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Morphological and structural characteristics of *Urochloa decumbens* Stapf. deferred pasture grazed by heifers under two periods of protein-energy supplementation

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ABSTRACT. The aim of this study was to evaluate the morphological and structural characteristics of deferred *Urochloa decumbens* Stapf. 'Basilisk' grazed by Nellore heifers under two periods of protein and energy supplementation (PES). The experiment was carried out from Jun 21 to Nov 15, 2016, under a completely randomized design and two PES periods (55 [P55] and 147 [P147] days). Forage mass (FM), leaf blade dry mass (LBDM), stem dry mass (SDM), dead material dry mass (DMDM), canopy height (CH), and forage bulk density (FBD) were evaluated. Data were analyzed by the SAS® PROC MIXED procedure and treatment means were compared with the Student's *t* test ($p < 0.05$). LBDM was higher for P147 heifers after 21, 84, and 126 days of grazing, similar to those observed after 63 days, and was higher for P55 heifers at 42, 105, and 147 days of grazing. SDM was lower for P147 heifers after 21, 42, 105, and 126 days, and similar in the other grazing periods. Protein and energy supplementation for heifers over 147 days resulted in a lower stem mass of *U. decumbens* Stapf. 'Basilisk' deferred pastures.

Keywords: Dead material; forage bulk density; leaf blades; stems; stockpiling.

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Introduction

Deferment pasture strategies are an efficient method of attenuating the effect of seasonality on forage production in Brazil, and are technically feasible when the regrowth period and grazing intensity of each forage species is considered. In addition, forage plants must have the capacity for high accumulation, and experience a limited reduction in forage quality during the stockpiling period; for this purpose, grazing is not allowed at the end of the rainy season and is used at the beginning or middle of the dry period (Hoffmann et al., 2014).

Urochloa decumbens is one of the most commonly used forage species in Brazil because it presents desirable characteristics, such as adaptation to most Brazilian regions, an herbaceous canopy, and a higher proportion of leaf than stem. Additionally, it presents less of a seasonality effect than grasses of the genus *Panicum* spp. and *Pennisetum* spp., which potentiate forage accumulation during the dry period (Santos, Fonseca, Gomes, Balbino, & Magalhães, 2010).

In addition, when seeking greater efficiency in the utilization of the forage from deferred pastures, knowledge on variation in the structure of these pastures and the morphological composition of the forage is essential. This is because changes in canopy height, forage mass, proportions of leaf, stems, and dead material modify the quality of the forage, mainly as a function of the physiological maturity of the plants (Santos et al., 2008).

Increasing the efficiency of forage utilization in deferred pastures is possible, mainly, because of protein-energy supplementation (PES). The use of PES promotes the inclusion of nitrogen compounds in the rumen, consequently increasing the population of fibrolytic bacteria population. Thus, there is an increase in the rate of ruminal degradation, passage, and consequent forage intake (Malafaia, Gonçalves, Ferreira, & Morenz, 2007). However, literature on changes in plant morphology and the structure of deferred grasses when occupied by animals receiving supplementation with multiple mixtures is limited.

In this way, the use of multiple supplements enables animals to improve their use of forage resources and, consequently, to improve production systems (Barros et al., 2015). During the dry period, protein is the main factor limiting ruminant performance (Van Niekerk & Jacobs, 1985); therefore, the supply of multiple mixtures can increase forage intake because of the increased nitrogen supply to the rumen environment.

Thus, stockpiling pasture related to PES can improve performance and reduce the heifer growth period. However, as a rule, PES supply occurs throughout the dry period, though such a measure is not necessary to maintain animal performance (Malafaia et al., 2007). This is because, when there is feedback from cattle after nutritional restriction, there is usually "compensatory growth". This phenomenon occurs when the weight gain of animals submitted to nutritional restriction is limited compared to that of animals without restriction. Compensatory growth may justify the adoption of partial PES periods (Yambayamba, Price, & Jones, 1996). In addition, increased voluntary consumption via PES may hamper the regrowth of deferred pastures if forage supply is not sufficient for the entire period of use. In this way, the adoption of partial PES periods can help to increase the economic efficiency of pasture production systems.

The aim of this study was to evaluate the morphological and structural characteristics of deferred pastures of *U. decumbens* Stapf. 'Basilisk', used under continuous stocking of Nellore heifers receiving PES, in two periods of the dry season in Valença – State of Rio de Janeiro, Brazil.

Material and methods

The present study was carried out at Santana Farm (Fazenda Santana), in Valença – Rio de Janeiro (43°42′11″O and 22°14′46″S), with an average altitude of 551 m and a Cfa climate (subtropical moist, according to Köppen and Geiger (1928)). An experimental area of 16.0 hectares was previously established (2006) with pastures of *U. decumbens* Stapf. 'Basilisk', divided in two areas with 8.0 hectares each to test supplementation periods over 147 (P147) or 55 days (P55). To this area, 60 kg ha^{-1} of N, 50 kg ha^{-1} of P_2O_5, and 50 kg ha^{-1} of K_2O were applied, and then, the pasture areas were deferred (Feb 02 to Jun 21, 2016). Fertilization was performed according to the management traditionally adopted on the farm. Soil chemical analysis for pasture P147 revealed the following results: 0.0; 1.7; 1.4, and 6.9 cmol$_c$ dm^{-3} for Na, Ca, Mg, and H + Al, as well as 2 and 47 mg dm^{-3} for P and K, respectively. The following were obtained for the P55 pasture: 0.0; 1.4, 0.8, and 7.3 cmol$_c$ dm^{-3} for Na, Ca, Mg, and H+Al, in addition to 2 and 26 mg dm^{-3} for P and K, respectively.

Meteorological data during the experimental period (monthly) were obtained from the National Institute of Meteorology (INMET) data set, with reference to the automatic station of Valença – o Rio de Janeiro (Figure 1).

Crop water balance was obtained from June to November 2016 (Figure 2), according to the proposed equations by Camargo and Camargo (2000).

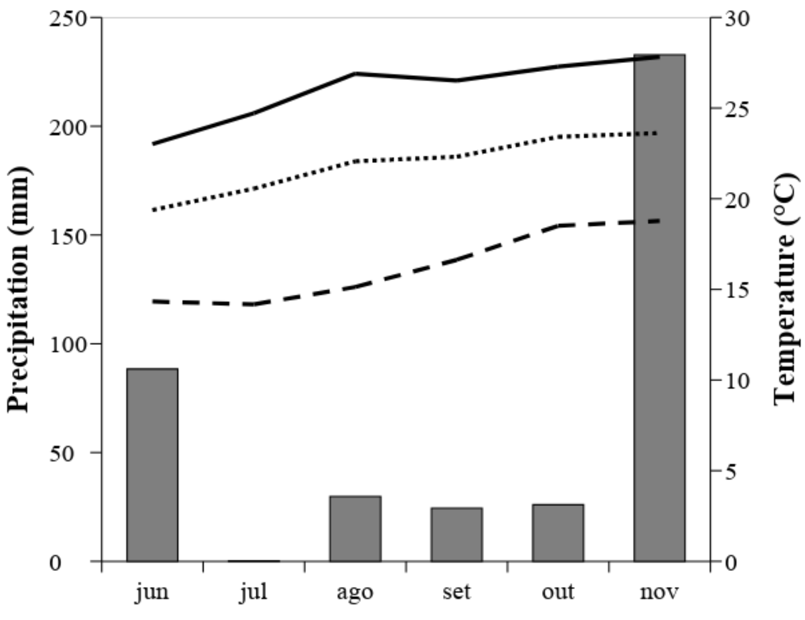

Figure 1. Monthly precipitation (⊠bars), maximum temperature (−−−), average temperature (······), and minimum temperature (- - -) from June to November of 2016 (INMET, 2016).

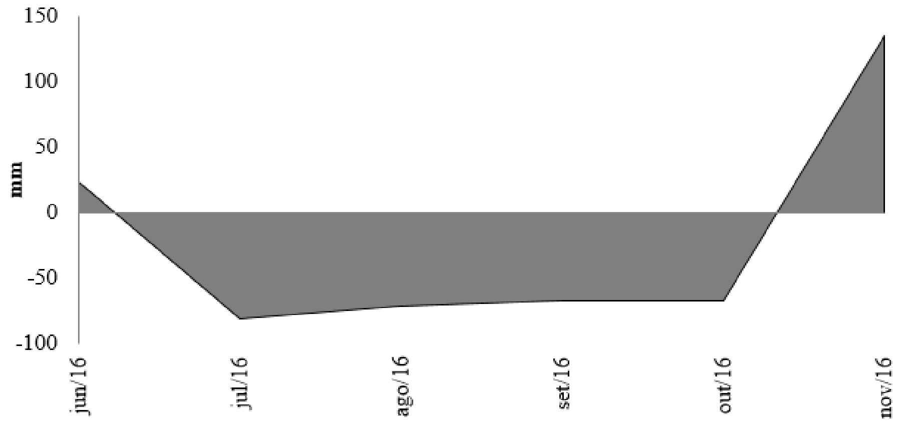

Figure 2. Water balance of the crop during the experimental period - June to November 2016 (Camargo and Camargo, 2000).

The experiment started on Jun 21, 2016 and ended on Nov 15, 2016. The experimental design was completely randomized with two periods of protein and energy supplementation (PES) as treatment (147 [P147] and 55 [P55] days) during the dry season. Ten forage samples were collected at 21-day intervals using metallic frames of 0.25 m^2 (0.5 × 0.5 m) and were considered as replicates (n = 10). Evaluations (forage height and harvest samples) were performed at pre-established points in the respective pastures, always by the same evaluator.

These evaluation points were maintained throughout the experimental period, so that the frame could represent a replicate. Recently, authors have used similar methodology to evaluate pastures, such as Leal et al. (2017), who used pre-established points in *Brachiaria* hybrid 'Mulato II' pasture as replicates, and Silva et al. (2018) who used units and sampling ("frames") as pasture replicates of *Panicum maximum* Jacq. 'Tanzania'.

Forage samples were manually harvested as close as possible to the soil level, followed by subsampling and fractionation on leaf, stem + sheet, and dead material. The morphological components were dried in a forced air ventilation oven at 55°C to a constant weight, to estimate masses per hectare. In addition, crude protein (CP) and neutral detergent insoluble fiber (NDF) were determined, as described by Van Soest, Robertson, and Lewis (1991). The height of the canopy was estimated with a centimeter ruler at three points inside the frame, for a total of 30 height points per area. In the present study, 36 Nellore crossbred heifers were used, which were distributed in two homogeneous plots (3/4 Nellore), heifer category, age (15 ± 1 months), and body weight (296 ± 4 kg). P147 treatment included 16 heifers and P55 treatment included 20 animals. The use of animals was approved by the animals right committee (CEUA-IZ), UFRRJ, under protocol number 23083.00822/2015-56.

Forage allowance (FA) was calculated using the equation: $FA = ([(FA \times A) \div GP] \div TWH) \times 100$, according to Schio et al. (2011), where: FA is the forage allowance estimated in kg ha^{-1} MS 100 kg^{-1} PC; MF is the mass of forage in kg ha^{-1}; A is the area of each pasture in hectares; GP is the grazing period in days; and TWH is the total weight of heifers of each group, in kg. The FA was estimated at 21-day intervals to monitor the experimental conditions, from July 7 to October 25 (2016), to ensure that this variable did not limit performance of forage consumption. Both treatments were managed under a continuous stocking rate and P55 heifers were supplemented with livestock salt (NaCl) from Jun 21 until the onset of PES on Sep 21. PES started on Jun 21 for P147 heifers until Nov 15 for both treatments. Thus, PES for P147 heifers occurred for a further 92 days, compared with that offered to P55 heifers. PES was provided at animal feeders in troughs of 30 × 40 × 15 cm per AU, and salt was provided in other troughs of 15 × 20 × 6 cm per UA. The protein-energy supplement formula (Table 1) was composed according to tabulated values contained in the National Research Council (NRC, 2001).

Salt (not complete mineral mix) was supplied to P55 heifers for 92 days, and served as the "control supplementation"; it did contain protein and energy ingredients (corn meal, soybean meal, and urea), or other sources of mineral nutrients that could affect the results. The expected intake of the protein-energy was 0.1% of the animals' body weight, as indicated by Hoffmann et al. (2014). The expectation was 0.01% for salt. The weekly intakes of supplement and salt were estimated on a precision scale of 1 g, based on the difference between the quantity supplied and the leftovers in the pasture troughs for each treatment.

Table 1. Ingredients and chemical composition of supplement supplied to beef heifers.

Ingredient	g kg^{-1}	Nutritional compound[1]	g kg^{-1}
Soybean meal	150	DM[2]	916
		CP[3]	399
Corn	600	NDF[4]	105
		Carbohydrates[5]	575
Urea	100	Ether extract[6]	24
		Calcium	0.5
Salt (NaCl)	150	Phosforous	2.4
		ME[7] (Mcal.kg^{-1})	2.32

[1]Values estimated based on dry matter (except the DM itself) according to NRC (2001). [2]Dry matter. [3]Crude protein. [4]Neutral detergent fiber. [5]Non-structural carbohydrates. [6]Ether extract. [7]Metabolizable energy.

Forage mass (FM), leaf dry mass (LDM), stem dry mass (SDM), dead material dry mass (DMDM), canopy height (CH), and forage bulk density (FBD) were estimated as described by Carnevalli et al. (2006). The data were analyzed as time-repeated measures using the MIXED procedure of the Statistical Analysis System (SAS, 2008) statistical package, version 9.2 for Windows. Analyzes of variance were made based on the PES periods and grazing period (fixed effects) and their interactions (random effects). The means of the treatments were estimated via LSMEANS and compared with PDIFF using the student's *t*-test ($p < 0.05$).

Results and discussion

The mean salt intake and PES of the P147 and P55 treatments (Table 2) were 0 and 260 g animal unit (AU)$^{-1}$ day^{-1}, and 42 and 181 g AU^{-1} day^{-1}, respectively, and were close to the values reported by Malafaia et al. (2007).

The forage allowances of pastures are shown in Table 3. According to Silva et al. (2009), FA in the order of 6.0 kg ha^{-1} DM 100 kg^{-1} BW can provide satisfactory selectivity for ruminants in pasture environments. The experimental conditions were similar for both treatments until the end of the experimental period. Thus, the effects on the morphological and structural characteristics of the pastures can be attributed to the treatments and grazing periods.

An effect ($p < 0.0001$) of grazing period on FM and DMDM was observed (Table 4). FM decreased by 36.3% from the beginning (21 days of grazing) to the end (147 days of grazing) of the evaluation period. These results are consistent with the findings of Ítavo et al. (2016), who evaluated non-protein nitrogen sources for Nellore steers recreated in the deferred pastures of *Urochloa brizantha* Syn. 'MG-4'. In this study, the authors observed a decrease in FM from 13,069 to 3634 kg ha^{-1} between July and October.

Table 2. Daily intake of salt and protein-energy supplement (PES) by beef heifers during the dry season.

Grazing period (days)	P147[1]		P55[2]	
	Salt (g AU^{-1} d^{-1})	PES (g AU^{-1} d^{-1})	Salt (g AU^{-1} d^{-1})	PES (g AU^{-1} d^{-1})
21	0	227	43	0
42	0	384	43	0
63	0	413	41	0
84	0	351	42	0
105	0	242	0	198
126	0	101	0	225
147	0	99	0	120

[1]147 days of PES. [3]55 days of PES.

Table 3. Forage allowance (FA) of *Urochloa decumbens* Stapf. 'Basilisk' pastures grazed by heifers receiving protein-energy supplementation (PES) for 147 or 55 days, during the dry season.

Period	Grazing period (days)	FA (kg ha^{-1} DM 100 kg^{-1} BW)	
		P147[1]	P55[2]
Jul 12, 2016	21	43.2	43.6
Aug 02, 2016	42	16.1	16.3
Aug 23, 2016	63	8.9	9.5
Sep 13, 2016	84	6.4	7.9
Oct 04, 2016	105	6.0	6.7
Oct 25, 2016	126	4.5	4.9
Mean	-	14.2	14.8

[1]147 days of PES. [2]55 days of PES.

Table 4. Forage mass (FM) and dead material dry mass (DMDM) of *Urochloa decumbens* Stapf. 'Basilisk' pastures grazed by heifers receiving protein-energy supplementation (PES) for 147 or 55 days, during the dry season.

Grazing period (days)	FM (kg ha^{-1})	SEM	DMDM (kg ha^{-1})	SEM
21	5984^{A}	159	3555^{AB}	95
42	4550^{B}	96	2881^{F}	62
63	3907^{C}	80	3236^{CD}	67
84	4080^{C}	125	3471^{BC}	115
105	4515^{B}	152	3814^{A}	124
126	3955^{C}	108	3114DE	96
147	3810^{C}	83	3049^{EF}	67

Averages of the same variable, followed by the same letter in the column, do not differ from each other by the student's "t" test ($p < 0.05$). SEM: standard error of the mean.

A higher FM at baseline, which decreases throughout the evaluation period can be attributed to the intake by heifers and to the better climatic conditions at the beginning of the experimental period. In the present study, higher precipitation (Figure 1) and positive water balance were observed in June (Figure 2), which also contributed to a higher FM during the first evaluation period (21 days).

In relation to DMDM, higher values were obtained after 21 and 105 days of grazing (3555 and 3814 kg ha^{-1}, respectively), and lower values were obtained after 42 and 147 days of grazing (2881 and 3049 kg ha^{-1}, respectively). In addition, the amount of dead material increased from 42 to 105 days of occupation. In this sense, Silva, Montagner, Euclides, Queiroz, and Andrade (2016) observed an increase in the percentage of dead material, from 51.5 to 70.3 g kg^{-1}, after 29 days in deferred pastures of *U. brizantha* and *U. decumbens*, under continuous stocking by Caracu breed steers. These results support the findings of Rodrigues Júnior et al. (2015), highlighting the accumulation of DMDM throughout the dry period due advancing physiological age of the plants. In addition, accelerated senescence and death of tillers may have occurred due to reduced precipitation and water deficit observed from July to October (Figure 1 and 2).

Garcia, Euclides, Alcalde, Difante, and Medeiros (2014) stated that if the forage allowance is similar between treatments, it will not affect forage intake, grazing time, or animal performance. This was observed in the present study, as there was no effect of treatment on the FM (Table 4). However, as previously discussed, the increased forage allowance in the present study resulted in changes in leaf mass as a function of the treatments. According to Janusckiewicz, Raposo, Morgado, Reis, and Ruggieri (2016), tropical grasses provide ruminants with opportunities for selection as they present variation in nutrient availability; this may explain the observed results. This variation was observed in the CP and NDF content with both treatments. The P147 treatment resulted in 58, 43, and 50 g kg^{-1} of CP and 728, 796, and 717 g kg^{-1} of NDF after 21, 105, and 147 days of grazing, respectively. For the P55 treatment, CP levels were 52, 42, and 50 g kg^{-1} and the NDF content was 735, 799, and 714 g kg^{-1} after 21, 105, and 147 days of grazing, respectively.

There was an interaction ($p < 0.0001$) between PES and grazing periods for leaf blade dry mass (Table 5). The highest and lowest LBDM were observed after 21 and 63 days of grazing, respectively, both for P147. From 21 to 63 days of grazing, there was a decrease in LBDM; however, there was increase for this variable was observed at 84 days. After 126 days, the LBDM was higher than on the previous evaluation dates. However, at 147 days, the LBDM was lower than previous one (126 days) and similar to that of 42 days of grazing. The highest and lowest values for LBDM were observed on Jul 07 and Aug 23, respectively, for P55. However, there was a decrease in LBDM values from 21 to 84 days, followed by an increase up to 147 days of grazing.

Table 5. Leaf blade dry mass (kg ha^{-1}) of *Urochloa decumbens* Stapf. 'Basilisk' in deferred pastures grazed by heifers receiving protein-energy supplementation (PES) for 147 or 55 days, during the dry season.

Grazing period (days)	P147[1]	P55[2]
21	757^{aA} (17)	651^{bA} (14)
42	428^{bC} (13)	568^{aB} (13)
63	215^{aE} (12)	227^{aG} (12)
84	321^{aD} (12)	263^{bF} (12)
105	305^{bD} (13)	409^{aE} (15)
126	521^{aB} (14)	464^{bD} (13)
147	425^{bC} (12)	525^{aC} (12)

Averages of the same variable, followed by the same letter in the column, do not differ from each other by the student's "t" test ($p < 0.05$). Between parentheses: standard error of the mean. [1]147 days of PES. [2]55 days of PES.

These results are similar to those reported by Roth et al. (2013), in which Nellore cattle during the growing phase but post-weaning, received a protein-energy supplement on pasture of *U. brizantha* Syn. 'Marandu' in the dry season and were managed under rotational stocking. Those authors reported that the proportion of green leaf was reduced in the first three evaluation periods (125 days of grazing), from 125 to 27 g kg^{-1} DM. However, there was an increase during the last period (147 days of grazing), from 27 to 134 g kg^{-1} DM. In the present study, there was also an increase in the number of leaves during the last evaluation period (147 days of pasture occupation), possibly due to the high precipitation and positive water balance in November (Figure 1 and 2).

The changes observed in the leaf mass values with the P147 and P55 treatments can be explained by the low stocking rate (1.56 AU ha^{-1}) and the increased forage supply (Table 3) during the experimental period. It is possible that the forage allowance enabled heifers to select their diet, resulting in a greater intake of leaf on some evaluation dates than on others. Januskiewicz et al. (2016) stated that a high forage allowance permits a greater selection of the canopy structure by animals, as demonstrated in the present study.

Comparing the P147 and P55 treatments, there were changes relating to the highest and lowest values of leaf blade dry mass in the grazing periods. After 21, 84, and 126 days of grazing, a greater LBDM was observed with the P147 treatment. After 42, 105, and 147 days of grazing, higher LBDM values were observed for P55 and, after 63 days of grazing, the values were similar ($p > 0.05$). These results do not corroborate those reported by Garcia et al. (2014), who studied crossbred steers receiving protein-energy supplementation during the growing phase in comparison to mixed mineral. Under this scenario, the authors did not observe a difference in LBDM (841 and 851 kg ha^{-1}) in the *U. decumbens* pastures during the dry season for both evaluated treatments.

There was an interaction effect ($p < 0.0001$) between the PES and grazing periods for SDM (Table 6). For P147, the highest stem mass was observed after 21 days and the lowest after 105 days of grazing. From this date until the end of the experiment, the SDM increased. In relation to P55, there was a general decrease in SDM during the experimental period, with the highest and lowest values recorded after 21 and 147 days of grazing, respectively. These results are consistent with those reported by Silva et al. (2016). Those authors noted that the proportion of stems was reduced during the experimental period (225 to 176 g kg^{-1}). These results can all be justified by the increase in forage utilization efficiency, which is common for ruminants fed with low quality fodder and subjected to a low supplementation intake (Silva et al., 2009). This scenario is common to deferred pastures and supplementation. Thus, increased fiber digestion allows a greater intake of components such as stalk, which are not preferred during grazing (Hoffmann et al., 2014).

Lower values for SDM were observed with the P147 treatment compared with the P55 treatment, after 21, 42, 105, and 126 days of grazing. Similar results were obtained in the other grazing periods, which may be explained by the higher efficiency of forage use by P147 heifers compared with P55 heifers, especially when supplements were provided only for P147 heifers.

A grazing period effect ($p < 0.0001$) was found on CH and FBD (Table 7). The highest CH was found after 21 days, and the lowest after 147 days of grazing due to the forage intake by heifers. The average height of the pastures on June 21, 2016 (beginning of the experimental period) was 47 cm, which was lower than that reported by Sousa et al. (2012) who found 61 cm in *U. brizantha* Syn. 'Piatã' deferred for 74 days. These results are due to the morphophysiological differences of the species. The 11 cm reduction in CH in the first 21 days of grazing may indicate a high forage intake during the initial period of grazing, due to the better climatic conditions (Figure 1) and higher LBDM (Table 5); these facts suggest better forage quality at the beginning of the experiment. Conversely, the similar CH found after 63 and 126 days of occupation can be justified by canopy "lodging", a phenomenon in which the pasture structure becomes more horizontal. This is common when nitrogen fertilization is performed during the final third of the rainy season and the sealing periods are prolonged (Teixeira et al., 2011), as occurred in the present study.

The highest FBD occurred after 21 days and the lowest after 42 days of grazing. This difference can be explained by the significant reduction in FM (Table 4), although there was no difference in CH during these periods. After 63 days of grazing, there was an increase in FBD due to a reduction in the average height of the pastures (from 35 to 28 cm). From this date, the FBD values increased up to 105 days of grazing. This type of modification in the relationship between FM and CH, increased the FBD (Santos, Fonseca, Balbino, Monnerat, & Silva, 2009). During the last two grazing periods (126 and 147 days), the FBD values were similar (147 and 148 kg ha^{-1} cm^{-1}). In addition, the mean FBD was 152 kg ha^{-1} cm^{-1}, higher than the 106 kg ha^{-1} cm^{-1} obtained by Teixeira et al. (2011) when canopies of *U. decumbens* were grazed after stockpiling of 95 days. The high FBD observed can be explained by the reduced stocking rate (1.56 AU ha^{-1}).

Table 6. Stem mass (kg ha^{-1}) of *Urochloa decumbens* 'Stapf. Basilisk' deferred pastures grazed by heifers receiving protein-energy supplementation (PES) for 147 or 55 days, during the dry season.

Grazing period (days)	P147[1]	P55[2]
21	1509^{bA} (24)	1865^{aA} (31)
42	1008^{bB} (19)	1228^{aB} (18)
63	458^{aC} (13)	458^{aC} (14)
84	380^{aD} (18)	394^{aD} (18)
105	294^{bF} (18)	457^{aC} (19)
126	358^{bE} (15)	430^{aCD} (13)
147	394^{aD} (9)	378^{aE} (9)

Averages of the same variable, followed by the same letter in the column, do not differ from each other by the student's "t" test ($P < 0.05$). Between parentheses: standard error of the mean. [1]147 days of PES. [2]55 days of PES.

Table 7. Canopy height (CH) and forage bulk density (FBD) of *Urochloa decumbens* 'Stapf. Basilisk' deferred pastures grazed by heifers receiving protein-energy supplementation (PES) for 147 or 55 days, during the dry season

Grazing period (days)	CH (cm)	SEM	FBD (kg ha^{-1} cm^{-1})	SEM
21	36^{A}	1	175^{A}	7
42	35^{A}	1	132^{D}	7
63	28^{B}	1	144^{C}	7
84	27^{B}	1	154^{BC}	7
105	27^{B}	1	167^{AB}	7
126	27^{B}	1	147^{C}	7
147	25^{C}	1	148^{C}	7

Averages of the same variable, followed by the same letter in the column, do not differ from each other by the student's "t" test ($p < 0.05$). SEM: standard error of the mean.

Conclusion

Protein-energy supplementation for heifers over 55 or 147 days does not modify the forage mass, dead material mass, canopy height and forage bulk density of *U. decumbens* Stapf. 'Basilisk' deferred pasture.

Leaf blade dry mass of deferred *U. decumbens* Stapf. 'Basilisk' was altered by the protein-energy supplementation period of heifers, mainly because of the variation in their forage allowance.

Lower stem dry mass was obtained in *U. decumbens* Stapf. 'Basilisk' deferred pasture grazed by heifers supplemented for 147 days compared with those supplemented for 55 days.

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