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Supplementation of suckling beef calves on a creep-feeding system and nutritional evaluation of lactating beef dams

Suplementação em sistema de creep-feeding de bezerros de corte lactentes e avaliação nutricional de matrizes de corte

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Abstract

This study was conducted to evaluate the productive and nutritional performance of suckling calves fed only a mineral mix (MM) or different levels of multiple supplement and the milk yield and nutritional parameters of beef cows on *Uruchloa decumbens* pastures. Thirty-two suckling calves, with an average age of 3 months and average initial weight of 109.3 ± 0.84 kg, and their respective mothers, with an average initial weight of 447.2 ± 47.1 kg, were used. The experimental design was completely randomized. The supplement contained approximately 25% crude protein (CP), and treatments consisted of the supply of different of multiple supplement levels for the calves. The levels of supply of the supplements were 0.2, 0.4, and 0.6% of the body weight for treatments $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively. The animals from the control treatment (MM) received only an MM *ad libitum*. The average daily gain (ADG) of the calves was 731.2, 810.6, 822.7, and 895.2 grams for treatments MM, $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively. Supplemented calves showed greater weight gain. The multiple supplement levels offered to the calves had a positive linear effect (P<0.10) on their ADG. The intakes in kg/day of dry matter (DM), organic matter (OM), CP, non-fibrous carbohydrates (NFC), digestible DM, digestible neutral detergent fiber (NDF), and total digestible nutrients (TDN) were higher (P<0.10) for animals that received multiple supplements compared with those fed only an MM. The levels of supply of multiple supplements had an increasing linear effect on ether extract (EE) intake, and a quadratic effect was found on DM intake, forage DM, OM, forage OM, CP, NFC, digestible DM, and TDN. The total apparent digestibility coefficients of DM, OM, NDF, NFC, and TDN were higher (P<0.10) for the animals that received multiple supplements. With the levels of supply of multiple supplements, an increasing linear effect was observed on EE digestibility. Calf supplementation did not affect the performance, milk yield, or nutritional parameters of the cows (P>0.10).

Key words: Intake, digestibility, Nellore, performance

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Resumo

Este trabalho foi realizado para avaliar o desempenho produtivo e nutricional de bezerros lactentes recebendo apenas mistura mineral ou diferentes níveis de suplementos múltiplos e a produção de leite e os parâmetros nutricionais de vacas de corte em pastagens de *Uruchloa decumbens*. Utilizaram-se 32 bezerros de corte, lactentes, com idade média de 3 meses e peso médio inicial de 109,3 $\pm$ 0,84 kg, e suas respectivas mães com peso inicial médio de 447,2 $\pm$ 47,1 kg. O delineamento experimental foi o inteiramente casualizado. O suplemento continha aproximadamente 25% de proteína bruta (PB) e os tratamentos consistiram-se do fornecimento de diferentes níveis de suplementos múltiplos para os bezerros. Os níveis de fornecimento de suplementos foram 0,2; 0,4 e 0,6% do peso corporal para os tratamentos N0,2, N0,4, e N0,6, respectivamente. Os animais do tratamento controle (MM) receberam exclusivamente mistura mineral *ad libitum.* O ganho médio diário (g) dos bezerros foi 731,2; 810,6; 822,7e 895,2, respectivamente, para os tratamentos MM, N0,2, N0,4, e N0,6. Os bezerros suplementadas apresentaram maior ganho em peso. Houve efeito linear positivo do nível de suplemento múltiplo fornecido aos bezerros (P<0,10) sobre o ganho médio diário. Os consumos em kg/dia de matéria seca (MS), matéria orgânica (MO), PB, carboidratos não fibrosos (CNF), MS digerida, fibra em detergente neutro digerida e nutrientes digestíveis totais foram superiores (P<0,10) para os animais que receberam suplementos múltiplos em relação aos animais que receberam apenas mistura mineral. Entre os níveis de fornecimento de suplementos múltiplos observou-se efeito linear crescente sobre o consumo de extrato etéreo e efeito quadrático sobre o consumo de MS, matéria seca de forragem, MO, matéria orgânica de forragem, PB, CNF, matéria seca digerida e NDT. Os coeficientes de digestibilidade aparente total da MS, MO, FDN, CNF e NDT foram superiores (P<0,10) para os animais que receberam suplementos múltiplos. Entre os níveis de fornecimento de suplementos múltiplos observou-se efeito linear crescente sobre a digestibilidade do EE. A suplementação dos bezerros não influenciou o desempenho das vacas, a produção de leite e os parâmetros nutricionais das vacas (P>0,10).

Palavras-chave: Consumo, desempenho, digestibilidade, Nelore

Introduction

From the perspective of short-cycle cattle farming on pastures, continuous weight gain starting in the supplementation phase is essential for the success of the production system (PAULINO et al., 2002). However, during the suckling phase, it would be difficult to fully meet the nutritional requirements for optimized gains with milk only (LOPES et al., 2014).

In beef cattle production systems, the milk produced by dams is not sufficient to meet the nutritional requirements of calves after 3 months of age (HENRIQUES et al., 2011). In Brazil, the decrease in milk production occurs during the rainy-dry season transition, when the quality and quantity of forage available for grazing is reduced. As a consequence, calves cannot manifest their genetic productive potential. Thus, performance is improved when animals receive multiple supplements (VALENTE et al., 2012).

Supplementation of suckling calves in a creep-feeding system is a strategy to increase the productivity of beef production systems. The application of these nutritional systems is necessary, because considering the energy and protein as limiting nutrients, it is observed that from the 9th and 15th weeks of life, for energy and protein, respectively, milk can no longer provide the necessary energy for the calf to gain around 800 g/d. Therefore, for Nellore calves to reach a weaning weight above 200 kg, they must be supplemented via the creep-feeding system from the 2nd month of life (PAULINO et al., 2010).

Creep-feeding results in a greater weight for the animals at weaning, and consequently shortens the weaning phase (PAULINO, 1999). However, the lack of precise information on the type and levels of supplements to be used as well as the productive response of the animals to different strategies of supplementation in the pre-weaning phase has made it difficult to adopt the practice of supplementation for calves.

This study was conducted to evaluate the productive and nutritional performance of creep-feeding calves receiving a mineral mix (MM) solely, or multiple supplements, and the milk yield, intake, and digestibility of the forage consumed by beef cows on Brachiaria grass pastures during the rainy-dry season transition.

Materials and Methods

Animals, experiment design, and diets

The experiment was conducted in the facilities of the Beef Cattle Sector of Universidade Federal de Viçosa, located in Viçosa, MG/Brazil (20º45' S and 42º52' W), from January to July 2012, corresponding to the rainy-dry season transition. The experimental area is located in a mountainous region at 670 m elevation that has an annual precipitation of 1.300 m. The experiment lasted 140 days and was divided into five 28-day experimental periods.

Thirty-two Nellore calves, with an average initial age of 3 months and weight of 109.3 ± 0.84 kg, and their respective mothers (beef cows with predominance of Zebu blood), with an average of 3 months of lactation, average initial age of 6 years, and weight 447.2 ± 47.1 kg, were used in this experiment.

The experimental area for the animals measured 28 ha, consisting of four 7.0-ha paddocks uniformly covered with *Uruchloa decumbens* (Brachiaria grass), provided with drinkers and troughs, which were covered and had private access by the calves.

The experimental design was completely randomized, with four treatments with eight replicates each. The animals spent 15 days adapting to the diet and experimental conditions.

Three levels of multiple supplements (Table 1) with approximately 25% protein were evaluated. The supplement was based on soybean meal, ground sorghum and corn grains, and an MM. The levels of supply were 0.2, 0.4, and 0.6% of the body weight (BW) for treatments $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively, plus a control group in which the animals received only the MM *ad libitum*. In addition to the MM *ad libitum*, cows also received 100 g/d of corn meal so as to stimulate the search and longer permanence close to the troughs and thus ensure the best supplement intake by the calves.

Table 1. Composition (in g/kg) of the supplement on a natural matter basis.

Ingredients (%)	Supplement
Ground corn grain	22.5
Ground sorghum grain	22.5
Soybean meal	50
Mineral mix[1]	5

[1]Proximate composition: dicalcium phosphate, 50.00; sodium chloride, 47.775; zinc sulfate, 1.40; copper sulfate, 0.70; cobalt sulfate, 0.05; potassium iodate, 0.05; and sodium selenite, 0.025.

The supplements were supplied daily at 10h00 in collective feeders dimensioned so as to provide simultaneous access to the animals. Water was available *ad libitum* throughout the entire experiment.

All animals were subjected to control of ecto- and endoparasites at the beginning of the experiment and also during the experimental period, whenever necessary.

The animals were weighed at the beginning of the experiment after a feed-deprivation period of 14 hours. Immediately following, the treatments were randomly assigned to the experimental units (animals). Four batches were formed by clustering the animals that would receive the same treatment. At the beginning of the experiment and at every 28 days, the animals were weighed without being feed-deprived, always in the morning, to monitor the performance and adjust the amount of supplement to be supplied to each group.

The variation in the body condition score (BCS) of the cows during the experimental period was determined as the difference between the final and initial scores. The 1-to-9-point scale was used, as recommended by the NRC (1996). The score was given by three evaluators, independently from each other.

To estimate the average milk yield of the cows, their production was sampled 15, 75, and 135 days after the beginning of the experiment. The cows were separated from their offspring at 18h00 and remained in the paddock, and they were milked at 06h00 on the next day. The times each cow was milked were recorded, and then milk yield was converted to 24-hour-milk-yield. Milking was performed manually by a previously trained employee. The milk secretion was stimulated by applying 2 mL of oxytocin (10 IU/mL; Ocitovet®, Brazil) in the mammary artery, milking immediately afterwards. Milk samples were collected to analyze the protein, fat, lactose, phosphorus, and calcium contents.

The animals were rotated over the paddocks fortnightly, aiming to control possible effects of the paddocks on the treatments (pasture availability, location of water and trough, relief, shading, etc.); the treatments followed the animal groups.

The average daily weight gain of the animals in each experimental phase was estimated as the difference between the final and initial weights divided by the number of experimental days.

Experimental procedures and sampling

The sample used for the qualitative evaluation of the pasture consumed by the animals was collected via manual grazing simulation every 14 days. This sample was weighed, immediately transferred to a forced-air-circulation oven at 60 ºC for 72 hours, and then ground in a knife mill (1 mm).

The pasture was collected on the 4th day of each experimental period to quantify the dry matter (DM) and potentially digestible dry matter (pdDM) by cutting the grass close to the soil level in four areas delimited by a metal frame (0.5 × 0.5 m) that were randomly selected in each experimental paddock. This sample was also weighed and immediately placed in a forced-air-circulation oven at 60 ºC for 72 hours.

The pdDM was estimated by the following equation (PAULINO et al., 2008):

$$pdDM = 0.98\times(100 - NDF) + (NDF - iNDF).$$

where: pdDM = forage content of potentially digestible DM (DM%); 0.98 = cell content true digestible coefficient; and NDF and iNDF = forage content of NDF and iNDF, respectively (DM%).

To evaluate the nutritional traits of the calves and cows, a 9-day trial was started on the 70th day of the experimental period. The "three-marker" method was adopted. To estimate the fecal output, the animals received chromic oxide (Cr_2O_3) conditioned in cartridge papers (DETMANN et al., 2001) and corresponding to 10 g per calf/d and 20 g per cow/d, applied using a metal probe directly into the esophagus, always at 10h00. To estimate the individual supplement intake by the calves, titanium dioxide (TiO_2) was offered via supplement at the proportion of 10 g of marker/kg of supplement (TITGEMEYER et al., 2001). To estimate the pasture DM intake, indigestible neutral detergent fiber (iNDF) was used as an internal marker (DETMANN et al., 2001).

Of the 9 days of the trial, 6 were used for the animals to adapt to Cr_2O_3 and TiO_2. In the last 3 days, feed was collected at different times (15h00, 11h00, and 07h00, respectively). The feces samples were collected immediately after defecation or directly from the rectum of the animals at the approximate amount of 200 g. Then the samples were identified per animal, dried in a forced-air-circulation oven (60 ºC/72 h), and ground in a knife mill (1 mm). On the 5th day of the trial, a manual simulation of grazing was performed per paddock separately, and these samples were used to estimate the intake and digestibility coefficients.

Chemical analyses

In the concentrate samples and samples of forage obtained by manual simulation of grazing, the concentrations of DM, mineral matter (MM), crude protein (CP), lignin, and ether extract (EE) were quantified according to AOAC (2000). Neutral detergent fiber (NDFap) was corrected for protein and ash using thermostable α-amylase and omitting the use of sodium sulfite, according to Mertens (2002). iNDF was obtained after *in situ* incubation in bags (F57 Ankom®) for 288 hours, following Valente et al. (2011). The concentrations of DM, NDFap, and iNDF were quantified in the forage samples intended for the calculations of the DM and pdDM masses, as previously described.

The non-fibrous carbohydrates (NFC) of the supplements were estimated according to recommendations of Hall and Akinyode (2000), using the following equation:

$$NFC = 100 - [M + E + NDFap + (CP - CPU + U)]$$

where: NFC = non-fibrous carbohydrates; MM = mineral matter content; EE = ether extract content; NDFap = neutral detergent fiber corrected for ash and protein content; CP = crude protein content; CPu = urea crude protein content; and U = urea content. All other items are expressed as DM%.

The obtained composition of the supplement and the forage can be seen in Table 2.

Table 2. Chemical composition of supplement and forage.

Item[1]	Supplement	Forage[5]
Dry matter[2]	944.0	262.8±0.91
Organic matter[3]	910.9	925.7±0.46
Crude protein[3]	254.1	119.3±0.89
Ether extract	19.4	17.2±0.07
NDFap[3]	151.9	576.6±1.46
NDIN	20.1	230.7±3.66
Non-fibrous carbohydrates[3]	485.4	242.3±0.86
Indigestible neutral detergent fiber	10.1	197.1±0.75
Lignin	31.3	67.2±0.38

[1]NDFap – neutral detergent fiber corrected for ash and protein; NDIN – neutral detergent insoluble nitrogen. [2]/ in g/kg of natural matter. [3]/ in g/kg of dry matter. [4]/ in g/kg of total nitrogen. [5]/Means of the samples obtained by manual simulation of grazing throughout the entire experimental period.

A composite sample of feces was prepared based on the air-dry weight per animal for the 3 collection days and stored in plastic containers, labeled, and subsequently analyzed for the chromium contents by atomic absorption spectrometry (WILLIAMS et al., 1962) and titanium dioxide by colorimetry (TITGEMEYER et al., 2001). Additionally, the DM, CP, EE, NDFap, iNDF, and MM contents were evaluated as previously described.

The fecal DM output was estimated using the chromic oxide marker based on the ratio between the amount of marker supplied and its concentration in the feces.

The individual supplement intake by the calves was estimated by the following equation:

$$ISI = ((FE \times CMF)/MSG) \times SSG,$$

where: ISI = individual supplement intake (kg/d); FE = fecal excretion, in kg/d; CMF = concentration of the marker in the feces (kg/kg); MSG = marker present in the supplement supplied to the group (kg/d); and SSG = supplement supplied to the group of animals (kg/d).

The voluntary DM intake by the calves was estimated using iNDF as an internal marker, according to the equation:

$$DMI\ (kg/d) = \{[(FE \times CMF) - MS]/CMFO\} + SDMI + MDMI,$$

where: CMF = concentration of marker in the feces (kg/kg); CMFO = concentration of marker in the forage (kg/kg); SDMI = supplement dry matter intake (kg/d); FE = fecal excretion (kg/d); MS = intake of marker from supplement (kg); and MDMI = milk dry matter intake (kg/d).

The equation above was adopted to calculate DM intake by the cows, disregarding SDMI and MDMI.

Statistical analyses

The PROC MIXED procedure of SAS (Statistical Analysis System, version 9.2) was used in all statistical analyses. For all statistical procedures, we adopted $\alpha = 0.10$. Means were compared by decomposing the sum of squares for treatments into orthogonal contrasts relative to the comparison between supplementation with multiple supplements and supplementation with an MM only, and the linear and quadratic effect for the levels of supply of multiple supplements. The initial BW of the calves was used as a co-variable.

Results

The average masses of DM and pdDM during the experimental period were 4.774 and 3.169 kg/ha, respectively, which represented an average pdDM mass of 195 g/kg BW. The Brachiaria grass obtained via manual simulation of grazing showed an average CP content of 119.3 g /kg DM.

The average daily gain (ADG) of the calves (Table 3) was 731.2, 810.6, 822.7, and 895.2 g/d for treatments MM, $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively.

Table 3. Means, standard deviation, and indicators of significance for initial body weight (IBW), final body weight (FBW), and average daily gain (ADG) of calves supplemented with different levels of multiple supplements or only mineral mix during the rainy-dry season transition.

	Supplements				Standard deviation	P-value[1]		
Item	MM	$N_{0.2}$	$N_{0.4}$	$N_{0.6}$		US	L	Q
IBW	111.2	109.6	107.1	109.6				
FBW[2]	218.4	230.3	232.2	243.1	38.01	0.0151	0.0998	0.4862
ADG[3]	731.2	810.6	822.7	895.2	0.109	0.0153	0.0998	0.4838

[1]/Indicators of significance for contrast among supplemented and unsupplemented animals (US) and for linear (L) and quadratic (Q) effects of the level of supply of multiple supplements. [2]/ in kg. [3]/ in g/d. [2]/$\hat{Y}$=229.31+1.96x (r2=0.2200). [3]/ $\hat{Y}$=0.769 + 0.035x (r2=0.1700).

Table 4 shows the estimated intake by the calves. The intakes in kg/d of DM, organic matter (OM), CP, NFC, digestible organic matter (DOM), digestible neutral detergent fiber (DNDF), and total digestible nutrients (TDN) were higher for the calves supplemented with multiple supplements than those fed only MM. The average intake of DM from the multiple supplements during the experimental period was 478, 639, and 1.126 g/d for treatments $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively.

Table 4. Means, standard deviation, and indicators of significance for the intake of diet components by calves supplemented with multiple supplements or fed only mineral mix.

Item	Supplements[1]				Standard deviation	P-value[2]		
	MM	$N_{0.2}$	$N_{0.4}$	$N_{0.6}$		US	L	Q
Dry matter[3]	2.709	2.946	2.992	4.082	0.385	0.0006	<.0001	0.0054
Forage dry matter	1.745	1.656	1.538	1.912	0.334	0.9288	0.2482	0.1599
Milk dry matter	0.971	0.838	0.858	1.039	0.335	0.5229	0.1001	0.4481
Organic matter[4]	2.569	2.778	2.680	3.356	0.364	0.0280	0.0074	0.0370
Forage organic matter	1.625	1.533	1.435	1.740	0.308	0.6913	0.3115	0.2133
Crude protein[5]	0.433	0.511	0.558	0.872	0.078	<.0001	<.0001	0.0003
Ether extract[6]	0.381	0.341	0.388	0.489	0.120	0.4890	0.0028	0.4954
NDFap	0.998	1.076	1.035	1.284	0.198	0.1817	0.1001	0.1902
Non-fibrous carbohydrates[7]	0.769	0.861	0.929	1.343	0.115	<.0001	<.0001	0.0023
Digestible dry matter[8]	1.866	2.168	2.261	3.197	0.319	<.0001	<.0001	0.0068
Digestible neutral detergent fiber	0.573	0.702	0.646	0.727	0.110	0.0285	0.6679	0.2338
Total digestible nutrients[9]	2.283	2.525	2.710	3.625	0.096	0.0004	<.0001	0.0558
Indigestible neutral detergent fiber	0.367	0.357	0.332	0.401	0.070	0.9182	0.3183	0.2335
	g/kg BW							
Dry matter[10]	16.63	17.88	18.15	25.35	0.233	0.0008	<.0001	0.0049
Forage dry matter[11]	10.64	10.07	9.23	12.42	0.212	0.9455	0.0181	0.0221
Organic matter[12]	15.62	16.72	16.06	20.21	2.176	0.0309	0.0046	0.0227
Forage organic matter[13]	9.92	9.34	8.62	11.36	1.976	0.8364	0.0300	0.0356
NDFap	5.97	6.52	6.20	7.73	1.309	0.0985	0.1607	0.1056

[1]/NDFap: neutral detergent fiber corrected for ash and protein. [2]/Indicators of significance for contrast among animals fed multiple supplements or only mineral mix and for linear (L) and quadratic (Q) effects of the level of supply of multiple supplements. [3]/$\hat{Y}$=3.96-1.52x+0.52x² (R^2=0.5925). [4]/$\hat{Y}$= 3.55-1.12x+0.34x²(R^2=0.2838). [5]/$\hat{Y}$=0.7143-0.329x+0.12x² (R^2=0.7931).[6]/$\hat{Y}$=0.268+0.066x (r^2=0.2490). [7]/$\hat{Y}$=1.115-0.417x+0.16x² (R^2=0.7564). [8]/$\hat{Y}$=2.83-1.05+0.38x² (R^2=0.6134). [9]/$\hat{Y}$=2.98-0.783x+0.322x² (R^2=0.4970).[10]/$\hat{Y}$=25.07-10.86x+3.71x² (R^2=0.5658).[11]/$\hat{Y}$=15.17-7.20x+2.11x²(R^2=0.3505).[12]/$\hat{Y}$=22.54-8.36x+2.56x² (R^2=0.3390).[13]/$\hat{Y}$=13.64-6.08x+1.79x² (R^2=0.3117).

When expressed as g/kg of body matter, the intakes of forage DM and forage OM were greater for the unsupplemented animals fed MM only.

The supply of multiple supplements affected the intakes, in kg/d, of DM, OM, CP, NFC, DDM, and TDN, which responded quadratically, and EE, which increased linearly.

When expressed as g/kg of BW, the multiple supplements affected the intakes of DM, FDM, OM, and FOM.

Table 5 shows the estimates of total apparent digestibility of the diet components according to the treatments to which the calves were subjected. Supplementation increased the total apparent digestibility coefficients of DM, OM, NDFap, and NFC, and also increased the TDN content. The level of supply of the multiple supplements increased EE digestibility linearly.

Table 5. Means, standard deviation, and indicators of significance for the total apparent digestibility coefficients of the components of the diet fed to calves supplemented with multiple supplements or only mineral mix.

Item	Supplements				Standard deviation	P-value[2]		
	MM	$N_{0.2}$	$N_{0.4}$	$N_{0.6}$		US	L	Q
Dry matter[1]	0.6854	0.7303	0.7481	0.7604	0.0057	0.0025	0.1981	0.8932
Organic matter[1]	0.7173	0.7707	0.7723	0.7351	0.0057	0.0133	0.4430	0.6099
Crude protein[1]	0.7460	0.7619	0.7727	0.8023	0.0780	0.1639	0.1853	0.7243
Ether extract[1,4]	0.9177	0.8984	0.9443	0.9394	0.0690	0.5657	0.0610	0.1827
Corrected neutral detergent fiber[1]	0.5871	0.6666	0.6523	0.6311	0.0560	0.0027	0.1689	0.8841
Non-fibrous carbohydrates[1]	0.7713	0.8461	0.8689	0.8615	0.0540	<.0001	0.4991	0.4546
Total digestible nutrients[1]	0.8397	0.8495	0.8968	0.8608	0.0960	0.0308	0.7505	0.1945
Serum urea nitrogen[3]	6.80	13.01	13.45	12.93	1.7732	<.0001	0.9539	0.6893

[1]/ in kg/kg. [2]/Indicators of significance for contrast among supplemented and unsupplemented (US) animals and for linear (L) and quadratic (Q) effects of the level of supply of multiple supplements. [3]/in mg/dL. [4]/$\hat{Y}=0.8838+0.0218x$ ($r^2=0.1423$).

No significant differences (P>0.10) were found for final BW, ADG, or final BCS of cows according to the treatments applied to their calves. Additionally, no differences were observed for intake or digestibility of the dietary components.

The yield and composition of the milk produced by the dams had no differences (P>0.10) among the treatments applied to the calves, indicating that supplementation did not affect their suckling behavior. The average milk yield was 7.01 kg per day, with 3.28% CP, 4.61% fat, and 4.27% lactose (Table 6).

Table 6. Descriptive statistics of the variables studied in the dams.

Item	Minimum	Mean	Maximum	Standard deviation
Initial body weight[1]	375.1	447.2	560.0	47.1
Final body weight[1]	400.0	469.2	570.1	43.4
Average daily gain[1]	-0.513	0.146	0.447	0.22
Initial body condition score[1]	3.5	4.3	5.2	0.43
Final body condition score[1]	3.8	4.7	5.5	0.44
Dry matter intake[2]	5.380	13.365	27.100	4.008
Organic matter intake[2]	4.980	12.374	25.090	3.710
NDF intake[2]	3.100	7.706	15.620	2.310
Crude protein intake[2]	0.642	1.594	3.233	0.478
Ether extract intake[2]	0.093	0.231	0.469	0.069
Non-fibrous carbohydrates intake[2]	1.760	2.562	5.760	0.839
TDN intake[2]	3.810	7.440	14.640	2.134
Dry matter digestibility[3]	0.5370	0.5857	0.6390	0.0250
Organic matter digestibility[3]	0.5630	0.6180	0.6780	0.0270
NDF digestibility[3]	0.5710	0.6372	0.6980	0.0288
Crude protein digestibility[3]	0.5530	0.6345	0.7030	0.0384
Milk yield[2]	3.97	7.01	11.80	1.83
Lactose[3]	2.77	4.27	4.70	0.48
Crude protein[3]	2.12	3.28	4.14	0.45
Ether extract[3]	2.72	4.61	6.06	0.92

[1]/ in kg. [2]/ in kg/d. [3]/ in %.

Because there was no effect of treatments applied to the calves on the evaluated variables for the dams, a descriptive analysis of the data was conducted for the dams. The descriptive statistics of the evaluated variables for the dams are displayed in Table 6.

Discussion

Forage is the basis of the grazing-cattle production system, and thus the animal performance is directly related to the forage allowance, which affects the grazing behavior, interfering with the quality and quantity of nutrients and nutritional properties ingested by the animals, which is a decisive factor in the performance of grazing animals.

To understand the grazing-cattle rearing system, one must understand the parts that compose it (animal, plant, and environment) as well as their interactions. The concept of pdDM was developed (PAULINO et al., 2004) to better express these interrelationships, and, according to Paulino et al. (2008), it is a measure that integrates the quantitative and qualitative aspects of the pasture, which enables greater precision in the actual evaluation of the support capacity and animal performance in the used area.

The availability of pdDM expressed as a function of BW leads to the qualitative and quantitative idea of the forage momentarily available to the animal, regardless of the stocking rate. Paulino et al. (2004), aiming to associate production per animal and per area, suggested the supply of 4 to 5% BW in pdDM (between 40 and 50 g pdDM/kg BW) of pasture for a satisfactory animal performance in a grazing system. In this study, the average pdDM mass was 190 g/kg BW, which is above the value recommended by this author, demonstrating that the amount of forage did not compromise the animal performance.

Precipitation during the experimental period was 271.6 mm, which positively affected the quality and quantity of forage available to the animals. The Brachiaria grass obtained via manual simulation of grazing averaged 119.3 g CP/kg DM (Table 2), which is above the 10% cited by Sampaio et al. (2009) as the level that optimizes the use of energy substrates from the forage, which explains the supplementation with nitrogen compounds to optimize the use of forage and consequently the animal performance. However, the supply of multiple supplements improved the performance of the calves, which can be proved by the better performance ($P<0.10$) of the calves that were fed multiple supplements in relation to those that received an MM only (Table 3). Approximately 23% of the nitrogen in the forage was in the form of neutral detergent insoluble nitrogen (NDIN), i.e., it was in the form of nitrogen slowly available to the animal.

This result can be attributed to the greater intake of nitrogen compounds and nutritional attributes (Table 4) by the animals provided with multiple supplements, which might have had a beneficial effect on the ruminal environment, promoting better use of the diet consumed by the supplemented animals and consequently greater weight gain. This result reinforces the importance of supplementing suckling calves so as to complement the intake of nutrients and nutritional attributes and optimize their productive performance, providing greater weights at weaning and reducing the duration of the post-weaning phase, because in tropical regions the consumption of milk and forage is not high enough to allow the calves to express their genetic potential (BARROS et al., 2014; VALENTE et al., 2012).

The levels of supply of multiple supplements increased the ADG of the calves linearly. The increase in the amount of supplement provided improved their performance.

The visual assessment of the BCS is a practice that seeks to understand the body composition of the adult animal in terms of fat percentage. Although it is considered a subjective measure, BCS is an important tool adopted in cattle production systems because it takes into account the accumulation of body reserves that females can mobilize during the suckling phase (OLIVEIRA et al., 2006). In this study, there were no significant differences (P>0.10) for the final BW, ADG, or final BCS (Table 6) of the cows according to the treatments applied to their calves.

The number of daily breastfeedings influences the milk production and physical wear of the mother (KRESS et al., 1990), such that a larger number of breastfeedings over a day could cause the cow to produce more milk as a response to the greater stimulus and consequently greater physical exhaustion. However, similarly to the results found in this study, Barros et al. (2014), Lopes et al. (2014), and Valente et al. (2012) did not find differences in milk production among the cows that had their offspring supplemented or did not receive multiple supplementations. The amount of supplement offered to the calves was not sufficient to alter the suckling behavior and consequent the milk production, BCS, and final BW of the cows. Thus, the milk production of the cows did not affect the performance of the calves, and so the differences observed in ADG are only due to the supply of multiple supplements.

Multiple supplementations increased the intakes (Table 4) in kg/d of DM, OM, CP, NFC, DDM, DNDF, and TDN. The difference in intake was probably caused by the consumption of DM from the supplement, as there was no difference in forage DM intake in kg/d between the calves provided with multiple supplements and only with an MM.

Among the levels of supply of multiple supplements, a quadratic effect was observed on the intakes in kg/d of DM, CP, NFC, DDM, and TDN (P<0.10), probably because the supplement intake was much greater when the animals received the 0.6% BW treatment. The supplement supply increased EE intake linearly, probably due to the greater intake of supplement, as there was no difference in DM intake from milk, the main source of this nutrient.

Measuring the effectively digested ingested mass allows us to integrate the effects of calf supplementation on intake and digestibility. In this study, an effect of multiple supplementations could be observed on DM intake and DM digestibility (Table 7), which elevated the DDM of the calves fed multiple supplements. The greater DM digestibility of the animals fed multiple supplements can be in part due to the greater intake of compounds of easy digestion and to the increased pasture digestibility, since there was an alteration in the total digestibility of NDFap (P>0.10) in response to supplement intake.

Multiple supplementations affected (P<0.10) the intake of TDN in kg/d. The increments observed in the TDN content in the diet with supplementation seem to reflect the elevation of the intakes of CP and NFC and the increase in the NDF digestibility, although there was no significant increase in NDF intake. This behavior is reinforced when we consider that supplementation elevated TDN intake and the intake of digestible NDFap (P>0.10).

The milk DM intake did not show significant differences (P>0.10), confirming that the milk yield of the dams was similar in the different animal groups, so it is not a factor that would interfere with the difference in performance among the animals.

According to data from Paulino et al. (2010), beef calves with a BW of 175 kg and an ADG of 750 g require 2.10 kg TDN/d. In our study, the TDN intake by the calves, in kg/d, was 2.286, 2.525, 2.710, and 3.625 for the supplements MM, $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively. The requirement of CP for calves with 175 kg of BW and an ADG of 750 g is 596.05 g/d. In this study, CP intake by the calves, in g/d, was 433, 511, 558, and 872 for the treatments MM, $N_{0.2}$, $N_{0.4}$, and $N_{0.6}$, respectively. Therefore, although the TDN was above the requirement for a gain of 750 g/d for all treatments, the CP intake limited the performance of the animals that received only mineral supplementation, so these animals could not have an ADG above 750 g/d.

The supply of increasing levels of multiple supplements increased CP intake and provided a linear increase in the ADG of the calves, thereby providing greater weight at weaning.

According to data from Paulino et al. (2010), beef cows with a BW of 450 kg, producing 7 kg of milk per day, and with an ADG of 150 g, have a TDN requirement of 5.93 kg/d. In this study, the TDN intake of the cows, in kg/d, was 7.440. The CP requirement for lactating cows with a BW of 450 kg and an ADG of 150 g is 1.215 g/d. In the present study, the CP intake of the cows was 1.594 g/d. Thus, for both the TDN and CP intakes, our results are consistent with Paulino et al. (2010).

An increase in total digestibility can be expected with the inclusion of multiple supplements in the diet of grazing animals, because these supplements present greater digestibility than forage. Multiple supplementations increased the total apparent digestibility of DM, OM, NDF, and NFC and increased the TDN content. This increase may be due to the presence of more easily digestible compounds in the diet of the animals that were fed multiple supplements, given that there was no increase in NDFap digestibility in response to the supplement intake; nevertheless, there was no increase in NDF intake.

The apparent digestibility coefficients of CP and NDF were highest in the animals fed multiple supplements due to the effect of the lower proportion of the fecal metabolic fraction in relation to the ingested nutrient (BARROS et al., 2011; CABRAL et al., 2006). Because the apparent digestibility coefficient is a relative measure, at low CP intakes these metabolic losses have a greater capacity to reduce the estimate of the digestibility coefficient of CP, with reflections on the digestibility coefficient of DM and OM. The microorganisms obtain nitrogen (N) from the diet and recycling, which results in a decrease in the proportion of endogenous N in the fecal nitrogen compounds as the N intake is increased (CABRAL et al., 2006; VALADARES et al., 1997).

The level of supply of multiple supplements had a positive and linear effect on the apparent digestibility of EE.

The serum urea nitrogen (SUN) levels are affected by the nutritional level, especially in ruminants; it is a sensitive and immediate indicator of protein intake (GONZALES; SCHEFFER, 2002). Therefore, the SUN estimates have been employed to diagnose the adequacy of the use of nitrogen compounds in the rumen according to the availability of degradable OM (SAMPAIO et al., 2009). The concentration of SUN was greater for the calves that received multiple supplements in relation to those fed only MM. This fact can be attributed to the greater CP intake of the supplemented animals, since the concentration of SUN is positively correlated with N intake. Among the supplemented animals, no effect of multiple supplements was found on the SUN content.

Valadares et al. (1997) suggested that plasma urea N levels between 13.52 and 15.15 mg/dL correspond to the maximum microbial efficiency and would probably be the limit from which there is protein loss in Zebu steers fed 62.5% TDN.

The average SUN level for the animals fed multiple supplements was 13.13 mg/dL, which is slightly lower than the minimum value corresponding to the maximum microbial efficiency suggested by Valadares et al. (1997). However, the SUN for the animals that received MM only was 6.80 mg/dL, which is below the value shown by the supplemented animals, indicating a possible impairment of the microbial activity, which might have compromised the performance of the unsupplemented animals. Among the levels of supply of multiple supplements, there was no difference for the SUN levels, probably because the level of supply of multiple supplements had a quadratic effect on CP intake and TDN intake. Therefore, there was a better synchrony between the availability of nitrogen and energy, which increased the synthesis processes in the animal body and thus linearly increased the ADG of the animals.

Conclusions

It is recommended to provide multiple supplements to suckling beef calves reared on a creep-feeding system during the rainy-dry season transition.

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