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Effects of antibiotic growth promoters mixed with mineral supplement on growth performance, ingestive behavior, and mineral intake of grazing bulls

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ABSTRACT - The objective was to evaluate the addition of antibiotic growth promoters to free-choice mineral supplement on ingestive behavior, mineral intake, and growth performance of grazing bulls. Sixty Nellore bulls [initial body weight (BW) of 219±17.8 kg and 15±2 months of age] were divided in 12 marandu grass paddocks. The treatments were: mineral supplement (control), mineral supplement + virginiamycin (VIRG), mineral supplement + lasalocid sodium (LASA) and mineral supplement + salinomycin sodium (SALI). Mineral supplements were formulated with target intake of 60 g d^{-1} and the growth promoters of 75 mg 100 kg^{-1} of BW. The experimental design was the completely randomized blocks. There was no treatment effect on ingestive behavior or mineral intake; however, the active ingredient intake differed between treatments. In the last experimental period, the intake of active ingredient LASA and SALI were higher than VIRG (0.66, 0.54, and 0.39 mg kg^{-1} of BW, respectively). Treatments also did not affect BW and average daily gain, which were 0.63, 0.60, 0.64, and 0.62 kg d^{-1} for control, VIRG, LASA, and SALI, respectively. Free-choice mineral supplementation intake by bulls has a high variability, and this impairs the regulation of the intake of antibiotic growth promoter additives. Therefore, the addition of antibiotic growth promoters to the mineral supplement does not affect ingestive behavior, mineral intake, and growth performance of grazing bulls.

Keywords: feed additive, cattle, ionophore, lasalocid, salinomycin, virginiamycin

Introduction

The free-choice mineral supplement is an alternative for the administration of antibiotic growth promoters that potentiate ruminal fermentation. Among several growth promoters, ionophores such as lasalocid and salinomycin sodium, and virginiamycin antibiotic, are noteworthy. They act mainly against gram-positive bacteria present in the rumen, improving ruminal fermentation efficiency (Page, 2003).

With the selection of gram-negative bacteria in the ruminal environment, under the same diet, animals produce more energy due to the increase of fermentative efficiency, mainly by the increase of propionate production, and reduce ammoniacal nitrogen production, which can generate improvements on feed efficiency, in addition to reducing the environmental impacts provoked by cattle production, since CH_4 emission is also reduced (Page, 2003). Thus, the improvement in the efficiency of protein and energy utilization of the diet (Russel and Strobel, 1989; Page, 2003) may reflect in higher weight gain of grazing animals (Bretschneider et al., 2008).

The beneficial effects of using antibiotic growth promoters in feedlot or grazing cattle that consume concentrated supplementation have already been extensively proven (Bretschneider et al., 2008; Golder and Lean, 2016). However, the use of mineral supplement as a vehicle for supplying antibiotic growth promoters has been widely employed, but with few studies proving its beneficial effects (Rode et al., 1994).

We hypothesized that the addition of antibiotic growth promoters to mineral supplements will increase weight gain of bulls grazing on tropical pastures. Thus the objective of this study was to evaluate the addition of antibiotic growth promoters to the free-choice mineral supplement on growth performance, ingestive behavior, and mineral intake of grazing bulls.

Material and Methods

The study was conducted according to the institutional committee on animal use (case number 366/2011). The experiment was carried out from January 19 to May 10, 2012 (112 d) in the Distrito Federal, Brazil (15°55'12.55" south latitude and 47°55'12.55" west longitude, with altitude close to 1000 m). According to the Köppen classification, the climate is Aw (tropical seasonal savanna) and is situated between tropical savanna and temperate rainy climate of dry winter, with an average rainfall of 1550 mm annually. The soil is classified as typical A-moderate Dystrophic Red-Yellow Latosol, with a very clayey texture, a tropical Cerrado sub-deciduous phase and flat relief (EMBRAPA, 1999). Rainfall and temperature variation during the experimental period were obtained from the farm automatic weather station (Figure 1).

The experimental area consisted of 12 paddocks with 2 ha each, formed with marandu grass pastures, *Urochloa brizantha* (Hochst. Ex A. Rich) R. D. Webster, cv. Marandu, [syn. *Brachiaria brizantha* (Hochst. Ex A. Rich) Stapf]. The paddocks had some native Cerrado vegetation that acted as shade to the animals. All paddocks had covered troughs for supplementation and drinking fountains with automatic replenishment.

We used 60 Nellore bulls of 15±2 months of age, average body weight (BW) of 219±17.8 kg, and numerically identified with auricular earring and marked with hot iron on the leg. Before the experiment,

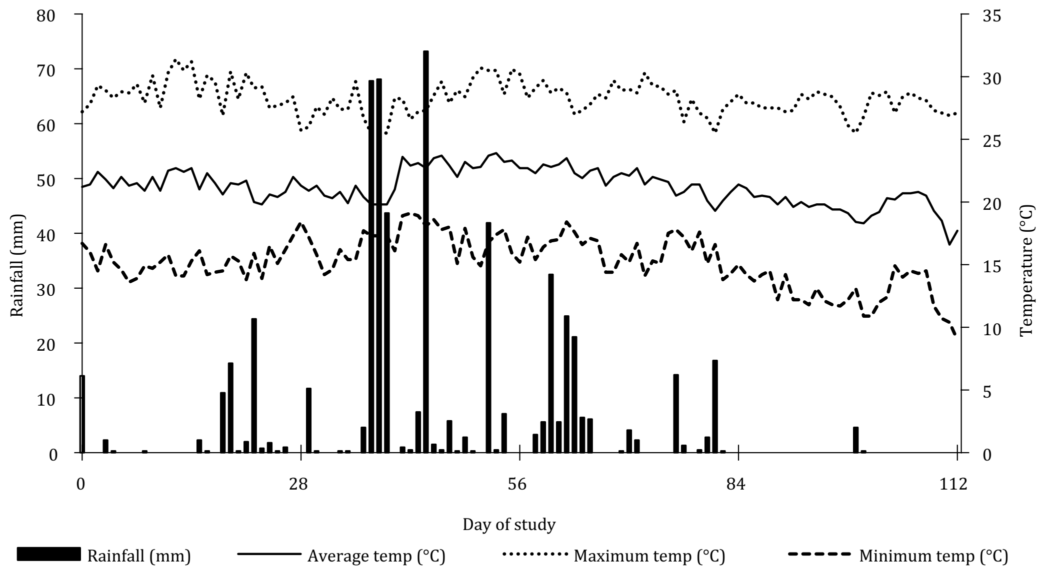

Figure 1 - Rainfall and average temperature during the experiment in Brasília, Distrito Federal, Brazil.

the animals underwent 40 d of adaptation on the marandu grass pasture, receiving free-choice mineral supplementation without any antibiotic growth promoters. Mineral supplements were produced and packaged by a mineral supplementation company that added antibiotic growth promoters to a commercial formula (Table 1) to meet the mineral requirements of growing beef cattle with average daily gain (ADG) of 0.600 kg d^{-1} (NRC, 1996) and the target intake of 60 g d^{-1}.

The animals were divided into paddocks and subjected to one of four treatments: mineral supplement (control), mineral supplement + virginiamycin (VIRG), mineral supplement + lasalocid sodium (LASA), or mineral supplement + salinomycin sodium (SALI). For all treatments employing growth promoters, the dose of active ingredient used was 75 mg 100 kg^{-1} of BW (Bretschneider et al., 2008). The animals were randomly chosen and divided into 12 groups, and each group was considered an experimental unit, totaling three repetitions for each treatment, with five animals each. The groups were separated into three blocks composed by four paddocks, with one group of each treatment per block. Weekly group rotations in the paddocks were performed inside each block, aiming at removing possible paddock effects on weight gain.

At the beginning of the experiment (d 0), the animals were weighed individually after water and food fasting for 16 h, and from this, weighing was repeated every 28 d. The ADG of animals was calculated by the difference between the final weight and initial weight at each experimental period, divided by the number of days of the period.

The mineral supplement associated or not with antibiotic growth promoters was supplied *ad libitum* in troughs, which allowed simultaneous access for all animals. The troughs were visually evaluated every day and replenished whenever they presented approximately 1 kg of leftovers. Weekly control of the mineral supplement intake was done by subtracting the weight of leftovers, corrected for moisture content, with the total provided during the week. For moisture correction of leftovers, 100 g samples were harvested and dried in a forced-air ventilation oven at 65 °C for 72 h.

Forage harvests were carried out every 28 d, simultaneously with the weighing of the animals, during the morning, therefore, without the presence of the animals in the paddocks. The evaluation of the forage mass was done using a 0.5 m^2 metal square randomly placed at eight points within the paddock, and forage cutting was performed at 5 cm from the soil. The samples were weighed in the

Table 1 - Guaranteed levels of mineral supplement containing antibiotic growth promoters[1]

Component	Treatment[2]			
	Control	VIRG	LASA	SALI
Calcium (g kg^{-1})	194	184	187	185
Sulfur (g kg^{-1})	16	16	16	16
Phosphorus (g kg^{-1})	70	70	70	70
Sodium (g kg^{-1})	109	109	109	109
Cobalt (mg kg^{-1})	50	50	50	50
Copper (mg kg^{-1})	1050	1050	1050	1050
Iodine (mg kg^{-1})	60	60	60	60
Manganese (mg kg^{-1})	900	900	900	900
Selenium (mg kg^{-1})	12	12	12	12
Zinc (mg kg^{-1})	3500	3500	3500	3500
Virginiamycin (mg kg^{-1})	-	2750	-	-
Lasalocid (mg kg^{-1})	-	-	2750	-
Salinomycin (mg kg^{-1})	-	-	-	2750

[1] Suplephós 70, Suplementar Nutrição Animal, Dourados, MS, Brazil.
[2] Control = mineral supplement, VIRG = mineral supplement + virginiamycin, LASA = mineral supplement + lasalocid sodium, and SALI = mineral supplement + salinomycin sodium.

field, homogenized, and two subsamples were taken and sent to the laboratory. In the laboratory, one of the subsamples was placed in paper bags to determine dry matter (DM) and forage dry mass (FDM), and in the other, the manual separation of green leaf, stem (stem + leaf sheath), and dead material (dried and/or dead leaves) was performed to determine the morphological constitution of the plant (Table 2).

Stocking rate (SR) was calculated from the sum of BW of the five animals in each paddock, divided by the weight of one animal unit (AU = 450 kg) and divided by the paddock area (2 ha). Forage allowance (FA) and green leaf allowance (GLA) were calculated by the following formula: (a/SR)/28, in which a = total mass for FA or green leaf dry mass for GLA and 28 = number of days of the experimental period (Table 2).

Forage samples from each paddock were analyzed according to AOAC (2000): DM, method 930.15; organic matter (OM), method 942.05; crude protein (CP), method 976.05; ethereal extract (EE), method 920.39; and ashes, method 942.05. The filter bag technique using a Tecnal unit (TE-149; Tecnal, Piracicaba, SP, Brazil) was employed for neutral detergent fiber (NDF) analysis using 5×5 cm filter bags with 100-µm porosity (non-woven fabric), in which 0.5 g of forage sample was added and submerged in neutral detergent solution (Van Soest et al., 1991). The NDF was expressed with correction for ashes and protein (NDFap). Non-fibrous carbohydrates (NFC) were calculated according to NRC (2001) as: NFC (g kg^{-1}) = 1000 − (g kg^{-1} NDFap + g kg^{-1} CP + g kg^{-1} EE + g kg^{-1} MM). The chemical composition of marandu grass is described in Table 3.

The ingestive behavior of the animals was evaluated on d 21 of each period, from sunrise to sunset (6.00 to 18.00h; 12 h). The evaluations were carried out by six previously trained evaluators, using binoculars with a 16-fold increase and annotations performed in 10-minute intervals. The evaluators were divided into two groups with six-hour scales, and each evaluator was positioned in an observation tower located in the center of each block, being responsible for the four paddocks of the block. Grazing, idle, rumination, water drinking, and mineral supplement intake time were measured.

The experimental design used was randomized blocks. Data were analyzed using the PROC MIXED of SAS (Statistical Analysis System, version 9.4) for time-repeated measures, with the evaluation dates (period) being used as a repeating effect, and the compound symmetry covariance structure was selected through the lowest Akaike information criterion. The statistical model used was:

$$y_{ijk} = \mu + T_i + P_j + \beta_k + (T \times P)_{ij} + \varepsilon_{ijk},$$

in which y_{ijk} = $_{ijk}$ observation, μ = overall average, T_i = treatment effect, P_j = period effect, β_k = block effect, $(T \times P)_{ij}$ = interaction effect between treatment i and period j, and ε_{ijk} = random error. The least

Table 2 - Marandu grass components in the experimental periods

Item	Period[1]			
	Day 0 to 28	Day 28 to 56	Day 56 to 84	Day 84 to 112
FDM (kg of DM ha^{-1})	3350	4100	4250	3800
Green leaf (g kg^{-1} of DM)	571	482	369	305
Stem (g kg^{-1} of DM)	405	470	534	560
Dead material (g kg^{-1} of DM)	24	48	97	135
Stocking rate (AU ha^{-1})	1.30	1.42	1.50	1.57
FA (kg of DM 100 kg^{-1} of BW day^{-1})	20.82	23.95	22.91	19.56
GLA (kg of DM 100 kg^{-1} of BW day^{-1})	12.06	11.59	8.54	5.16

FDM - forage dry mass; DM - dry matter; AU - animal unit; FA - forage allowance; BW - body weight; GLA - green leaf allowance.
[1] The values presented are the average of the results of the initial and final collections of each experimental period.

Table 3 - Chemical composition of marandu grass in experimental periods

Item (g kg^{-1})	Period[1]			
	Day 0 to 28	Day 28 to 56	Day 56 to 84	Day 84 to 112
Forage dry mass				
DM	227.8	260.6	291.0	339.4
NDFap	719.4	737.8	752.3	763.7
ADF	376.7	393.4	401.8	416.4
CP	64.3	48.9	40.6	36.8
EE	27.4	21.5	13.4	9.2
Ashes	74.1	65.9	60.4	57.8
NFC	114.9	125.9	133.3	132.5
Stem				
CP	43.1	36.0	33.4	29.9
NDFap	764.6	789.9	792.5	791.3
ADF	436.0	452.6	458.2	464.2
Ashes	62.7	48.7	39.7	37.7
Green leaf				
CP	79.9	64.6	62.6	67.6
NDFap	692.0	698.0	697.2	696.9
ADF	335.4	335.3	327.1	329.1
Ashes	61.7	59.9	57.3	59.0

DM - dry matter; NDFap - neutral detergent fiber corrected for ashes and protein; ADF - acid detergent fiber; CP - crude protein; EE - ethereal extract; NFC - non-fibrous carbohydrates (NFC = 1000 − (NDFap + CP + EE + MM), NRC, 2001).
[1] The values presented are the average of the results of the initial and final collections for each experimental period.

squares averages were compared using the Tukey test if a significant F-test was detected. Significance was defined when P≤0.05.

Results

There was no treatment effect on ingestive behavior activities (Table 4). There was a period effect on grazing time and water drinking time. Grazing time was lower during the first period and increased until the fourth. Water drinking time was higher in the first period and lower in the fourth period. Rumination time presented an interaction period × treatment. In general, the first period did not differ from the second, but it was superior over the third and fourth for all treatments. There were no effects of treatment × period, treatment, and period for idle time (Table 4).

There was no treatment effect on mineral supplement intake in g d^{-1} or g kg^{-1} of BW; however, there was a period effect for these variables (Table 5). Mineral supplement intake in g d^{-1} was greater in the first three periods compared with the fourth. When the mineral supplement intake was evaluated, in g kg^{-1} of BW, it was greater in the first two periods compared with the third and fourth periods. The active ingredient intake presented interaction period × treatment (Table 5). For this variable, for all treatments, intake was greater in the first period and lower in the fourth. In the first period, the intake of the active ingredient LASA was greater than that of VIRG and SALI, and in the last period, intake of LASA and SALI were greater than that of VIRG.

There was an increase in BW throughout the experimental periods, but there was no effect of the antibiotic growth promoters and nor interaction with the periods (Table 6). The ADG of the animals did not differ among treatments and there was no interaction with the periods, but it decreased throughout the experimental periods for all treatments (Table 6).

Table 4 - Average time (minutes) spent by Nellore bulls during day time period (6.00 to 18.00 h) in grazing, idle, rumination, water drinking, and mineral supplement intake activities

Item	Treatment[1]				Average per period[2]	SEM	P-value		
	Control	VIRG	LASA	SALI			Period (P)	Treatment (T)	P×T
Grazing time (min)							<0.0091	0.6417	0.0844
Day 0 to 28	404.0	422.0	436.0	440.0	425.5C	15.6			
Day 28 to 56	517.3	520.0	486.7	448.0	493.0B	5.1			
Day 56 to 84	474.0	482.0	491.3	430.0	469.3BC	23.8			
Day 84 to 112	546.0	504.7	542.0	523.3	529.0A	7.9			
Idle time (min)	122.3	124.0	124.5	139.0	-	5.0	0.0883	0.1667	0.9887
Rumination time (min)							<0.0001	0.7395	0.0482
Day 0 to 28	156.7A	157.3A	140.0A	142.0A	-	22			
Day 28 to 56	101.3AB	76.0AB	82.7AB	91.3AB	-	18.7			
Day 56 to 84	78.0B	65.3B	85.3B	105.3B	-	15.3			
Day 84 to 112	54.7B	102.7B	80.0B	92.0B	-	14.1			
Water drinking time (min)							0.0009	0.7072	0.3511
Day 0 to 28	16.7	22.0	21.3	14.0	18.5A	2.4			
Day 28 to 56	14.7	10.7	19.3	19.3	16.0AB	2.4			
Day 56 to 84	13.3	14.0	12.7	9.3	12.3AB	2.4			
Day 84 to 112	6.7	17.3	3.3	7.3	8.7B	2.4			
Mineral supplement intake time (min)	9.3	4.6	2.3	7.2	-	1.6	0.7412	0.0944	0.3217

SEM - standard error of the mean.
[1] Control = mineral supplement, VIRG = mineral supplement + virginiamycin, LASA = mineral supplement + lasalocid sodium, and SALI = mineral supplement + salinomycin sodium.
[2] Averages per period are presented only when the P-value for period is ≤0.05 and T×P >0.05.
Different uppercase letters differ from each other in the columns by Tukey's test (P≤0.05).

Table 5 - Average mineral supplement intake and antibiotic growth promoters for Nellore bulls raised on Marandu grass

Item	Treatment[1]				Average per period[2]	SEM	P-value		
	Control	VIRG	LASA	SALI			Period (P)	Treatment (T)	P×T
Mineral supplement intake (g animal^{-1} day^{-1})							<0.0001	0.3585	0.7585
Day 0 to 28	107.19	99.08	144.76	115.88	116.73A	9.09			
Day 28 to 56	96.71	90.36	133.00	122.29	110.59A	9.09			
Day 56 to 84	99.31	70.99	108.82	110.21	97.33A	9.09			
Day 84 to 112	51.98	40.57	66.62	56.00	53.79B	9.09			
Mineral supplement intake (g kg^{-1} of BW)							<0.0001	0.3368	0.7118
Day 0 to 28	0.46	0.42	0.62	0.49	0.50A	0.03			
Day 28 to 56	0.38	0.35	0.52	0.48	0.43A	0.03			
Day 56 to 84	0.37	0.26	0.40	0.40	0.36B	0.03			
Day 84 to 112	0.18	0.14	0.24	0.20	0.19C	0.03			
Active ingredient intake (mg kg^{-1} of BW)							<0.0001	0.0003	0.0006
Day 0 to 28	-	1.17Ab	1.69Aa	1.36Ab	-	0.03			
Day 28 to 56	-	0.97ABa	1.43Aa	1.31Aa	-	0.08			
Day 56 to 84	-	0.73BCa	1.11Ba	1.11Aa	-	0.08			
Day 84 to 112	-	0.39Cb	0.66Ca	0.54Ba	-	0.02			

BW - body weight; SEM - standard error of the mean.
[1] Control = mineral supplement, VIRG = mineral supplement + virginiamycin, LASA = mineral supplement + lasalocid sodium, and SALI = mineral supplement + salinomycin sodium.
[2] Averages per period are presented only when the P-value for period is ≤0.05 and T×P >0.05.
Different uppercase letters differ from each other in the columns and different lowercase letters differ from each other in the rows by Tukey's test (P≤0.05).

Table 6 - Average body weight and average daily gain of Nellore bulls raised on Marandu grass and receiving mineral supplementation with antibiotic growth promoters

Item	Treatment[1]				Average per period[2]	SEM	P-value		
	Control	VIRG	LASA	SALI			Period (P)	Treatment (T)	P×T
Average body weight (kg)							<0.0001	0.5690	0.9180
Day 0	219.1	219.8	221.9	219.0	220.0A	1.30			
Day 28	247.2	246.8	251.0	247.9	248.2B	1.29			
Day 56	262.3	263.7	266.9	263.2	263.9C	1.31			
Day 84	277.8	276.8	281.4	279.4	278.9D	1.30			
Day 112	288.2	286.0	291.6	289.1	288.7E	1.32			
Average daily gain (kg day^{-1})							<0.0001	0.6595	0.3980
Day 0 to 28	0.99	0.96	1.05	1.01	1.00A	0.02			
Day 28 to 56	0.57	0.61	0.63	0.54	0.58B	0.02			
Day 56 to 84	0.53	0.48	0.49	0.58	0.52B	0.02			
Day 84 to 112	0.44	0.35	0.39	0.36	0.38C	0.02			
Average	0.63	0.60	0.64	0.62	-	0.02			

SEM - standard error of the mean.
[1] Control = mineral supplement, VIRG = mineral supplement + virginiamycin, LASA = mineral supplement + lasalocid sodium, and SALI = mineral supplement + salinomycin sodium.
[2] Averages per period are presented only when the P-value for period is ≤0.05 and T×P >0.05.
Different uppercase letters differ from each other in the columns by Tukey's test (P<0.05).

Discussion

The time bulls spent on daily activities is in line with the frequency observed for grazing cattle, as they spent 90 to 95% of the time in grazing, rumination, and idle activities (Kilgour et al., 2012). There was an increase in grazing time throughout the experimental periods, which coincided with the decrease in GLA and a decrease in the nutritional quality of the pasture, indicating that a longer grazing time was required to meet nutritional requirements. The average time used by the animals in grazing activity was 7.98 h, exactly the same time observed for crossbred steers kept in marandu grass pasture, consuming 2 g kg^{-1} of BW of concentrate supplement in a tropical climate during the rainy season (Mendes et al., 2015).

The rumination time found by Mendes et al. (2015) was 7.52 h and, according to review study by Kilgour (2012) for beef cattle, it ranged from 4.7 to 10.2 h. These results were much higher than those found in this study, which was less than 2 h. These same authors mentioned that a great part of this activity is done in the nocturnal period and, since the ingestive behavior in this study was evaluated only during the diurnal period, it justifies the low average time observed for this activity. The shortest water drinking time, in the fourth period compared with the first, is related to the decrease in minimum temperature (NRC, 1996) at the end of the experiment.

The mineral supplement intake was not reduced when associated with antibiotic growth promoters. The literature mentions that the addition of salinomycin to free-choice mineral supplement for steers reduced the intake of mineral by half compared with the control group (131 and 65 g d^{-1}, mineral supplement and mineral supplement + salinomycin, respectively; Bagley et al., 1988). Furthermore, the addition of lasalocid to free-choice mineral supplement for heifers showed similar mineral intake as the control group in two consecutive years (83.2 and 89.1, 140.3 and 147.2 g d^{-1}, mineral supplement and mineral supplement + lasalocid, year 1 and 2, respectively; Rode et al., 1994).

Throughout the experimental periods, there was a reduction in mineral supplementation intake (g d^{-1} and g kg^{-1} of BW d^{-1}) and also of active ingredient intake (mg kg^{-1} of BW d^{-1}). The highest mineral supplementation intake occurs with a great allowance of forage mass and high nutritional quality (Rode et al., 1994), and the decrease in the nutritional quality of the pasture, due to the lower proportion of green leaf:stem, led to a decrease in the mineral supplement intake.

The target dose of the antibiotic growth promoters (0.75 mg kg^{-1} of BW d^{-1}) was established in accordance with a meta-analysis performed by Bretschneider et al. (2008), who demonstrated that the antibiotic growth promoters used have dose-dependent results with quadratic behavior and an optimum performance point between 0.75 and 1 mg kg^{-1} of BW d^{-1}. Although the active ingredient intake was higher than expected, with the exception of the LASA supplement, the average daily dose was close to the maximum response point (Bretschneider et al., 2008). However, positive effects of lasalocid sodium on ADG (0.6 and 0.7 kg d^{-1} for control and lasalocid, respectively) were obtained during the grazing period with bulls receiving 250 mg per animal (1.2 mg kg^{-1} of BW d^{-1}) incorporated into 1 kg of beet sugar (Boucque et al., 1988).

The absence of effect of the antibiotic growth promoters added to the mineral supplement on growth performance in this study opposes the findings of Bretschneider et al. (2008) and Golder and Lean (2016). In a meta-analysis, Golder and Lean (2016) found that the use of lasalocid by cattle, both confined or grazing, increased the ADG (40 g d^{-1}) without affecting DM intake. In another meta-analysis, Bretschneider et al. (2008) evaluated the effect of antibiotic growth promoters exclusively for grazing beef cattle and observed increase on ADG with virginiamycin supply in 13.1% (0.61 and 0.69 kg d^{-1} for control and virginiamycin, respectively), lasalocid in 10.3% (0.78 and 0.86 kg d^{-1} for control and lasalocid, respectively), and salinomycin in 37.5% (0.48 and 0.66 kg d^{-1} for control and salinomycin, respectively). These results are explained by changes in ruminal metabolism, such as the lower concentration of acetate, higher propionate rate, and improved efficiency of rumen nitrogen use, measured as the flow of non-ammonia nitrogen compounds into the small intestine (Salinas-Chavira et al., 2009). It is noteworthy that most of the meta-analysis studies used the concentrated supplement as a vehicle for growth promoters, which differs from this study.

The lack of effects of growth promoters on BW and ADG can be explained by the great variability in the daily voluntary intake of mineral supplementation by grazing cattle (Manzano et al., 2012), since the responses depend on a consistent daily intake (Rode et al., 1994). Manzano et al. (2012) compared the feeding behavior and free-choice mineral supplement intake, offered *ad libitum* to grazing steers throughout the year seasons spring-summer and autumn and did not observe similarity between seasons (96.6 vs. 85.4 g d^{-1} for spring-summer and autumn, respectively) but found differences among animals, days, and periods. Individual intake was different between animals ranging from 0 to 400 g d^{-1} in spring-summer for 0 to 440 g d^{-1} in autumn. The inclusion of NaCl (261.5 g kg^{-1}) was very similar to that used in this study (277 g kg^{-1}).

The free access of cattle to the powdered mineral supplement has been shown to be of interest for meeting mineral requirements, but not as a vehicle for antibiotic growth promoter additives. The absence of consumption, under-consumption, or over-consumption may compromise the effectiveness of the active ingredient.

Conclusions

The free-choice mineral supplementation intake of bulls has a high variability and hampers the regulation of the intake of antibiotic growth promoter additives. The use of mineral supplements as a growth promoter vehicle does not affect ingestive behavior, mineral intake, and growth performance of grazing bulls, and this can lead to waste and increasing costs in cattle production.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: G.L. Franco. Methodology: G.L. Franco. Project administration: J.M.S. Diogo and G.L. Franco. Supervision: J.M.S. Diogo, M.C. D'Oliveira and C.J. Silva. Visualization: J.M.S. Diogo, C.Q. Mendes and S.L.S. Cabral Filho. Writing-original draft: J.A.M. Beltrame. Writing-review & editing: M. Vedovatto.

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