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Effect of frequency of protein-energetic supplementation on the performance and ingestive behavior of Nellore calves kept in a tropical pasture in the dry season

Frequência de suplementação proteico-energética sobre o desempenho e comportamento ingestivo de bezerros Nelore mantidos em pastagem tropical na estação seca

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Abstract

With the objective to evaluate different frequencies of supplementation on the performance and ingestive behavior of Nellore calves kept on *Urochloa brizantha* cv. Marandu pasture, 56 animals with initial average body weight (BW) of 174.5 kg were submitted to the following treatments: no supplement and 1x, 3x, and 7x supplementation per week. The supplement was provided in the amount of 3.5 g kg^{-1} of BW day^{-1}. BW and evaluation of behavior were assessed every 28 days. The randomized block's design with two repetitions was used. The analyses of variance were carried out by the GLM procedure in the SAS software, and the means were compared by the Tukey's test at 5% significance. The supplementation increased the average daily gain (ADG; $P \leq 0.05$); however, it did not differ between frequencies (0.005, 0.190, 0.183, and 0.177 kg $head^{-1}$ day for the no supplement treatment and 1x, 3x, and 7x per week, respectively). The animals in the no supplement treatment showed longer grazing time ($P \leq 0.05$) compared to those receiving the supplement. However, results did not differ between frequencies (10.44, 8.57, 8.32, and 8.59 hours day^{-1} for no supplement treatments and 1x, 3x, and 7x per week, respectively). Thus, the frequency of supplementation can be reduced to once a week without reducing animal performance.
Key words: Grazing. Marandu-grass. Management. Weight gain.

Resumo

Com o objetivo de avaliar diferentes frequências de suplementação sobre o desempenho e comportamento ingestivo de bezerros Nelore mantidos em pasto de *Urochloa brizantha* cv. Marandu, 56 animais, com peso corporal (PC) inicial de 174,5 kg, foram submetidos aos seguintes tratamentos: sem suplementação,

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1x, 3x e 7x por semana. O suplemento foi oferecido na quantidade de 3,5 g kg^{-1} de PC dia^{-1}. A pesagem e a avaliação do comportamento foram feitas a cada 28 dias. O delineamento foi de blocos inteiramente casualizados com duas repetições. As análises de variância foram realizadas pelo procedimento GLM do SAS e as médias comparadas pelo teste de Tukey a 5% de significância. A suplementação aumentou o ganho médio diário (GMD; $P \leq 0{,}05$), porém não diferiu entre as frequências (0,005, 0,190, 0,183 e 0,177 kg dia^{-1} para sem suplementação, suplementados 1x, 3x e 7x, respectivamente). Os animais do tratamento sem suplementação apresentaram maior tempo de pastejo ($P \leq 0{,}05$) em relação aos animais suplementados, porém não diferiram entre as frequências (10,44, 8,57, 8,32 e 8,59 horas dia^{-1} para aqueles sem suplementação, 1x, 3x e 7x respectivamente). Assim a frequência de fornecimento pode ser reduzida para uma vez por semana, sem prejuízo ao desempenho animal.

Palavras-chave: Ganho de peso. Capim-marandu. Manejo. Pastejo.

Introduction

The cost for labor to provide protein-energetic supplementation for pasture cattle can significantly contribute to the total cost of production. Reducing the frequency of supplementation can reduce labor and transportation costs, with potential for increased profits (DREWNOSKI; POORE, 2012). Bonadimann et al. (2017) found that the supplementation concentrated in three times a week did not affect the performance of animals but led to a reduction in the distribution of labor costs necessary to provide concentrated supplement during the rainy season.

The use of highly energetic supplements with a high proportion of rapidly fermentable non-structural carbohydrates can reduce ruminal pH when supplied in high quantity and in a sporadic manner, affecting the multiplication of cellulolytic bacteria and reducing consumption, digestibility, and weight gain in cattle (DREWNOSKI et al., 2011). However, Morais et al. (2009) observed that when supplementation is provided in small amounts (3.5 g kg^{-1} BW day^{-1}), the frequency of supplementation can be reduced to as little as three times a week without causing an alteration in ruminal parameters such as pH, volatile fatty acids, and ammoniacal nitrogen. In addition, this decrease in the supplementation frequency does not alter the grazing time and the performance of cattle kept in the pasture of *Urochloa brizantha* cv. Marandu.

The use of more challenging frequencies of supplementation, such as once a week, should be tested to investigate the possible changes in weight gain and ingestive behavior of cattle kept on tropical pastures during the dry season. Thus, this study evaluated the effects of different frequencies of protein-energetic supplementation on the performance and ingestive behavior of Nellore calves kept in *Urochloa brizantha* cv. Marandu in the dry season.

Material and Methods

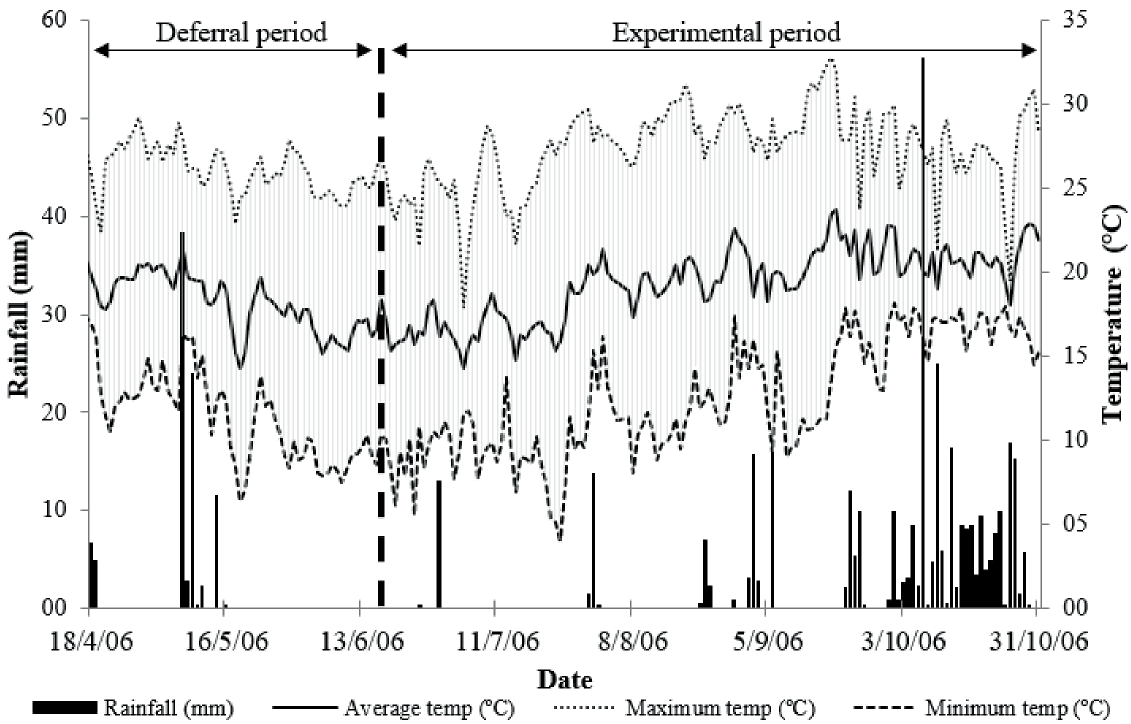
The experimental protocols were approved by the Animal Ethics Committee of the Federal University of Mato Grosso do Sul (number 119 in 2006).

The experiment was conducted at the Água Limpa Farm (FAL), which belongs to the University of Brasília (UNB) and is located in the Federal District of Brazil at 15°55’12.55” south latitude and 47°55’12.55” west longitude and at an altitude close to 1,000 meters. According to the Köppen classification, the climate is Aw (tropical seasonal savanna) and is situated between tropical savannah and temperate rainy dry winter, with an average rainfall of 1,550 mm annually. The soil is classified according to the Brazilian Soil Classification System (EMBRAPA, 2013) as a typical dystrophic Red-Yellow Latosol with a very clayey texture, tropical Cerrado sub-deciduous phase, and flat surface.

The experimental period lasted 140 days, from June 13 to October 31 of 2006. Rainfall and temperature variations during this period were obtained at the FAL-UNB automatic weather station (Figure 1).

The experimental area consisted of eight paddocks of approximately two hectares each, established with pastures of marandu grass, *Urochloa brizantha* (Hochst. Ex A. Rich) R. D. Webster, cv. Marandu, [syn. *Brachiaria brizantha* (Hochst. ex A. Rich) Stapf] and provided with drinkers and feed bunks for the supply of free-choice mineral and the protein-energetic supplement. The pasture was deferred for 56 days prior to the experiment to guarantee a good supply of forage mass to the animals.

Figure 1. Rainfall and average temperature during pasture deferral and experiment (April-October of 2006) at the Água Limpa Farm, Federal District, Brazil.



Fifty-six calves of the Nellore breed, aged eight months and mean BW of 174.5 ± 21 kg, were used in the experiment. The animals were divided into 8 groups, corresponding to four treatments with two replicates. The calves were maintained in continuous grazing but were rotated in the paddocks every seven days to eliminate possible effects, particular for each paddock, on weight gain.

The animals were identified with earrings of five different colors, numbered, and distributed randomly in the following treatments: no supplementation - control treatment; 1x - supplementation provided once a week on Wednesdays; 3x - supplementation provided three times a week (Mondays, Wednesdays, and Fridays); and 7x - supplementation provided daily. The supplement was offered in the feed bunks, always close to 01:00 p.m., in the amount of 3.5 g kg^{-1} BW day^{-1}. All groups were given free-choice mineral *ad libitum* with the following composition: Ca - 120 g kg^{-1}, P - 88 g kg^{-1}, Na - 132 g kg^{-1}, S - 12 g kg^{-1}, Zn - 3630 mg kg^{-1}, Mn - 1300 mg kg^{-1}, Co - 55,5 mg kg^{-1}, Cu - 1530 mg kg^{-1}, Fe - 1800 mg kg^{-1}, Se - 15 mg kg^{-1}, I - 75 mg kg^{-1}, and F - 880 mg kg^{-1}.

Table 1 describes the distribution of ingredients and the chemical composition of the protein-energetic supplement.

The animals were weighed at the beginning of the experiment and subsequently every 28 days. They were kept in water-and-feed fasting for 16 hours before weighing. The average daily gain (ADG) was calculated by the difference between final weight and initial weight in each experimental period, divided by the number of days in the period.

The evaluation of the supplied pasture dry matter was carried out on the first day of each experimental period by cutting the grass 5 cm high from the soil. For that, 16 samples of forage contained within the area of a 0.5 m² metal rectangle, randomly allocated, were collected in each experimental paddock. After weighing the collected material, two subsamples were selected, stored in plastic bags, properly identified, and sent to the laboratory for further analysis. The first subsample was placed in paper bags and dried in a forced air ventilation oven at 65 °C for 72 hours for the determination of dry matter (DM) and forage mass estimation. The manual separation of green blade (green leaves), stem (stem and sheath), and dead material (dried and/or dead leaves) were performed in the second subsample to determine the morphological constitution of the plant expressed as the percentage of total weight.

Table 1. Ingredients and chemical composition of the protein-energetic supplement offered to calves kept on *Urochloa brizantha* cv. Marandu pasture in the dry season.

Item	% of DM
Supplement composition	
Corn	70
Soybean meal	24
Urea	3
Mineral mixture[1]	3
Chemical composition	
Dry matter	88.51
Crude protein	25.93
Neutral detergent fiber	12.38
Acid detergent fiber	11.86
Ethereal extract	3.75
Non-fibrous carbohydrates	58.56
Ashes	4.81
TDN	83.95

[1]Mineral mixture composition: g kg^{-1} (Ca 150, P 42, S 48, Mg 36, Na 70) mg kg^{-1} (Co 50, Cu 600, Fe 1500, I 40, Mn 1400, Se 10, Zn 2400, F 420).
DM, dry matter; TDN, total digestible nutrients.

The protein-energetic supplement and forage samples were analyzed according to the AOAC (1990): dry matter (DM) with method 930.15; crude protein (CP) with method 976.05; ethereal extract (EE) with method 920.39; and ashes with method 942.05. The filter bag technique using a Tecnal unit (TE-149; Tecnal, Piracicaba, SP, Brazil) was used for the analyses of neutral detergent fiber (NDF) using 5 x 5 cm filter bags and 100 µm porosity (non-woven fabric) in which 0.5 g of forage sample was added. These bags were subsequently immersed in a neutral detergent solution (VAN SOEST et al., 1991) in the Tecnal equipment. The same methodology used for the NDF was used to determine the acid detergent fiber (ADF); however, an acid detergent solution was used (VAN SOEST et al., 1991). Non-fibrous carbohydrates (NFC) were calculated according to Hall (2000) using the equation: NFC = 100 - [(%total CP - %CP urea + % urea) + (%NDF) + %EE + %ashes]. The *in vitro* dry matter digestibility (IVDMD) was analyzed according to Goering and Van Soest (1970). The percentage of total digestible nutrients (TDN) in the supplement was obtained by the equation proposed by Cappelle et al. (2001): TDN = 91.0246 - (0.571588 x NDF).

The animal behavior data were obtained visually and documented by four observers (one for every 2 paddocks); these observers were previously trained and placed in observation towers with the aid of binoculars with 16x magnifying lenses. The data collection started at 07:00 a.m. and ended at 07:00 p.m. (720 minutes) each day. Five observations were conducted during the experiment (one at each period). The animals in the treatments receiving the 1x and 3x supplementation per week were observed on the day of supplementation and on the day when there was no supplement in the feed bunks; the data tabulation of these two treatments used the average of these two days of observation. Behavioral activities were observed in all animals in the group. The time spent per animal on the activities of grazing, ruminating, resting, at the feed bunk, at the drinker, and in the salt trough, were estimated from observations made every 10 minutes. The time of supplement in the feed bunks was obtained by the difference between the time when the supplement was totally consumed, and the time it was provided.

The experimental design was of completely randomized blocks with two replicates. The paddocks were considered as experimental units in all analyzes. The statistical analyzes were performed through analysis of variance using the GLM procedure of the SAS software (Statistical Analysis System, Inst. Inc. Cary, NC) and the means were compared by the Tukey's test at 5% significance.

Results and Discussion

The amount of forage mass varied during the experimental periods (Figure 2). It was increased between the beginning of the experiment (June) and July, with a subsequent reduction until the end of the experiment (October). The highest proportion of green leaves was observed in June, decreased until September, and increased again in October. Conversely, the highest proportion was observed in June and the lowest in October. The dead material showed the lowest proportion at the beginning of the experimental period and increased at the end of the study. The high amount of forage mass observed in the first three months of the experiment (mean of 7,302 kg of DM ha^{-1}) occurred due to the deferral of the pasture for 56 days before the beginning of the experiment. The water deficit that occurred during the experimental period (Figure 1) resulted in low forage production, and in association with animal consumption, the amount of forage mass was reduced to values close to 4,000 kg DM ha^{-1} in October.

Due to the high proportion of leaves at the beginning of the experiment, the animals consumed preferentially this morphological constituent. However, due to the low rainfall at the beginning of the experiment and this high consumption of leaves, this resource diminished until September. Rainfall increased in September, and leaf regrowth began, increasing the number of leaves in the following month. The animals increased the consumption of stem in August due to the low proportion of leaves, which was reflected in the reduction of this constituent until the end of the experiment.

Throughout the experiment, the proportions between green leaves and stems were observed as low. These can be attributed to plant maturation, low rainfall, and animal consumption. These factors reduce forage quality by increasing the proportion of fiber and lignin and reducing soluble carbohydrates, with consequent reduction of digestibility, microbial protein production, and weight gain (DIXON; STOCKDALE, 1999).

The forage DM contents were 45, 51, 61, 59, and 44% in the months of June, July, August, September, and October, respectively. The levels of CP (Figure 3) were low throughout the experiment, with values lower than 3.2% in the DM. The lowest forage CP content occurred in August and the highest in October. High levels of NDF were observed throughout the experiment, with mean values of 74.6%. The ADF levels were also high, averaging 47.6%; the lowest value was observed in June, with a linear increase during the following months. The highest IVDMD was observed in June, with a decrease until September, and a small increase at the end of the experiment (October).

Figure 2. Average production (kg of DM ha-1) per period of forage mass and proportion of green leaf, stem, and dead material of *Urochloa brizantha* cv. Marandu in the dry season.

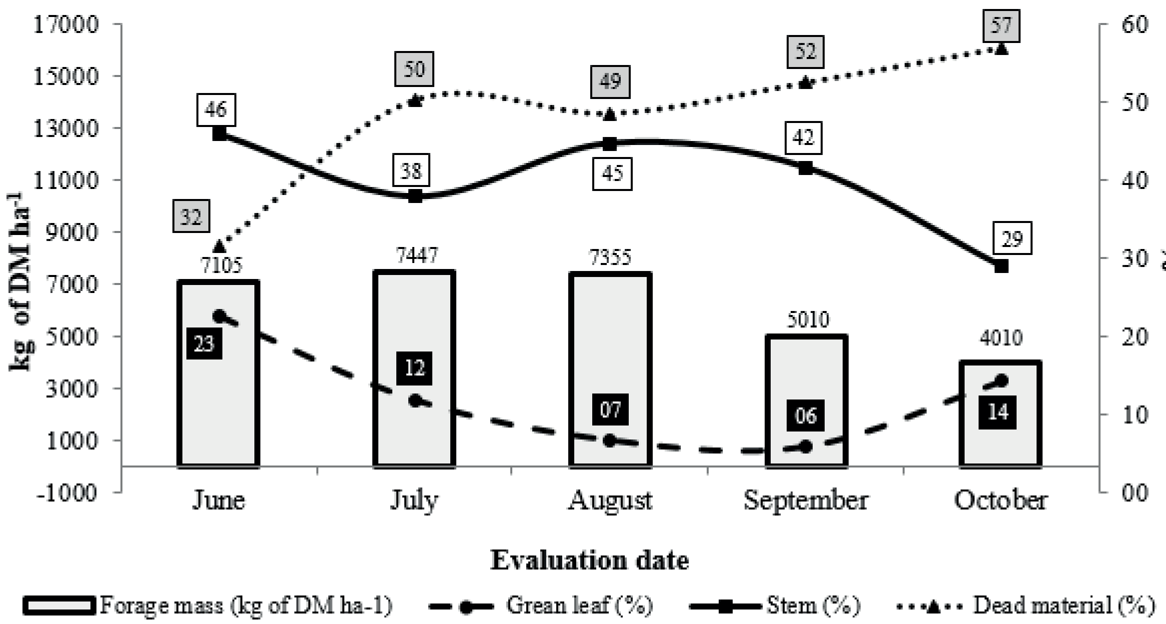
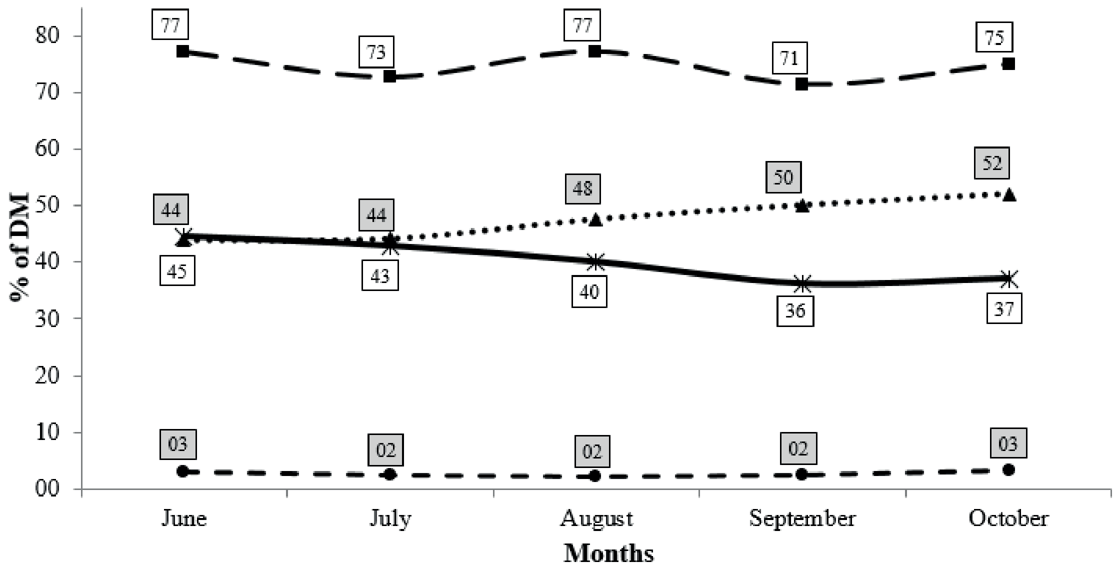


Figure 3. Chemical composition and *in vitro* digestibility of *Urochloa brizantha* cv. Marandu in the dry season.



CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; IVDDM, *in vitro* digestibility of the dry matter.

The reduction in the number of leaves during the experiment with alteration in the ratio between green leaves and stem, associated with the increase of dead material, was reflected in the reduction of forage digestibility and increase in fiber contents. The levels of CP below 3.2% throughout the experiment, if not corrected via supplementation, may affect the multiplication of ruminal microorganisms and as a consequence, reduce the rate of forage passage and consumption. This occurs when CP values are less than 8% (DETTMANN et al., 2014).

The final BW (BWf), average daily gain (ADG), and final stocking rate (FSR) presented the same statistical behavior, being higher ($P \leq 0.05$) in the supplemented animals when compared to the non-supplemented group (Table 2). However, no differences ($P > 0.05$) were observed in these parameters between the frequencies of supplementation used.

The highest ADG observed in the supplemented animals is a consequence of the greater contribution of essential nutrients such as CP, TDN, and minerals. The supply of these nutrients through supplements may have contributed to increasing the consumption of forage. The increase in consumption, with the use of a concentrated supplement in diets based on low-quality forage, is due to a positive associative effect usually attributed to the addition of nutrients that are limiting for microorganisms such as nitrogen, sulfur, and others. The supply of these nutrients to ruminal microorganisms causes their multiplication rate to be high, reflecting in an increase in the rate of passage, consumption, and consequently weight gain (DIXON; STOCKDALE, 1999).

Table 2. Growth performance and stocking rate of calves receiving different frequencies of supplementation and kept on *Urochloa brizantha* cv. Marandu pasture in the dry season.

	Treatments[2]					
Item[1]	No supplementation	1x	3x	7x	SEM	P value
BWi	175.56	172.11	176.01	174.65	5.855	0.9662
BWf	176.11[b]	201.10[a]	200.11[a]	199.43[a]	2.769	≤0.0001
SRi	1.36	1.33	1.37	1.36	0.014	0.3926
SRf	1.37[b]	1.55[a]	1.57[a]	1.55[a]	0.037[a]	0.0409
ADG	0.005[b]	0.190[a]	0.183[a]	0.177[a]	0.020	≤0.0001

[1]BWi, initial body weight; BWf, final body weight; SRi, initial stocking rate; SRf, final stocking rate; ADG, average daily gain.
[2]No supplementation, control treatment; 1x - supplementation provided once a week on Wednesdays; 3x - supplementation provided three times a week (Mondays, Wednesdays, and Fridays); and 7x - supplementation provided daily.
SEM - standard error of the mean.

The absence of the effect of the frequency of supplementation on the ADG and BWf of animals corroborates the results obtained by Morais et al. (2014). These authors provided three supplementation frequencies (daily and 3 and 5 times a week) in the proportion of 5 g kg^{-1} of BW day^{-1} to Nellore cattle kept on *Urochloa brizantha* cv. Marandu; although these amounts were higher than those used in the present study (3.5 g kg^{-1} BW day^{-1}), the authors did not observe differences on growth performance, forage intake, dietary supplement intake, and digestibility. This indicates that the adaption of animals to variability in nutrient intake does not alter performance.

Morais et al. (2009) tested three supplementation frequencies (daily and 3 and 5 times a week) in the proportion of 3.5 g kg^{-1} of BW day^{-1} in Nellore steers kept on *Urochloa brizantha* cv. Marandu pasture and did not observe an alteration in the ruminal parameters of fermentation such as pH, volatile fatty acids, and ammoniacal nitrogen. The authors could conclude that the evaluated parameters were maintained even after reducing the frequency of supplementation, which is important for ruminal fermentation, intake, and diet digestibility. In low-quality diets with low CP levels (as in the present study), the effects of reducing the frequency of supplementation are less evident than in higher-quality diets. This is mainly due to the increased efficiency of nitrogen recycling in low-quality diets (FARMER et al., 2004).

The results of ingestive behavior are presented in Table 3. The grazing time was reduced with the supplementation ($P \leq 0.05$); however, the frequency of supply did not produce any change. The resting time was higher ($P \leq 0.05$) in animals submitted to the treatment of receiving the supplement 3x per week compared to those without supplementation. However, it did not differ from the 1x and 7x treatments. The animals that received supplementation remained longer at the feed bunk compared to those that did not receive it ($P \leq 0.05$). However, there was no difference between the different frequencies of supplementation. The time in the drinker, consuming free-choice mineral or ruminating did not differ ($P > 0.05$) between treatments. The time of rationing in the feed bunk was longer ($P \leq 0.05$) in animals in the 1x treatment, followed by the 3x and 7x treatments.

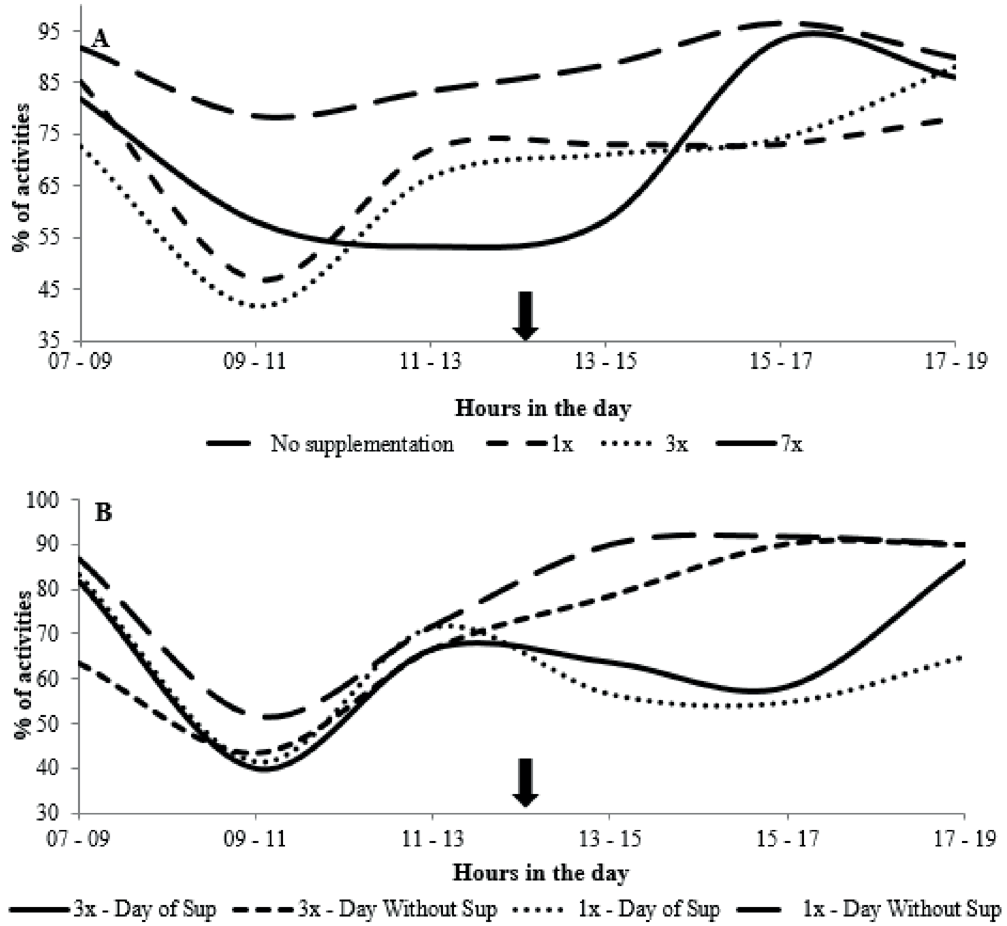
Table 3. The ingestive behavior of calves receiving different frequencies of supplementation and kept on *Urochloa brizantha* cv. Marandu pasture in the dry season.

Item	Treatments[1]				SEM	P value
	No supplementation	1x	3x	7x		
Grazing	10.44^{a}	8.57^{b}	8.32^{b}	8.59^{b}	0.2634	≤0.0001
Ruminating	0.46	0.86	0.91	0.85	0.1439	0.1280
Resting	0.68^{b}	1.16^{ba}	1.81^{a}	1.41^{ba}	0.2175	0.0080
Feed bunk	0.00^{b}	1.06^{a}	0.60^{a}	0.77^{a}	0.179	0.0047
Drinker	0.32	0.29	0.26	0.30	0.0620	0.9082
Salt	0.10	0.06	0.13	0.08	0.0450	0.7174
Ration time in the feed bunk	0^{e}	47.46^{a}	10.49^{c}	1.53^{d}	0.1400	≤0.0001

[1]No supplementation, control treatment; 1x - supplementation provided once a week on Wednesdays; 3x - supplementation provided three times a week (Mondays, Wednesdays, and Fridays); and 7x - supplementation provided daily.
SEM - standard error of the mean.

Figure 4A shows that the animals without supplementation spent most of their time in grazing activities; the greatest values were observed between 07:00 and 09:00 a.m. and 03:00 and 05:00 p.m. The animals supplemented 7x showed a reduction in grazing time from 09:00 a.m. to 03:00 p.m., but there was a high increase in the period from 03:00 p.m. to 5:00 p.m. The animals supplemented 1x and 3x showed a similar proportion of average grazing time (mean days with and without supplementation). The highest values were observed at the beginning (07:00 to 09:00 a.m.) and at the end of the day (05:00 to 07:00 p.m.), and the lowest values were observed from 09:00 to 11:00 a.m. When the 1x and 3x supplemented animals were evaluated separately on the day of supplementation and also on the day when there was no supply of supplement in the feed bunk (Figure 4B), the proportion of grazing time diminished on the day of supplementation at 01:00 p.m. at 05:00 p.m., and increased at the same times on days when there was no supplementation.

Figure 4. Effect of supplementation frequencies on grazing time (% of activities) in Nellore calves kept on *Urochloa brizantha* cv. Marandu pasture in the dry season. Figure A shows the percentage of time used for grazing according to treatments: no supplementation - control treatment; 1x - supplementation once a week on Wednesdays; 3x - supplementation 3 times per week (Mondays, Wednesdays, and Fridays); and 7x - daily supplementation. Figure B shows the percentage of time used for grazing in the 1x and 3x treatments on the day of supplementation (Day of Sup) or without supplementation (Day without Sup). Arrows indicate supplementation delivery times.



The reduction in grazing time during the days with supplements compared to those without supplements was probably due to the partial replacement of time to consume concentrate. Supplemented animals may have increased grazing time during non-evaluated periods. According to Dixon and Stockdale (1999), low supplement amounts, as used in the present experiment (3.5 g kg^{-1} of PC day^{-1}), hardly reduce forage intake; in addition, the associative effect of the supplement under these conditions may even occur, increasing the forage consumption.

The grazing time was not influenced by the frequency of supplementation. These results were similar to those found by Morais et al. (2014). According to these authors, when the supply is not daily, on days when the supplement is provided the animals spend more time consuming supplement and reduce the time of grazing. However, on days when they do not receive a supplement, grazing time increases, so the frequency of feeding does not affect the total hours of grazing or average grazing time during the week. This result shows the adaptation of animals to search for food when they are given an inconstant supply of supplements.

Conclusions

The supply of protein-energetic supplement reduced the grazing time in Nellore calves kept on *Urochloa brizantha* cv. Marandu pasture; however, the frequency of supplementation did not alter this variable.

The provision of a supplement increases animal weight gain, but the frequency with which it is provided does not alter cattle performance. Thus, the supplementation frequency can be reduced to up to once a week for low-consumption supplements (3.5 g kg^{-1} BW day^{-1}). This approach results in a reduction of production labor and operating expenses without compromising animal performance.

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References

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS - AOAC. Association of Official Analytical Methods Inc. 15th ed. Arlington: AOAC, 1990. 770 p.

BONADIMANN, R.; MORAES, E. H. B. K.; MORAES, K. A. K.; PINA, D. S.; OLIVEIRA, A. S.; MENESES, D. M.; STINGUEL, H.; ALMEIDA, C. M. Frequency of concentrate supplementation for grazing beef cattle. *Semina: Ciências Agrárias,* Londrina, v. 38, n. 4, p. 2141-2150, 2017.

CAPPELLE, E. R.; VALADARES FILHO, S. C.; SILVA, J. F. C. da; CECON, P. R. Estimativas do valor energético a partir de características químicas e bromatológicas dos alimentos. *Revista Brasileira de Zootecnia,* Viçosa, MG, v. 30, n. 6, p. 1837-1856, 2001.

DETTMANN, E.; VALENTE, E. E. L.; BATISTA, E. D.; HUHTANEN, P. An evaluation of the performance and efficiency of nitrogen utilization in cattle fed tropical grass pastures with supplementation. *Livestock Science*, Amsterdam, v. 162, n. 1, p. 141-153, 2014.

DIXON, R. M.; STOCKDALE, C. R. Associative effects between forages and grains: consequences for feed utilization. *Australian Journal of Agricultural Research*, Collingwood, v. 50, n. 5, p. 757-773, 1999.

DREWNOSKI, M. E.; POORE, M. H. Effects of supplementation frequency on ruminal fermentation and digestion by steers fed medium-quality hay and supplemented with a soybean hull and corn gluten feed blend. *Journal of Animal Science,* Champaign, v. 90, n. 3, p. 881-891, 2012.

DREWNOSKI, M. E.; POORE, M. H.; BENSON, G. A. Effect of frequency of supplementation of a soyhulls and corn gluten feed blend on hay intake and performance of growing steers. *Animal Feed Science and Technology*, Amsterdam, v. 164, n. 1, p. 38-44, 2011.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA. Sistema brasileiro de classificação de solos. 3. ed. Brasília, DF: EMBRAPA, 2013. 353 p.

FARMER, C. G.; COCHRAN, R. C.; NAGARAJA, T. G.; TITGEMEYER, E. C.; JOHNSON, D. E.; WICKERSHAM, T. A. Ruminal and host adaptations to changes in frequency of protein supplementation. *Journal of Animal Science*, Champaign, v. 82, n. 3, p. 884-894, 2004.

GOERING, H. K.; VAN SOEST, P. J. *Forage fiber analyses (apparatus, reagents, procedures, and some applications).* Washington: U. S. Government Printing Office, 1970. 20 p. (Agriculture Hand Book No. 379 ARS -USDA).

HALL, M. B. *Calculation of non-structural carbohydrate content of feeds that contain non-protein nitrogen.* Gainesville: University of Florida, 2000. 76 p. (Bulletin, 339).

MORAIS, J. A. S.; BERCHIELLI, T. T.; QUEIROZ, M. F. S.; ABDELHAFID, K.; REIS, R. A.; SOUZA, S. F. Influence of supplementation frequency on intake, digestibility and ruminal fermentation in beef cattle steers grazing palisade grass. *Revista Brasileira de Zootecnia*, Viçosa, MG, v. 38, n. 9, p. 1824-1834, 2009.

MORAIS, J. A. S.; QUEIROZ, M. F. S.; KELI, A.; VEGA, A.; FIORENTINI, G.; CANESIN, R. C.; REIS, R. A.; BERCHIELLI, T. T. Effect of supplementation frequency on intake, behavior and performance in beef steers grazing Marandu grass. *Animal Feed Science and Technology*, Amsterdam, v. 189, n. 1, p. 63-71, 2014.

VAN SOEST, P. J.; ROBERTSON, J. B.; LEWIS, B. A. Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, Champaign, v. 74, n. 10, p. 3583-3597, 1991.