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Cattle production supplemented on signal grass pastures during the rainy season

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ABSTRACT. The effects of four supplement doses (0, 1, 2 and 3 kg animal^{-1} day^{-1}) on pasture characteristics and on cattle production on *Brachiaria decumbens* cv. Basilisk pastures in continuous stocking with variable stocking rate were assessed. Experimental design comprised completely randomized blocks with two replications. Concentrate supplementation did not influence mass (4141 kg ha^{-1} of DM) and production rate of forage (97.6 kg ha^{-1} day^{-1} of DM), morphological components and nutrition value in hand-plucked forage. Similarly, the number of live (1.607 tillers m^{-2}) and dead (636 tillers m^{-2}) tillers was not affected by concentrate supplementation. There were linear increases in animal performance (from 0.70 to 1.13 kg animal^{-1} day^{-1}), stocking rate (1.9 to 3.8 animal unit ha^{-1}) and animal production per area (1.8 to 6.2 kg ha^{-1} body weight) with supplementation doses. Concentrate supplementation does not change the structural characteristics of signal grass pastures managed in continuous stocking at 20 cm high, but increases animal production.

Keywords: *Brachiaria decumbens*, sward height, continuous stocking, forage production, animal selectivity.

Produção de bovinos suplementados em pastos de capim braquiária no período das águas

RESUMO. Foram avaliados os efeitos de quatro doses de suplemento (0, 1, 2 e 3 kg animal^{-1} dia^{-1}) sobre as características estruturais do pasto e a produção de bovinos em pastagens com *Brachiaria decumbens* cv. Basilisk, em lotação contínua com taxa de lotação variável. O delineamento experimental foi de blocos completos casualizados, com duas repetições. O suplemento concentrado não influenciou a massa (4.141 kg ha^{-1} de MS) e a taxa de produção de forragem (97,6 kg ha dia^{-1} de MS), os componentes morfológicos e o valor nutritivo na forragem de pastejo simulado. De maneira semelhante, as densidades populacionais de perfilhos vivos (1.607 perfilhos m^{-2}) e mortos (636 perfilhos m^{-2}) não foram afetadas pelo suplemento concentrado. Ocorreram aumentos lineares no desempenho animal (de 0,70 para 1,13 kg animal^{-1} dia^{-1}), na taxa de lotação (de 1,9 para 3,8 UA ha^{-1}) e na produção animal por área (de 1,8 a 6,2 kg ha^{-1} de peso corporal) com as doses de suplemento. O suplemento concentrado não altera as características estruturais de pastos de capim braquiária manejados em lotação contínua e altura de 20 cm, porém incrementa a produção animal.

Palavras-chave: *Brachiaria decumbens*, estrutura do pasto, lotação contínua, produção de forragem, seletividade animal.

Introduction

Pasture for Brazilian cattle herds is highly relevant due to the vastness of the country, favorable climate conditions for the production of the biomass of foraging plants and relatively low production costs when compared to other alternatives in animal feed. However, livestock indexes based on the use of pastures in Brazil do not reach the country's capacity. Several studies are being conducted to intensify the production system on pastures (Moreira et al., 2004; 2008).

Since the 2000 s, pasture management in Brazil has been undergoing significant development. Foraging plants are being studied as a component of the pasture ecosystem and administered for the best control of pasture structure. These studies have recommended pasture heights in continuous stocking (Da Silva & Nascimento Junior, 2007). In the case of signal grass (*Brachiaria decumbens*) in continuous stocking, adequate rates of forage accumulation occur in 20 cm-high plants (Fagundes et al., 2005) and greater animal productivity per area have been reported in signal grass at the height of 20 cm (Moreira et al., 2011). Concentrate supplementation has been another strategy to intensify animal production on pastures (Adami et al., 2013; Gomide, Reis, Simili, & Moreira, 2009; Silva et al., 2010). It may actually provide nutrients lacking in pastures and, consequently, contribute to improve animal performance, increase stocking rates of pastures and decrease the production cycle by slaughtering younger and heavier animals, following the requirements of the market (Reis, Ruggieri, Oliveira, Azenha, & Casagrande, 2012).

Concentrate supplementation changes the intake of pasture (Silva et al., 2010) and affects its productive and structural characteristics (Gomide et al., 2009). However, most research evaluates only the effect of concentrate supplementation on animal performance or gain per area (Coutinho Filho, Justo, & Peres, 2005; Roman et al., 2008).

It is highly relevant that pasture structure is not restricted to intake by animals so that supplementations may be technically and economically feasible. One must also understand how concentrate supplementation affects the growth of the pasture and the performance of the animals, especially pastures managed with height goals.

Current assay evaluated the structural characteristics of pasture and the performance of cattle on *Brachiaria decumbens* cv. Basilisk pastures supplemented with four different doses of the concentrate.

Material and methods

Current assay was conducted between January 4 and April 6, 2011, in an area of the Animal Science Department of the Universidade Federal de Viçosa, Viçosa, Minas Gerais State, Brazil, at 20º 45' S and 42º 51'W and an altitude of 651 m. The climate of the region is Cwa, or rather, subtropical, with mild and dry winters, and well-defined dry and rainy seasons. Mean annual temperature is 19ºC, between 22 and 15ºC, respectively for mean maximum and minimum temperatures, mean relative air humidity at 80% and mean annual rainfall at 1.340 mm. Relative climate data during the experimental period were registered at the Meteorological Station of the Universidade Federal de Viçosa, Minas Gerais State, Brazil, some 500 m close to the experimental area (Table 1).

Table 1. Monthly means of minimum, mean and maximum temperatures, rainfall and total monthly evaporation between January and April 2011.

Mouth	Minimum temperature (ºC)	Mean temperature (ºC)	Maximum temperature (ºC)	Rainfall (mm)	Evaporation (mm)
January	19.7	23.3	29.2	187.1	76.3
February	18.9	23.3	30.9	84.8	83.4
March	19.1	22.1	27.5	284.4	53.4
April	17.3	20.8	26.9	56.6	53.6
Mean	18.8	22.4	28.6	153.225	66.7

The experimental area with *Brachiaria decumbens* Stapf. cv. Basilisk grass (signal grass) established in 1997, was subdivided into eight split-plots (experimental units), varying between 0.25 and 0.39 ha, plus a reserve area, with a total of approximately 3 ha.

The soil was classified as clayey Red-Yellow Latosol, Empresa Brasileira de Pesquisa Agropecuária (Embrapa, 2006), featuring a mild wavy ground relief. Soil samples at a depth of 0-20 cm were retrieved from each experimental unit to analyze and assess fertility, before the start of the experiment, in November 2010 (Table 2). Since signal grass is soil acid-tolerant, soil corrective was not employed but 150 kg ha^{-1} of the formula (20 N - 05 P_2O_5 - 20 K_2O) were applied in three applications (January, February and March, 2011).

All split-plots were managed in continuous stocking, at variable rates, between January 2011 and April 2011. During this period all mean heights of the pasture were measured weekly and maintained at a height of 20 cm (Moreira et al., 2011). Seventeen Holstein x Nellore cross-breed heifers, average weight 200 kg and mean age 7 months, were used for the assay. The animals received concentrate supplementation for seven days prior to being distributed in the split-plots.

Table 2. Chemical characteristics of soil samples at 0 - 20 cm layer in eight split-plots on the experimental area in November 2010.

Split-plot	pH	P	K	Ca^{2+}	Mg^{2+}	Al^{3+}	H + Al	T	V	M	P-rem
	H_2O	mg dm^{-3}		----------- $cmol_c$ dm^{-3} -----------					%		mg L^{-1}
1	4.9	2.3	88	1.19	0.34	0.50	5.9	7.66	23.0	22.1	23.6
2	5.0	3.7	100	1.70	0.56	0.40	5.9	8.42	29.9	13.7	26.9
3	5.1	4.1	101	2.19	0.71	0.20	6.1	9.26	34.1	6.0	25.0
4	5.0	3.9	86	1.70	0.45	0.40	5.9	8.27	28.7	14.4	21.7
5	5.0	3.2	124	1.69	0.62	0.30	6.3	8.93	29.5	10.2	21.1
6	4.8	3.8	134	1.69	0.51	0.40	5.6	8.14	31.2	13.6	28.4
7	5.0	4.8	132	1.71	0.55	0.20	5.1	7.70	33.8	7.1	29.9
8	5.2	5.8	89	1.50	0.44	0.30	4.3	6.47	33.5	12.1	32.6

Treatments comprised four doses of concentrate supplementation (0, 1, 2, 3 kg animal^{-1} day). Table 3 shows the components of the supplementaion and its concentrations at each level. Mineral salt was supplied to the animals *ad libitum* in all treatments. Experimental design consisted of randomized blocks, with two replications, determined by the relief of the experimental area.

Table 3. Ingredients of the concentrate supplementation.

Ingredient	Supplementation level (kg day^{-1} animal^{-1})			
	0	1	2	3
Corn meal (%)	0.0	68.0	73.0	74.7
Soybean meal (%)	0.0	19.0	19.0	19.0
Mineral salt (%)	0.0	10.0	5.0	3.3
Urea (%)	0.0	3.0	3.0	3.0

Equilibrium animals with similar characteristics as those in the assay were also introduced and removed to maintain average height of pasture at approximately 20 cm. The same supplementation dose was provided to these animals.

A single manger (1.5 m long x 30 cm wide and 25 cm deep) was constructed for the concentrate supplementation in each split-plot of the experimental area, close to the water trough.

Pasture heights were monitored as from the first week of January, at every 28 days, till the end of the experimental period at the beginning of April. Fifty sites per experimental unit were evaluated weekly, following a zigzag trail. Pasture height at each site, measured by one-meter ruler with 1.0 cm scales, was the distance between the plant canopy and ground level.

Three samples per experimental unit were selected at sites representing mean pasture height to evaluate the population density of the tillers. Samples consisted of plants harvested at ground level within an area limited by a 0.25 m rebar frame fixed to the ground with two metal hooks placed on the opposite vertexes of the frame to avoid any displacement during assessment. Tillers within the frame only were harvested, with scissors, close to the ground surface. They were conditioned in tagged plastic bags and taken to the laboratory, where they were separated and quantified as live and dead tillers, following method by Moreira et al. (2009). Live tillers were characterized by green leaves and stem, whereas a dead stem characterized the dead ones. Estimates of tillers per square meter were obtained by multiplying the number of tillers within the square (0.0625 m^2) by 16. The general mean of the split-plot consisted of the average rates of the three samples.

Forage mass was estimated according to method by Moreira et al. (2009). Three samples per experimental unit were selected at representative sites of mean pasture height. In each sampling site, tillers were harvested at ground level every 28 days within the area delimited by a 0.40 m rebar frame. Each sample was conditioned in a plastic bag, identified and taken to the laboratory where it was weighed and subdivided into two parts. After, weighing, one sub-sample was conditioned in a paper bag and placed in a forced-air buffer during 72 hours, at 65°C, when it was weighed once more. The other sub-sample was manually separated into live leaf and stem and dead leaf and stem. Each component was weighed and dried in a forced-air buffer for 72h, at 65°C, when it was weighed once more. Available forage mass (in kg ha^{-1} DM) was estimated by dividing the forage mass within the frame by 62500, corresponding to the multiplication of the area of the frame (0.16 m^2) by the area of the hectare (10000 m^2). The percentage of each morphological component in the forage was calculated by dividing the mass of the morphological component by the sum of the mass of all the morphological components, multiplying the result by 100. The general average per split-plot was the average of rates of the three samples.

Forage accumulation was calculated by the agronomic method of difference, with paired samplings and exclusion cages (1.5 high x 1.5 long x 1.0 m wide). Three cages per split-plot were placed on the sites with the average height of the pasture. Other three pairs of sites were identified and the cages were similarly placed at every 28 days after harvest of the forage inside and outside the cage. The forage plant was harvested at ground level with the 0.40 m rebar, at all sites, inside and outside the cages. Samples were taken to the laboratory, weighed and dried in a forced-air buffer for 72h, at 65°C. Accumulation of forage was calculated by the difference between the forage mass inside the cage on the last day of exclusion and outside the cage on the day it was placed. Forage accumulation during the experimental period was estimated by the sum of forage accumulation every 28 days, by the formula:

$$AF = MFg - MFp$$

where:

AF = accumulation of forage;

MFg = mass of forage inside the cage on the last day of exclusion;

MFp = mass of forage on the pasture outside the cage on the day the cages were placed.

At the start of the experiment and at every 28 days up to the end of the experiment, grazing simulation was performed by harvesting a forage sample per experimental unit in the areas where the animals were grazing and simulating the morphological composition of the forage consumed by the heifers. A single trained person undertook samplings (simulation) by observing forage intake by all the animals within the experimental area. Each sample (approximately 400 g) was conditioned in a tagged plastic bag and its morphological components separated in the laboratory, dried in a forced-air buffer for 72h, at 65ºC, and weighed again. Samples of simulated grazing were evaluated with regard to neutral detergent fiber rates and crude protein. Samples of simulated pasture were analyzed by near infrared spectroscopy (NIRS), following procedures by Marten, Halgerson and Cherney (1983).

Selectivity by animals with regard to the different morphological components of the pasture was evaluated by the equation below, proposed by Santos et al. (2011): ISA = SP/FD where ISA = index of apparent selectivity; SP = morphological component in the sample of grazing simulation (%); FD = morphological component in the sample of available forage (%).

Mean daily body weight gain per animal (kg animal day^{-1}) was calculated by the difference in weight of the test animals between two consecutive weightings (initial and final) divided by the number of days between the weightings. Animals were weighted after a 12-h fast at the start and at the end of the experimental period.

Stocking rate was calculated by the number of permanence days of the test and equilibrium animals in each split-plot by the respective split-plot area and added to the total initial weight. The results were then divided by the split-plot area and once more divided by 450. The product was the final stocking rates given in animal unit (AU) ha^{-1} so that 1 AU corresponded to 450 kg of body weight.

Mean weight gain per area unit (kg ha^{-1} of body weight) was calculated by the quotient of accumulated weight gain of animals in each split-plot by the respective area of experimental unit, and the result divided by the period under evaluation.

Analysis of variance was undertaken, coupled to regression analysis, whose greatest model of response surface due to treatment means was

$$\hat{Y}_i = \beta_0 + \beta_1 S_i + \beta_2 S_i^2 + e_i$$

where:

$\hat{Y}_i$ = response variable; S_i = supplementation level; β_0, β_1 and β_2 = parameters to be calculated; e_i = experimental error.

The models' adjustment level was calculated by the coefficient of determination and by the significance of the regression coefficients tested by test *t* based on the residues of the analysis of variance. The coefficients of variation of each response variable were calculated. All statistical analyses were done at 10% probability

Results and discussion

The variation in daily amount of concentrate supplementation provided to the heifers did not change ($p > 0.10$) the structural characteristics of signal grass (Table 4). The structure of the canopy forage may be defined as the distribution and arrangement of the aerial parts of the plant within the community (Laca & Lemaire, 2000). The structure is relevant since it affects the production of forage and pasture intake by the animals Fonseca et al., 2012). Lack of effect of concentrate doses on the structure of pasture is due to the fact that all pastures were managed at a similar mean height (20 cm). Since the luminous environment inside the canopy probably did not vary, the intraspecies competition due to growth, especially light, was relatively constant in all pastures.

Table 4. Structural characteristics of pasture with signal grass managed with mean height of 20 cm, in continuous stocking with cattle, during the rainy period.

Number of tillers[1]		Forage mass[2]	Production of Forage[3]	Morphological composition (%)			
Live	Dead			LLB	LS	DLB	DS
1607	636	4141	97.6	28	35	11	26

[1]Tiller m^{-2}; [2]in kg ha^{-1} of dry mass; [3]in kg ha^{-1}day^{-1} of dry mass; LLB: live leaf blade; LS: live stem + live foliar sheath; DLL: dead leaf blade; DS: dead stem + dead leaf sheath.

Since the micro climate inside the pasture was similar due to the maintenance of pastures at the same height, the tissue flow, characterized by morphogenesis and by tillering dynamics, may not have been modified. Consequently, the structure of pasture and the production rate of forage did not vary by different doses of concentrate. Corroborating the results of current analysis and based on the previous arguments, Casagrande et al. (2011) researched *B. brizantha* cv. Marandu in a continuous stocking with cattle and failed to report any variations in the structure of pasture when management based on the control of mean height was practiced.

Higher doses of the concentrate given to heifers may have caused the replacement of pasture by the concentrate (Reis et al., 2012) and, consequently, each animal started to consume less pasture. However, the intake of pasture per unit of area did not change. So that the mean height of pasture at 20 cm could be maintained, stocking rate was increased in the pastures where the animals received a greater amount of concentrate (Table 5). Therefore, variable stocking rate was relevant for the maintenance and control of pasture structure within the desired objective (20 cm).

When fixed stocking rate is employed, the difference in pasture intake caused by different ingestions of the concentrate by cattle may modify the structure of the pasture. In fact, Gomide et al. (2009) assessed different doses of concentrates for cattle kept on *B. brizantha* cv. Marandu pastures managed in intermittent stocking and at a fixed stocking rate. The authors reported that, as a rule, higher doses of concentrate increased foliar area index, interception of light by the canopy, forage mass and leaf: stem ratio of the pasture, which modified the structure of the pasture.

Since the pasture structure was not modified by the variable intake of concentrate by the animals, the morphological characteristics and the nutrition rate of the simulated grazing sample were not affected too ($p > 0.10$) by the intake of the concentrate (Table 5). In fact, according to Santos et al. (2011), there is a cause and effect relationship between the structure of the pasture (cause) and the morphology of the forage consumed by the grazing animal (effect).

Table 5. Characteristics of simulated grazing sample by cattle on signal grass managed at a mean height of 20 cm, in continuous stocking, during the rainy period.

Morphological composition (%)			Nutrition value (% of DM)					
LLB	LS	DT	OM	CP	NDF	ADF	IVDOM	LIG
56.9	24.7	18.4	89.1	13.6	72.1	34.4	56.7	3.05

DM: dry matter; LLB: live leaf blade; LS: live stem + live leaf sheath; DT: dead tissue (leaf + dead stem); OM: organic matter; CP: crude protein; NDF: neutral detergent fiber; ADF: acid detergent fiber; IVDOM: *in vitro* digestibility of organic matter; LIG: lignin.

Sample of simulation grazing had a better morphological composition than the forage available in pasture. Cattle preferentially consume live leaves to the detriment of the other morphological components of the pasture (Santos et al., 2011). The consumption of live leaves by the animals is justified due to their accessibility, less resistance in shearing (Nave, Pedreira, & Pedreira, 2010) and securing, and better nutrition value (Santos, Fonseca, Balbino, Silva, & Monnerat, 2010). On the other hand, animals avoid the consumption of stems and dead tissues due to the difficulty in securing them, their position at the basal layer of the pasture (Palhano et al., 2005), and their low nutrition value (Santos et al., 2010).

Further, crude protein rates in signal grass managed at a height of 20 cm during the rainy period were high (Table 5). It should be underscored that requirements of nitrogen compounds by microorganisms are not complied with at basal dietetic levels of less than 7% of crude protein (Van Soest, 1994). Although the simulated forage pasture was similar to that selected by the cattle, CP rates were not restricted, and stimuli on the digestion rate of the fibrous faction of the pasture were still extant with the rise in protein levels from 13 to 14% (Lazzarini et al., 2009). Consequently, forage intake similar to that harvested in grazing simulation warrants the optimization of the digestion of the potentially digestible fiber of the pasture.

Results belie that *B. decumbens* is a forage plant with the worst nutrition rates when compared to other forage species. Signal grass has a satisfactory nutrition value when managed properly. Moreover, pasture management has a preponderant effect on its quality (Da Silva & Nascimento Junior, 2007).

Selectivity index for the morphological components of the mono-species signal grass was termed 'apparent' since rates were obtained from samples harvested by grazing simulation (Tables 4 and 5) and not by animals, as when fistulated animals are used. However, it is taken for granted that data from grazing simulation correspond to those obtained by fistulated animals. In fact, Moraes, Paulino, Zervoudakis, Valadares Filho and Moraes (2005) did not report any difference in the chemical or morphological characteristics of forage harvested by simulated grazing or by fistulated animals.

ASI is always greater than 1 when it refers to the pasture's morphological component preferentially selected by the animal, namely, the live leaf blades (Figure 1). On the other hand, the morphological components which are not preferred by the animal (live stem and dead tissue) will always have ASI lower than 1 (Figure 1) (Santos et al., 2011). Further, the more distant ASI is from 1, the more selectivity occurs. In other words, there is a higher selection or rejection of the morphological component respectively preferred or not (Santos et al., 2011). In this case, a normal standard of selectivity by the animals occurred in signal grass (Figure 1).

In their research on *B. decumbens* cv. Basilisk, managed under differed grazing and by pregnant cattle during the winter months, Santos et al. (2011) reported that, during the first day of grazing (when the pasture structure was adequate), ASIs were 2.0, 0.4, 0.5, 0.001 respectively for live leaf blade, live stem, dead leaf blade and dead stem. The above rates were similar to those in current assay. However, at the end of the grazing period when pasture had a restricting structure to grazing, ASIs were 9.3, 0.5, 0.5, 0.7 respectively for live leaf blade, live stem, dead leaf blade and dead stem.

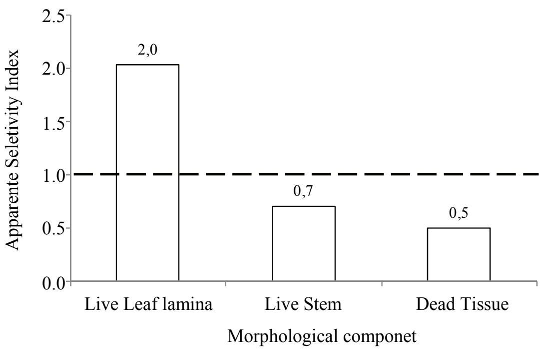

Figure 1. Apparent Selectivity Index (ASI) of cattle by the components of signal grass managed in continuous stocking during the rainy season; morphological components with ASI lower or higher than 1 (line) are respectively shunned or preferred by the heifers.

Mean daily gain, stocking rate and animal production per area increased linearly ($p < 0.10$) with the supplementation doses (Table 6).

Table 6. Animal productivity in signal grass pasture according to supplementation levels (S).

Variable	Equation	r^2	CV (%)
MDG (kg animal^{-1} day^{-1})	$\hat{Y} = 0.703 + 0.14145{*}S$	0.98	21.65
SR (AU ha^{-1})	$\hat{Y} = 1.857 + 0.6460{*}S$	0.93	24.04
PRODA (kg ha^{-1} BW)	$\hat{Y} = 1.804 + 1.47040{*}S$	0.97	25.01
CONS (kg animal^{-1} day)	$\hat{Y} = 0.013 + 0.316950{*}S$	0.99	7.60

MDG: mean daily gain; SR: stocking rate; PRODA: Production per area (kg^{-1} ha of BW); BW: body weight; CONS: Consumption; CV: Coefficient of variation; *Significant by test *t* ($p < 0.10$).

Estimated mean weight gain ranged between 0.70 and 1.13 kg animal^{-1} day^{-1}, from the absence of supplementation till the dose of 3.0 kg animal^{-1}day^{-1}. Mean stocking rate was estimated between 1.9 and 3.8 AU ha^{-1}, respectively for absence of supplementation and a dose de 3.0 kg animal^{-1} day^{-1}. Mean production per area ranged between 1.804 and 6.22 kg ha^{-1} of BW at doses between 0 and 3 kg animal^{-1} day^{-1}.

Rates for animal performance were high even without concentrate supplementation, with mean daily weight gain at 0.70 kg animal^{-1} day^{-1}. This fact shows that efficient forage harvest in pasture with signal grass with adequate management targets (20 cm) for this type of grass intensified the production process and, consequently, high performance rates. High stocking rates were also reported with concentrate supplementation and indicated greater intensification of the production system in which quantity and quality of the pasture would be less restricting to animal consumption. In fact, the optimization of animal performance by concentrate supplementation may be justified by increasing the capacity of pastures (Reis et al., 2012) and decreasing the meat production cycle by slaughtering younger and heavier animals, complying with market requirements.

Under continuous stocking, maintaining pasture in equilibrium, with relatively constant rates of forage mass or mean pasture height over time (Table 4) indicates that forage accumulation rate lies in equilibrium with the removal rate of the pasture by grazing animals (Bircham & Hodgson, 1983). Since in current assay there was a lack of effect ($p > 0.10$) on the concentrate given to animals on forage production (Table 4) and since stocking rate had to be raised to maintain the pasture at a height of 20 cm, the animals preferred supplementation to pasture. In equilibrium conditions between production and removal of forage in the pasture, as in current assay, increase in stocking rate with higher concentrate doses (Table 6) should be accompanied by a decrease in individual consumption of pasture by the animals, characterizing the substitution of pasture by the concentrate.

Increase in pasture stocking rate by high concentrate doses (Table 6) may increase animal pounding on tillering and de-leafing pattern of individual tillers, which may result in possible modifications in pasture structure, even though it did not occur in current assay (Table 4). The high stocking rate may have probably been compensated by lower grazing time by animals with high concentrate doses in the pasture (Cabral, Bauer, Cabral, Souza, & Benez, 2011). The above may justify the relative stability of the pasture structure during the grazing period.

Conclusion

Concentrate supplementation of *Brachiaria decumbens* cv. Basilisk pasture during the rainy period increases pasture productivity, but fails to enhance alterations in the structural characteristics of the pasture when managed in continuous stocking and at variable stocking rates to maintain relatively constant mean height

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