intercostal space, near the costochondral joint, during one minute. The respiratory rate (RR, $breaths.min^{-1}$) was measured by observing the movements of the animal's right flank, in one minute. The rectal temperature (TR, ºC) was measured by the introduction of a digital thermometer in the animal's rectum until the sounder alarm. The surface temperature (TS, ºC) was obtained by a digital infrared thermometer (Incoterm, ST-700), on the side area.

Observations about human behavior were made without milkers knowing their nature so that they maintained spontaneous behavior. Thus, we only report that the animal behavior would be observed, as suggested by Lensink et al (2000).

The milker's behavior data were adapted from Breuer et al (2000), collected through direct observations with continuous collections during the accommodation and release of cows in the milking parlor. Frequencies of occurrences and absences of negative behavioral patterns (tapping, yelling, and pushing) and positive patterns (talking, groping, and naming) were recorded.

We analyzed the following behavioral data: vocalization (VOC), defecation (DEF), micturition (MIC) and movement (MOV), according to a methodology adapted from Rosa (2004). The behaviors were quantified during the dwell time in the milking parlor, that is, from the entrance of the animal to the leaving time the milking parlor. In addition to behavioral variables, the milking time (TOR) was recorded individually, with the aid of a chronometer, according to Rosa (2004), and was done from the placement of the teat cups until its withdrawal.

Kruskal-Wallis nonparametric test was performed for behavioral variables, physiological variables and milking time, and for man-animal interactions. Chi-square test for the presence or absence of animal behaviors in the milking parlor and Pearson's correlation between the physiological and behavioral variables.

doi.org/10.31893/2318-1265jabb.v7n1p1-5

## Results and Discussion

The climatic conditions effects can influence the responses of the animal's body temperature. According to Berman et al (1985), dairy cows may be affected by heat stress when the air temperature increases above 25ºC. In this conditions, the evaporative heat loss decreases causing the animal to use the peripheral vasodilatation to aid in the heat loss. However, the averages found for TAR (Table 1) were within the thermal comfort zone. The WBGT presented values below 74, which is defined as a thermal comfort situation and the RHL, coming from the mean radiant temperature of 300,65 K or 27,5ºC, in which Oliveira (2007) found an intersection between the sensible and latent heat loss promoting thermal equilibrium in Saanen dairy goats. The significant difference between farms for RH occurred due to the rainfall in the first days of the experiment at farm B, but both values were within the thermal comfort range of 50 to 80% (Baêta e Souza 2010).

The physiological variables (Table 2) were significantly different among farms, except heart rate, which was within the range recommended by Detweiler (1996) for dairy cows, ranging from 48 to 84 beats.min$^{-1}$. Corroborating with the values found in our study, Hopster et al (2002) evaluated the physiological responses of primiparous cows in two milking systems, conventional (tandem) and automated, and found differences among the milking systems with mean values varying between 90 and 91 beats.min$^{-1}$ in the conventional system, while in the automated system it was between 78 and 80 beats.min$^{-1}$.

The studied variables are influenced by the thermal environment, however, in this study, it is within the thermal comfort zone (Table 1). Thus, the superiority found for TS and TR was attributed to the higher milk production of the cows at Fazenda A. The highest mean value of the RR, at Farm B, was attributed to management (Table 3). Even so, the mean values found for both farms were within the normal range of an adult cattle for TR, which is between 37.5 to 39.3°C (Martello et al 2004) and the RR varies between 24 and 36 breaths.min$^{-1}$ (Ferreira et al 2006).

The talking and naming actions (Table 3) were not significant, but groping was found to be more frequent at Farm B. This may have occurred because there is direct contact between the animal and the milker, while in the fishbone milking parlor (Farm A) this contact it is smaller. Likewise, the pushing and yelling actions were not significant, but the tapping actions were present at Farm B, demonstrating that the groping can become the tapping when the animal does not respond skillfully to the milker, as verified by the higher incidence of this interaction. Already Oliveira et al (2014) evaluating the effect of the milker's behavior on the animal behavior found significant effects on the actions of talking, groping, pushing, tapping and yelling.

**Table 1** Averages of the air temperature (TAR, ºC), relative humidity (RH, %), black globe temperature (TGN, ºC), Wet-Bulb Globe Temperature Index (WBGT) and radiant heat load (RHL).

| Variables | TAR | RH | TGN | WBGT | RHL |
|---|---|---|---|---|---|
| Farm A | 21.63 | 68.51$^{b}$ | 22.13 | 68.86 | 463.50 |
| Farm B | 21.15 | 77.91$^{a}$ | 21.95 | 68.99 | 459.77 |

The different letters in the column indicate a significant difference (F test, P<0.05).

**Table 2** Averages of the surface temperature (TS, °C), rectal temperature (TR, °C), respiratory rate (RR, breaths.min$^{-1}$) and heart rate (HR, beats.min$^{-1}$).

| Variables | TS | TR | RR | HR |
|---|---|---|---|---|
| Farm A | 31.35$^{a}$ | 37.73$^{a}$ | 23.37$^{b}$ | 64.99$^{a}$ |
| Farm B | 30.50$^{b}$ | 36.76$^{b}$ | 29.17$^{a}$ | 64.22$^{a}$ |

The different letters in the column indicate a significant difference (Kruskal-Wallis, P<0.05).

The results showed that there was no difference in the positive actions between the farms, but the negative actions were significantly higher at Farm B. Cows discriminate milkers that handle of the aversive way for up to 180 days after the last contact (Hotzel et al 2005). According to Oliveira et al (2014), positive actions such as groping and talking of calm and introverted milkers caused an increase in milk yield.

**Table 3** Averages of the talking (CONV), groping (TAT), naming (NOM), tapping (BAT), yelling (GRI) and pushing (EMP), positive behavioral patterns (POS) and negative behavior patterns (NEG).

| Variables | CONV | TAT | NOM | BAT | GRI | EMP | POS | NEG |
|---|---|---|---|---|---|---|---|---|
| Farm A | 4.75$^{a}$ | 2.50$^{b}$ | 16.58$^{a}$ | 0.58$^{b}$ | 1.08$^{a}$ | 0.17$^{a}$ | 23.83$^{a}$ | 1.83$^{b}$ |
| Farm B | 4.42$^{a}$ | 4.67$^{a}$ | 26.42$^{a}$ | 3.08$^{a}$ | 3.08$^{a}$ | 0.50$^{a}$ | 35.50$^{a}$ | 6.67$^{a}$ |

The different letters in the column indicate a significant difference (Kruskal-Wallis, P<0.05).

The behaviors occurrences of cows' vocalization, micturition, and movement, in both farms, were low (Table 4), demonstrating that the handling was considered adequate. However, in the Farm B, it was observed that there was a

doi.org/10.31893/2318-1265jabb.v7n1p1-5

higher percentage of animals that defecated, possibly due to an aversive handling (Table 3). Peters et al (2010) also found that dairy cows present a higher occurrence of defecation when submitted to negative (aversive) human handling conditions. However, Oliveira et al (2014) found similar behaviors of movement, micturition, defecation, and vocalization when submitted to three milkers, being a calm, an introverted and another sanguine.

**Table 4** Absence and occurrence frequencies of vocalization (VOC), defecation (DEF), micturition (MIC) and movement (MOV).

| | | VOC | MIC | DEF | MOV |
|---|---|---|---|---|---|
| | Absence | 96.43 | 79.37 | 72.62 | 89.3 |
| Farm A | Occurrence | 3.57 | 20.63 | 27.38 | 10.7 |
| | P-value | <.0001 | <.0001 | <.0001 | <.0001 |
| | Absence | 98.20 | 82.61 | 61.60 | 88.40 |
| Farm B | Occurrence | 1.80 | 17.39 | 38.40 | 11.60 |
| | P-value | <.0001 | <.0001 | <.0001 | <.0001 |

Chi-square test.

Milking time (Table 5) showed a positive and significant correlation ($P < 0.01$) with TS, TR, and HR and negative correlation with RR. This shows that animals with a longer milking time, consequently a higher milk yield, have higher TS, TR and HR because this is an activity that generates heat excess. The negative correlation with RR occurs because the latent heat loss in the respiratory system was not necessary, where the sensible heat loss enough to maintain the cows' thermoregulation because the thermal environment in the milking parlor was thermally adequate.

The correlation between surface temperature and movement's behavior was positive and significant ($P < 0.05$) indicating that the higher movement may have generated a higher heat production.

**Table 5** Correlations between the physiological and behavioral variables of the dairy cows studied.

| Variables | TOR | VOC | MIC | DEF | MOV |
|---|---|---|---|---|---|
| TS | 0.15** | 0.08 | 0.07 | 0.01 | 0.10* |
| TR | 0.11** | 0.01 | -0.00 | 0.08 | -0.00 |
| HR | 0.13** | 0.01 | 0.02 | 0.06 | 0.07 |
| RR | -0.24** | -0.01 | 0.03 | 0.05 | -0.08 |

* ($P < 0.05$) **($P < 0.01$)

## Conclusions

Under the conditions of this experiment, the milking system type influenced the physiological responses. The bucket at the bottom provided greater contact between the milker and the cow, leading to a greater negative interaction reflected by the defecation behavior.

## References


Azevedo RA, Felix TM, Júnior ODSP, Almeida AC, Duarte ER (2011) Perfil de propriedades leiteiras ou com produção mista no norte de minas gerais. Revista Caatinga 24:153-159.

Baêta FC, Souza CF (2010) Ambiência em edificações rurais: conforto animal. Viçosa.

Berman A, Folman Y, Kaim M, Mamen M, Herz Z, Wolfenson D, Arieli A, Graber Y (1985) Upper critical temperatures and forced ventilation effects for high-yielding dairy cows in a subtropical climate. Journal of Dairy Science 68:1488-1495.

Bilby TR, Tatcher WW, Hansen PJ (2009). Estratégias farmacológicas, nutricionais e de manejo para aumentar a fertilidade de vacas leiteiras sob estresse térmico. In: XIII Curso Novos Enfoques na Produção e Reprodução de Bovinos, Uberlândia: Universidade Federal de Minas Gerais, 59-71.

Breuer K, Hemsworth PH, Barnett JL, Matthews LR, Coleman GJ (2000) Behavioural response to humans and the productivity of commercial dairy cows. Applied Animal Behaviour Science 66:273-288.

Buffington DE, Collazo Arocho A, Canton GH, Pitt D, Thatcher WW, Collier RJ (1981) Black globe humidity index (BGHI) as a comfort equation for dairy cows. Transactions of the ASAE 24:711-714.

Cunningham JG, Klein BG (2008) Tratado de fisiologia veterinária. 4 ed. Rio de Janeiro: Elsevier.

Detweiler D (1996) Regulação cardíaca. In: Reece S. Dukes Fisiologia dos animais domésticos. 11. ed. Rio de Janeiro: Guanabara Koogan, cap. 9, p. 157-169.

Ferreira F, Pires MFA, Martinez ML, Coelho SG, Carvalho AU, Ferreira PM, Facury Filho EJ, Campos WE (2006) Parâmetros fisiológicos de bovinos cruzados submetidos ao estresse calórico. Arquivo Brasileiro de Medicina Veterinária e Zootecnia 58:732-738.

Hopster HRMB, Bruckmaier RM, Van der Werf JTN, Korte SM, Macuhova J, Korte-Bouws G, Van Reenen CG (2002) Stress responses during milking; comparing conventional and automatic milking in primiparous dairy cows. Journal of Dairy Science 85:3206-3216.

Hötzel MJ, Machado Filho LP, Yunes MC, Silveira MCAC (2005) Influência de um ordenhador aversivo sobre a produção leiteira de vacas da raça Holandesa. Revista Brasileira de Zootecnia 34:1278-1284.

Instituto Brasileiro de Geografia e Estatística (IBGE) (2017) Pesquisa Pecuária Municipal. https://biblioteca.ibge.gov.br/visualizacao/periodicos/84/ppm_2016_v44_br.pdf. Acessado em: 23 de julho de 2018.

Lensink J, Boissy A, Veissier I (2000) The relationship between farmers' attitude and behaviour towards calves, and productivity of veal units. In Annales de Zootechnie 49:313-327

Martello LS, Júnior HS, da Luz S, Titto EAL (2004) Respostas fisiológicas e produtivas de vacas holandesas em lactação submetidas a diferentes ambientes. Revista Brasileira de Zootecnia 33:181-191.

Miranda JEC, Freitas AF (2009) Raças e tipos de cruzamentos para produção de leite. Empresa Brasileira de Pesquisa Agropecuária, Juiz de Fora, Brasil. Disponível em: https://www.infoteca.cnptia.embrapa.br/bitstream/doc/737102/1/CT98Racasetiposdecruzamentos.pdf. Acessado em: 29 de julho de 2018.

Monteiro AA, Tamanini R, Silva LCC, Mattos MR, Magnani DF, D'Ovidio L, Nero LA, Barros MAF, Pires EMF, Paquereau BPD, Beloti V (2007) Características da produção leiteira da região do agreste do estado de Pernambuco, Brasil. Semina: Ciências Agrárias 28:665-674.

Oliveira AL (2007) Mecanismos termorreguladores de cabras da raça Saanen. Tese, Universidade Estadual Paulista/Faculdade de Ciências Agrárias e Veterinárias.

Oliveira GCB, Silva RR, Veloso CM, Marques JDA, Dias DLS, Silva FF, Carvalho GGP, Leite LC, Lisboa MM, Abreu Filho G (2014) Interação ordenhador-vaca e as respostas comportamentais, produtivas e econômica dos animais. Archivos de Zootecnia 63:381-384.

Peters MDDP, Barbosa Silveira ID, Machado Filho P, Machado AA, Pereira LMR (2010) Manejo aversivo em bovinos leiteiros e efeitos no bem-estar, comportamento e aspectos produtivos. Archivos de Zootecnia 59:435-442.

Pinheiro AC, Saraiva EP, Saraiva CAS, Fonseca VFC, Almeida MEV, Santos SGGC, Amorim MLCM, Rodrigues Neto PJ (2015) Características anatomofisiológicas de adaptação de bovinos leiteiros ao ambiente tropical. Agropecuária Técnica 36:280-293.

Rosa MS (2004) Ordenha sustentável: a interação retireiro-vaca. Tese, Universidade Estadual Paulista/Faculdade de Ciências Agrárias e Veterinárias.

Silva RG (2000) Introdução a Bioclimatologia Animal. Nobel, São Paulo.

doi.org/10.31893/2318-1265jabb.v7n1p1-5