Effects of supplement type and narasin inclusion on supplement intake by *Bos indicus* beef bulls grazing a warm-season forage

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ABSTRACT: This study aimed to evaluate the effects of supplement type and narasin inclusion on the frequency and supplement intake of grazing *Bos indicus* beef bulls. Four hundred animals were ranked by initial BW (383 ± 35 kg) and allocated into one of four paddocks of *Brachiaria brizantha* cv. Marandú (100 animals/paddock). Paddocks were randomly assigned to receive either a mineral salt (MIN) or a protein-energetic supplement (PREN) containing or not narasin (N) for a 90-d period. An individual electronic data capture system with 11 feed bunks was used to individually measure supplement intake and meal frequency in each paddock. The evaluations and analysis of individual intake, frequency of visits to the feeder, and intake per visit (I/V) were performed every 15 d and classified as periods (PR1 through PR6). All data were analyzed as a 2 × 2 factorial design with the PROC MIXED procedure of SAS. A supplement type × N × PR interaction was observed ($P < 0.0001$) for daily supplement intake. No differences were observed between MIN, whereas PREN had a greater ($P \leq 0.03$) supplement intake on PR1 and PR3, but a reduced supplement intake on PR6 compared with PREN + N ($P = 0.02$). Moreover, no supplement type × N interaction ($P = 0.47$) or N ($P = 0.44$) effects were observed for daily supplement intake in the present study. A supplement type × N × PR interaction was detected ($P < 0.0001$) for the frequency of visits in the feeders. Throughout the experimental period, animals from the MIN + N had a greater ($P \leq 0.02$) frequency of visits compared with MIN cohorts. A supplement effect was detected for I/V ($P = 0.02$), whereas neither a narasin effect ($P = 0.74$) nor interactions ($P \geq 0.16$) were observed. Animals offered PREN had a greater I/V when compared with MIN cohorts (145 vs. 846 g/d for MIN and PREN, respectively; SEM = 16.1). When these data are reported as percentage of days visiting the feeder within each PR, MIN and MIN + N animals visited the feeder for 25.8% and 35.9% of the days, respectively. Conversely, no differences were observed ($P = 0.65$) in the overall mean visits per PR between PREN and PREN + N (12.8 vs. 12.3 d for PREN and PREN + N, respectively; SEM = 0.195). As percentage of days visiting the feeder, PREN and PREN + N visited the feeder for 85.1% and 81.9% of the days, respectively. In summary, narasin inclusion did not reduce supplement intake, regardless of supplement type, but increased the frequency of visits to the feeder for the MIN treatment.

Key words: frequency of visits, grazing, intake, narasin, supplement

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INTRODUCTION

Worldwide, a large proportion of the livestock industry relies largely on forages as the source of nutrients for meat and milk production. In conventional beef production systems (cow-calf, stocker, and feedlot), forages represent up to 81% of the feedstuff required for a beef animal from birth to slaughter (Watson et al., 2015). In tropical areas, the major forage sources available for grazing are warm-season C_4 forages and although these have greater productivity compared with cool-season forages, their nutritional composition is inferior (Bohnert et al., 2011). This difference is primarily due to the reduced nonstructural carbohydrates (NSC) and CP concentrations, as well as greater fiber content in warm-season grasses (Wilson et al., 1983; Barbehenn and Bernays, 1992). During a significant portion of the year, tropical grasses often do not have the balanced nutrient composition that allows an adequate rumen environment and fiber digestion, intake, and subsequent performance. Hence, supplementation programs are often required to optimize cattle performance (McDowell and Arthington, 2005).

Among the supplementation strategies available, mineral and/or protein-energy supplementation are often adopted in pasture-based systems. As an example, Fieser et al. (2007) and Cappellozza et al. (2014a, 2014b) demonstrated that mineral only and protein-energy supplementation improved the performance of beef steers and heifers, respectively, compared with nonsupplemented cohorts. Nonetheless, the intake of salt-based mineral supplements is extremely variable among animals, year, and season (Arthington and Swenson, 2004), but research in this area is very limited. Additionally, the use of ionophores increases cattle performance in pasture-based systems (Fieser et al., 2007; Silva et al., 2015), decreases supplement intake, and increases the variability of intake across animals and over time (Cockwill et al., 2000). Narasin is an ionophore that improved the performance of grazing beef cattle, without affecting supplement intake (Silva et al., 2015). Based on this rationale, we hypothesized that the inclusion of narasin into mineral and protein-energy supplements would reduce the daily and/or animal variation of intake in grazing beef cattle, without a negative impact on supplement intake. Hence, our objective was to evaluate the effects of narasin inclusion into mineral salt- and protein-energy-based supplements on supplement intake and frequency of intake of growing beef bulls.

MATERIALS AND METHODS

This experiment was conducted at a commercial beef cattle operation (Fazenda Mata Roxa) located in Corumbaíba, state of Goiás, Brazil (18°08′33″ S, 48°33′41″ W, and elevation of 622 m) from January to May 2015. All cattle used were cared for in accordance with acceptable practices and experimental protocols reviewed and approved by the Elanco Institutional Animal Care Use and Committee.

Animals and Diets

This study was divided into a 30-d adaptation phase (days 30 to 1) and a 90-d intake treatment phase.

On day 30 of the experiment, 400 Nelore bulls were ranked by initial shrunk BW (after 16 h of feed and water restriction; 383 ± 35 kg; 22 ± 3 mo of age) and allocated into one of four paddocks of *Brachiaria brizantha* cv. Marandú with an approximate area of 65 ha each (1 paddock/treatment and 100 animals/paddock) in a manner that all paddocks had equivalent initial average shrunk BW. Paddocks were randomly assigned to receive, in a 2 × 2 factorial design, a mineral salt (MIN) or a protein-energy supplement (PREN) containing or not narasin (N). This design resulted in four treatments that were offered for a 90-d period: 1) mineral supplementation (MIN; Fosbovi 20; DSM Produtos Nutricionais, São Paulo, Brazil; n = 100), 2) MIN + narasin supplementation (MIN + N; Zimprova, Elanco Saúde Animal, São Paulo, Brazil, n = 100), 3) MIN + inclusion of protein and energy sources (PREN; Fosbovi Protéico Energético 45 Águas; DSM Produtos Nutricionais; n = 100), and 4) PREN + narasin supplementation (PREN + N; Zimprova, Elanco Saúde Animal; n = 100). From days 30 to 1, animals received the supplement treatments only (MIN or PREN), without the inclusion of narasin, to ensure animals were trained to the system location in each individual paddock. Additionally, animals were not rotated among pastures, but forage sampling was performed to evaluate the availability and nutritional profile of the paddocks, as well as to mitigate any potential differences between treatments (or paddocks).

On day 0 of the study, narasin supplementation began for MIN + N and PREN + N cattle. The MIN and PREN supplements were designed

Table 1. Nutritional profile of the supplements (mineral and protein-energy) offered daily for the entire experiment

Item	MIN[a]	PREN[a]
Calcium, g/kg	107.0 to 132.0	25.0 to 28.0
Phosphorus, g/kg	88.0	18.0
Sulfur, g/kg	12.0	10.0
Sodium, g/kg	126.0	15.6
Cobalt, mg/kg	55.5	3.0
Copper, mg/kg	1,530.0	250.0
Iron, mg/kg	1,800.0	–
Iodine, mg/kg	75.0	10.0
Manganese, mg/kg	1,300.0	400.0
Selenium, mg/kg	15.0	3.00
Zinc, mg/kg	3,630.0	700.0
Fluorine, mg/kg	880.0	180.0
Item as g/kg of product		
CP	–	450.0
NPN (% CP)	–	306.3
TDN	–	600.0

Treatments were offered on a daily basis throughout the experimental period (days 0 to 90).

[a]MIN = Mineral salt supplement (*n* = 200; Fosbovi 20; DSM Produtos Nutricionais); PREN = Protein-energy mineral supplementation (*n* = 200; Fosbovi Protéico Energético 45 Águas; DSM Produtos Nutricionais).

to be self-limiting supplements and their expected intake, according to the manufacturer label, was 25 and 170 g/100 kg of BW, respectively. Nutritional profile of the supplements is described in Table 1. Based on the aforementioned expected supplement intake, MIN + N and PREN + N were formulated to contain 1,779 and 180 mg of narasin/kg of supplement DM, respectively, and to deliver 120 to 150 mg of narasin per head/d. Throughout the experimental period, all animals had ad libitum access to the treatments and water.

The amount of supplement to be offered to the respective MIN and PREN treatments was based on previous day intake plus 10% to account for day-to-day variation of intake and also to allow orts, so the animals would be able to select the feed they were consuming.

An individual electronic data capture system (Intergado; Contagem, Minas Gerais, Brazil) with 11 feed bunks built and placedwithin each of the four paddocks was used in the present study for treatment delivery. The full description of the equipment and the validation of the system were described by Chizzotti et al. (2015). Briefly, all 11 feed bins contained an ear tag detector in the front side of the feeder so that every time an animal was entering the feeder, the bin could be read, identified, and the intake was measured via a scale with load cells located underneath each bin. All animals were fitted with an ear tag containing a passive transponder and had free access to each of the 11 feed bins within each paddock. The system documented the duration of each visit, number of visits, and supplement intake by recording the animal ID, bin number, initial and final times of each visit, and the amount of feed consumed by each animal. Individual supplement intake was continuously recorded throughout the experimental period (days 0 to 90), whereas data were exported to Intergado Web Software and reports were generated on a daily basis. In case of a malfunctioning ear tag was observed, the system recorded the supplement intake and duration of the visit and classified this event as “zero tag.” Moreover, if such event occurred, the animal was removed from the analysis and returned only after the ear tag was replaced by a new one during the handling activities performed every 30 d.

Sampling

Evaluation of individual supplement DMI and frequency of visits to the feeder were determined every 15 d and were classified into periods, such as days 0 to 15 = Period 01 (PR1), days 16 to 30 = Period 02 (PR2), days 31 to 45 = Period 03 (PR3), days 46 to 60 = Period 04 (PR4), days 61 to 75 = Period 05 (PR5), and days 76 to 90 = Period 06 (PR6). The cumulative 15-d intake was used as repeated measures of treatments and individual treatment intake was evaluated on a daily basis throughout the experimental period to ensure ad libitum availability. The frequency of visits to the feeder was calculated based on total number of visits within each period (PR1 through PR6) and during the entire experimental period (days 0 to 90). Based on the intake and visit to the feeder data, the intake per visit (I/V) was calculated, whereas results were compiled and analyzed as PR.

Herbage mass was determined by hand-clipping forage to ground level inside a 1 m^2 quadrant (20 random locations within each pasture), as described by Fieser et al. (2007). Clipping was performed at the beginning of each PR to determine minimum forage allowance as 2.0% of BW and 1.2% NDF intake and to ensure no forage intake restriction associated with availability occurred. Clipped samples were dried in a forced-air oven at 50°C and weighed for DM determination. Herbage mass was calculated by recording the DM weight per 1 m^2 from clipped sample and converted to kg of DM/ha for each paddock. The estimated forage availability was further classified into low (L) or high (H), by calculating the median of the herbage mass values. Moreover, forage samples were also collected monthly and sent to a commercial laboratory for nutrient content analysis (Labtec Laboratório de Análises Químicas, Hortolândia, SP, Brazil). At collection, care was taken to ensure minimal soil contamination of the forage samples. Calculation of forage TDN concentration was performed according to the equations proposed by Weiss et al. (1992), and samples were analyzed in duplicates by wet chemistry procedures for concentrations of CP (method 984.12; Association of Official Analytical Chemists (AOAC), 2006), ADF (method 973.18 modified for use in an Ankom 200 fiber analyzer; Ankom Technology Corp., Fairport, NY; AOAC, 2006), and NDF (Van Soest et al., 1991; modified for use in an Ankom 200 fiber analyzer; Ankom Technology Corp.).

Statistical Analysis

Animal was considered the experimental unit. All data were analyzed using the PROC MIXED procedure of SAS (Version 9.3; SAS Institute Inc.; Cary, NC) and the Satterthwaite approximation to determine the denominator df for the test of fixed effects. Given the fact that the forage availability was measured within each PR, treatment intake and frequency of visits were averaged to meet forage mass evaluation. Hence, the model statement used for frequency of total treatment intake contained the effects of supplement type (MIN or PREN), narasin inclusion, PR, and all resulting interactions. Data were analyzed using animal (supplement × narasin) and forage availability (L or H) as random variables. The specified term for the repeated statement was period, whereas animal (supplement × narasin) was the subject. The autoregressive 1 covariance structure was selected as it provided the smallest Akaike information criterion. Results are reported as least square means and separated using the PDIFF. Significance was set at $P \leq 0.05$ and tendencies were denoted if $P > 0.05$ and $P \leq 0.10$. Results are reported according to the main effects if no interactions were significant or according to the highest-order interaction detected.

RESULTS AND DISCUSSION

The main objective of the present study was to evaluate the frequency of intake and supplement intake of *Bos indicus* bulls consuming only a mineral- or a protein-energy-based supplement with or without the addition of narasin. This goal was proposed based on multiple studies in the literature that reported a lack of efficacy of supplements offered to grazing animals (Bagley et al., 1988; Goulart, 2010), suggesting that there might be an erratic intake of supplement by the grazing beef herd. A secondary goal was to evaluate whether narasin supplementation would affect the frequency and supplement intake of grazing animals.

Two distinct and unexpected events were observed in the present study that reduced the number of observations in each 30-d period for all treatment groups: 1) malfunctioning ear tags and 2) animals that did not visit the feed bunk during the evaluation period. These were analyzed as a 30-d period, due to the reduced incidence that did not allow the evaluation within each 15-d period, as performed for the other variables. The number of malfunctioning ear tags was not affected by treatment ($P = 1.00$; 9.0, 9.0, 7.7, and 11.0 malfunctioning tags for MIN, MIN + N, PREN, and PREN + N, respectively; SEM = 6.64) or period ($P = 0.21$; 11.0, 8.5, and 8.0 for days 0 to 30, 31 to 60, and 61 to 90, respectively; SEM = 3.22). Additionally, the number of animals that did not visit the feed bunks was also similar across treatments ($P = 0.84$; 8.3, 1.3, 1.0, and 0.7 animals for MIN, MIN + N, PREN, and PREN + N, respectively; SEM = 6.89) or PR ($P = 0.25$; 3.0, 1.8, and 3.8 animals for days 0 to 30, 31 to 60, and 61 to 90, respectively; SEM = 3.51). It is important to mention that even with the occurrence of these events, the number of observational units was more than adequate to provide powerful results and the study integrity was not compromised.

The forage nutritional profile in each paddock and herbage mass are shown in Table 2. These data demonstrate that forage was below the recommendations for this forage cultivar (Minson, 1990; NRC, 1996), which in turn would result in greater grazing time and a reduced forage selection ability by the herd. Nonetheless, when forage DMI was simulated using 2.0% of BW of DMI and/or 1.2% of BW in NDF, the nutrient consumption from forage was sufficient to maintain an adequate performance of the animals (Mertens, 1994; NRC, 1996, 2016).

A supplement type × narasin × period interaction was observed ($P < 0.0001$) for daily supplement intake. This interaction occurred primarily because no differences were observed between the mineral supplements, whereas PREN had a greater ($P \leq 0.03$) supplement intake on PR1 and PR3, but a reduced supplement intake on PR6 compared with PREN + N ($P = 0.02$; Table 3). Moreover, no supplement type × narasin interaction ($P = 0.47$) or

Table 2. Nutritional profile and the availability of the forage used in the present study (*B. brizantha* cv. Marandú)

Item	MIN	MIN + N	PREN	PREN + N
Day 0				
DM, %	30.8	29.7	29.1	28.2
CP, % DM	6.71	7.60	7.20	7.95
NDF, % DM	75.9	76.8	77.9	76.1
ADF, % DM	39.2	38.9	42.2	41.6
TDN[a], % DM	52.7	52.8	51.2	51.5
Day 30				
DM, %	25.2	21.5	29.7	30.2
CP, % DM	6.03	6.08	6.75	6.62
NDF, % DM	79.8	78.3	76.0	74.0
ADF, % DM	45.6	41.2	43.5	42.0
TDN, % DM	49.6	51.7	50.6	51.3
Day 60				
DM, %	29.5	29.2	24.9	23.6
CP, % DM	5.97	4.98	5.58	5.79
NDF, % DM	71.6	74.7	69.8	71.4
ADF, % DM	42.1	43.3	41.2	41.5
TDN, % DM	51.3	50.7	51.7	51.6
Forage availability (kg of DM/ha)[b]				
PR1	975	1,126	980	1,162
PR2	883	952	896	1,188
PR3	919	1,008	882	1,006
PR4	937	1,194	964	837
PR5	921	1,081	965	853
PR6	1,042	1,090	795	928

Samples for nutritional profile were collected monthly, whereas the samples for forage availability were performed every 15 d throughout the experimental period.

[a]Calculations were performed according to the equations proposed by Weiss et al. (1992).

[b]Forage availability was estimated by clipping the forage to ground level.

narasin (P = 0.44) effects were observed for daily supplement intake in the present study (Table 3), indicating that narasin inclusion did not affect the daily supplement intake of grazing *B. indicus* beef bulls, regardless of supplement type. These data are in agreement with Silva et al. (2015), who reported that the inclusion of 1300 mg of narasin/kg of mineral salt did not negatively affect the supplement intake of *B. indicus* beef heifers. Moreover, Polizel et al. (2017) reported that the administration of 1083 mg of narasin/kg of mineral salt to grazing *B. indicus* beef steers did not reduce mineral supplement intake during an 84-d feeding period. The narasin dosage consumed by the animals from Silva et al. (2015) and Polizel et al. (2017) was 15.6 and 15.8 ppm, respectively. Similarly, Gobato et al. (2017) reported similar mineral salt intake of beef heifers receiving a high-concentrate diet (84% of diet DM) over a 28-d experimental period.

During the present study, regardless of narasin inclusion, the mineral salt intake was well below the expectations and these data will be discussed hereafter (25 g/100 kg BW). Moreover, the CV (%) for the treatment groups within each period are reported in Table 4 and ranged from 64.6% to 137.1% for MIN, 65.2% to 102.1% for MIN + N, 36.1% to 46.1% for PREN, and 31.8% to 47.7% for PREN + N. In comparison to our results, Fieser et al. (2007) reported greater mineral intakes and lower CV values (24% to 43%) of mineral intake containing or not monensin in beef steers grazing wheat pasture. Importantly, the nature of these differences might be due to the location of the mineral feeder, which was near the water source, and the pasture size (7.3

Table 3. Supplement intake of *B. indicus* beef bulls receiving a mineral supplement containing or not (MIN) protein-energy (PREN) with or without narasin (N)

	MIN		PREN			P value[a]			
Item	N−	N+	N−	N+	SEM	Supp	N	Supp × N	Supp × N × PR
Daily supplement intake, g/d	37.7	38.6	743.1	705.2	26.75	< 0.0001	0.44	0.47	< 0.0001
Period									
1	39.1	42.1	891.9[a]	712.5[b]	39.80				
2	16.4	19.1	613.8	582.0	39.79				
3	40.0	41.7	656.5[a]	549.5[b]	39.63				
4	42.4	36.6	691.3	597.0	39.66				
5	44.4	50.9	813.0	851.0	39.62				
6	44.1	41.3	792.2[a]	939.0[b]	39.80				

MIN = Mineral salt supplement (Fosbovi 20; DSM Produtos Nutricionais); MIN + N = MIN + narasin (1,779 mg/kg; Zimprova; Elanco Animal Health); PREN = Protein-energetic mineral supplement (Fosbovi Protéico Energético 45 Águas; DSM Produtos Nutricionais); PREN + N = PREN + narasin (180 mg/kg; Zimprova). Different letters on the same line denote differences at the $P < 0.05$ level.

[a]Supp = Main effect of supplement; N = main effect of narasin; Supp × N = 2-way interaction of supplement type × narasin; Supp × N × PR = 3-way interaction of supplement type × narasin × period.

to 9.7 ha vs. 65 ha). Therefore, steers in Fieser et al. (2007) were in closer proximity to mineral feeders and housed in a smaller area compared with the bulls in the present study. Moreover, data from the present study might reflect the reality of commercial grazing beef operations in Brazil (extensive), where pastures are larger and animals usually travel long distances to access the mineral feeder and the water through.

A supplement type × narasin × period interaction was detected ($P < 0.0001$) for the frequency at which the animals visited the feeders (Figure 1A and B). Throughout the experimental period, animals from the MIN + N had a greater ($P \leq 0.02$) frequency of visits in the feeder compared with MIN cohorts (Figure 1A). When these data are reported as percentage of days visiting the feeder within each 15-d period, MIN and MIN + N animals visited the feeder for 25.8% and 35.9% of the days, respectively. In agreement with our results, Aubel et al. (2011) also reported a similar low frequency of mineral salt intake (approximately 3 d) in mature beef cows during a 14-d period of evaluation (21%). To the best of our knowledge, this is the first research article demonstrating that ionophore inclusion into a mineral supplement increased the frequency of feeder visits and the reason for these results are unknown, but deserve further investigation. This might be extremely important, primarily because some of the nutrients delivered through a mineral mixture are required on a daily basis and a greater frequency of intake represents a greater

Table 4. Period and overall mean coefficient of variation (CV %) for the intake of the supplements offered to the animals in the present study

	Treatments			
Period	MIN	MIN + N	PREN	PREN + N
01	64.6%	84.0%	36.1%	32.5%
02	137.1%	102.1%	40.2%	37.7%
03	103.1%	65.2%	41.7%	31.8%
04	85.5%	74.8%	40.8%	34.7%
05	76.5%	66.2%	39.5%	47.7%
06	75.6%	78.9%	46.1%	47.1%
Mean	90.4%	78.5%	40.7%	38.6%

MIN = Mineral salt supplement (Fosbovi 20; DSM Produtos Nutricionais); MIN + N = MIN + narasin (1,779 mg/kg; Zimprova; Elanco Animal Health); PREN = Protein-energy mineral supplement (Fosbovi Protéico Energético 45 Águas; DSM Produtos Nutricionais); PREN + N = PREN + narasin (180 mg/kg; Zimprova).

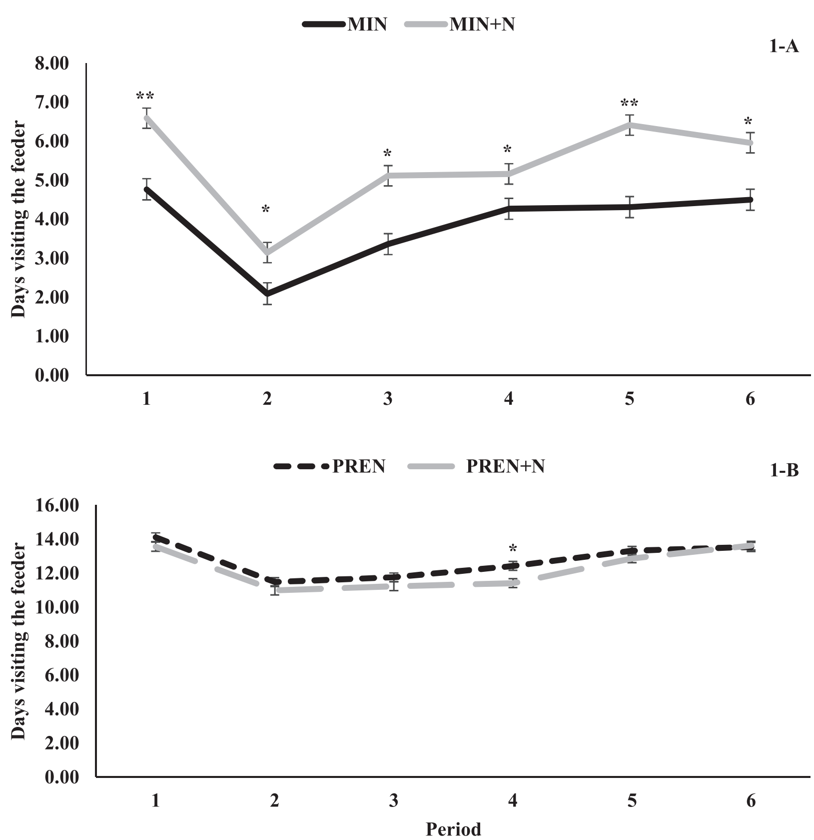

Figure 1. Frequency at which *B. indicus* bulls offered mineral (MIN; $n = 100$) or protein-energy (PREN; $n = 100$) supplements containing (MIN + N [$n = 100$] and PREN + N [$n = 100$], respectively) or not narasin visited the feeder during the experiment. A supplement type × narasin × period interaction was observed ($P < 0.0001$). Error bars represent the SE of the least square means. (A) reports the comparison between MIN and MIN + N, whereas (B) reports the comparison between PREN and PREN + N. *Differences between treatments at the $P < 0.05$ level. **Differences between treatments at the $P \leq 0.01$ level.

amount of nutrients delivered on a daily basis. Additionally, previous research demonstrated that ionophore supplementation improved ruminal and intestinal absorption of several minerals, including Mg, K, P, Zn, and Cu, in cattle receiving a high-concentrate (Starnes et al., 1984) and a high-forage (Spears et al., 1990) diet, indicating that this technology might benefit the mineral regulation and/or metabolism within the body of ruminants.

On the other hand, animals from the PREN had a greater (P = 0.04) frequency of visits compared with PREN + N cohorts only during PR3 (Figure 1B), which was not sufficient to influence the overall mean of visits per period (P = 0.65; 12.8 vs. 12.3 d for PREN and PREN + N, respectively; SEM = 0.195). This difference may be partially attributed to the reduced numerical herbage mass observed in paddocks from PREN animals compared with PREN + N cohorts (Table 2). When these data are reported as percentage of days visiting the feeder, PREN and PREN + N cohorts visited the feeder for 85.1% and 81.9% of the days, respectively. Based on that, even when a PREN supplement is offered to the herd, the frequency of visits is not maximized (or 100%), indicating that in a grazing extensive system and independently of the supplement type, daily intake of supplement by the entire herd is not often observed and the animal-to-animal variation is not something that can be managed through different supplementation strategies (Bowman and Sowell, 1997). In fact, the same authors (Bowman and Sowell, 1997) reported that the animal-to-animal variation is the biggest factor accounting for the variation in mineral intake. However, there are other factors that influence the consumption of mineral mixtures and were not evaluated herein, including soil fertility and forage type, season, energy and protein availability, individual requirements, salt content of the water, palatability of the mineral mixture, availability of fresh minerals, and physical form of minerals (McDowell, 1996; Bowman and Sowell, 1997).

A supplement effect was detected for I/V (P = 0.02), whereas neither a narasin effect (P = 0.74) nor interactions ($P \geq 0.16$) were observed. As expected, animals offered PREN had a greater I/V when compared with MIN cohorts (145 vs. 846 g/d for MIN and PREN, respectively; SEM = 16.1). These data also demonstrate that when the animals visit the feeder (either MIN or PREN), individual supplement intake is within the recommended and expected range. Additionally, narasin seems to increase the frequency of intake of the herd, without effects on the I/V, suggesting a more regular pattern of nutrient intake when this molecule is included into supplements.

In accordance with the aforementioned, Figures 2 and 3 demonstrate the number of animals visiting the system, average intake for the animals that visited the feeder, and the average intake divided by the total number of animals in the mineral salt (MIN and MIN + N) and protein-energy (PREN and PREN + N) groups. On days 19 and 38 (MIN + N only), 39, 59, 88 (MIN only), and 29 and 75 (both groups) of the study, intake measurements were not performed due to issues with the system. Similarly, intake was not recorded on days 5 and 56 (PREN only) and 20 (PREN + N only). Corroborating the data discussed above and by evaluating the figures, it is clear that when the animals visit the mineral salt feeder, most of the times, they consume the amount required/expected based on their BW. Similarly, they consumed the expected amount of narasin for both MIN and PREN supplements (data not shown). However, the number of animals visiting the system on a daily basis is extremely variable and low, and this fact might be responsible for the variation in the performance data obtained with mineral salt supplementation and reported in the literature (Bagley et al., 1988; Reffett-Stabel et al., 1989; Fieser et al., 2007). Although much less variable, the intake and number of animals visiting the PREN feeders were not always within the recommended and expected range of intake (on a BW basis; Figure 3).

Several nutrients and nutritional compounds are offered to the herd through mineral and/or protein-energy supplements, providing macro- and micro-minerals, energy and protein, as well as feed additives, such as ionophores. More specifically, when beef and/or dairy animals are offered minerals or ionophores through a total mixed ration (TMR), intake may not be a concern, given that the variation between the expected and actual intake is relatively small. However, supplementation to grazing animals is more challenging due to the fact that the intake and the frequency at which the animals visit the feeder are not regular, as corroborated by the data of the present study. As an example, supplement intakes below the recommended/expected range did not improve the performance of the herd (Bagley et al., 1988), whereas intakes above the recommended amount impaired performance (Potter et al., 1976), which might lead to health issues, such as intoxication and death (Wouters et al., 1997).

In tropical areas, the most feasible and simplest alternative for offering supplements to the herd is through mineral supplements and self-feeding

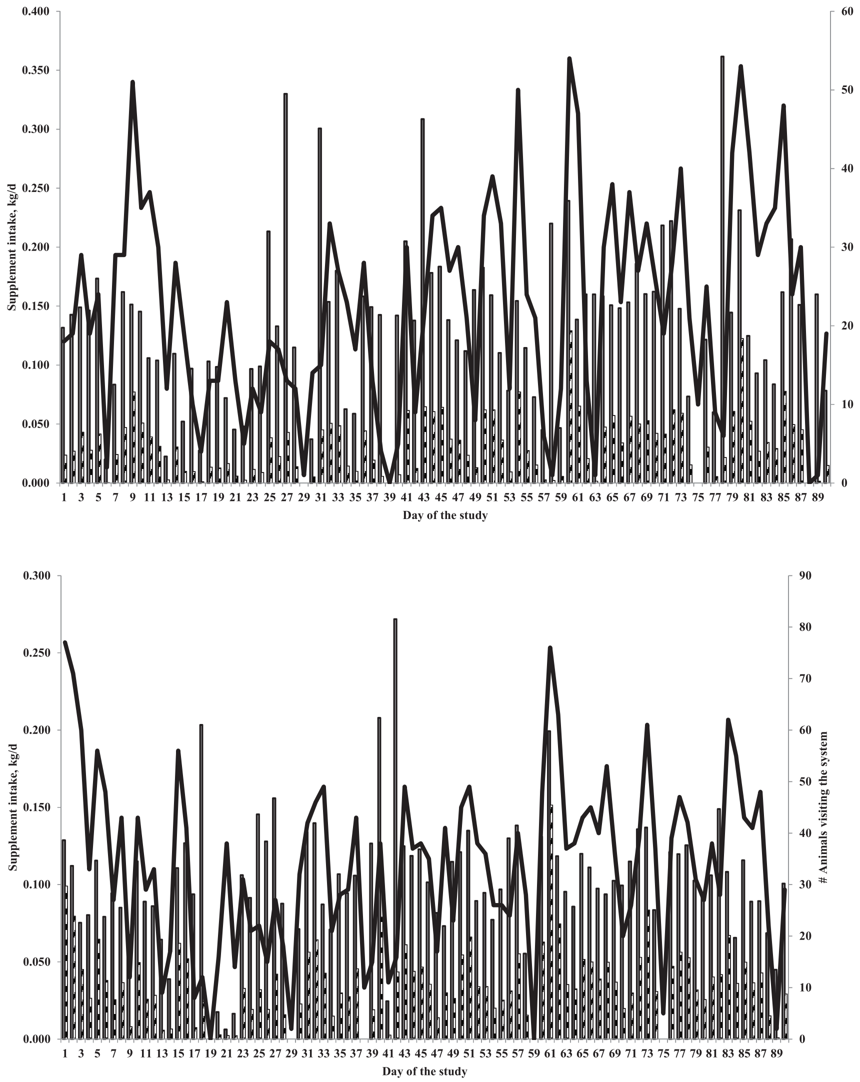

Figure 2. Number of animals visiting the system in the mineral (MIN; top graph) and mineral + narasin (MIN + N; bottom graph) groups. The dark line represents the number of animals visiting the feeder, whereas the gray bar represents the average intake for the animals that visited the feeder and the stripped bar represents the intake divided by the total number of animals in the paddock.

free-choice mineral supplements have been widely used in grazing beef herds (McDowell, 1996). Additionally, these supplements could be used as carriers for other molecules, such as ionophores, to improve the growth performance of the beef herd. Narasin is an ionophore produced by the *Streptomyces aureofaciens* strain and from the same family as the monensin, lasalocid, and salinomycin (Berg and Hamill, 1978). As other ionophores, narasin is effective against gram-positive bacteria, resulting in greater rumen propionate and decreased rumen acetate and butyrate proportions, as well as reduced acetate:propionate ratios and decreased ruminal proteolysis, which in turn will increase the absorption of amino acids from dietary origin in the small intestine. Moreover, in an in vitro study, Nagaraja et al. (1987) demonstrated that lower doses of narasin resulted in greater rumen propionate concentrations when compared with monensin and lasalocid, as well as being more effective in inhibiting the production of lactic acid than other ionophores and nonionophores compounds. Additionally, Polizel et al. (2016a, 2016b) demonstrated that narasin inclusion into high-forage diets increased total SCFA proportion, as well as NDF and ADF digestibility when compared with the negative control group.

Other studies have demonstrated that when ionophores (lasalocid, monensin, and salinomycin) are offered to grazing animals, supplement intake decreases. Cockwill et al. (2000) reported lower number of animals visiting the feeder when mineral salts were fed and suggested that ionophores tend to reduce daily supplement intake, increase the variation of intake per animal, and increase the variation of intake per day during the ionophore offer. In agreement, other studies have corroborated with this statement from Cockwill et al.

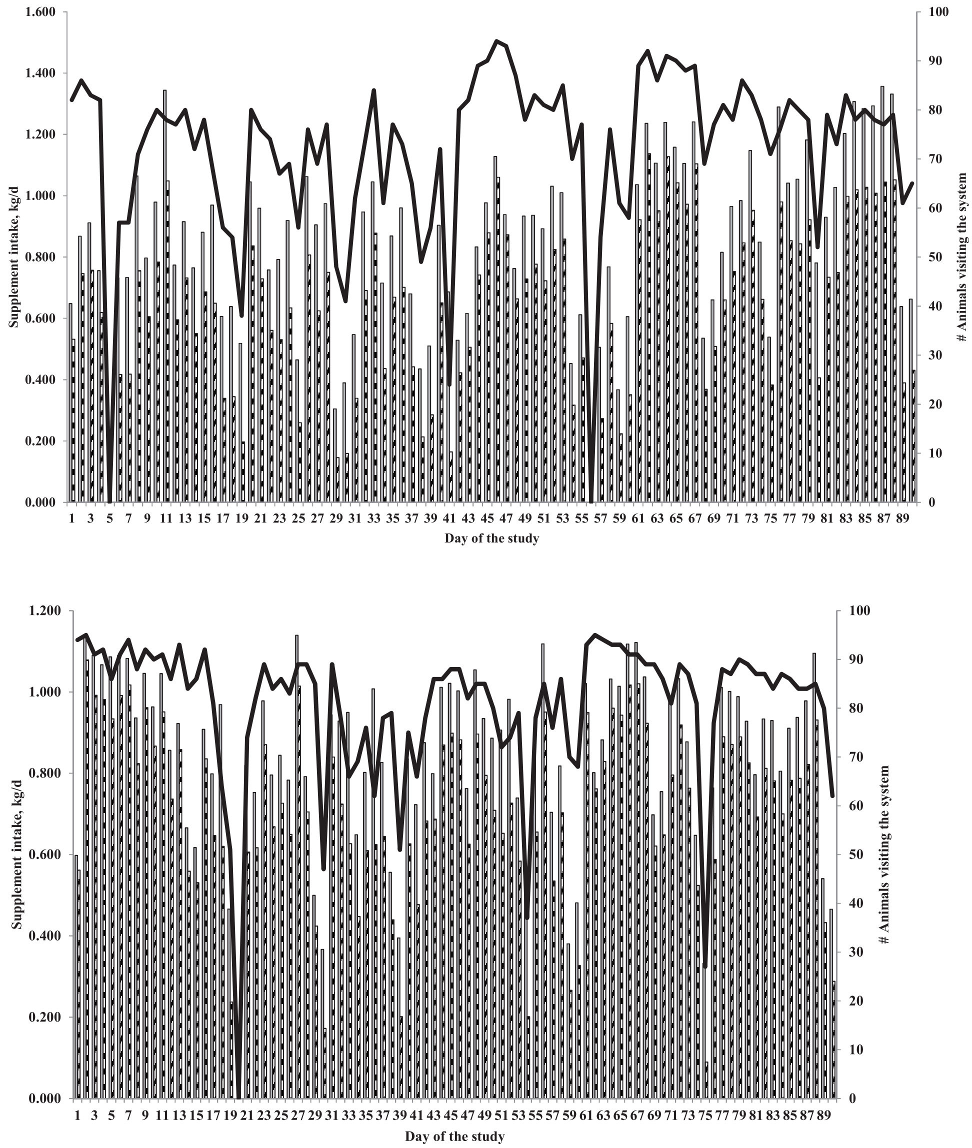

Figure 3. Number of animals visiting the system in the mineral (PREN; top graph) and mineral + narasin (PREN + N; bottom graph) groups. The dark line represents the number of animals visiting the feeder, whereas the gray bar represents the average intake for the animals that visited the feeder and the stripped bar represents the intake divided by the total number of animals in the paddock.

(2000). As an example, Bagley et al. (1988) reported that salinomycin inclusion into a mineral mixture decreased the mineral intake of beef steers from 131 to 65 g/d. Similarly, Beck et al. (2014) reported that steers offered a mineral supplement containing monensin had a reduced supplement intake compared with nonsupplemented cohorts (160 vs. 100 g/d, respectively). Lastly, Reffett-Stabel et al. (1989) demonstrated that lasalocid and salinomycin supplementation into a mineral mixture to grazing Angus steers decreased the mineral consumption when compared with nonsupplemented cohorts. Conversely to these studies, the present data demonstrate that narasin did not affect MIN and PREN supplement intakes and also increased the number of visits to the feeder (approximately 10% increase), indicating that narasin inclusion might be a feasible alternative to improve the supplement intake and consequently, the performance of grazing animals.

In summary, grazing *B. indicus* bulls present an erratic frequency of mineral intake. Narasin inclusion did not reduce supplement intake, regardless of supplement type, but narasin inclusion into a mineral mixture increased the frequency of visits to the feeder. Additional studies are warranted to understand the mechanisms by which narasin alters the frequency of visits to the feeder.

Conflict of interest statement. None declared.

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