JOURNAL OF ANIMAL BEHAVIOUR AND BIOMETEOROLOGY

RESEARCH ARTICLE
Published Online: May 2, 2023
https://doi.org/10.31893/jabb.23013

Ingestive behavior of Holstein × Zebu cows managed on deferred supplemented pasture

Thamara Amaral Diniz[a] | Cinara da Cunha Siqueira Carvalho[b] ✉ | Victória Leite de Matos[b] | José Reinaldo Mendes Ruas[b] | Hugo Pereira Santos[c] | Maria Dulcinéia da Costa[a] | Mário Henrique França Mourthé[d] | Layza Lorena Medeiros Fonseca[b] | Hellem Cristiane Mendes Rocha[b] | Flávio Pinto Monção[b] | Vicente Ribeiro Rocha Júnior[b]

[a]Minerva Foods, Brazil.
[b]Universidade Estadual de Montes Claros, Departamento de Ciências Agrárias, Janaúba, MG, Brazil.
[c]Universidade Estadual do Sudoeste da Bahia, Itapeting, BA, Brazil.
[d]Instituto de Ciências Agrárias, Universidade Federal de Minas Gerais, Montes Claros, MG, Brazil.

Abstract This study aimed to evaluate the ingestive behavior of F1 Holstein × Zebu cows grazing on deferred pasture receiving different supplementation strategies. The experimental design was completely randomized, in a 3×4 factorial, with three supplementation strategies and four evaluation periods. The ingestive behavior of 24 cows divided into three groups of supplementation provided at milking was observed, and two of these groups received protein in the pasture. Ingestive behavior was monitored every 10 minutes for 24 hours and analyzed in the form of periods (morning, afternoon, night, and dawn) and total time. The animals remained longer grazing during the afternoon when the BGHI presented values of 83.8. Protein consumption did not influence grazing time but interfered with forage consumption. For the total grazing time, the animals in group 2 spent less time grazing. The groups of animals presented no difference concerning the time spent on rumination and idleness. During night and dawn, when the climate was characterized as thermal comfort, the animals spent more time ruminating. The climatic conditions did not influence the ingestive behavior, as the grazing peak was observed at times of higher BGHI. However, supplementation of the animals in group 2 modified the ingestive behavior of F1 H × Z cows.

Keywords: BGHI, crossbred dairy cattle, environment, ethology, supplementation

1. Introduction

Milk production faces a challenge when the climatic environment presents a combination of high temperatures and intense solar radiation throughout the year. These conditions modify the thermal equilibrium of the animal, which causes changes in the physiological and behavioral responses, resulting in decreased milk yield in tropical climate areas (Domingos et al 2013).

Climatic conditions and the seasonality of forage production influence the feeding behavior of grazing cattle. The climate interferes with the time devoted to grazing at the same time as the pasture, during drought periods, presents lowered nutritional value due to the lack of rains. As a strategy, pasture deferment is used to provide forage in these periods (Castro et al 2008). However, in the deferred pasture, there is an accumulation of stalks and dead tissues and a decrease in the quality of remaining leaves, which results in low dry matter intake by grazing animals, affecting the intake of energy, protein, and minerals (Malafaia et al 2003).

Thus, supplementation is adopted to correct the nutrient deficiency in the pasture, optimize the intake of dry matter and forage nutrients, and enhance animal performance (Santos et al 2004). Based on the above, this study aimed to evaluate the ingestive behavior of Holstein × Zebu F1 cows in deferred pastures receiving different supplementation strategies.

2. Materials and Methods

The experiment was conducted in Felixlândia-MG (18°43'S and 44° 52'O) during September (winter-spring) of 2017. The climate is classified as a savannah tropical, according to Köppen, with two distinct seasons: dry winter and rainy summer. The average annual rainfall is 1,126 mm, and the average annual temperature is a maximum of 29.7 °C and a minimum of 16.6 °C.

To evaluate the ingestive behavior, 24 Holstein × Zebu F1 lactating cows were assessed, showing means age of seven years and seven months, age at the first delivery of three years, the average period of lactation of 267 days, with a mean lactation of 2,835 kg day^{-1}. During the experiment, the average milk yield was 12 kg day^{-1}, and the average body weight was 546 kg.

A completely randomized design was used in a 3 × 4 factorial, with three supplementation strategies and four evaluation periods. The morning period was between 07:00 and 12:00, 12:00 to 18:00 (afternoon), 18:00 to 00:00 (night), and 00:00 to 06:00 (dawn).

The distribution of the animals was randomized into three groups of different supplementation strategies, with eight animals in each group: Group 1 - concentrate with 24.8% of crude protein (CP) + mineral supplement; Group 2 - concentrate with 17.6% of CP + protein supplement with 45.8% of CP; and Group 3 - concentrate with 24.8% of CP + protein supplement with 45.8% of CP.

For groups 1 and 3, 1 kg of concentrate was supplied during milking for every 3 kg of milk produced above 5 kg of initial milk. For group 2, 1 kg of concentrate was provided for every 3 kg of milk produced above the initial 0 kg. Mineral supplements (group 1) and protein supplements (groups 2 and 3) were available at will daily in troughs in the pasture. The individual protein supplement consumption was estimated using the difference between the offered and the daily leftovers and presented an average of 669 g day^{-1}.

The cows were kept in a 15ha area composed of two pastures, with 5 ha (group 1) and 10 ha (group 2 and 3), respectively, and a pasture of *Brachiaria decumbens* (*Uruchloa decumbens*), differed and managed in continuous grazing, divided in two paddocks with 5 ha (group 1) and 10 ha (group 2), respectively, with a stocking rate of 2.02 and 2.06 animals ha^{-1}. The paddocks were equipped with drinking fountains to supply water at will.

To evaluate the quantity and quality of the pastures, the samples of the grasses were collected (by the beginning, middle, and end of the experiment) by cutting all the plants contained in 5 cm of the soil at ten random points in the paddocks, using a square frame (0.25 m^2). Samples were also collected by the manual grazing simulation method to evaluate the chemical-bromatological composition of the pastures, according to Johnson (1978).

The paddocks were homogenous regarding forage supply (2,616.50 kg ha^{-1} and 3,008.80 kg ha^{-1}, respectively), according to AOAC (1990). The bromatological composition of the pastures presented an average of 84.50% of dry matter (DM); 2.45% crude protein (CP); neutral detergent fiber, corrected for ashes (NDFca) (Detman et al., 2012), and 48.51% of total digestible nutrients (NDT) (Weiss 1999). These characteristics confirm the difference of the pasture during the dry season, mainly for showing high contents of DM and NDF and low contents of CP.

For the supplements, the protein supplement showed 86.78% of DM, 45.84% of CP, and 7.84% of NDFca. Concentrate A presented 89.36% of DM, 17.62% of CP, and 40.13% of NDFca, while concentrate B presented 89.13% of DM, 24.81% of CP, and 19, 05% of NDFca.

The climatic variables data were monitored by measuring air temperature, relative humidity, dew point temperature, and black globe temperature, using two continuous reading RHT 10 data loggers programmed to perform the collection every 30 minutes. With this data, the black globe-humidity index (BGHI), proposed by Buffington et al (1981), was calculated.

To evaluate the activities of the ingestive behavior, the cows and the observers were submitted to an adaptation period of three days, and for the diet, 14 days. Behavioral observations were attributed to measuring the time spent by the animals grazing, ruminating, in idleness, and consuming the protein supplement in the trough. The samples were collected every 10 minutes (Silva et al 2008), starting at 9 am and finishing at 5 pm, comprising six consecutive days of observations (Pereira et al 2018).

Observations began at 21:00, when the animals returned from milking and continued until 1 pm, when the animals were removed from the pasture for the night milking, returning to the pasture at 3 pm, when observations continued until 5 am, on the next day, before the first milking (Pereira et al 2018).

The data were submitted for analysis of variance using PROC MIXED from SAS (SAS-Institute Inc; Cary; NC; USA). The homogeneity of the variances (PROC UNIVARIATE), the normality of the residues, and the additivity of the parameters were verified, and no significant effects were observed, attending the principles. Treatments and periods were included in the model as fixed effects factors, and the means, when significant by the F test, were compared by the Student-Newman-Keuls (SNK) test at a 5% level of significance.

3. Results

Regarding the climatic environment, it was verified that the highest values ($P < 0.05$) of air temperature were recorded in the afternoon (33.6 °C), followed by morning (31.8 °C), night (20.3 °C) and dawn (15.0 °C) (Figure 1). Relative humidity was lower than 40% ($P < 0.05$) in the morning (33.2%) and the afternoon (24.4%). Due to this low humidity, rapid evaporation in the animals can lead to skin irritation and general dehydration of the mucous membranes. When characterizing the comfort conditions to which the animals were exposed, it was found that in the morning and afternoon, the BGHI values (81.6 and 83.8, $P < 0.05$) of the environment were characterized as a danger sign; however, during the night and dawn, the environment was characterized as thermal comfort (BGHI<74).

In the analysis of ingestive behavior, there was an interaction ($P < 0.05$ and Standard error: 0,062) between treatments and grazing periods (Figure 2a and 2b). However, there was no interaction ($P > 0.05$) for the consumption time of the protein supplement. The animals in the control group remained 35.1 min day^{-1} and 47.5 min day^{-1} more grazing in the morning and dawn compared to the animals in the other groups ($P < 0.05$), and during the afternoon and night periods, the animals in groups 2 and 3 remained longer on grazing in comparison with the animals in the control group.

Regarding the total time of grazing, there was a difference ($P < 0.05$ and Standard error: 0,008) for the treatments, but there was no difference ($P > 0.05$) concerning the consumption of protein supplements (Figure 3). The animals of the control group and group 3 did not differ for the total grazing time, being 518.4- and 512.4-min day^{-1}, respectively. The animals in group 2 spent less time grazing (481.2 min day^{-1}).

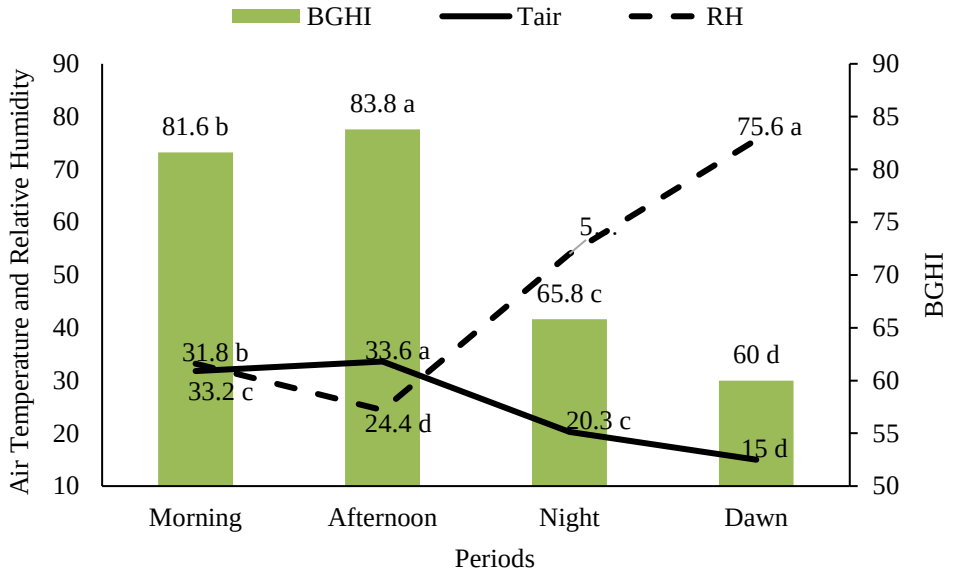


Figure 1 Mean values of climatic variables throughout the day, separated by periods.

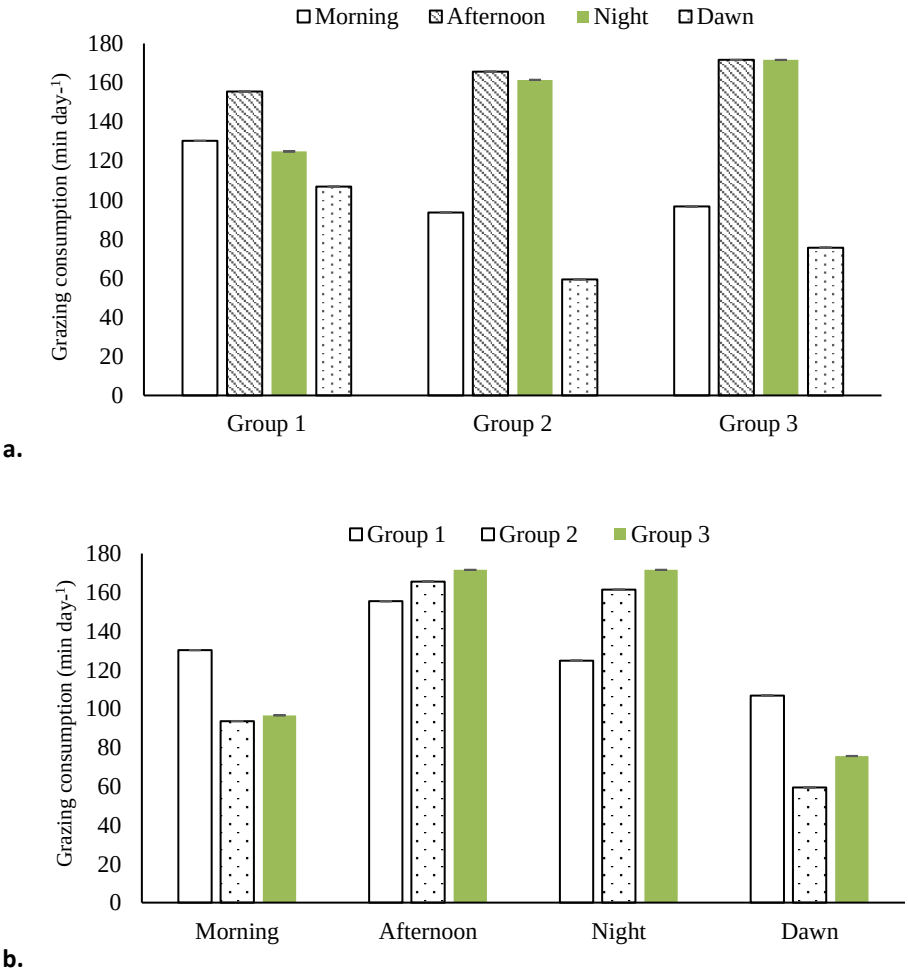


Figure 2 a. Time values on grazing consumption (min day^{-1}) of F1 Holstein x Zebu cows under different supplementation strategies in the groups. **b.** Time values on grazing consumption (min day^{-1}) of F1 Holstein x Zebu cows under different supplementation strategies in the periods.

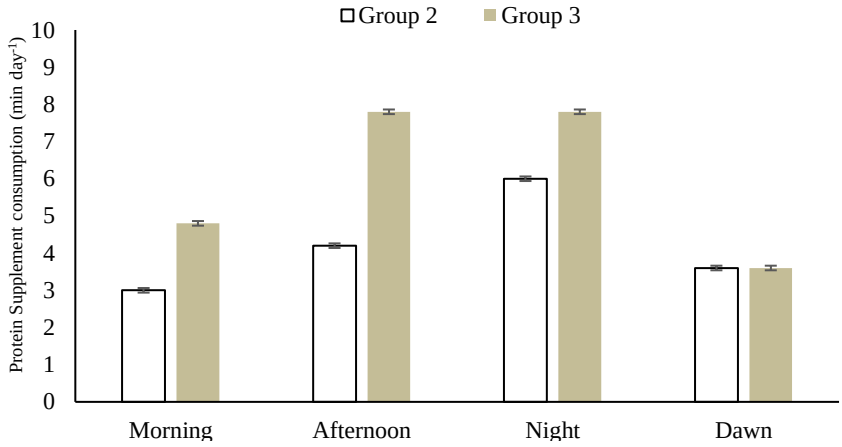


Figure 3 Time values on protein supplement consumption (min day^{-1}) of F1 Holstein x Zebu cows under different supplementation strategies in the groups.

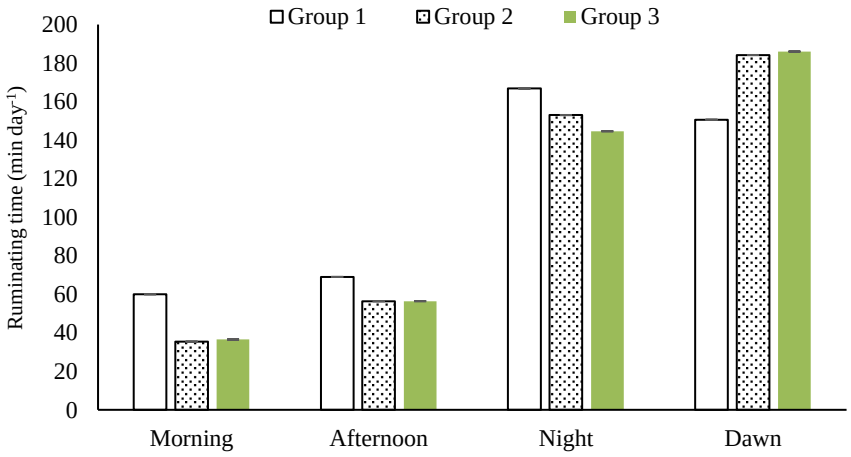


Figure 4 Ruminating time (min day^{-1}) values of F1 Holstein x Zebu cows under different supplementation strategies.

There was no interaction ($P > 0.05$ and Standard error: 0,108) for rumination time between treatments and periods (Figure 4). The animals spent more time ruminating in the morning, 173.4 min day^{-1}, followed by the nocturnal period, 154.8 min day^{-1}, and less time spent in rumination during the afternoon and morning, with a mean of 52.2 min day^{-1}. Regarding the total rumination time, there was no difference between treatments ($P > 0.05$), and the mean was 433.8 min day^{-1}.

In the time spent in leisure time, there was interaction ($P < 0.05$ and Standard error: 0.0784) for treatments and periods (Figure 5a and 5b). The animals remained longer in idleness during the night and dawn periods. In the night period, the control group stayed longer in idleness, 66.6 min day^{-1}, compared to the animals in groups 2 and 3, that dedicated around 38.4- and 37.2-min day^{-1}, because these animals spent time grazing during the night. However, during the dawn period, the groups did not differ ($P > 0.05$) due to the higher rumination peak occurring in this period. The total idle time did not differ ($P < 0.05$) concerning the groups.

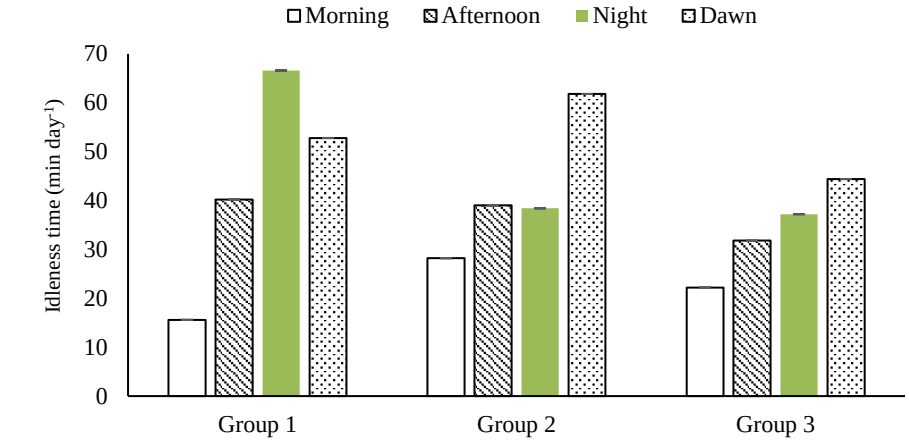
4. Discussion

Pereira et al (2018) evaluated the ingestive behavior of F1 Holstein × Zebu cows during the summer and found mean temperatures of 33.8 °C in the morning and 33.5 °C in the afternoon. However, as the air temperature decreased at night and dawn, the air humidity rose to 40-70%, the recommended value for most domestic species (Ferreira 2011).

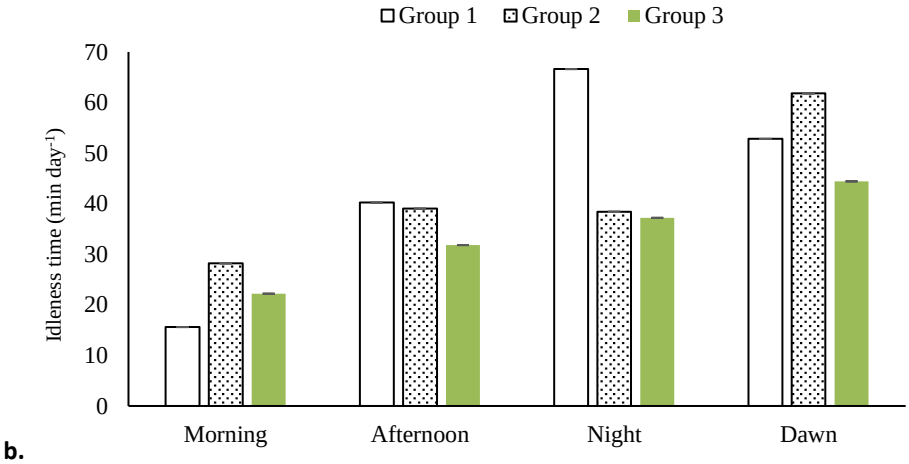
For the F1 animals, even with high air temperature and low relative humidity values, the animals did not modify their behaviors in the morning and afternoon, emphasizing the adaptation of F1 Holstein x Zebu cows. Diniz et al (2017) evaluated the adaptability of F1 Holstein × Zebu cows in the semi-arid region of Minas Gerais (Brazil) state during the spring. The climatic environment was characterized as an emergency in the afternoon due to a BGHI of 87.6 and an air temperature of 37.8 °C. Castro et al (2018), evaluating the physiological responses of F1 Holstein × Zebu cows during the summer in the central region of Minas Gerais, recorded an emergency situation with BGHI maximum values of 87.7 at noon.

The behavior ingestive of the animals of the control group in the morning can be explained by the fact that they did not receive the protein supplement and, upon arriving in

the pasture after milking, there is a need to graze to supply energy and nutritional demand. Unlike the animals in groups 2 and 3, the protein supplement was replaced in the morning, stimulating consumption and impacting the grazing time once the animals became satiated.



a.



b.

Figure 5 a. Idleness time (min day^{-1}) values of F1 Holstein x Zebu cows under different supplementation strategies in the groups. **b.** Idleness time (min day^{-1}) values of F1 Holstein x Zebu cows under different supplementation strategies in the periods.

The highest time spent on grazing occurred when air temperature and BGHI were high (Table 1). In these same periods, the highest protein supplement consumption was also registered, influencing forage consumption. Mader et al (2010) reported the opposite situation since they noted that dairy cattle in a thermal stress environment show decreased food intake. For Pires and Campos (2003), grazing peaks occur at times of day when the air temperature is lower because of thermal comfort. Because these animals are F1 and adapt to high air temperatures, their ingestive behavior was not altered, as they reached grazing peaks under thermal stress conditions.

The animals in groups 2 and 3 consumed the protein supplement even at night, resulting in decreased grazing (satiety) during dawn. In contrast, the animals in group 1 kept grazing as they could not access the protein supplement.

The total time of grazing for the animals of groups 1 and 2, not been deferred, can be justified by the supplementation with 24.8% of CP during milking since such supplementation stimulates forage consumption due to the supply of N-NH_3 to the ruminal microorganisms, thus requiring a longer grazing time (Malafaia et al 2003). For the animals of group 2, the total grazing time decreased, and the supplementation by offering more energy (17.6% of CP) suppressed the energy intake of the animals, acting as a signal in the decrease in food consumption (Hodgson 1990).

Silva et al (2005), evaluating the behavior of Holstein × Zebu crossbred heifers with different levels of protein supplementation, found an average of 452.81 min day^{-1}. Carlotto et al (2010) found values for average daily grazing time for cows supplemented with common salt, mineral salt and protein salt of 515-, 490- and 494-min day^{-1}, respectively. Still, there was no influence of supplementation but of the structure and composition of the grass – anonni 2 to which they were subjected.

It is possible to infer that the supplementation influenced total grazing time and that the use of the protein did not; however, it maintained the physical state and the

productive performance of the animals, mainly at a time of the year in which there are restrictions of quality and quantity forage due to drought and high temperatures.

In addition, the F1 Holstein x Zebu animals ruminate during the periods of the day in which the climatic environment provides comfort, so there is greater absorption of the caloric increase from the diet (Fischer et al 2002; Pereira et al 2018). According to Van Soest (1994), time spent in rumination is influenced by the nature of the diet and, therefore, proportional to the cell wall content of the roughages (the more significant the addition of roughages in the diet, the longer the time spent in rumination). Furthermore, Silva et al (2005) stated that the efficacy of food rumination is positively affected by the increase of dry matter in the diet.

Based on the presented data, it is possible to infer that, in environments characterized as dangerous and emergency, F1 Holstein × Zebu cows can be managed without compromising feed consumption due to the adaptability and rusticity conferred by heterosis.

5. Conclusions

Supplementation with 17.6% CP leads to a reduction in total grazing time. The highest grazing peak of the animals was observed when the BGHI values were high; that is, the climatic conditions do not influence the ingestive behavior of F1 H × Z cows.

Ethical considerations

The project was evaluated and approved by the Committee of Ethics in Animal Experimentation and Welfare of the State University of Montes Claros (UNIMONTES) - case # 145/2017.

Conflict of Interest

Declare that there is no conflict of interest.

Funding

This work was carried out with the support of the Coordination of Improvement of Personnel of the superior level - Brazil (CAPES) - Code of financing 001. The Epamig by the availability of the place and animals; to Fapemig, for financial support (PPM 00558-16); to Finepe and MCTI, for the financial support to the project nº 1334/13; to INCT-Animal Science; and UNIMONTES.

References

AOAC - Association of Official Analytical Chemists.(1990) Official methods of analysis. 15. ed. Washington.

Buffington DE, Collazo-Arocho A, Canton GHW, Pitt D, Thatcher WW and Collier RJ (1981) Black-Globe-Humidity Index (BGHI) as comfort equations for dairy cows. Transactions of the ASAE, St. Joseph 24:711-14.

Castro ALO, Carvalho CCS, Ruas JRM, Pereira KCB, Menezes GCC and Costa MD (2018) Physiological parameters of F1 Holstein x Zebu cows reared in environments with and without shading. Brazilian Archive of Veterinary Medicine and Animal Science 70:722-730. doi:10.1590/1678-4162-9305

Carlotto SB, Medeiros RB, Pellegrini CB, Garcia RPA, Lisboa CAV and Saibro JC (2010) Diurnal ingestive behavior of primiparous cows on native pasture dominated by grass- annoni-2 with protein and mineral supplementation in different seasons. Brazilian Journal of Zootechnics 39:454-461. doi: 10.1590/S1516-35982010000300002

Detmann, E. et al. (2012) Methods for food analysis. Viscount of Rio Branco: Supreme, 214.

Diniz TA, Carvalho CCS, Ferreira HB, Castro ALO, Pereira KCB, Gonçalves MCM, Soares TE and Menezes JC (2017) F1 Holstein x Zebu cows in the final third of gestation show physiological adaptation when raised in the semi-arid environment. Journal of Agroveterinary Sciences 16:70-75.

Domingos HGT, Maia ASC, Souza JBFJ, Silva RB, Vieira FMC and Silva RG (2013) Effect of shad and water sprinkling on physiological responses and milk yields of Holstein cows in a semi-arid region. Livestrock Science 154:169-174. doi: 10.1016/j.livsci.2013.02.024

Ferreira RA. (2011) Greater Production with Better Environment: For Poultry, Swine and Cattle Publisher: Learn Easy, Viçosa, Minas Gerais.

Fischer V, Deswysen AG, Dutilleul P and Boever J (2002) Nictemeral Distribution Patterns of Ingestive Behavior of Dairy Cows, at the Beginning and at the End of Lactation, Fed with a Diet Based on Corn Silage. Brazilian Journal of Zootechnics 31:2129-2138. doi: 10.1590/S1516-35982002000800029

Hodgson J (1990) Grazing management: Science into practice. Longman Scientific and Technical, Longman Group, London, UK.

Johnson AD (1978) Sample preparation and chemical analysis of vegetation. In: t´Mannetje, L. (Ed.). Measurement of grassland vegetation and animal production. Aberystwyth: Commonwealth Agricultural Bureaux 96-102.

Mader TL, Johnson LJ and Gaughan JB (2010) A comprehensive index for assessing environmental stress in animals. Journal of Animal Science 88:2153-2165. doi: 10.2527/jas.2009-2586

Malafaia P, Cabral LS, Vieira RAM, Costa RM and Carvalho CAB (2003) Protein-energy supplementation for cattle raised on pastures: Theoretical aspects and main results published in Brazil.Livestock Research for Rural Development 15.

Pereira KCB, Carvalho CCS, Ruas JRM, Menezes GCC, Castro ALO and Costa MD (2018) Effect of the climatic environment on ingestive behavior of f1 Holstein x Zebu cows. Brazilian Journal of Animal Health and Production (UFBA)19:100-108. doi:10.1590/S1519-99402018000200006

Pires MFA, Campos, AT (2008) Animal Comfort for increased milk production. Technical Production Center – CPT, Viçosa, Minas Gerais, 254.

Santos EDG, Paulino MF, Queiroz DS, Valadares FILHO SC, Fonseca DM and Lana RP (2004) Evaluation of deferred grazing of Brachiaria decumbens Stapf.: 1. Chemical-bromatological characteristics of forage during drought. Brazilian Journal of Zootechnics 33:203-213. doi: 10.1590/S1516-35982004000100024

Silva RR, Silva FF, Carvalho GGP, Franco IL, Veloso CM, Chaves MA, Bonomo P, Prado IN and Almeida FS (2005) Ingestive behavior of feedlot holland x zebu crossbred heifers. Animal Science Archives 54:75-85.

Silva RR, Prado IN, Carvalho GGP, Santana JR HÁ, Silva FF and Dias DLS (2008) Effect of using three observation intervals on the accuracy of the results obtained in the study of the ingestive behavior of grazing dairy cows. Brazilian Animal Science 9: 319-326.

Van Soest PJ (1994) Nutritional ecology of the ruminant. 2.ed. Ithaca: Cornell University Press, 476.

Weiss W (1999) Energy prediction equations for ruminant. In: Cornell Nutrition Conference for Feed Manufacturers, 61. Ithaca. Proceedings, Cornell University. Ithaca 176-185.