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Floristic diversification of spreading liverseed grass pasture according to different cutting intensities, obtained by grazing simulation

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ABSTRACT. This study aimed to evaluate the impacts of different forage cutting intensities, obtained by grazing simulation, on the floristic diversity and productivity of a pasture cultivated with spreading liverseed grass. The experiment was set up in a randomized block design, with four replications and treatments arranged in a 5 × 2 factorial scheme, with five levels of cutting intensity of the simulated grazing (0, 25, 50, 75, and 95% of the forage canopy) associated with two levels of weed coexistence (presence and absence). The evaluations of floristic diversity, number of individuals, and total dry matter of weeds were obtained at 15, 30, 45, 60, and 90 days after grazing simulation (DAGS). All plots were evaluated at the end of the experimental period (90 DAGS) for the amount of dry biomass produced by the pasture. The results showed that higher forage cutting intensities, obtained by grazing simulation, increased the floristic diversity, the number of individuals, and the dry matter accumulated by weeds in a pasture grown with spreading liverseed grass, reducing by up to 56% the production of total dry matter of the forage.

Keywords: *Brachiaria decumbens* (Hochst) Stapf; weed; weed competition; simulated grazing.

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Introduction

The increased world population and, consequently, the demand for food require intense changes in the agricultural sector, including greater diversification and production efficiency (Röös et al., 2017). However, these changes must occur while addressing environmental issues related to the use of good agricultural practices aimed at maximum utilization of areas considered degraded, without compromising the environment (Carvalho et al., 2019).

Pasture degradation is one of the main problems for Brazilian livestock, being estimated at least 32 million hectares of cultivated pastures under the degradation process in the Central Brazil region (Carvalho et al., 2017; Marques et al., 2019). This process is characterized by a decreased productivity of forage plants due to factors such as low soil fertility, inadequate forage management, and continuous stocking with a high fixed stocking rate, leading to the total dominance of the area by weeds (Costa, Townsend, Magalhães, Paulino, & Rodrigues, 2015).

Cattle production systems on pastures of *Brachiaria decumbens* in Brazil predominantly use the continuous stocking method due to its operational ease, among other factors (Moreira et al., 2015; Santos, Gomes, & Fonseca, 2014). Thus, the grazing intensity of animals promotes changes in the environmental and spatial heterogeneity due to selective grazing, directly affecting the floristic diversity of the pasture (Galzerano, Malheiros, Raposo, da Silva Morgado, & Ruggieri, 2013; Silva Neto et al., 2015).

Weeds, by competing for growth factors such as space, light, water, and nutrients, can drastically reduce the physiological reserves of forages and also increase the time for pasture formation and recovery and cause injury and/or intoxication to animals (Carvalho, Pimentel, Fonseca, & Santos, 2016; Marchi, Silva, Ferreira, Marques, & Moraes, 2019a). Because of this, the extractive aspects of the exploitation system associated with the consequences of the weed presence compel animals to eat foods with low nutritional value, which provides a low feeding efficiency and animal performance (Marchi et al., 2019b).

The knowledge of the structural variables and morphogenesis of forage plants has been an important tool for determining the conditions of adequate pastures and thus ensuring animal production in areas under continuous stocking (Euclides, Montagner, Barbosa, & Nantes, 2015; Jakelaitis, Gil, Simões, Souza, & Ludtke, 2010). Bearing in mind the influence of grazing on the heterogeneity and biodiversity of pastures, this study aimed to evaluate the impacts of different forage cutting intensities, obtained by grazing simulation, on the floristic diversity and productivity of a pasture grown with spreading liverseed grass (*Brachiaria decumbens* [Hochst] Stapf).

Material and methods

The experiment was conducted on a pasture located at the geographical coordinates 15°52′29″ S and 52°18′37″ W GR, with an average altitude of 350 meters above sea level and an Aw climate according to the Köppen (1948) classification, characterized as having average temperatures above 27°C during the hottest months (November to February), average temperatures above 18°C during the coldest months (June to August), and average annual precipitation between 1,000 and 1,500 mm, distributed in two well-defined periods: an intense rainy season from October to March and a drought period from April to September (Marques et al., 2019).

The soil of the area was characterized as an Oxisol, with the following physicochemical characteristics: pH in $CaCl_2$ of 4.3; organic matter of 22.0 g dm^{-3}; P Mehlich of 2.7 mg dm^{-3}; base saturation of 23.50%; K, Ca, Mg, and H+Al contents of 0.15, 0.66, 0.42, and 4.0 $cmol_c$ dm^{-3}, respectively; and sand, silt, and clay of 692, 97, and 211 g kg^{-1}, characterizing it as medium-textured soil.

The experimental area was characterized as an abandoned pasture, without animal exploitation and, consequently, without grazing for a period of more than eight years. As a result, no epigeal manifestation of plant species other than spreading liverseed grass (*B. decumbens*) was not observed in the area.

The experiment was installed in a randomized block design, with four replications and treatments arranged in a 5×2 factorial scheme, with five levels of cutting intensity of the simulated grazing (0, 25, 50, 75, and 95% of the original canopy height, which was approximately 40 cm) associated with two conditions of weed coexistence (presence and absence). Each experimental plot had a total area of 12 m^2 (4.0 × 3.0 m), and the central 6 m^2 of the plots was used as a useful area.

The experimental area was previously mowed at approximately 10 centimeters from the ground to eliminate plant residues from previous years. After this procedure, the area was left to recover the pasture and standardize the forage canopy at a height of approximately 40 cm for a period of approximately 45 days, when the simulated grazing began.

The different cutting intensity levels obtained by the simulated grazing were carried out by cutting the forage at the respective stipulated height, and all the cut material was immediately removed from the plots to prevent them from imposing a physical barrier on weed propagules that were eventually present in the soil seed bank. The simulated grazing activities were carried out manually using pruning shears to avoid tearing of stems and leaves.

Concomitantly, the plots without weed coexistence were maintained free from spontaneous species using the post-emergence application of 2.5 L ha^{-1} of an herbicide based on 40 g ae L^{-1} aminopyralid + 320 g ae L^{-1} 2,4-D (Tordon XT, soluble concentrate (SL), CORTEVA®) + 0.3% (v/v) mineral oil. The sprayings were carried out whenever necessary using a CO_2-pressurized knapsack sprayer with a boom equipped with four fan spray tips XR 11002 and calibrated to apply the equivalent of 200 L ha^{-1} of spray solution.

Floristic diversity was evaluated at 15, 30, 45, 60, and 90 days after grazing simulation (DAGS) in the useful area of each experimental unit using a 0.25 m^2 metal frame. The species were identified, numerically quantified, and taken to the laboratory to be dried in a forced-air circulation oven at 65°C until constant weight. Subsequently, the shoot dry matter of the collected species was determined using a scale with an accuracy of 0.01 g.

The species diversity index was calculated using the Shannon-Wiener equation (Jakelaitis, Soares, & Cardoso, 2014):

$$H' = -\sum_{i=1}^{S} ni \ln pi$$

in which H′ is Shannon's diversity index, S is the number of species, pi is the proportion of individuals represented in the sample by the species *i*, estimated as ni/N, where ni is the measure of the importance of the species *i* (number of individuals), and N is the total number of individuals, and ln is the Neperian logarithm.

All plots were evaluated for the amount of dry matter produced by the pasture at the end of the experimental period (90 DASG), when forage samples were collected by cutting at 10 cm above the ground inside the area delimited by the 0.25 m^2 metal frame randomly placed on each experimental unit. The samples were taken to the laboratory, where they were divided into green leaf, dry leaf, green stem, and dry stem. Inflorescences eventually present were considered as part of the green stem fraction.

The samples were then packed in paper bags and maintained in a forced-air circulation oven at 65°C until constant weight, which allowed determining the dry matter of the fractions using a scale with a precision of 0.01 g. The total dry matter (g m^{-2}) was calculated after obtaining the dry matter of the fractions, while the percentage of reduction in productivity was calculated using the following equation:

$$RP = (TDM_{absence} - TDM_{presence}/TDM_{absence}) \times 100$$

where RP is the reduction in productivity (%), $TDM_{absence}$ is the total dry matter obtained under the condition of weed absence, and $TDM_{presence}$ is the total dry matter obtained under the condition of weed presence, at each simulated grazing intensity.

The values of total dry matter and fractions produced by the forage were analyzed using the F-test, and the effects of treatments were compared using the Tukey test at a 5% probability, using the statistical program AgroEstat (Barbosa & Maldonado Jr., 2015).

The results of floristic diversity, number of individuals, and dry matter accumulated by weeds were subjected to regression analysis, and the degrees of freedom of the evaluated factor were sliced into linear and quadratic effects by the program Origin 8.5.1 SR1. The regression model was chosen considering the highest value of the coefficient of determination (R^2) at $p \leqslant 0.05$, according to the F-test and respecting the biological response.

Results and discussion

The evaluations of the weed communities carried out during the experimental period showed 12 eudicotyledonous weed species grouped into nine botanical families and no occurrence of monocotyledonous species (Table 1). Soder, Rook, Sanderson, and Goslee (2007) observed that, in general, eudicotyledonous weeds tend to increase their competitive characteristics under high grazing pressures, while grasses tend to decrease them due to the selective behavior of animals during the grazing process.

Table 1. List of spontaneous species observed in a *Brachiaria decumbens* pasture after being subjected to different grazing intensities.

Family	Species	Common name	Code
Compositae	*Bidens pilosa*	Hairy beggarticks	BIDPI
	Chaptalia nutans	Heal and draw	CHKNU
Euphorbiaceae	*Croton glandulosus*	Vente conmigo	CNVGL
	Chamaesyce hirta	Pillpod sandmat	EPHHI
Lamiaceae	*Hyptis suaveolens*	Pignut	HPYSU
Malvaceae	*Sida santaremensis*	Moth fanpetals	SIDSN
Mimosaceae	*Mimosa debilis*	Sensitive plant	MINDE
Rubiaceae	*Spermacoce latifolia*	Oval-leaf false buttonweed	BOILF
	Diodia teres	Poorjoe	DIQTE
Solanaceae	*Solanum palinacanthum*	Nightshade	SOLPL
Sterculiaceae	*Waltheria indica*	Uhaloa	WALAM
Tiliaceae	*Triumfetta bartramia*	Diamond burbark	TIUBA

The relationship between the number of weeds as a function of the cutting intensity, obtained by grazing simulation, showed the difference in the appearance of species in each type of simulation, as the absence of simulated grazing (0%) conditioned the lower floristic diversity in all periods in which the evaluations were carried out. However, this floristic heterogeneity increased linearly and simultaneously with an increase in the simulated grazing intensity and the period in which the evaluation was performed (Figure 1).

The grazing simulations at 25 and 50% of the original forage height provided the lowest floristic diversity values (1.69 and 1.49, respectively) at 90 DAGS than the other simulated grazing treatments. Grazing at 75% of the original forage height allowed values of floristic diversity from 2.27 to 90 DAGS. Thus, a considerable increase in the floristic diversity was observed when the highest grazing intensity (95%) was used, with diversity above 3.96 from 15 DAGS and reaching 4.56 at 90 DASP (Figure 1).

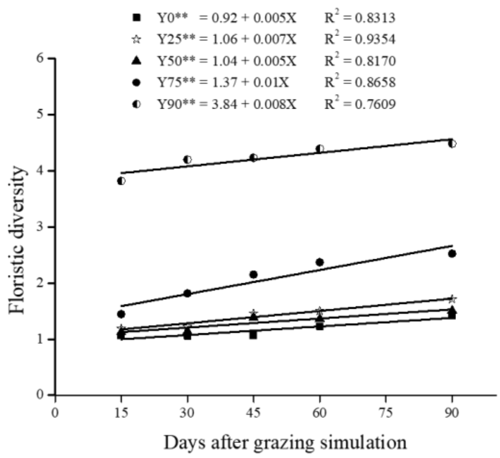

Figure 1. Floristic diversity of spontaneous vegetation obtained at 15, 30, 45, 60, and 90 days after grazing simulation with *Brachiaria decumbens*. ** $p < 0.01$.

The 12 weed species found in this study showed different forms of distribution detected by the evaluation of the Shannon-Wiener floristic diversity. High values of floristic diversity indices show a large number of more uniform communities, in which the dominance of groups of species is more attenuated. Shannon's diversity is considered high when the values found are higher than three, intermediate between two and three, low between one and two, and very low when lower than one (Corsini, Scolforo, Oliveira, Mello, & Machado, 2014; Schlickmann et al., 2019). Therefore, grazing intensities of 0, 25, and 50% obtained low floristic diversity during the entire experimental period, 75% had an intermediate diversity from 45 DAGS, and 95% presented a high diversity at all evaluated periods.

According to Morais et al. (2018), the animal component in pastures where high grazing intensities occur promotes changes in the environmental and spatial heterogeneity due to selective grazing, directly affecting the floristic diversity of the pasture where it is located and acting directly on the competition patterns for environmental resources among plant species.

The number of individuals that appeared after grazing simulation was relatively lower under the condition with no simulated grazing, with less than 10 plants m^{-2} being found up to 60 DAGS. The highest simulated grazing (95%) also conditioned the establishment of a higher number of individuals per unit area, ranging from 44 to 94 plants m^{-2} throughout the experimental period (Figure 2).

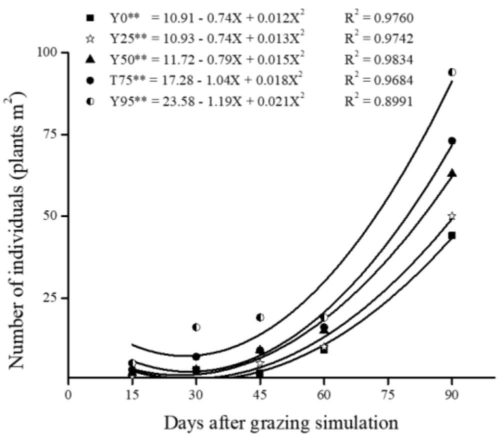

Figure 2. Number of individuals (plants m^{-2}) observed in the spontaneous vegetation obtained at 15, 30, 45, 60, and 90 days after grazing simulation of *Brachiaria decumbens*. ** $p < 0.01$.

High grazing intensities reduce the ability of plants to obtain the nutrients necessary for reestablishment, causing lower forage productivity and leaving places for weed establishment (Inoue et al., 2012; Oliveira et al., 2013).

The total dry matter (g m^{-2}) accumulated by weeds showed an increase with a quadratic behavior as the simulated grazing intensity and the time of coexistence increased. The highest amounts of dry matter accumulated by weeds were obtained when the highest forage cutting intensity was used in the simulated grazing (95%), regardless of the time when the evaluation was performed (Figure 3). It probably occurred because areas with high grazing intensity present weeds with higher competition for essential elements, such as water, nutrients, space, and light (Freitas, Bendito, Santos, & Sousa, 2016).

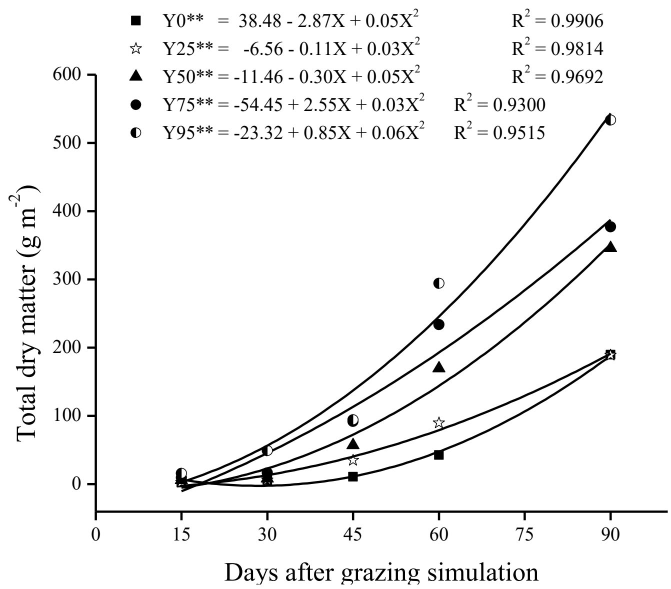

Figure 3. Total dry matter (g m^{-2}) observed in the spontaneous vegetation obtained at 15, 30, 45, 60, and 90 days after grazing simulation of *Brachiaria decumbens*. ** $p < 0.01$

The simulated grazing intensities at 0, 25, 50, 75, and 95% allowed weeds to produce total dry matter values of 185, 226, 366, 418, and 539 g m^{-2}, respectively, at 90 DAGS (Figure 3). Because of this, the presence of weeds may influence productivity parameters of *B. decumbens* from 50% of cutting intensity of the original forage height. Marchi, Bellé, Foz, Ferri, and Martins (2017) observed that only 288 g m^{-2} of the total dry matter of weeds are capable of significantly altering the productivity of *Brachiaria brizantha* cv. Marandu, as they compete for environmental resources.

According to Rocha Júnior, Silva, and Guimarães (2013), productive unsustainability in pasture agroecosystems becomes more critical in intensive farming systems, pointing out that areas of the continuous stocking with a high fixed animal stocking rate make grasses scarce and increase the weed presence, which can make economically unfeasible activity.

The alteration and establishment of spontaneous vegetation also conditioned changes in the recovery capacity and dry biomass production of the forage grass. The elimination of spontaneous vegetation using herbicide (weed absence) provided accumulations of green leaf and stem dry biomass statistically higher than those obtained when the forage coexisted with the spontaneous vegetation (weed presence) up to 90 DAGS, regardless of the adopted grazing intensity (Table 2).

Table 2. Average dry matter value (g m^{-2}) of green leaf (GL), dry leaf (DL), green stem (GS), and dry stem (DS) produced by *Brachiaria decumbens* as a function of the coexistence with the spontaneous vegetation at 90 days after being subjected to grazing intensities.

Grazing	GL (g m^{-2})		DL (g m^{-2})		GS (g m^{-2})		DS (g m^{-2})	
	Abs	Pres	Abs	Pres	Abs	Pres	Abs	Pres
0	228 aA	166 aB	98 aA	85 aA	452 aA	300 aB	126 aA	136 aA
25%	221 aA	163 aB	82 aA	62 abA	383 bA	270 abB	87 bA	93 bA
50%	213 aA	149 aB	74 aA	49 abA	370 bA	214 bcB	77 bA	42 cB
75%	210 aA	99 bB	60 aA	25 bB	342 bA	168 cB	76 bA	34 cB
95%	206 aA	95 bB	56 aA	19 bB	328 bA	148 cB	66 bA	22 cB
F grazing (G)	7.2**		8.1**		14.4**		31.1**	
F coexistence (C)	130.3**		14.0**		139.4**		13.8**	
F (G × C)	2.9*		0.4^{NS}		0.8^{NS}		4.5**	
LSD (G)	32.9		32.1		60.7		26.1	
LSD (C)	14.6		14.2		26.4		11.6	
CV (%)	12.8		35.9		13.9		23.5	

Abs – weed absence; Pres – weed presence; NS – not significant. **Significant at the 1% probability level, *significant at the 5% probability level. Means followed by the same uppercase letter in the row or the same lowercase letter in the column do not differ statistically from each other by the Tukey test at the 5% probability level.

The higher variability found in pastures with higher grazing intensity is due to the large empty spaces between clumps. In addition, as the pasture height increased, these empty spaces were occupied by tillers and leaves, increasing the productive components of the forage (Santos et al., 2011; Paula Neto et al., 2014).

No statistical difference was observed regarding the amount of dry matter in the green leaf fraction as a function of grazing intensity under the situation in which the forage remained free from the weed presence, where the amount of accumulated dry matter varied between 206 and 228 g m^{-2} (Table 2). This result shows the possibility of forage grass recovery regarding a new leaf flow, even if it is subjected to strong grazing intensities, but as long as the presence or permanence of competing species in the environment is not allowed.

However, even without the presence of competing species, the spreading liverseed grass did not fully recover regarding the accumulation of green stem dry matter when subjected to grazing intensities of 25, 50, 75, and 95% of the original forage height, with the accumulations obtained by these intensities being lower than that observed when there was no grazing simulation (Table 2). These results corroborate with Carloto et al. (2011), who reported that grazing intensity significantly modified canopy structure, forage nutritional value, and dry matter.

The accumulated dry matter in the dry leaf and stem fractions had practically the same trend observed in the green leaf and stem fractions, that is, the higher the intensity of simulated grazing, the lower the amount of dry matter accumulated both in the absence and in the presence of spontaneous plants (Table 2).

The effect of the change in the floristic composition is even more evident when all the fractions are evaluated together as the total dry matter accumulated by the spreading liverseed grass. Notably, both grazing and the presence of weeds decreased the total forage dry matter, as the values found under the weed absence condition were statistically higher ($p < 0.05$) than the values obtained under the weed presence condition, regardless of the intensity of simulated grazing (Table 3).

The coexistence with weeds resulted in reductions higher than 23% in the amount of dry matter produced. The highest reductions were observed in the simulated grazing intensities of 75 and 95%, in which the total amounts of dry matter accumulated by the forage under the weed presence condition were 52.6 and 56.7% lower than the amounts accumulated in the respective grazing intensities under the weed absence condition (Table 3).

In general, the most important mechanism for the creation of structural heterogeneity of the pasture and, consequently, local floristic diversity is the selective defoliation (Rook et al., 2004), which results from the diet options of the herbivorous mammal among the species and plant parts within the same species. This selective defoliation creates, within the pastures, areas that are intensely and repeatedly grazed and others that are grazed less frequently. This changes the competitive hierarchy between plants as a result of the direct removal of phytomass, nutrients, and alteration of the pattern of light interception and competition for nutrients from the soil (Scimone, Rook, Garel, & Sahin, 2007; Soder et al., 2007).

Table 3. Total dry matter (g m^{-2}) produced by *Brachiaria decumbens* and percentage of reduction as a function of the coexistence with spontaneous vegetation at 90 days after being subjected to grazing intensities.

Grazing	Coexistence		Reduction
	Weed absence	Weed presence	(%)
0	904 aA	687 aB	24.0
25%	773 bA	588 aB	23.9
50%	734 bA	454 bB	38.1
75%	688 bA	326 cB	52.6
95%	656 bA	284 cB	56.7
F grazing (G)		42.1**	
F coexistence (C)		241.4**	
F G × C		4.2**	
LSD (G)		119.2	
LSD (C)		83.7	
CV (%)		9.5	

**Significant at the 1% probability level. Means followed by the same lowercase letter in the column or the same uppercase letter in the row do not differ statistically from each other by the Tukey test at a 5% probability.

All these factors explain the results obtained in this study, as the phytomass produced by the forage decreased, while the floristic biodiversity and the spontaneous vegetation phytomass increased with an increase in the grazing intensity used selectively on the spreading liverseed grass. In addition, the association of high grazing pressure and forage coexistence with invasive plants drastically reduced the production of total forage dry matter.

Thus, if there is a need to adopt more intense grazing levels for animal maintenance, the adoption of some weed elimination method selective for the forage can allow higher dry matter productivity by spreading liverseed grass.

Conclusion

Higher forage cutting intensities, obtained by grazing simulation, increased the floristic diversity, the number of individuals, and the dry matter accumulated by weeds in a pasture grown with spreading liverseed grass, reducing by up to 56% the production of total forage dry matter.

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