




## Vegetation composition and forage mass in grassland with a double structure under two winter grazing regimes

André Alfredo Coelho<sup>1</sup>  José Pedro Pereira Trindade<sup>2</sup> Leandro Bochi da Silva Volk<sup>2</sup>  
Clodoaldo Leites Pinheiro<sup>2</sup> Fernando Luiz Ferreira de Quadros<sup>3</sup>

<sup>1</sup>Laboratório de Ecologia de Pastagens Naturais (LEPAN), Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brasil. E-mail: andrecoelho.zot@gmail.com. \*Corresponding author.

<sup>2</sup>Laboratório de Estudos em Agroecossistemas e Recursos Naturais (LABECO), Empresa Brasileira de Pesquisa Agropecuária (Embrapa) Pecuária Sul, Bagé, RS, Brasil.

<sup>3</sup>Departamento de Zootecnia, Centro de Ciências Rurais (CCR), Universidade Federal de Santa Maria (UFSM), Santa Maria, RS, Brasil.

**ABSTRACT:** *Remnant areas of Pampas grassland have a distinct double structure. Efficiency of livestock farming on these grasslands depends on practices that are synchronized with natural variation. This study examined the changes in vegetation composition and forage mass during winter to understand the effects of grazing methods in a natural pasture with a double structure that was grazed by heifers. An experimental area in the municipality of Bagé, Rio Grande do Sul, was subjected to continuous or rotational grazing treatments, with two replicates each. Frequency of the structural composition and forage mass of the lower stratum and animal weight was measured at the beginning and end of the experimental period (June 7 to October 7, 2016, respectively). Data were analysed with PCA ordination, regression and variance analysis. Both structural composition and forage mass changed during the experimental period. *Axonopus affinis* and *Paspalum notatum* were characteristic of continuous grazing, while *Mnesithea selloana* and *Axonopus argentinus* characterized rotational grazing (the latter had the highest levels of forage mass). Although, grazing methods changed the composition of forage mass in winter, they did not affect average daily gain of the animals.*

**Key words:** forage allowance, grazing, heifers, native grassland.

## Composição da vegetação e massa de forragem em pastagem natural de dupla estrutura sob dois manejos no inverno

**RESUMO:** *Áreas remanescentes de campo nativo do bioma Pampa têm apresentado dupla estrutura acentuada. A eficiência da pecuária sobre tais condições é dependente da adoção de práticas sincronizadas às peculiaridades naturais. Objetivou-se ampliar a compreensão da mudança da composição da vegetação e da massa de forragem, durante a estação de inverno, como efeito do manejo do pastejo em uma pastagem natural, de acentuada dupla estrutura pastejada por novilhas. A unidade experimental, situada no município de Bagé, Rio Grande do Sul, consiste em dois tratamentos (pastoreio contínuo e rotativo) e duas repetições. Os dados foram obtidos no início (7/6/2016) e fim do período experimental (7/10/2016), sendo estes: frequência da composição estrutural e do estrato inferior, massa de forragem deste estrato e peso dos animais. Os dados foram analisados com métodos multivariados, regressão linear e comparação de médias. A composição da estrutura e da massa de forragem se alterou no período. *Axonopus affinis* e *Paspalum notatum* representaram o pastoreio contínuo; e *Mnesithea selloana* e *Axonopus argentinus* o pastoreio rotativo, estando esta última espécie relacionada aos maiores níveis de massa de forragem. Na estação hiberna, os métodos de manejo interferiram na composição da massa de forragem sem interferir no desempenho positivo dos animais.*

**Palavras-chave:** campo nativo, oferta de forragem, método de pastejo, recria de novilhas.

## INTRODUCTION

Many of the remnant native grasslands of Rio Grande do Sul include rocky outcrops, shallow soils, and rugged topography that impede agriculture. Naturally, these regions also contain non-forage species and/or species that are less preferred by livestock; which although, part of biome, are not controlled by grazing cattle (BORBA & TRINDADE, 2009).

Double structures (horizontal and vertical distribution of pasture by caespitose and prostrate

plants) comprise a large part of the biome coverage, which has been shaped by fires and grazing to produce the contemporary physiognomies of these natural grasslands (RAMBO, 2005; SOARES et al., 2005). Land ownership reconfiguration has reduced the territorial extent of properties and caused difficulties in maintaining or increasing zootechnical indexes (RIBEIRO & QUADROS, 2015). Suitability of the Pampas grasslands for livestock is also limited in its ability to provide nutrition to animals that have high forage demands (SOARES et al., 2015).

The use of “forage allowance” as a criterion to calculate stocking density has been widely used from forage research to provide technical advice of farmers. In natural, sharp, double-structured pastures, estimation of forage mass is complex and sometimes inaccurate. The under- or over-estimation of forage mass stems from unequal distribution of the strata, which makes it difficult to predict exactly what will be consumed by animals, resulting in a low correlation between forage mass allowance and weight gain of live animals (CARVALHO et al., 2015; SOARES et al., 2015). Therefore, to achieve guaranteed animal performance, some farmers have used “forage accumulation” instead of “forage allowance” (TRINDADE et al., 2016).

Estimated forage mass is an important management tool, and understanding its relationship with natural grassland physiognomy is essential to assess responses to different grazing methods. Therefore, this study examined the dynamics of vegetation structure and the composition of forage mass under different grazing methods in a natural grassland with a distinct double structure that was grazed by beef heifers.

## MATERIALS AND METHODS

An area of natural grassland with a distinct double structure, with vegetation typical of the Serra of Southeast of Rio Grande do Sul, was monitored from June 7 to October 7, 2016. The area was in the municipality of Bagé, which belongs to the Empresa Brasileira de Pesquisa Agropecuária - “Campos Sul Brasileiros” Research Center (EMBRAPA - CPPSUL). The area had no previous agricultural management and had been managed by the Laboratory of Agroecology and Natural Resources Studies (LABECO) since 2012.

The soil was classified as Typical Haplic Orthic Luvisol (STRECK et al., 2008). The Köppen classification climate of the region was humid temperate - Cfb, with an average annual temperature of 16°C, and an average annual rainfall of 1380mm (MORENO, 1961). The average temperature and rainfall were: 10.2°C and 32mm (June), 12°C and 128mm (July), 14.4°C and 95mm (August), 13.5°C and 55mm (September), and 17.3°C and 119mm (October), respectively (source: Embrapa South Livestock).

The area comprised four experimental units of 4.9ha each. Two units were managed under continuous grazing (treatment C) and two were subdivided into eight paddocks each and managed under rotational grazing (treatment R). Treatments

were arranged in a completely randomized design, with two replicates per treatment. The average period of time spent by animals in the paddocks was 2 days (MACHADO et al., 2013). Forage species were prioritized into functional groups A and B, including *Axonopus affinis*, *Paspalum notatum*, *Mnesithea selloana*, and *A. argentinus* (QUADROS et al., 2009).

Vegetation structure was assessed using three transects arranged every 30m in the treatment R paddocks and every 50 meters in the treatment C paddocks. Transects followed orientation of the point-intercept method adapted from MUELLER-DOMBOIS & ELLEMBERG (1974). Vegetation was identified every 1m, from a list of the 27 most relevant structural components. Arrays of presence and absence (1 = presence, 0 = absence) were generated to estimate the structural frequency of species in each replicate unit.

Areas covered by plants <20cm, except for the grass *Eragrostis plana*, were considered to comprise the lower stratum (ESIN). Forage mass was estimated using comparative yield, which was adapted from HAYDOCK & SHAW (1975) and systematic sampling of the ESIN. A pair of shears and a 0.25-m<sup>2</sup> quadrat was used to cut plants at ground level, and the material was wrapped in paper bags. In the uncut quadrats, green mass was visually estimated by at least two observers. A combination percentage, equal to 100%, was assigned to each quadrat (with and without cutting) for up to three species to estimate the surface composition. In treatment R, 12 visual estimates and 3 cuts were made per paddock, while in treatment C, 30 visual estimates and 10 cuts were made. After collection, the material was dried in a fan oven at 60°C until constant mass, to obtain the partial percentage of dry matter. The upper stratum was reduced by mowing the plant material at 20cm from the soil surface in August 2016.

Twenty-five 3-year-old Brangus heifers, mean live weight 327kg, were used for grazing. Heifers were fed using a protein/energy supplement *ad libitum*, and maintained at an average stocking density of 1.1AU/ha in each treatment C replicate and 0.8AU/ha in each treatment R replicate. Unequal stocking density between treatments was not used to directly compare the management methods, but to investigate the dynamics of vegetation composition and forage mass in each grazing treatment.

The initial and final forages allowances were calculated using the equation:

$$FA = [(FM\ ESIN \times \%ESIN)/LW/ha] \times 100$$

where, FA is forage allowance, FM ESIN is the forage mass of the ESIN, %ESIN is the percentage coverage of ESIN, and LW/ha is the animal live weight per hectare.

### Statistical analysis

Principal Coordinates Analysis (PCA) in MULTIV 3.47b software was used to analyze vegetation structure, forage mass, and composition of the lower strata, using quantitative data of the same scale, and a dissimilarity measure of the Euclidian distance between sample units. The figures were generated from the correlations of the first and second principal coordinates. Linear regression was used to examine the relationship between forage mass and species composition in each sample unit. The mean initial and final frequencies of major components of forage mass were analyzed using Student's t-tests. Difference in average daily gain (ADG) of animals between grazing treatments was tested using analysis of variance ( $\alpha < 0.05$ ) in SAS software.

## RESULTS AND DISCUSSION

Vegetation structure changed over the experimental period (Figure 1A). The PCA summarized 94.74% of the total variation in axes one (horizontal) and two (vertical). Percentage of lower strata (ESIN) and dead material (MAMO) increased in August, mainly in response to mowing. The practice of "high mowing" deposited biomass on the ESIN, but did not suppress it, as indicated by the increase in biomass in both treatments. The percentage coverage increased from 39% to 42% in treatment R, and from 24% to 41% in treatment C. Decrease in *Eragrostis plana* (ERPL), *Saccharum angustifolium* (SAAN), and *Eryngium horridum* (ERHO) might have been associated with treatment R. The mowing season affected the contribution of ERHO to grassland coverage. Due to the abundance of thorns, ERHO was avoided by the heifers and it competed with other species with better forage potential. PELLEGRINI et al. (2007) reported a significant increase in ERHO after summer mowing in another grassland in this region. Cutting of inflorescences inhibits apical growth and stimulates tillering of the plant (TAIZ & ZEIGER, 2009), which increases its coverage frequency.

Structural nature of the sampled units showed a different tendency, as demonstrated by the prevalence of SAAN in treatment R units (20% at the beginning and 12% at the end of the experiment), and ERPL in treatment C units (28% at the beginning and 26% at the end of the experiment). Although, treatment C displayed a higher initial frequency of ERPL, which was due to the management history, the decrease was not significantly different from that in treatment R, at nearly 2%.

The forage mass and composition of the lower strata varied during the experiment (Figure

1B). PCA summarized 73.6% of the total variation. In treatment R, the mean forage mass of the lower strata (MFinf) was reduced from 1704.4 to 956.1kg DM/ha, while in treatment C, it decreased from 933.3 to 689.6kg DM/ha. CARVALHO (2014) observed a reduction in biomass in the lower strata in the same region and suggested it was due to the higher intake of the animals. *A. affinis* and *P. notatum* represented the left quadrants of the PCA diagram (being most abundant in ESIN) of the composition of MFinf in treatment C, whereas *A. argentinus* and *M. selloana* represented the same for treatment R, at the right down quadrant. DUTRA (2016) observed a larger percentage of *M. selloana* in summer in areas with rotational grazing in this region. Phenotypic plasticity of growth form, from prostrate to caespitose, of *A. argentinus* and *M. selloana* explains its higher contribution to MFinf, as it responded to the rest periods provided by the rotational grazing system. Prostrate species *A. affinis* (stoloniferous) and *P. notatum* (rhizomatous) presented resilience strategies against higher grazing intensity in continuous grazing systems (SOSINSKI & PILLAR, 2004).

Dispersion of species descriptors of the composition of the forage mass correlated to a greater degree with the horizontal axis. *A. argentinus* displayed the highest correlation (0.85) with the horizontal axis, and this species was associated with higher forage mass. *A. argentinus* was most stable in the forage mass of treatment R, but was virtually absent in treatment C (Table 1). This can be attributed to the ecosystem functionality fostered by the grazing treatment, which naturally produced greater stability in forage production due to the increased number of species (QUADROS et al., 2009). Figure 2 shows that 88% of the forage mass was related to the species composition in treatment R ( $R^2=0.88$ ). Rotational grazing caused more change in the composition of the forage mass between the initial and final measurements, which was reflected in the Euclidean distance (Figure 1B). Although, both experimental units had the same degree of soil heterogeneity, areas of shallow and stony soils in treatment R units showed a transition of species (STRINGHAM et al., 2003), possibly as a result of the lower grazing frequency (DUTRA, 2016). This phenomenon was also observed by TRINDADE et al. (2008) in sandy fields in the southwest region of Rio Grande do Sul.

Vegetation structure in each treatment did not decrease the live weight of animals during winter as observed by MEZZALIRA et al. (2012) and SOARES et al. (2015). The ADG was 0.1kg

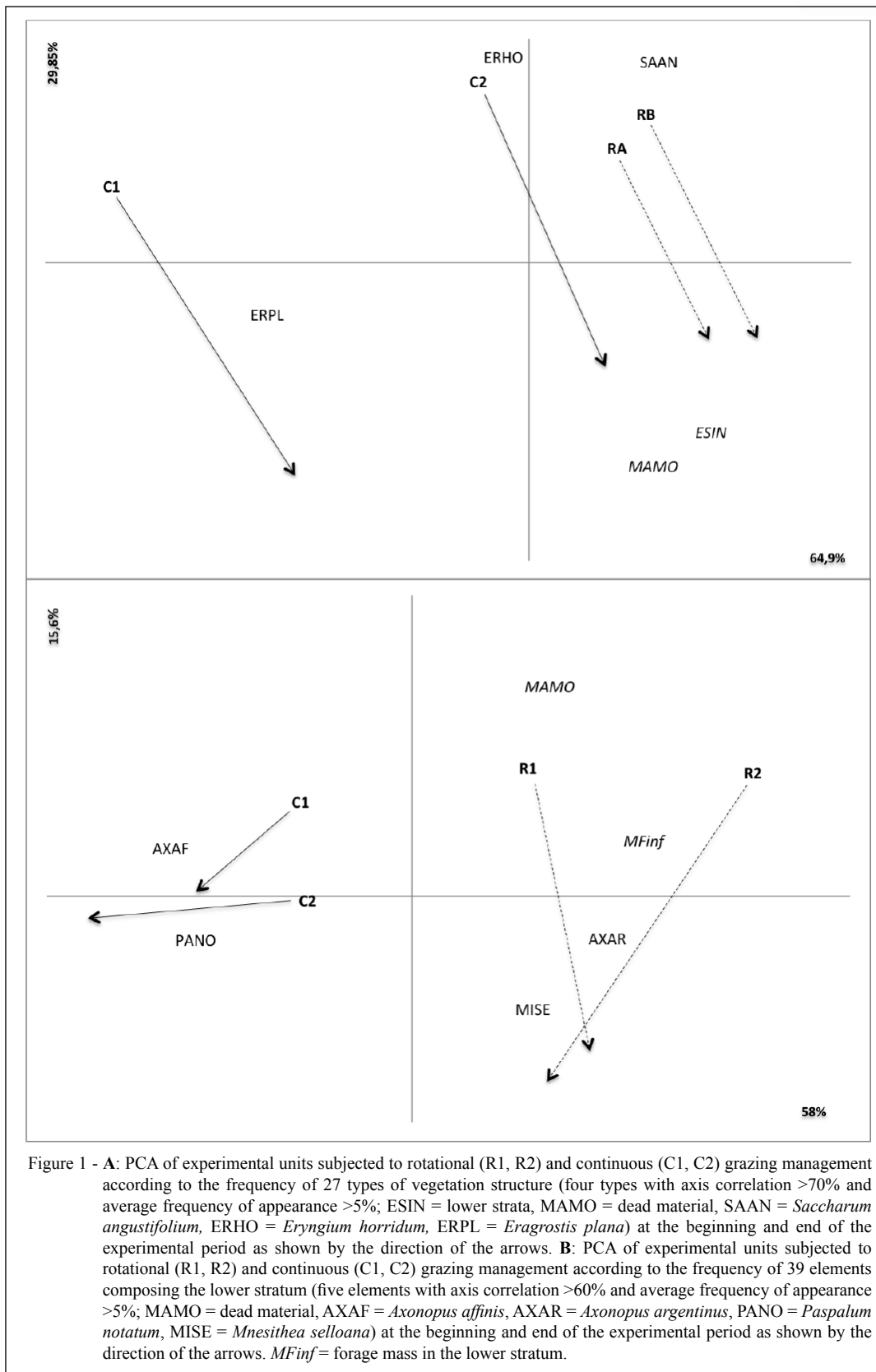


Table 1 - Mean initial and final frequencies (%) of components of forage mass in the lower strata, which showed a higher PCA correlation, in a native double-structure pasture under rotational (R) and continuous (C) grazing regimes.

	--- <i>Axonopus affinis</i> ---		----Dead material----		-- <i>Paspalum notatum</i> --		-- <i>Mnesithea selloana</i> --		- <i>Axonopus argentinus</i> -	
	Jun	Oct	Jun	Oct	Jun	Oct	Jun	Oct	Jun	Oct
R	15.3 <sup>a</sup>	14.2 <sup>a</sup>	17.3 <sup>a</sup>	0.5 <sup>b</sup>	9.4 <sup>a</sup>	16.3 <sup>a</sup>	11.5 <sup>a</sup>	14.5 <sup>a</sup>	13.5 <sup>a</sup>	15.8 <sup>a</sup>
C	25.7 <sup>b</sup>	34.5 <sup>a</sup>	6.4 <sup>a</sup>	2.4 <sup>a</sup>	2.8 <sup>a</sup>	2.7 <sup>a</sup>	8.0 <sup>a</sup>	8.8 <sup>a</sup>	6.6 <sup>a</sup>	0.9 <sup>b</sup>

\*Means with different letters in the same columns per component were significantly different in Student t-tests ( $\alpha \leq 0.05$ ).

in treatment R and 0.17kg in treatment C ( $P=0.11$ ). SOARES et al. (2015) did not observe any differences between grazing treatments in this experimental area. CARVALHO (2014) described very similar compositions of vegetation during autumn/winter (2013) to those in this study. The high forage masses that were not grazed suggested that determining the supply of forage suitable for a variable stocking density of heifers is complex.

BREMM et al. (2012) concluded that between 34 and 44% of grass tussocks (upper

stratum), with a predominance of ERPL, would be detrimental to the foraging behavior of cattle and could decrease weight gain. In this study, frequencies of initial coverage of the upper stratum in treatments R and C were 61% to 76%, respectively, and up to 15.7% and 37.3% were ERPL, respectively. At the end of the experiment, coverage of tussocks in treatments R and C was 58% and 59%, respectively, with 12.9% and 44.07% ERPL, respectively. Thus, percentage of estimated tussocks in treatment C were considered critical for animal performance,

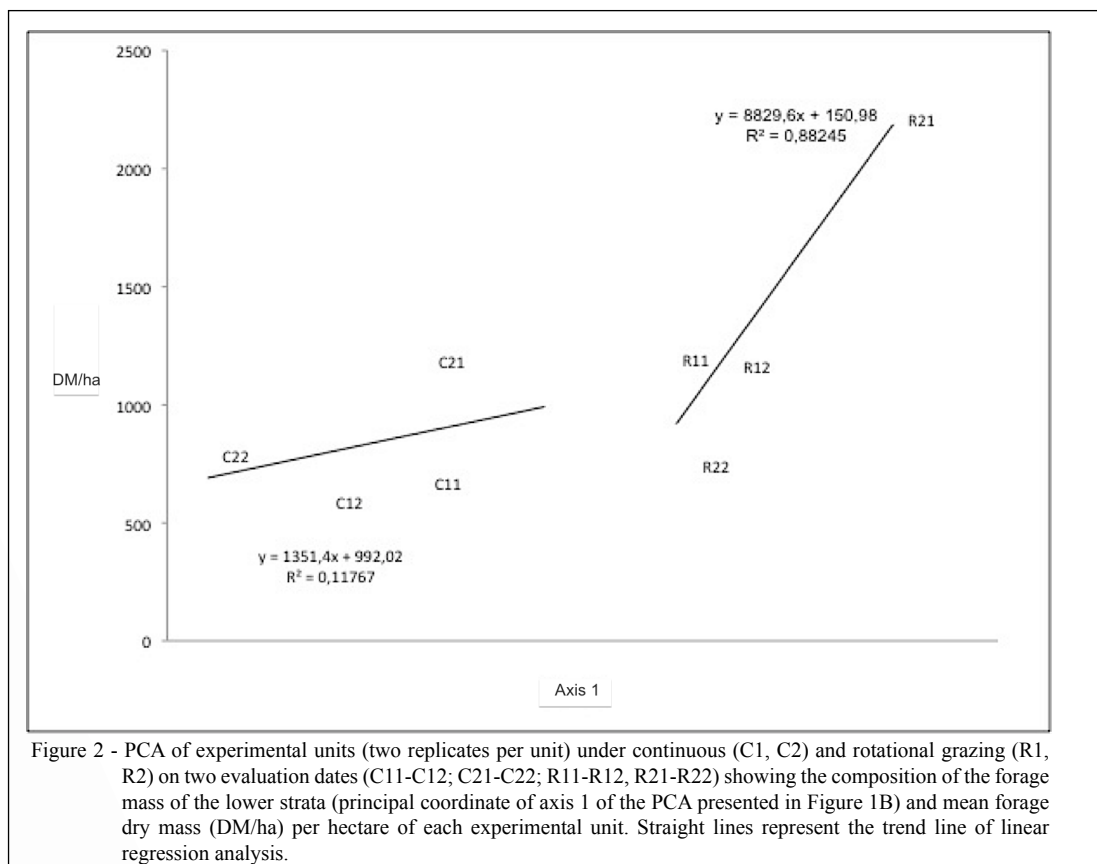


Figure 2 - PCA of experimental units (two replicates per unit) under continuous (C1, C2) and rotational grazing (R1, R2) on two evaluation dates (C11-C12; C21-C22; R11-R12, R21-R22) showing the composition of the forage mass of the lower strata (principal coordinate of axis 1 of the PCA presented in Figure 1B) and mean forage dry mass (DM/ha) per hectare of each experimental unit. Straight lines represent the trend line of linear regression analysis.

according to BREMM et al. (2012). However, we did not observe this effect, as there was no difference in ADG between the grazing treatments.

Forage mass from the lower strata (initial and final) decreased from 6.5% to 3.8% in treatment R, but increased from 2.4% to 2.8% in treatment C. The decrease might have been related to low grassland growth in winter (TRINDADE et al., 2016). In treatment C, the increase was due to the relative increase in the surface area of the lower stratum. SOARES et al. (2005) and MEZZALIRA et al. (2012) concluded that 8% and 12% of the forage on offer from the lower strata in spring and other seasons, respectively, provided satisfactory live weight gains. MEZZALIRA et al. (2012) recorded an ADG of 0.193kg from June to October under continuous grazing. However, a 4% forage on offer (more similar to that in this study) decreased by 0.217kg over the same period. Composition of the upper stratum suggested it is possible to guarantee reserves of dry forage matter for use during critical periods. However, the importance of the type of animal for the rate of consumption of such material should be emphasized (SOARES et al., 2015).

## CONCLUSION

The grazing method changed the composition of forage mass in the lower strata without affecting the weight gain of the animals. Increase in the number of different species in forage mass of the lower stratum provided a higher forage stability during winter.

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## BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

The authors of the article titled "Vegetation composition and forage mass in grassland with a dual structure under two winter grazing regimes" declare, for all due purposes, that the project that gave rise to the data presented herein was not submitted for evaluation to the Ethics Committee of the Universidade Federal de Santa Maria, but we are aware of the content of the resolutions of the Conselho Nacional de Controle e Experimentação Animal (CONCEA) <<http://www.mct.gov.br/index.php/content/view/310553.html>> when involving animals. Thus, the authors assume full responsibility for the data presented and are available to respond to any enquiries, if required by the competent bodies.

## DECLARATION OF CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## REFERENCES

- BORBA, M. F. S.; TRINDADE, J. P. P. Desafios para a conservação e a valorização da pecuária sustentável. In: Pillar, V. P. et al. (Ed). **Campos Sulinos**. Brasília: MMA. p. 391-403, 2009.
- BREMM, C. et al. Foraging behaviour of beef heifers and ewes in natural grasslands with distinct proportions of tussocks. **Applied Animal Behaviour Science**, v. 141, p. 108-116, 2012.
- CARVALHO, P. C. F. et al. Can animal performance be predicted from short-term grazing processes? **Animal Production Science**, [s.l.], v. 55, p. 319-327, 2015.
- CARVALHO, R. M. R. de. **Características estruturais e dinâmica temporal da composição florística de uma pastagem natural manejada sob diferentes métodos de pastoreio**. 2014. 54 f. Dissertação (Mestrado) - Curso de Zootecnia, Zootecnia, Universidade Federal de Santa Maria, Santa Maria, 2014.
- DUTRA, G. M. **Alternativas de manejo para pastagem natural na Serra do Sudeste**. 2016. 70 f. Dissertação (Mestrado) - Curso de Zootecnia, Zootecnia, Universidade Federal de Santa Maria, Santa Maria, 2016.
- HAYDOCK, K. P.; SHAW, N. H. The comparative yield method for estimating dry matter yield of pasture. **Australian Journal of Experimental Agriculture and Animal Husbandry**, v. 15, p. 663-670, 1975.
- MACHADO, J. M. et al. Morphogenesis of native grasses of Pampa Biome under nitrogen fertilization. **Revista Brasileira de Zootecnia**, v. 42, p. 22-29, 2013.
- MEZZALIRA, J. C. et al. Produção animal e vegetal em pastagem nativa manejada sob diferentes ofertas de forragem por bovinos. **Ciência Rural**, v. 42, p. 1264-1270, 2012.
- MORENO, J. A. **Clima do Rio Grande do Sul**. Porto Alegre: Secretaria da Agricultura, v. 41 p. 1961.
- MUELLER-DOMBOIS, D.; ELLENBERG, H. The Point-Intercept Method. In: **Aims and Methods of Vegetation Ecology**. Wiley International Edition. Cap. 6. 84: 90 p. 1974.
- PELLEGRINI, L. G. de. et al. Diferentes métodos de controle de plantas indesejáveis em pastagem nativa. **Revista Brasileira de Zootecnia**. v. 36, p. 1247-1254, 2007. Available from: <<http://dx.doi.org/10.1590/S1516-35982007000600005>>.
- QUADROS, F. L. F. et al. Abordagem funcional da ecologia campestre como instrumento de pesquisa e apropriação do conhecimento pelos produtores rurais. In: PILLAR, V. D. P., et al. (Eds). **Campos Sulinos**. Brasília/DF. v. 15, p. 206-213, 2009.
- RAMBO, B. A Serra do Sudeste: A vegetação da Serra do Sudeste. In: RAMBO, Balduino. **A Fisionomia do Rio Grande do Sul**. 3. ed. Porto Alegre: Unisinos, 2005.
- RIBEIRO, C. M.; QUADROS, F. L. F. de. Valor histórico e econômico da pecuária. In: PILLAR, V. de P.; LANGE, O. (Eds). **Os Campos do Sul**. Porto Alegre: UFRGS. v. 2, p. 19-22, 2015.

- SOARES, A. B. et al. Produção animal e de forragem em pastagem nativa submetida a distintas ofertas de forragem. **Ciência Rural**, v. 35, p. 1148-1154, 2005.
- SOARES, É. M. et al. Beef heifers performance in natural grassland under continuous and rotational grazing in the autumn-winter. **Ciência Rural**, v. 45, p. 1859-1864, 2015.
- SOSINSKI, E. E.; PILLAR, V. D. P. Respostas de tipos funcionais de pastejo à intensidade de pastejo em vegetação campestre. **Pesquisa Agropecuária Brasileira**, v. 39, p. 1-9, 2004.
- STRECK, E. V. et al. A classificação de solos: Luvisolos. In: STRECK, E. V. et al. (Ed). **Solos do Rio Grande do Sul**. 2. ed. Porto Alegre: EMATER/RS Ascar, v. 3, p. 81-86, 2008.
- STRINGHAM, T. K. et al. State and transition modeling: An ecological process approach. **Journal of Range Management**, v. 56, p. 106-113, 2003.
- TAIZ, L.; ZEIGER, E. Crescimento e Desenvolvimento. In: TAIZ, L.; ZEIGER, E. (Eds). **Fisiologia Vegetal**. 4. ed. Porto Alegre: Artmed, v. 16, p. 435-475, 2009.
- TRINDADE, J. P. P. et al. Massa de Forragem e Taxa de Acúmulo de Campo Nativo em Sistemas de Produção de Pecuária Familiar da Serra do Sudeste do Rio Grande do Sul. **XXVI Zootec**, Santa Maria, RS. Maria. p. 1-3, 2016.
- TRINDADE J.P.P. et al. Vegetação campestre de areais do Sudoeste do Rio Grande do Sul sob pastejo e com exclusão do pastejo. **Pesquisa Agropecuária Brasileira**. v. 43, p. 771-779. 2008.