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Short-term protein-energy supplementation at weaning or in the transition of dry-rainy season on performance of Nellore calves kept on Mombaça or Marandu grasses

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ABSTRACT - The objective was to examine the effect of two short-term protein-energy supplementation (STPES) strategies at the rearing phase on the performance of Nellore calves grazing on Mombaça or Marandu grasses. The experiment used 72 calves (7-mo old, 229±3.0 kg body weight [BW]) allotted in a completely randomized block design to four treatments in a 2 × 2 factorial arrangement: two forage cultivars (*Panicum maximum* cv. Mombaça vs. *Brachiaria brizantha* cv. Marandu) and two STPES (WEAN – STPES immediately after weaning vs. TRAN – STPES in the transition of dry-rainy). The WEAN animals received 1 kg day^{-1} (n = 36) of a protein-energy supplement, whereas TRAN animals were subjected to STPES at 2 g/kg BW day^{-1} (n = 36), both for 53 days. Every 28 days, calves were weighed to measure performance, and pastures were sampled to evaluate productive and structural traits. Growth performance was analyzed considering a completely randomized block design with a 2 × 2 arrangement of treatment, whereas forage responses included repeated measures. Marandu had a higher forage mass (3,586 kg) than Mombaça (2,890 kg), but there was no difference in forage mass in each cultivar between preconditioning periods. The nutritional composition of Marandu and Mombaça cultivars did not differ and had similar results of *in vitro* fermentation variables. Stocking rate was higher for WEAN, in the Mombaça pastures. The STPES at weaning on Marandu provided greater gains per area. When applied in the period following the weaning and coinciding with the dry season, the STPES improves the performance of newly weaned calves kept on Marandu and Mombaça grasses.

Keywords: animal production, rearing, supplementation, weight gain

1. Introduction

In recent years, beef cattle farming has established itself as an important food-producing activity in Brazil. The country occupies a prominent position in the international beef market, with its main competitive advantage being pasture-based production. However, due to climatic factors, tropical pasture production is seasonal, which leads to seasonal variations in grass availability and quality (Euclides et al., 2018). This qualitative and quantitative fluctuation may limit animal performance (Da Silva et al., 2009) as a result of nutritional requirements not being properly met (Euclides et al., 2007).

Among several grasses that are employed in the different production systems, *Panicum maximum* cv. Mombaça and *Brachiaria brizantha* cv. Marandu grasses have been largely widespread. Although they exhibit high yield potential (Jank et al., 2010), the known qualitative and quantitative seasonal variations of these grasses are remarkable. According to Euclides et al. (2014), an alternative approach is to make more intensive use of feed supplementation, especially at critical times such as the post-weaning phase and in the dry to rainy transition phase, which could increase animal growth rates, allowing for earlier slaughter.

Among the techniques available to improve growth performance, the weaning preconditioning has been reported. Dated back to 1967, preconditioning is based on practices like dehorning, castration, and vaccinations pre- and post-weaning, but also recommends improved feed supplementation to calves (Dhuyvetter, 2004). Considering that many calves are weaned in the autumn, in Brazil, when pasture quality has decreased, and that the transition between the dry and the rainy season may impose additional nutritional restraints, improving feed supplementation through short-term provision of protein-energy supplements may avoid body weight (BW) loss in both situations.

Therefore, the objective of the present study was to evaluate the effects of short-term protein-energy supplements for calves grazing two forage cultivars (*Panicum maximum* cv. Mombaça or *Brachiaria brizantha* cv. Marandu) in the rearing phase, either immediately after weaning or in the transition of the dry-rainy season.

2. Material and Methods

The experiment was carried out in Campo Grande, MS, Brazil (20°27' S, 54°37' W, 530 m asl), from June 19 to November 27, 2018, totaling 161 days of evaluation. This period comprised the dry season and the transition of dry-rainy season. Animal care and use was conducted according to the institutional Animal Care and Use Committee (CEUA: 01/2020).

According to the Köppen classification system, the climate of the region is a tropical rainy savannah type, Aw subtype, characterized by a seasonal distribution of rainfall, with the occurrence of a dry season during the coldest months (May to September). Average annual precipitation is around 1500 mm, of which 80% is distributed in the rainy season (October to April). Temperature and precipitation data during the experimental period (Figure 1) were collected by the meteorological

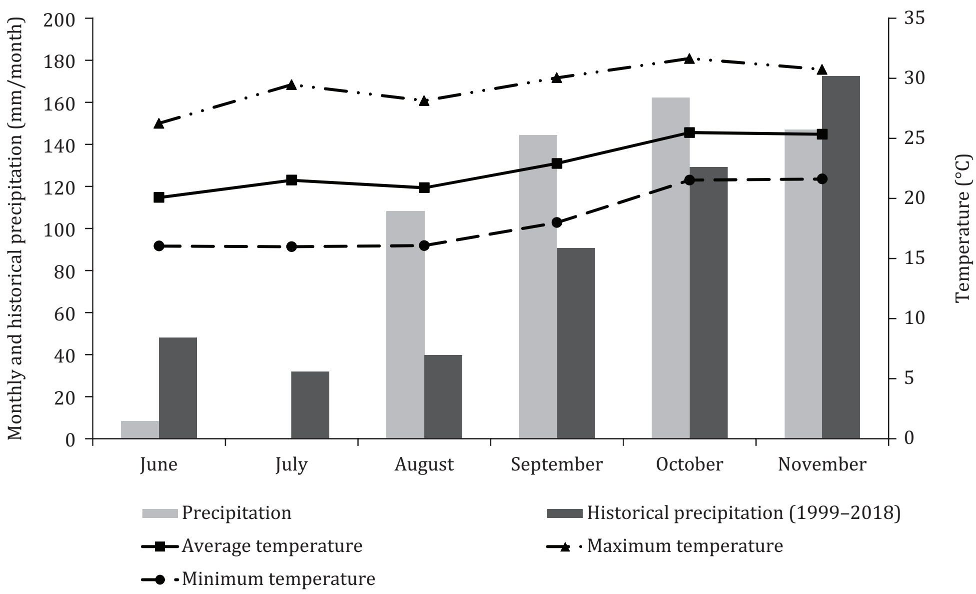

Figure 1 - Average, minimum, and maximum temperatures and monthly and historical precipitation (1999-2018) during the experimental period.

station of Embrapa Beef Cattle, 3 km away from the experimental area. Based on the monthly mean temperature and monthly precipitation, the monthly water balance was calculated, adopting 75 mm as the soil water-holding capacity (Figure 2). The soil in the experimental area is classified as dystric red Ferralsol (Embrapa, 1999).

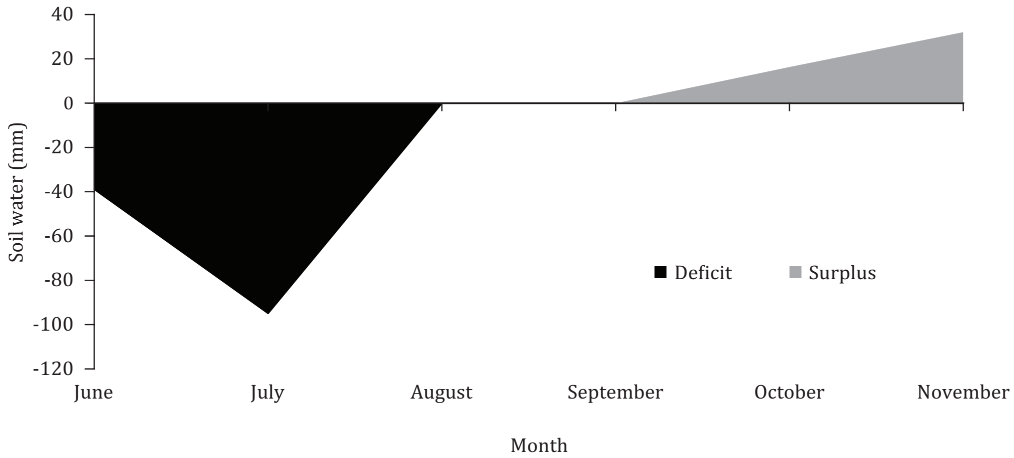

Figure 2 - Soil water balance during the experimental period.

The experiment was laid out in a completely randomized block design to evaluate two forage cultivars (*Panicum maximum* cv. Mombaça or *Brachiaria brizantha* cv. Marandu) associated with short-term protein-energy supplementation at two different periods of the rearing phase: immediately after weaning (WEAN) or in the transition of dry-rainy season (TRAN), in a 2 × 2 factorial arrangement of treatments.

The experimental area consisted of 12.0 ha of Mombaça grass that were divided into eight paddocks, grouped within two subareas (blocks), and 14.6 ha of Marandu grass divided into 12 paddocks, grouped within three subareas (blocks). The continuous grazing method was employed with a variable stocking rate that was determined based on the individual weight gain of the animals. A total of 72 Nellore calves at approximately seven months of age, with an average initial weight of 229±3.0 kg, were used. The animals were distributed according to their weight so that the average weight in each paddock was similar.

For WEAN, the calves received protein-energy supplement (21% crude protein [CP] and 63% total digestible nutrients [TDN]) at 1.0 kg/animal day^{-1} for 53 days (06/19/2018 to 08/11/2018); after this period, the animals received low-intake protein supplementation for 107 days (08/12/2018 to 11/27/2018). For TRAN, the animals received low-intake protein supplementation immediately after weaning for 107 days (06/19/2018 to 10/04/2018); afterwards, animals received a protein-energy supplement at 2 g/kg BW day^{-1} for 53 days (10/05/2018 to 11/27/2018). The low-intake protein supplement contained 25% CP and 64% TDN, for an intake estimated at 1 g/kg BW per day.

The STPES was supplied daily at 08:00 h, whereas the protein supplement was supplied three times a week (Monday, Wednesday, and Friday). The amount of protein supplements to be supplied was adjusted weekly to ensure approximately 5% orts. These were collected once weekly, weighed, and taken to the laboratory to determine the dry matter (DM) content. Supplement intake was calculated in g/animal day^{-1}, considering the difference between the amount supplied and orts.

The animals were weighed twice in each supplementation cycle, after being feed-deprived for 16 h, to determine the average daily gain (ADG), which was calculated as the difference in animal weight between the beginning and end of each period divided by the number of days between weighing events. Weight gain per area was calculated by multiplying the ADG of the animals by the number of animals kept in each paddock.

The grasses were collected every 28 days to determine the forage mass (FM). Nine samples of Mombaça grass and 20 samples of Marandu grass (1 m^2) were randomly selected and collected at soil level in each paddock. These were weighed to determine the fresh weight and then divided into two sub-samples. One sub-sample was weighed and dried inside paper bags in a forced-air oven at 55 °C until reaching constant weight to determine FM. The other sub-samples were grouped and then separated into leaf (leaf blade), stem (true stems + leaf sheath), and dead material. The total dry weight was used to calculate the percentage of each component and determine the leaf:stem ratio.

Forage accumulation rate (FAR) was evaluated according to cultivar paddock structure. In Mombaça grass, an area of 0.25 ha was excluded from grazing in all paddocks (1.5 ha), so the grazing area per paddock was reduced to 1.25 ha. After 28 days, that plot was opened for grazing, and a new area of 0.25 ha was excluded from grazing, and so on every 28 days. Those areas were sampled every time they were excluded and opened for grazing. Nine samples of 1 m^2 per plot were cut at ground level and processed as described previously. Forage accumulation rate was calculated as the difference between the forage mass when the plot was opened and forage mass when it was excluded from grazing, considering only the green portion (leaves and stems), dividing by the number of days between samplings.

In Marandu grass, four exclusion cages (1 m^2) for each paddock were used. Every 28 days, the cages were placed in points representative of the average canopy height, with similar mass and morphological composition to the areas under grazing. Herbage inside and outside of the cages was harvested at the ground level and sampled as described above; then, herbage mass was determined. Following each harvest, the cages were placed at other points within the paddock according to the same method. Herbage accumulation rate was calculated as the difference between forage mass inside (current harvest) and outside (previous harvest) the cage, considering only the green part (leaves and stems), divided by the number of days between samplings.

Leaf blades and stems were dried at 55 °C for 72 h, weighed, and then ground in a knife mill with a 1-mm sieve for analysis of CP, neutral detergent fiber (NDF), and neutral detergent lignin (NDL) by near-infrared reflectance spectrophotometry (NIRS), following Marten et al. (1985).

The leaf samples were further analyzed by the *in vitro* gas production technique, which has been widely used to assess the effect of bioactive molecules on the kinetics of rumen microbial fermentation (Makkar, 2005). This technique basically consists of incubating the samples in bottles kept at 39 °C in an anaerobic medium inoculated with rumen fluid. As fermentation progresses, the gas accumulated in the headspace of these bottles is measured. The gas production curves are established, and measurements and gas release are repeated at regular intervals throughout the incubation time.

Leaf samples (0.5 g) were incubated in duplicate in 250-mL glass bottles containing 50 mL buffer solution and 25 mL rumen inoculum (Goering and Van Soest, 1970). Rumen contents were removed from two rumen-cannulated cattle fed sorghum silage and mineral salt *ad libitum*, and squeezed by hand; next, the rumen fluid was collected in a bucket with two layers of cloth. The filtered fluid was collected directly in a pre-warmed thermos bottle (39 °C) and immediately taken to the laboratory. The bottles were closed hermetically using ANKOM^{RF} Gas Production System modules (Ankom Technology, Macedon, NY, USA) containing an automated radio-frequency (wireless) gas measuring device and kept in a water bath at 39 °C for 48 h. Two blank bottles containing only rumen inoculum and buffer solution were also added to discount the gas production by the fermentation produced from these solutions.

Pressure readings (psi) were measured at 15-min intervals, in a total of n = 192 per curve, and converted to milliliters of gas using Avogadro's Law, according to the following equation: Vg = VfPpsi × 0.068004084, in which Vg = gas volume at 39 °C (in mL), Vf = fermentation bottle headspace (in mL), and Ppsi = cumulative pressure recorded in psi. Results were expressed in milliliters of gas produced per gram of incubated organic matter (mL/g OM). Cumulative gas production data were analyzed using the logistic model of Schofield et al. (1994), having the model parameters estimated by the modified Gauss-Newton algorithm applied in the NLIN procedure of SAS software (Statistical Analysis System, version 9.3). The following model was adopted: $V(t) = V_{NFC}/(1+\exp(2-4*kd_{NFC}*(TL))) + V_{FC}/(1+\exp(2-4*kd_{FC}*(TL)))$, in which V(t) = produced gas (in mL); V_{NFC} = maximum gas volume of the non-structural carbohydrate fraction (in mL); V_{FC} = maximum gas volume of the structural carbohydrate fraction (in mL); kd_{NFC} and kd_{FC} = degradation rate of the non-structural and structural carbohydrate fractions, respectively (in %/h); T = incubation times (in h); and L = lag time (in h).

To determine dry matter degradability (DMD), in the same incubation procedure described above, 0.5 g of the samples was placed in non-woven fabric (TNT) filter bags, which were then weighed again at the end of the trial. Dry matter degradability was calculated as the ratio of the amount of DM in the substrate remaining after incubation (g) to the amount of DM in the original substrate (g) multiplied by 100. These data were used to calculate the total *in vitro* gas production per digestible dry matter (DDM): DDM = amount of substrate (g) × DMD/100 and Total volume (mL/g DDM) = Total volume (mL)/DDM (g).

Data were analyzed using analyzes of variance, by the GLM procedure available in SAS v. 9.4. The statistical model included fixed effects of blocks, cultivar, STPES period, and their interaction.

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + e_{ijk},$$

in which Y_{ijk} = record of each observation, μ = mean, A_i = cultivar effect, B_j = preconditioning period, AB_{ij} = interaction effect of cultivar and STPES period, and e_{ijk} = error effect. Effects were considered significant at the 5% probability level.

3. Results

No interactions were observed among cultivar, time of the year (pasture evaluation period), and STPES for FAR, FM, leaf, stem, and dead material percentage (P>0.05; Table 1). There was no interaction between cultivar and time of the year for FAR and FM (P>0.05). However, there was cultivar vs time of the year interaction for leaf and stem percentage (P<0.0001), and for dead material percentage (P<0.001). Whereas the lowest values for leaf and stem in Marandu pastures occurred in Aug/Sep and Oct/Nov periods, respectively, the lowest values for leaf and stem were found in Jun/Jul and Aug/Sep, respectively, in Mombaça pastures. For dead material, the lowest values were found in Jun/Jul and Oct/Nov for Marandu and Mombaça, respectively.

There was no interaction effect between STPES × cultivar × time of the year or interaction effect between STPES × cultivar or STPES × time of the year (Table 2) for the evaluated variables of rumen kinetics (P>0.05) by the gas production technique and forage nutritional value throughout the experiment. There was no effect of cultivar or time of the year and their interaction (P>0.05) for the variables lag time (L), gas volume produced by non-fibrous carbohydrates (V_{NFC}), degradation rate of non-fibrous carbohydrates (kd_{NFC}), volume of gas produced by fibrous carbohydrates (V_{FC}), total gas

Table 1 - Forage production variables and pasture condition as a function of forage cultivar and time of the year

Variable	Cultivar						SEM	P-value		
	Marandu			Mombaça				Time	Cultivar	Interaction
	Jun/Jul	Aug/Sep	Oct/Nov	Jun/Jul	Aug/Sep	Oct/Nov				
Net accumulation rate (kg/ha/day)	−6.6b	16.8a	31.7a	−5.7b	30.6a	36.2a	5.32	0.0001	0.0637	0.5402
Forage mass (kg/ha)	4113.4a	3360.2b	3284.5b	3360.6a	2756.3b	2554.4b	141.86	0.0001	0.0005	0.7948
Leaf (%)	18.7b	11.8c	24.5a	12.6c	19.3b	41.7a	1.25	0.0001	0.0001	0.0001
Stem (%)	31.6a	16.7b	15.7b	18.5a	12.5b	14.3b	0.99	0.0001	0.0001	0.0001
Dead material (%)	49.9c	72.0a	59.7b	68.9a	68.2a	44.0b	1.56	0.0001	0.9022	0.0001

SEM - standard error of the mean.
Means followed by different lowercase letters in the same row differ from each other (P<0.05).

production by 24 and 48 h of fermentation, total gas volume per gram of degraded dry matter (TVDDM), or CP, ADF, and ADL contents.

There were no time or interaction effect for the degradation rate of fibrous carbohydrates (kd_{FC}, P>0.05), although Marandu grass showed lower kd_{FC} values than Mombaça grass (0.022 vs 0.025 %h,

Table 2 - Rumen fermentation variables by the gas production technique and nutritional value as a function of forage cultivar and time of the year

Variable	Cultivar						SEM	P-value		
	Marandu			Mombaça				Time	Cultivar	Interaction
	Jun/Jul	Aug/Sep	Oct/Nov	Jun/Jul	Aug/Sep	Oct/Nov				
L (h)	4.79	5.92	5.66	4.05	5.79	5.36	0.31	0.1846	0.5066	0.9221
V_{NFC} (mL)	35.17	32.26	38.86	41.16	30.09	30.96	2.10	0.3830	0.8371	0.3355
kd_{NFC} (%h)	0.116	0.089	0.093	0.078	0.088	0.107	0.005	0.7337	0.3937	0.1405
V_{FC} (mL)	55.15	52.53	52.18	41.63	52.80	63.54	3.05	0.4269	0.9313	0.2377
kd_{FC} (%h)	0.0237	0.0181	0.0241	0.0288	0.0207	0.0245	0.001	0.0563	0.0416	0.2930
Gas production (24 h, mL/g DM)	67.54	64.07	66.70	71.64	73.55	66.37	3.27	0.9333	0.3271	0.9627
Gas production (48 h, mL/g DM)	87.32	84.48	89.86	91.64	97.38	91.94	3.25	0.9805	0.2362	0.7920
DMD (%)	55.68	60.08	59.18	59.87b	66.59a	57.85b	0.59	0.0003	0.0375	0.0154
TGVDDM (mL/g DM)	315.2	277.0	309.7	308.3	292.4	321.1	11.20	0.5195	0.6665	0.9200
CP (%DM)	9.365	10.011	9.275	11.173	8.813	8.984	0.25	0.1947	0.8232	0.0710
NDF (%DM)	73.774	74.696	75.967	73.382	75.572	76.219	0.34	0.0117	0.6974	0.7179
ADF (%DM)	38.703	38.693	38.874	37.780	38.572	39.548	0.41	0.4480	0.9239	0.5805
ADL (%DM)	3.492	3.257	3.465	3.289	3.496	3.534	0.04	0.5417	0.7017	0.2000

L - lag time; V_{NFC} - maximum gas volume of the non-structural carbohydrate fraction; VFC - maximum gas volume of the structural carbohydrate fraction; kd_{NFC} and kd_{FC} - degradation rate of the non-structural and structural carbohydrate fractions, respectively; DMD - dry matter degradability, %; TGVDDM - total gas production volume/degraded dry matter; CP - crude protein; NDF - neutral detergent fiber; ADF - acid detergent fiber; ADL - acid detergent lignin; SEM - standard error of the mean.

Table 3 - Animal production variables as a function of forage cultivar, preconditioning period, and time of the year

Variable	Treatment				SEM	P-value		
	Preconditioning period		Cultivar					
	Weaning	Transition	Marandu	Mombaça		Preconditioning period	Cultivar	Interaction
June/July								
Initial live weight (kg)	227.4	229.9	229.1	228.1	1.462	0.4529	0.7635	0.9685
Final live weight (kg)	227.6	221.7	230.4	218.9	2.993	0.3036	0.0588	0.6920
Average daily gain (kg/day)	0.051	−0.059	0.074	−0.082	0.035	0.0437	0.0081	0.1326
Stocking rate (AU/ha)	2.029	1.798	2.416	1.411	0.141	0.0213	<0.0001	0.0663
Gain per area (kg/ha)	10.05	−16.38	6.24	−12.57	6.687	0.0202	0.0812	0.0506
August/September								
Final live weight (kg)	250.5	246.8	245.1	252.2	2.391	0.4421	0.1533	0.4129
Average daily gain (kg/day)	0.447	0.488	0.306	0.628	0.049	0.4968	0.0001	0.5758
Stocking rate (AU/ha)	1.854	1.766	2.486	1.134	0.186	0.5583	<0.0001	0.7953
Gain per area (kg/ha)	66.53	69.77	56.12	80.18	7.378	0.8310	0.1318	0.7659
October/November								
Final live weight (kg)	282.5	279.1	272.5	289.1	3.267	0.5388	0.0099	0.8843
Average daily gain (kg/day)	0.583	0.585	0.509	0.658	0.028	0.9624	0.0037	0.2249
Stocking rate (AU/ha)	2.443	2.355	2.625	2.173	0.097	0.6176	0.0219	0.7525
Gain per area (kg/ha)	133.1	131.1	125.1	139.2	6.740	0.8913	0.3407	0.4825
Total gain per area (kg/ha)	214.6	179.6	187.4	206.8	13.14	0.2127	0.4809	0.5475

SEM - standard error of the mean; AU - animal units.

P<0.05). There was an interaction effect (P<0.05) between cultivar and evaluation time for DMD (%) (P<0.05). Dry matter degradation did not differ between the periods on Marandu grass. On Mombaça grass, DMD was highest in August/September, but did not differ between June/July and October/November. There was an effect of the evaluation period on the leaf NDF content (P<0.05), but this variable was not affected by the cultivars or an interaction (P>0.05). The NDF content in the leaf was higher in October/November than in June/July (76.1 vs. 73.6%, P<0.05), whereas in August/September (75.1%), this variable was not significantly different from the other months (P>0.05).

The animal production variables were analyzed separately for each evaluation period (Table 3). There was no interaction effect between forage and STPES period for any of the evaluated variables; therefore, the decomposed means are not shown. Interaction trends (P<0.10) were observed for the variables of stocking rate and weight gain per area in June and July. For stocking rate, there was no effect of STPES period on Marandu grass (P>0.05, 2.44 vs. 2.39 AU/ha for weaning and transition, respectively); however, on Mombaça grass, stocking rate was higher (P<0.01) for WEAN (1.61 AU/ha) than for TRAN (1.21 AU/ha). In terms of gain per area, there was no effect of STPES period when cv. Mombaça was used (P>0.05, −10.07 vs. −15.05 kg/ha for weaning and transition, respectively), but when cv. Marandu was evaluated, WEAN provided greater gains per area than in the TRAN (P<0.01, 30.18 vs. −17.71 kg/ha for weaning and transition, respectively).

The WEAN increased ADG, weight gain per area, and stocking rate in June/July (P<0.05). There was no difference in initial or final live weight (P>0.05). From August to September and October to November, the STPES period did not affect any of the variables (P>0.05).

The animal production variables differed significantly (P<0.05) between cvs. Marandu and Mombaça. From June to July, higher ADG, stocking rate, and weight gain per area (P<0.05), in addition to a trend of higher final live weight (P<0.10), were observed in cv. Marandu. However, in August/September, despite the higher stocking rate provided by cv. Marandu, ADG was higher in cv. Mombaça (P<0.05), which contributed to the similarity between the cultivars regarding final live weight and weight gain per area (P>0.05). A similar behavior occurred in October/November, when cv. Mombaça provided higher ADG and final live weight, whereas cv. Marandu provided higher stocking rate (P<0.05). Nevertheless, weight gain per area was similar between the cultivars (P>0.05).

4. Discussion

The results of forage production and characteristics indicate that the animals were under similar grazing conditions and the differences observed in performance reflected the supplementation strategy. The larger FM (P<0.001) produced by cv. Marandu (3,586 kg/ha DM) as compared with cv. Mombaça (2,890 kg/ha DM) is due to the deferment performed during the rainy season. The deferment technique was not used for Mombaça grass, as it is not recommended (Jank et al., 2010), due to the stem accumulation characteristic of the species and its flowering time (April).

The climatic conditions influenced the behavior of the cultivar. Marandu exhibited the highest leaf percentage in October/November, when the soil water balance was positive (Figure 2). Leaf percentage in the forage canopy was lowest in August/September, when the first rains occurred (Figure 1), due to consumption by grazing animals in previous periods. In June/July, when there was no rain (Figure 1) and the soil water balance was negative (Figure 2), leaf percentage was intermediate, reflecting the accumulation of forage caused by deferment. Euclides et al. (2007) described the importance of the practice of closing pastures of *Brachiaria* cultivars to accumulate forage and ensure its availability during the drought, for animals kept on pasture.

The lower percentage of leaves observed in cv. Mombaça in June/July was due to the water deficit observed in this period (Figures 1 and 2). However, after the first rains, leaf percentage increased, which is related to the high productive potential of cv. Mombaça (Jank et al., 2010). Grazing animals have a preference for consuming leaves over stems (Hodgson, 1990). In June and July, a negative net FAR was observed due to water deficit (Table 1), but as the animals were not removed from the area, they continued to select and consume leaves, which resulted in an increased presence of stems in the canopy.

Cultivar Marandu showed the lowest percentage of dead material from June to July. From August to September, there was a higher percentage of dead material, reflecting the lower percentage of leaves, due to consumption by animals. From October to November, the dead material percentage was intermediate, due to the increase in the amount of leaves in the canopy. As regards cv. Mombaça, a higher percentage of dead material was observed from June to September, after which time the percentage of this component decreased due to the increase in net forage accumulation (Table 1).

The pasture condition descriptor variables were influenced by the management of the cultivars and varied according to the climate of each evaluation period. The climate was responsible for variations in net FAR, which influenced the percentage of leaves in the canopy. Regardless of the evaluated period, the nutritional composition of cvs. Marandu and Mombaça did not differ (CP: 9.55 and 9.66% DM; NDF: 74.81 and 75.06% DM; ADF: 38.76 and 38.63% DM; ADL: 3.4 and 3.44% DM, respectively), which resulted in similar parameters measured and estimated by the *in vitro* gas production technique.

Sort-term protein-energy supplementation right after weaning prevented weight loss between June and July, with a 110 g difference in ADG, in addition to providing greater weight gains per area, as a result of the 10% higher stocking rate. This period coincides with the onset of drought, with low rainfall and an impact on pasture quality, as verified by the lower digestibility (Mombaça), leaf:stem ratio, and leaf percentage (Mombaça) and increased stem percentage, which demonstrates the benefit of using short-term protein-energy supplementation strategy in this period. The results agree with findings of Lima et al. (2012), who compared protein-energy vs protein supplementation from April to July for cattle and observed higher ADG for the former strategy.

In the subsequent period, when all animals received only low-intake protein supplement, all performance variables were similar, probably because WEAN and TRAN cattle were subjected to similar nutritional conditions (Table 1). It is important to point out that the previous performance had no impact on the subsequent performance and that protein-energy supplementation immediately after weaning increases weight gain instantly and does not necessarily influence performance after its end.

Our study agrees with the findings of Silva et al. (2019), comparing short-term (55 days) and long-term (147 days) protein-energy supplementation of beef heifers in the dry season. The authors observed similar body weights in the end of the dry season between treatments and reported greater economic efficiency of short-term protein-energy supplementation.

Protein-energy supplementation did not affect (P>0.05) weight gain from October to November when compared with low-intake protein supplementation. This result can be explained mainly by two factors: the weaning stress and the nutritional quality of the pasture. According to Lynch et al. (2019), one of the important practices carried out in beef cattle production systems is weaning, when there is a complete transition from the nutritional and social dependence of the mother to complete independence. As the period from June to July represents the first weeks after the animals are separated from their dams, one hypothesis is that protein-energy supplementation at this stage mitigates the effect of weaning stress on performance, due to greater nutritional uptake. This was not the case for the transition of dry-rainy season, since there is no similar stress in this period.

From the nutritional point of view, various pieces of evidence support the assertion that the transition of dry-rainy season provided better nutritional uptake from the pasture, as demonstrated by the higher accumulation rate and higher leaf percentage (Table 1). A previous study in the same experimental area (Araújo et al., 2017) had already pointed to the rapid improvement in the leaf and CP contents and digestibility of Mombaça grass pastures when significant rainfall occurred from September onwards. Reports also exist stating that, in the transition of dry-rainy, forages would not be considered deficient in nitrogen, showing CP contents close to 100 g/kg DM (Detmann and Valadares Filho, 2010). Overall, the literature points to lesser benefits of feed supplementation on pasture when the nutritional quality is high (Poppi and McLennan, 1995), which could explain the lack of short-term protein-energy supplementation benefits in the transition of dry-rainy.

However, the literature supports the unproven hypothesis in this study that short-term protein-energy supplementation in the transition of dry-rainy season could result in performance gains. The study by

Araújo et al. (2017) demonstrated the potential benefit of short-term protein-energy supplementation on Mombaça grass pastures, as the authors reported increased ADG at weaning, as compared with low-intake protein supplementation. There are also reports that the availability of digestible DM in the transition of dry-rainy season may be low, affecting performance (Paulino et al., 2002) and that, in worse management scenarios, the decrease in protein content and in DM digestibility can affect intake and animal performance. Thus, the possibility of benefits of the short-term protein-energy supplementation in the transition of dry-rainy season should not be discarded, especially in conditions of worse management and more severe drought, for which further research is warranted.

The differences between cultivars for animal performance variables may have reflected their distinct characteristics in terms of growth, response to water conditions and management. The better animal performance shown by the calves kept on Mombaça grass after August may be related to the increase in precipitation, which affected leaf production and its nutritional quality. These, in turn, are supported by the increase in accumulation rate, leaf:stem ratio, DM digestibility, and fibrous carbohydrate degradation rate. As for stocking rate, the highest values found in cv. Marandu are mainly related to the forage mass, which was higher not only at the beginning, but throughout the experimental period.

5. Conclusions

Short-term protein-energy supplementation improves the performance of newly weaned calves kept on Marandu and Mombaça grass pastures when applied in the period immediately after weaning, in the dry season of the year. However, this improvement may not result in gains when the entire dry season is considered—including the transition of dry-rainy season—, especially under a favorable rainfall. Mombaça grass may improve animal growth rate in the dry to transition periods; however, Marandu grass may support greater stoking rates and weight gain in the early dry period.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: R.C. Gomes. Data curation: R.C. Gomes. Formal analysis: R.C. Gomes. Funding acquisition: R.C. Gomes. Investigation: D.B. Montagner, C.T. Marino and R.C. Gomes. Methodology: C.T. Marino, V.P.B. Euclides and R.C. Gomes. Project administration: R.C. Gomes. Resources: G.S. Difante, V.P.B. Euclides and R.C. Gomes. Supervision: D.B. Montagner, C.T. Marino, G.S. Difante and R.C. Gomes. Validation: R.C. Gomes. Visualization: L.P. Bitencourt, C.T. Marino, A.P. Neves and R.C. Gomes. Writing – original draft: L.P. Bitencourt, D.B. Montagner, C.T. Marino, G.S. Difante and R.C. Gomes. Writing – review & editing: L.P. Bitencourt, D.B. Montagner, C.T. Marino, G.S. Difante, A.P. Neves and R.C. Gomes.

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