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ARQUITETURA DE TOUCEIRAS DE *ANDROPOGON LATERALIS* SOB OFERTAS DE FORRAGEM CONTRASTANTES

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ARQUITETURA DE TOUCEIRAS DE *ANDROPOGON LATERALIS* SOB OFERTAS DE FORRAGEM CONTRASTANTES

Dissertação apresentada como requisito para obtenção do Grau de Mestre em Zootecnia, na Faculdade de Agronomia, da Universidade Federal do Rio Grande do Sul.

Orientador: Paulo César de Faccio Carvalho

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RESUMO: Compreender as respostas da vegetação à herbivoria têm sido um dos focos na ecologia de plantas nas últimas décadas. Estas estão ligadas a fatores tais como a intensidade e frequência de desfolha, bem como respostas espécie específicas. Dentro de ambientes pastoris heterogêneos, como os Campos presentes no bioma Pampa, essas respostas podem ser um indicativo do funcionamento individual das espécies. O presente experimento foi conduzido na Estação Experimental Agronômica da Universidade Federal do Rio Grande do Sul (EEA-UFRGS), dentro de um protocolo experimental de longa duração (desde 1986) caracterizado pela utilização de diferentes níveis de oferta de forragem de uma pastagem natural característica do Bioma Pampa. O objetivo do presente trabalho foi definir as respostas de plantas de *Andropogon lateralis* Nees., espécie altamente representativa do estrato superior de plantas destas pastagens, com base em características funcionais (altura das touceiras, projeção da copa e perímetro da base), bem como definir, através de análise de agrupamento, grupos de touceiras de *A. lateralis* com características similares. As ofertas de forragem aqui utilizadas foram fixas 8%, 12% e 16% (kg de matéria seca para 100 kg de peso vivo animal), além de uma variável 8-12% (8% na primavera e 12% nas demais estações do ano). Foi utilizado método de pastoreio contínuo e o delineamento experimental de blocos casualizados (com 4 tratamento e duas repetições cada) com medidas repetidas no tempo, sendo o fator de bloqueamento os diferentes tipos de solos do experimento. Para as medições utilizou-se dez touceiras por unidade experimental onde as amostragens dos caracteres acima citados foram repetidas ao longo cinco meses (de março a julho, sendo uma medição por mês). Nossos resultados indicam que as touceiras apresentaram um padrão de diminuição das dimensões altura e projeção da copa conforme passamos do final do verão até inverno, enquanto o perímetro da base apresenta comportamento inverso. Análises de grupamento indicaram a formação de dois grupos para o primeiro período enquanto que para os demais períodos houve a formação de três grupos distintos. Este trabalho nos traz novos indicativos de como a relação planta-animal se manifesta no Campos Sulinos, onde respostas na estrutura de *Andropogon lateralis* (altura e projeção da copa) são função direta da OF empregada.

Palavras chave: *Andropogon lateralis*, classificação, características funcionais de plantas, Campos sulinos.

ANDROPOGON LATERALIS TUSSOCKS’ ARCHITECTURE UNDER CONTRASTING FORAGE ALLOWANCES [1]

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ABSTRACT: Understanding vegetation responses to herbivory has been a focus in plant ecology in recent decades. These are linked to factors such as the intensity and severity of defoliation, as well as specific species responses. Within heterogeneous pastoral environments, such as the Campos in the Pampa biome, responses may be indicative of the individual functioning of the species. The experiment resulting in this work was carried out at the Agricultural Experimental Station of the Federal University of Rio Grande do Sul (EEA-UFRGS), within a long-term experiment (since 1986) characterized by the use of different levels of forage allowance in a characteristic natural pasture of the Pampa Biome. The objective of the present work was to define the responses of *Andropogon lateralis* Nees., a representative upper strata plant species of these pastures, based on functional traits (tussocks height, canopy projection and basal perimeter), as well how to define, through cluster analysis, groups of plants with similar characteristics. The forage allowances used here were fixed 8%, 12% and 16% (kg of dry matter for 100 kg of live animal weight), in addition to a variable 8-12% (8% in spring and 12% in other seasons of the year). Grazing method was continuous stocking, and the experimental design used was randomized blocks (with 4 treatments and two repetitions) with repeated measures over time. The blocking factor was different soil types. For the measurements, ten tussocks per experimental unit were used where the sampling of the characters mentioned above were repeated over five months (from March to July, one measurement per month). Results indicate that tussocks showed decreasing pattern in height and canopy projection as we went from late summer to winter, while basal perimeter showed the opposite behavior. Cluster analyzes indicated the formation of two groups for the first period, while for the other periods there was the formation of three distinct groups. This work brings us new indications of how the plant-animal relationship manifests in Campos Sulinos, where responses in the structure of *Andropogon lateralis* (height and canopy projection) are a direct function of the FA employed.

Key words: *Andropogon lateralis*, classification, plant functional traits, Campos grasslands.

[1] Master of Science dissertation in Animal Science, Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil. (xx p.) March, 2020.

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%T - Tussock percentage cover (%);

AFS – Área foliar específica;

BP – Basal perimeter (cm)

CP – Canopy projection (cm^2);

FA – Forage allowance (kg DM. ha^{-1});

FM – Forage Mass (kg DM. ha^{-1});

GR – Daily growth rate (kg DM. ha^{-1}).

LDMC – Leaf dry matter content;

LSASH – Low strata average sward height (cm);

OF – Oferta de forragem (kg $MS.ha^{-1}$);

SLA – Specific leaf area;

SR – Stocking Rate (kg LW. ha^{-1});

TMSF – Teor de matéria seca foliar;

TH -Tussock height (cm)

CAPÍTULO I

1 INTRODUÇÃO

O Rio Grande do Sul é um dos maiores produtores de bovinos do Brasil, prova disso é o tamanho de seu rebanho, totalizando aproximadamente 11,5 milhões de cabeças (IBGE 2017). A pecuária de corte na região sul do Brasil, principalmente no Rio Grande do Sul, é baseada na produção a pasto com ênfase nas pastagens naturais, as quais compreendem o bioma Pampa e os Campos de Altitude no Bioma Mata Atlântica. Aproximadamente 70% da superfície destinada a bovinocultura de corte no estado é ocupada por paisagens compostas por estes biomas (CARVALHO et al., 2006). O Pampa é caracterizado pela riqueza da composição florística, com ocorrência de mais de 400 espécies de gramíneas e 200 espécies de leguminosas (BOLDRINI, 2009).

Uma das características do bioma é a ocorrência de espécies formadoras de touceiras: gramíneas de hábito cespitoso que formam aglomerados em forma de tufos (LEITH 1978; WALTER 1979). Plantas deste tipo geralmente compõe o que se chama de estrato superior do pasto e, de forma geral, apresentam menor valor nutricional quando comparadas com espécies do estrato inferior.

Em alguns locais a manutenção do campo é realizada se valendo do conceito de oferta de forragem (OF), onde a carga animal é definida em função da quantidade de matéria seca de pasto disponível para dada área (ALLEN et al., 2011), evidenciando a importância das interações planta-animal. Apesar deste conceito apresentar boa aplicação, na prática informações demonstram que este conceito apresenta limitações para descrever o processo de construção da produção animal em pastagens (CARVALHO et al., 1997), principalmente por não levar em consideração a forma na qual o alimento se apresenta ao herbívoro. Apesar de poucos grupos trabalharem com estimativas de oferta de forragem em pastagens naturais o estrato superior de plantas, usualmente, é suprimido dos seus cálculos de taxa de acúmulo, isso se dá principalmente pela falta de conhecimento do que o animal de fato pasteja. Estudos atuais propõem que o animal consome plantas do duplo estrato, incluindo touceiras (BONNET et al., 2015). Esse conhecimento traz para a ciência do pastejo uma abordagem completamente nova, onde as interações planta-animal passam a ser observadas sob nova ótica.

Considerando a importância das touceiras, não somente como mantenedoras de ambientes e/ou como limitantes de consumo em campo nativo, devemos compreender melhor os processos que as envolvem, buscando definir quais as estratégias e formas de crescimento mais comuns às mesmas, sobretudo em ambiente com formações vegetais diversas sob ofertas de forragem contrastantes.

Uma das formas de se averiguar a *fitness* dessas plantas é através de caracteres chamados de funcionais. Características funcionais de plantas têm a propriedade de conectar mudanças ambientais com a estrutura e o funcionamento dos indivíduos (DÍAZ et al., 2001; DÍAZ et al., 2006; LAVOREL et al., 2007), podendo desempenhar função de indicador do funcionamento tanto a nível de indivíduo quanto a nível de comunidade.

Neste contexto, este trabalho objetivou compreender melhor estas relações representadas por modificações de caracteres estruturais (altura de touceiras, projeção de copa e circunferência de base, no caso deste estudo) em função de diferentes OF, empregadas por longo período, tomando como planta indicadora *A. lateralis* a mais predominante do estrato superior.

2 REVISÃO BIBLIOGRÁFICA

Pastagens naturais

Pastagens naturais são ecossistemas complexos e de ampla ocorrência, ocupando cerca de um quarto da superfície terrestre (cerca de 39 milhões de km²) (COSTANZA et al., 1997). Um dos maiores desafios envolvendo esse ambiente é compreender a gama de relações que ocorre entre os mais diversos tipos de indivíduos e a influência de fatores, tanto bióticos quanto abióticos. De forma geral, campos naturais estão sujeitos à exploração antrópica através da herbivoria, fenômeno que tem influência (direta e indireta) na disponibilidade de recursos, o que pode acarretar mudanças na estrutura da vegetação (DERNER et al., 2009).

O Rio Grande do Sul, um dos maiores produtores bovinos do Brasil - rebanho de aproximadamente 11,5 milhões de cabeças (IBGE, 2017) - a pecuária de corte é baseada na produção a pasto com ênfase no uso das pastagens naturais do bioma Pampa. Aproximadamente 70% da área do estado destinada a bovinocultura de corte é representada por paisagens compostas por este bioma (CARVALHO et al., 2006).

Os campos sulinos caracterizados predominantemente por pastagens naturais que se entremeiam com matas de galerias (OVERBECK et al., 2007). Levantamentos botânicos realizados por Boldrini (2009), demonstraram a riqueza da composição florística, apontando a existência de 450 espécies de gramíneas e 200 de leguminosas, sendo grande parte das espécies perenes e de crescimento estival. De acordo com NABINGER et al. (2009), as espécies predominantes são de rota metabólica C_4, caracterizadas por apresentarem maior produtividade nas estações quentes do ano (primavera/verão), entretanto, o ecossistema relatado apresenta como característica marcante a coexistência de espécies de distintas rotas metabólicas.

Estrutura do pasto

A estrutura deste tipo de vegetação está fortemente ligada à ocorrência de distúrbios que moldam suas características, influenciados principalmente pelo uso da terra (e.g., - pastejo e queimadas) (OLIVEIRA & PILLAR, 2004; BLANCO et al., 2014). O pastejo - realizado principalmente por grandes herbívoros - acarreta modificações na estrutura da vegetação através de mecanismos de seleção que são afetados majoritariamente pela palatabilidade das plantas e pela variação topográfica, modificando a heterogeneidade espacial dos habitats (MORRIS, 2000).

Em pastagens naturais a taxa de acúmulo de forragem está fortemente relacionada a dois fatores: composição botânica e estrutura da vegetação. Esses são influenciados por fatores ambientais (temperatura, regime hídrico e estação do ano), edáficos (tipo de solo e topografia) e técnicas de manejo do pastejo (PALLARÉS et al., 2005). É comum que estes ecossistemas sejam fortemente influenciados pela heterogeneidade, representada na forma de múltiplos estratos (BRISKE et al., 2008), o que torna difícil a compreensão da dinâmica deste sistema. Conforme ZHAO et al. (2006), a alta pressão de pastejo é fator chave no que diz respeito a redução da biodiversidade em áreas de pastagem, além de diminuição da produtividade sob condições específicas (BAI et al., 2007).

Neste contexto é importante salientar que os distúrbios supracitados (fogo e pastejo) são fundamentais para evitar a dominância competitiva por parte de gramíneas formadoras de touceiras acarretando na perda de diversidade botânica (supressão por competição) e consequente transformação da área em vegetação dominada por árvores e arbustos (MÜLLER et al., 2007; OVERBECK et al., 2005, 2007; PILLAR & VÉLEZ 2010).

Existem diversas formas de manejo do pasto. Dentre as utilizadas recentemente há o ajuste via Oferta de Forragem (OF) – descrita como a relação entre a quantidade de matéria seca de forragem disponível para determinada carga animal por unidade de área (ALLEN et al., 2011) – e o manejo do pasto via estrutura (GONÇALVES et al., 2009; DA TRINDADE et al. 2012, 2016) definida como a distribuição tridimensional da parte aérea da forragem (LACA & LEMAIRE, 2001). Essas diferentes técnicas de manejo podem acarretar respostas diversas nas relações solo-planta-animal, levando à formação de diferentes fisionomias do campo.

A modificação da estrutura do pasto, além de alterar o equilíbrio ecológico entre espécies presentes no duplo estrato (inferior e superior), também afeta o comportamento ingestivo dos herbívoros na busca, manipulação, apreensão e ingestão da forragem (HODGSON, 1990).

Touceiras

Touceiras podem ser definidas como gramíneas de hábito de crescimento cespitoso dominante onde a formação vegetal ocorre em “tufos”, que resulta em uma estrutura compacta em relação à organização dos perfilhos na planta. São espécies que ocorrem em todos os continentes, sendo mais representativas em biomas compostos predominantemente por pastagens (LEITH 1978; WALTER 1979). Sua aparição está associada aos mais diversos tipos de clima, podendo ocorrer em ambientes áridos (MARES, 2017) até ambientes com elevada umidade (HUTCHINGS & DE KROON, 1994).

De acordo com WALTER (1979), dentro dos sistemas de produção animal as espécies formadoras de touceira são geralmente indesejadas, por apresentarem baixo valor nutricional. Em seus biomas de ocorrência natural são frequentemente removidas através da aração ou gradagem para que se estabeleçam outras espécies de crescimento menos dominante.

O padrão de organização dos perfilhos dentro de touceiras pode resultar em uma arquitetura muito compacta, com aumento do sombreamento e alteração da taxa de crescimento dessas plantas. HENDON & BRISKE (1997) afirmam que touceiras que receberam múltiplas desfolhas em sua estação de crescimento apresentaram decréscimo no número de perfilhos e na área basal quando comparados a plantas que não sofreram o processo de desfolha. CALDWELL et al. (1981) verificaram que a severidade de desfolha altera o crescimento dessas espécies. Para touceiras, que podem apresentar arquitetura mais compacta e consequente maior auto sombreamento, a desfolha pode atuar como facilitador para aumento da fotossíntese, pois além de abrir o dossel aumentando a passagem de luz, pode aumentar a taxa fotossintética para folhas em recuperação à desfolha. Não que necessariamente a desfolha seja um fator favorável a essas plantas. De forma generalista, a dominância entre touceiras pode se alterar em função de regimes de desfolha não seletiva (FYNN et al., 2005).

Características funcionais de plantas

São definidas como características morfo-fisio-fenológicas que podem impactar na adaptação do indivíduo ao ambiente, sendo diretamente ligadas ao crescimento, reprodução e sobrevivência; considerados os componentes da performance individual (VIOLLE et al., 2007). Além da indicação de como o indivíduo se adapta ao ambiente, as características funcionais de plantas são um indicativo direto de como as espécies respondem ao ambiente. Essas respostas de plantas são um indicativo direto de como um ecossistema se apresenta com relação às questões ecológicas (McGILL et al., 2006).

Conforme citado, os campos naturais do sul do Brasil apresentam mais de 400 espécies de gramíneas compondo sua vegetação caracteristicamente multiestratificada. Portanto, seria necessário um grande esforço para se estudar cada espécie individualmente. Devido a elevada diversidade florística, alguns autores desenvolveram uma abordagem fundamentada no agrupamento de espécies com base em características funcionais comuns (CRUZ et al., 2010; DÍAZ et al., 1997). Estes agrupamentos foram denominados grupos funcionais de plantas e são baseados na similaridade entre espécies quanto às respostas ao ecossistema e a variações ambientais (CRUZ et al., 2002), mensuradas com base nas características foliares de plantas.

CRUZ et al. (2010), em trabalho desenvolvido no campos sul rio-grandenses, dividiram as principais espécies em 4 grupos funcionais de acordo com o teor de matéria seca foliar (TMSF, em $mg.g^{-1}$) e área foliar específica (AFE, em $m^2.kg^{-1}$). Os grupos denominados A e B foram definidos como espécies utilizadoras de recursos, ou seja, indivíduos que têm uma dinâmica de utilização de recursos mais acelerada. Agindo como "captadores", estes indivíduos são geralmente associados à maior valor nutricional e são, de forma geral, mais preferidos pelos herbívoros; enquanto grupos C e D são definidos como indicativos de espécies mantenedoras de recursos por apresentarem dinâmica de utilização de recursos mais conservativa, e geralmente são associados a plantas do estrato superior em campo nativo (Tabela 1).

Tabela 1. Grupos funcionais de plantas propostos por CRUZ et al. (2010) utilizando como atributos de classificação o teor de matéria seca (TMSF) e área foliar específica (AFE), onde G e T identificam os tipos de *Andropogon lateralis* pastejado (G) e em forma de touceiras (T).

Grupo	TMSF ($mg.g^{-1}$)	AFE ($m^2.kg^{-1}$)	Espécies

A	<300	24	*Axonopus affinis, Panicum sabulorum*
B	310	16	*Andropogon lateralis G, Coelorachis selloana, Paspalum paucifolium, P. notatum,*
C	380	8	*Andropogon lateralis T, Piptochaetium montevidense, Sporobolus indicus*
D	500	6	*Aristida* spp. *(Aristida laevis, Aristida phylifolia, Aristida venustula)*

Fatores bióticos e abióticos estão diretamente ligados à modificação nestas estruturas funcionais de plantas, e muitos trabalhos têm considerado eventos de pastejo como um dos fatores de maior influência sobre estas respostas.

Interações planta-animal

As relações planta-animal, principalmente para ambientes pastoris heterogêneos, ainda não foram completamente desvendadas. Alguns estudos têm evidenciado o papel de estruturas (por exemplo touceiras) nas interações do animal com o ambiente, podendo ser um mantenedor de funções ou até um limitante de consumo.

TRINDADE et al. (2012; 2016), encontraram relação direta entre o aumento da massa de forragem (MF) e variáveis como altura do estrato inferior e a frequência de touceiras (%) para diferentes ofertas de forragem (OF) em campo nativo. No mesmo estudo foi evidenciada interação entre a estação do ano e a variação de altura do estrato inferior, o que não ocorreu para frequência de touceiras. A presença de touceiras no campo pode acarretar mudanças não apenas na estrutura do pasto, mas também no comportamento seletivo do animal, podendo alterar fatores como o tempo de pastejo, o número de bocados e a taxa de ingestão. Segundo TRINDADE et al. (2012), existe relação direta entre a frequência de touceiras e o tempo de pastejo, onde a frequência ótima de touceiras para redução do tempo de pastejo em campo nativo está na faixa de 20 a 30%. Para frequências maiores, os mecanismos de comportamento adotados como resposta (deslocamento e tempo de pastejo) se tornam onerosos para o animal. BREMM et al. (2012)

expõem que para frequências de touceiras maiores que 35% o consumo de forragem é limitado, alterando o comportamento ingestivo do animal.

Quando analisamos em detalhe o comportamento ingestivo e a seleção por parte do animal, fica evidenciado que as touceiras compõem uma fatia significativa do total que pode ser consumido. Isto é claramente evidenciado quando comparamos refeições em diferentes momentos (05:45 até 08:10 e 09:00 até 11:00) onde a quantidade de touceiras (relativo ao total de matéria seca do período) consumidas por bovinos em campo nativo foi de 22% em ambos os casos (BONNET et al., 2015). Apesar das touceiras comporem fatia considerável do total consumido no processo de herbivoria, o valor nutricional destas plantas é menor que o de espécies componentes do estrato inferior por apresentarem maior proporção de tecido senescente ao longo do ano e também por características ligadas à formação da parede celular.

Espécie de estudo

Andropogum lateralis (Nees) Hack – popularmente conhecida como “Capim-caninha”, é pertencente à tribo *Andropogoneae*. É uma espécie dominante em diversas regiões do RS, e se destaca por ser (na maioria dos casos) uma planta perene formadora de touceiras, de cor verde-acinzentada e com presença de inflorescências plumosas (ARAÚJO, 1971).

Essa espécie é conhecida por ter alta contribuição na produção primária da região (DAMÉ et al., 1997), sendo capaz de formar estruturas que transitam entre o estrato inferior e superior do pasto através da modificação na estratégia de alocação e utilização de recursos (CRUZ et al., 2010) e devido a sua elevada plasticidade fenotípica, expressa como a capacidade de moldar sua arquitetura em função de distúrbios e/ou estresse.

3 HIPÓTESE

Distintas ofertas de forragem aplicadas por longo período modificam as características funcionais de touceiras de *Andropogon lateralis* (altura, projeção da copa e perímetro da base) resultando em distintas arquiteturas destas plantas que compõem o estrato superior do pasto. Além disso, supomos que estas distintas formações das plantas de *A. lateralis* possam ser agrupadas conforme a (dis)similaridade de características geradas pelo gradiente de ofertas de forragem, e que estas relações são modificadas ao longo do tempo.

4 OBJETIVOS

4.1. Definir se a aplicação de ofertas de forragem distintas ao longo do tempo resulta em diferentes arquiteturas de touceiras de A. lateralisdo estrato superior.
4.2. Definir, se possível, um agrupamento destas plantas em diferentes “clusters”, conforme características do dossel (altura média, projeção da copa e perímetro da base).
4.3. Averiguar se a relação dos caracteres estruturais é temporalmente dependente.

CAPÍTULO II[2]

[2] Manuscrito elaborado com base nas normas do periódico Journal of Applied Ecology

Grazing-induced changes in *Andropogon lateralis* tussocks: a trait-based perspective

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Summary

1. Grazing effects on vegetation have been much studied in the last few decades. However, few studies considered plant responses over time, and few studies have tried to group plants based in an array of traits to define individual-environment feedbacks.

2. Aiming to identify changes in plant traits, we sampled *Andropogon lateralis* tussocks within a long-term grazing experiment with four contrasting forage allowances (8%, 8-12%, 12% and 16%) in a typical *Campos* grassland in southern Brazil. Three plant traits were evaluated at fire measurement dates from summer to winter: plant height, canopy projection and basal perimeter.

3. High forage allowances led to the development of tall plants with wide canopies, indicating dominance over neighbor plants. Tussock height and projection decreased

along the growing season, suggesting that growth processes are decreasing while grazing and senescence increase.

4. Basal perimeter, here used to indicate how plants occupy the environment at ground level, increases from summer to winter. Results indicate a strategy to reach a broader surface as a resource capture strategy.

5. *Synthesis and applications*. Our results indicate that plant traits are tightly associated to long-term application of forage allowances. *A. lateralis* adapts its responses to grazing according to the intensity. Our findings allow for new mindsets about natural grassland sustainable managements according to plant and animal perspectives, by connecting a *Campos* highly representative specie architectural traits responses to the levels of grazing applied

Keywords: plant traits, resource utilization strategy, grazing management, forage allowance, upper canopy strata, tussocks, *Campos*.

Introduction

Grazing by domestic herbivores has been related to major shifts in grassland plant community structure and functioning worldwide (Cingolani et al., 2005; Díaz et al., 2006). Defoliation leads changes of species composition and canopy level structure, whose magnitude depend on a series of factors such as resource availability (Milchunas et al., 1988; Vesk et al., 2004; Anderson et al., 2007), grazing history (Milchunas et al., 1988; Adler et al., 2004; Díaz et al., 2006), life history (Pakeman, 2004; Díaz et al., 2007; Ruppert et al., 2015), local climate, grazing method (Briske et al., 2008; Boavista et al., 2019) and intensity (Bullock et al., 2001; Cingolani et al., 2005; De Bello et al., 2005; Laliberté & Tylianakis, 2012; Hui & Guoqi, 2014; Li et al., 2017). In natural grasslands, such as the South

American *Campos*, vegetation is usually composed of a patchy multi-strata canopy environment with a high diversity of species (Andrade et al., 2019) that will show specific responses to different grazing intensities (Cruz et al., 2010).

Understanding the thresholds of plant responses at community and individual levels has been a major challenge when it comes to how plants manage and respond to environmental variations. Despite the availability of a large number of plant-resource models summarizing the effects of defoliation and disturbances at community scale, such as CSR (Grime, 1977), LHS (Westoby, 1998) and resource availability (Coley et al., 1985), still, just few works have dealed with plant responses at individual scale and its variation throughout time.

Several studies have used a traits-based approach to link ecological shifts to plant responses with simple and easy-measurement techniques (Díaz & Cabido, 1997; Westoby, 1998; Reich et al., 2007). In a general, plant communities tend to respond to heavy grazing by favoring species and individuals with low size with high specific leaf area (SLA), fast regrowth and high nutritional value; conversely, lenient grazing usually results in plants with high stature, low SLA, elevated leaf dry matter content (LDMC) and slow regrowth. Most works relating functional community composition or Plant Functional Types (PFTs) to grazing are based on the comparison of grazed and ungrazed situations (Cayssials & Rodríguez, 2018) and different grazing intensity (Bullock et al., 2001; Cingolani et al., 2005; De Bello et al., 2005; Laliberté & Tylianakis, 2012; Hui & Guoqi. 2014; Li et al., 2017). Still, there's one point unconsidered in most of those studies, usually, there's lack of information when it comes to overall vegetal community structure and functioning.

Stocking density is usually utilized as a proxy to grazing intensity, representing a poor description of the forage mass– stocking density ratio, also known as forage allowance (FA). The application of the FA concept represented an advance in grazing research, given that it describes far much better the plant-animal interaction than stocking density solely (Carvalho; Santos; & Neves, 2007). Areas submitted to the same FA for a long period tend to form specific physiognomies. High FA leads to the formation of a multistrata and rather high canopy structure, while low FA usually has as an outcome the formation of single strata with low canopy height. The extreme case of overgrazing can lead to decreasing shifts in primary productivity and plant species diversity (Bai et al., 2007).

We postulated that long-term submission to levels of FA lead to the formation of different plant-architectural types, based on plant functional traits, where plants under higher FA tent to be taller and with a broader canopy projection. We hypothesized that those shifts in plant types and specific independent plant traits are temporal-dependent, leading to variations in plant form and size.

Materials and methods

STUDY AREA

This study was carried out within a long-term experiment located at Estação Experimental Agronômica (EEA, 30º05'S, 51º39'W) of the Universidade Federal do Rio Grande do Sul (UFRGS), placed in the Depressão Central region, Rio Grande do Sul – Brazil (Fig. 1). Vegetation in the region is characterized by dominance of natural grasslands, in the region called *Campos*, a characteristic patchy (multistrata) environment with high vegetal species diversity (Overbeck et al., 2007; Andrade et al., 2019) within Pampa biome. Local climate is defined as humid subtropical (Cfa, according to Köppen's classification) with mean annual precipitation of 1445 mm, regularly distributed over the year. Mean annual temperature is 18.8 ºC, with mean monthly temperature ranging from 9 ºC (winter) to 25 ºC (summer) (Bergamaschi et al., 2013). Soil predominant types at the experimental plots are classified as Aluminic Acrisols in summit areas and as Dystric Planosols in flooding occurrence areas (IUSS, 2006). The topography is defined as gently slopped, and average above sea level altitude of 46 meters.

The experimental area is characterized by vegetation with a multispecific sward arrangement. Overall species composition is mainly represented (average coverage) by *Paspalum notatum* (25.73%), *Andropogon lateralis* (9.73%), *Paspalum paucifolium* (9.69%), *Axonopus affinis* (6.60%), *Eryngium horridum* (3.98%), *Eleocharis loefgreniana* (3.34%), *Centella asiatica* (3.27%), *Paspalum pumilum* (2.91%) and *Piptochaetium montevidense* (2.04%) (Pinto et al., 2019).

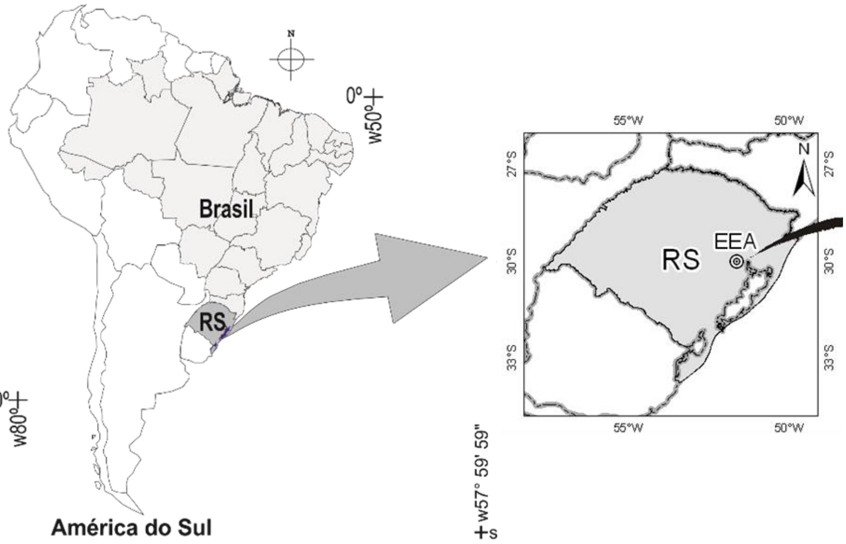


Figure 1. Map indicating the experimental site location (black arrow).

GRAZING EXPERIMENT

This research is part of a long-term experiment started in 1986 at EEA/UFRGS, designed to assess the effect of diverging forage allowances (FA) on beef cattle performance under continuous stocking. Allen et al. (2011) defined FA as an instantaneous plant-animal relationship, depicted by the proportion of herbage mass (kg ha^{-1}) and the animal live weight (kg ha^{-1}) in some unit of area at a certain point of time. The experiment consists in 4 different levels of FA, three of them are fixed 8%, 12%, 16% (kg of DM/100 kg of animal live weight) and one variable 8-12% (8 kg of DM/100 kg of animal live weight in spring and 12 kg of DM/100 kg of animal live weight throughout other seasons). Each treatment has two replicates, represented by paddocks (~4,5 ha each), and the herbage mass - animal live weight relationship is monthly maintained by adjustments utilizing the “put-and-take” method (Mott & Lucas, 1952). In this study, we did not consider the 4% level, as a. lateralis does not occur with tussock growth form here.

All measurements were conducted considering the bimodal vegetation structure (lower and upper strata). As most of animals’ herbage consumption occurs in the lower strata (mostly prostrate form grasses) (Bonnet et al., 2015), evaluations of parameters related to plant-animal interface (e.g., FA, sward height, herbage mass, etc.) were performed only at this strata, disregarding the tussocks of the upper strata (mostly tussock forming grasses). Details of animal management for adjusting FA, please see Da Trindade et al. (2012; 2016). Historical data series (2004-2018) of the main pasture-animal parameters is presented in Table 1.

Table 1. Pasture-animal historical data series (2004-2018) from the long-term grazing experiment on natural grassland: FA (kg DM. ha^{-1}), SR – Stocking Rate (kg LW. ha^{-1}), FM – Forage Mass (kg DM. ha^{-1}), LSASH – Low strata average sward height (cm), %T - Tussock percentage cover, GR – Daily growth rate (kg DM. ha^{-1}). (Source: Nativão experiment database).

FA	SR (kg LW.	FM (kg DM.	LSASH (cm)	%T (%)	DGR (kg

(kg DM.ha^{-1})	ha^{-1})	ha^{-1})			DM. ha^{-1})
8%	430	1080	6	20	11
8-12%	390	1320	7	30	10.3
12%	315	1400	8	32	10.8
16%	260	1650	9	41	12.2

SPECIE SELECTION AND PLANT FUNCTIONAL-STRUCTURAL TRAITS

Differently from pasture-animal parameters, specie selection for this experiment was focused on upper strata. *Andropogon lateralis* Nees is a regional highly representative C4 photosynthetic pathway grass specie that contribute significantly to total above-ground net primary production (Damé et al., 1997), covering (mean cover) 6,3% of the Campos grasslands surface (Andrade et al., 2019). *A. lateralis* belongs to Panicoideae subfamily and Andropogoneae tribe, its characteristic growth form is caespitose (erect form grasses), usually resulting in tussocks-like architectural formations except when it's under high frequent mowing or grazing conditions. This is a widespread specie, which, in areas of natural occurrence in southernmost South America is characterized by perennialization, flourishing in those areas occurs from spring to autumn (Benitez, & Fernandez, 1977; Araujo, 1971).

Sampling was carried out between 03/09/2019 to 07/16/2019. Evaluations consisted of measurements of plant canopy height, canopy cover (projection) and basal perimeter. Measurements were performed on 10 marked tussocks per paddock, located in the hill portion of the relief, where the measurements were repeated in five sampling periods (every 28 days, approximately). Tussocks were selected using a visual rating of the most occurring tussock types (based on architectural dimensions) in each plot. Tussock height samplings were performed using a sward-stick. Five points were randomly chosen per tussock for each sampling period, and its height was assessed as the average. Basal perimeter was measured using a measuring tape wrapped placed at tussock's base at ground level. Canopy cover was assessed by digital images taken from a cell phone camera (iPhone 6S, Apple®) with 4032 x 3024 pixels spatial resolution (approximately 12 Mp). Photos were repeated in every experimental period for each tussock holding the camera in zenithal position. We utilized a known area object (red squared paper templet with 0,03 x 0,03 meters dimensions) to scale pixel's number and set comparison with tussocks' canopy projection. Photos were saved in JPG format and posteriorly analyzed in Adobe™ Photoshop 7.0 software using "polygonal lasso" function to determine red squared templet edges, and "histogram" function to determine pixels number for the delimited area. Then, we performed the same procedure to determine canopy's pixel number by connecting the tussock's canopy further leaf top points to generate a polygonal form and then set its area in pixels number (Fig. 2). Comparison of objects pixels number and area was set according to:

$$CPA = \frac{(TA\ x\ CPPn)}{TPn}$$

Where:

CPA – Canopy projection area;

TA – Templet area;

CPPn – Canopy projection pixels number;

TPn – Templet pixels number;

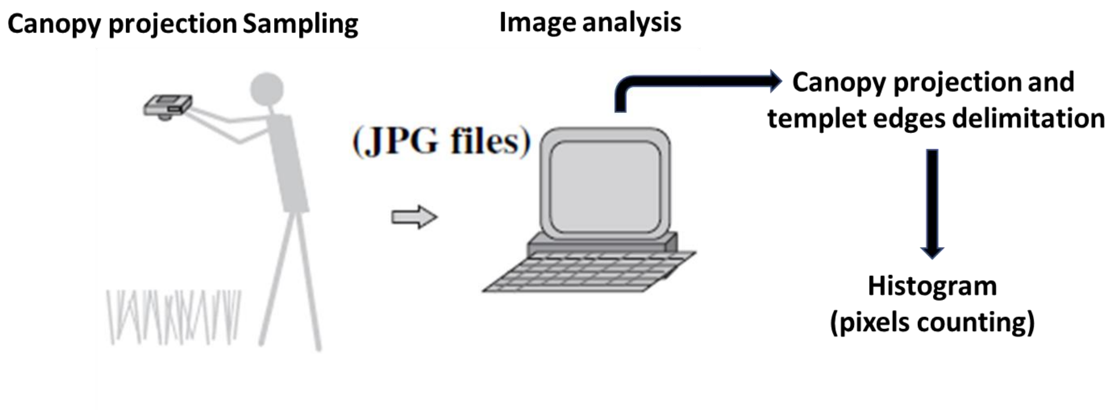


Figure 2. Diagram illustrating photo sampling and processing (adapted from Casadesús et al., 2007).

EXPERIMENTAL DESIGN AND DATA ANALYSIS

Experimental design is arranged in complete randomized blocks with two replicates and four treatments represented by the FA previously presented, with the five periods representing repeated measurements in time. The blocking criteria were different types of soil.

We split our analysis into three steps according to the necessity of better understand vegetation temporal patterns and define most relevant factors to build a grouping analysis. In the first step, depicted by a classical univariate analysis, a mixed model with fixed effects of FA, periods, FA-periods interaction and block as a random effect was analyzed by MIXED procedure, considering a 5% significance level. Periods were considered repeated measurements on time. Covariance matrix in the model was defined by the lower value of Akaike Information Criteria (AIC). When differences were observed we compared the means by Tukey test ($P<0.05$). Normality analysis was performed to every variable data by Shapiro-Wilk test indicating the lack of normality for average canopy height (ACH) and canopy projection (CP), which were transformed using logarithmic operations. Also, we defined the variance homogeneity through the Bartlet test. Error independency and outliers were tested. All univariate analysis was conducted in SAS software (version 9.4).

In the second and third steps of our analysis, we performed multivariate statistical methods, aiming to classify data in groups using hierarchical cluster analysis (HCA - Seath & Sokal, 1973) and to define variables pattern relationship, using multiple factor analysis (MFA - Escofier & Pagès, 1998). Multivariate analyses were conducted using RStudio (Version 1.2.1335) and they were performed after standardization applying logarithmic equations. This procedure was conducted utilizing *decostand* function in vegan package.

The HCA aimed at defining groups of *A. lateralis* tussocks that shared combined common structural characteristics and was performed calculating the Euclidean distance using *vegdist* function for quantitative data. Our clustering was obtained by *average* algorithm identification method for data similarity. The *nbclust* function in the Nbclust package was used to determine the number of clusters according to the different results obtained by variating all combinations.

MFA was initially developed to set analysis of variables when splitting into groups using standardized data with the objective to equivalate the weight of the groups. Our groups were defined by the sampling period as the descriptive (qualitative) data and the measured variables were the numeric (quantitative) variables. To perform MFA, we utilized FactoMineR e Factoextra packages. MFA allows us to condensate major original data quantity contained in p variables (p=3, three dependent variables, in this study) in two latent orthogonal variables named principal components - which are linear combinations of original variables generated with the two highest autovalues of data covariance matrix (Hair, 2006). This way, the three variables of the initial data set were characterized by two new latent variables, giving the possibility of set its location in bidimensional figures (principal components data ordination).

Results

Univariate analysis showed that there was no interaction for FA and sampling periods to basal perimeter (P=0.9940), canopy projection (P=0.9881) and average canopy height (P=0.9329). Nevertheless, we found significative difference for FA (P<0.0001) in all variables (Table 2).

Table 2. Means and standard deviations for basal perimeter, canopy projection and average sward height according to different forage allowances (signifant letters indicate significant differences, for each parameter; p<0,05).

Forage allowance	Basal perimeter (cm)	Canopy projection (cm^2)	Average height (cm)
8%	53.71 ± 1.93 c	1551.81. ± 80.09 c	19.19 ± 0.40 c
8-12%	63.73 ± 2.02 b	2385.05 ± 103.38 b	22.94 ± 0.48 b
12%	66.70 ± 2.35 b	2395.84 ± 113.34 b	22.47 ± 0.51 b
16%	84.34 ± 2.12 a	4680.98 ± 179.18 a	33.06 ± 0.77 a
P	<.0001	<.0001	<.0001

Tussocks were larger as FA increased. Higher values for all variables were observed in 16% FA, and lowest at 8% FA, being 8-12% and 12% intermediate.

In a period-dependent analysis, is observed (Table 3) that tussock height followed a declining evolution in this value, the same response is showed for canopy projection, where higher values are observed in the first period (late summer) while lower values in the last (early winter). Basal perimeter showed an inverse response, as the grazing season progress BP values increased.

Table 3. Average measured variables values in function of the periods, where: TH – Tussock height (cm), BP – basal perimeter (cm) and CP – canopy projection (cm²).

	Period 1 (03/09/2019)	Period 2 (04/12/2019)	Period 3 (05/14/2019)	Period 4 (06/18/2019)	Period 5 (07/16/2019)
TH	26.6±0.89 a	25.8±0.9 ab	24.9±0.9 ab	24.3±0.8 b	20.7±0.7 c
BP	64.7±2.8 b	63.6±2.7 b	65.6±2.6 b	70.6±2.6 a	71.1±2.6 a
CP	3168.36±221.18 a	2841.74±200.48 a	2724.25±190.08 ab	2767.54±191.95 ab	2313.54±161.97 b

Tussock height and canopy projection were positively correlated (Figure 3; R^2=0.69; $P<0.05$), and so were tussock height and basal perimeter (R^2=0.51) and – even though with a low correlation, canopy projection and basal perimeter (R^2=0.26).

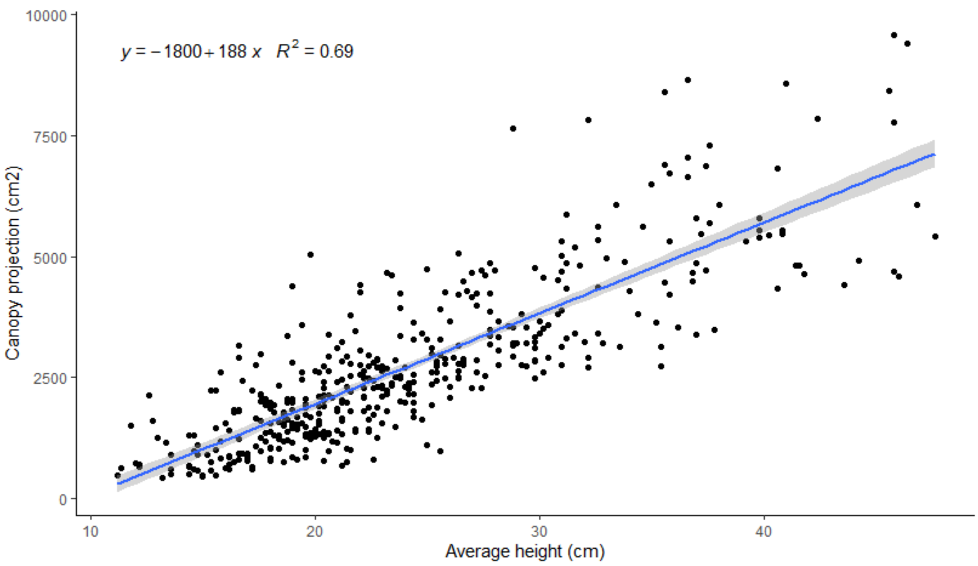
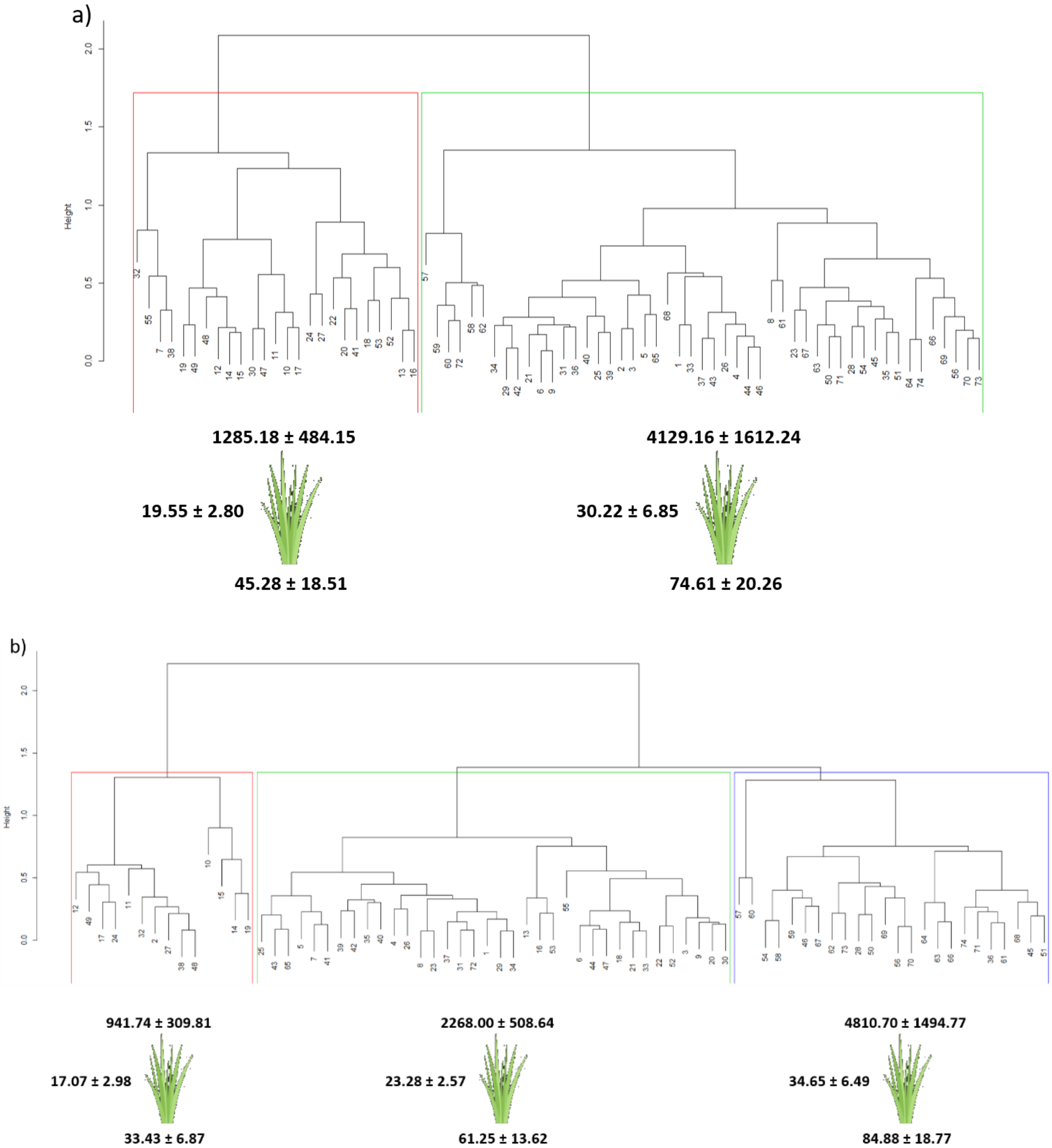
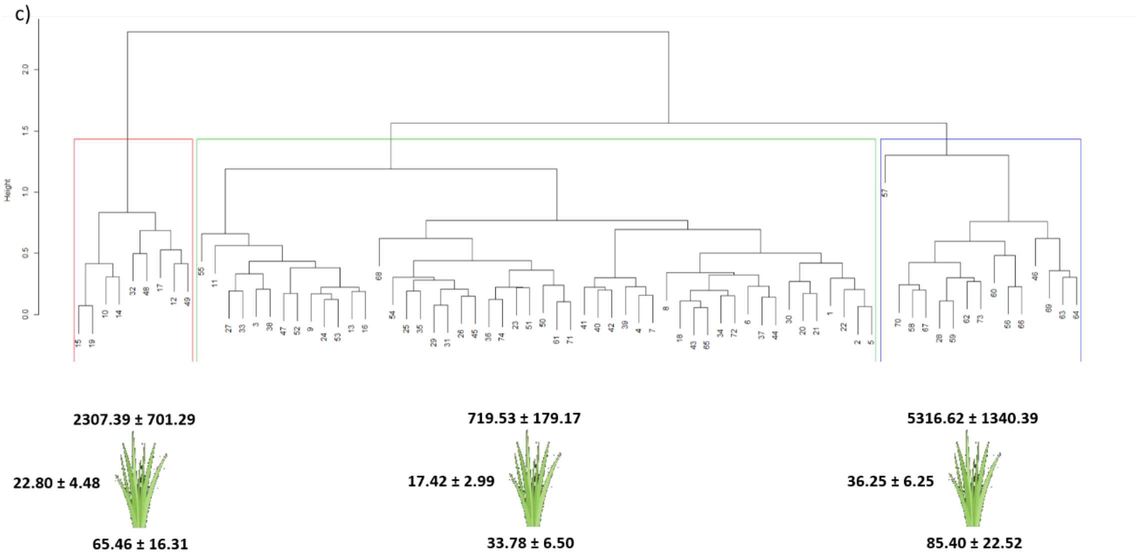


Figure 3. Relationship of tussock height to canopy projection of *A. lateralis* submitted to variable forage allowances (R^2=0.69).

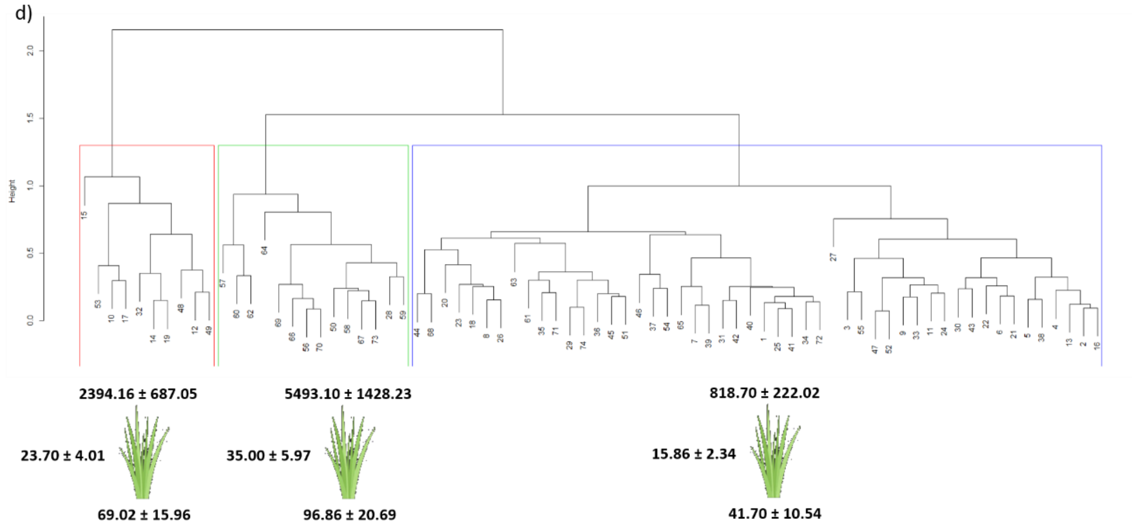
Dendrograms for all periods obtained by cluster analysis are shown in Figure 3.



c)


Height
2307.39 ± 701.29
22.80 ± 4.48
65.46 ± 16.31
719.53 ± 179.17
17.42 ± 2.99
33.78 ± 6.50
5316.62 ± 1340.39
36.25 ± 6.25
85.40 ± 22.52

d)


Height
2394.16 ± 687.05
23.70 ± 4.01
69.02 ± 15.96
5493.10 ± 1428.23
35.00 ± 5.97
96.86 ± 20.69
818.70 ± 222.02
15.86 ± 2.34
41.70 ± 10.54

e)

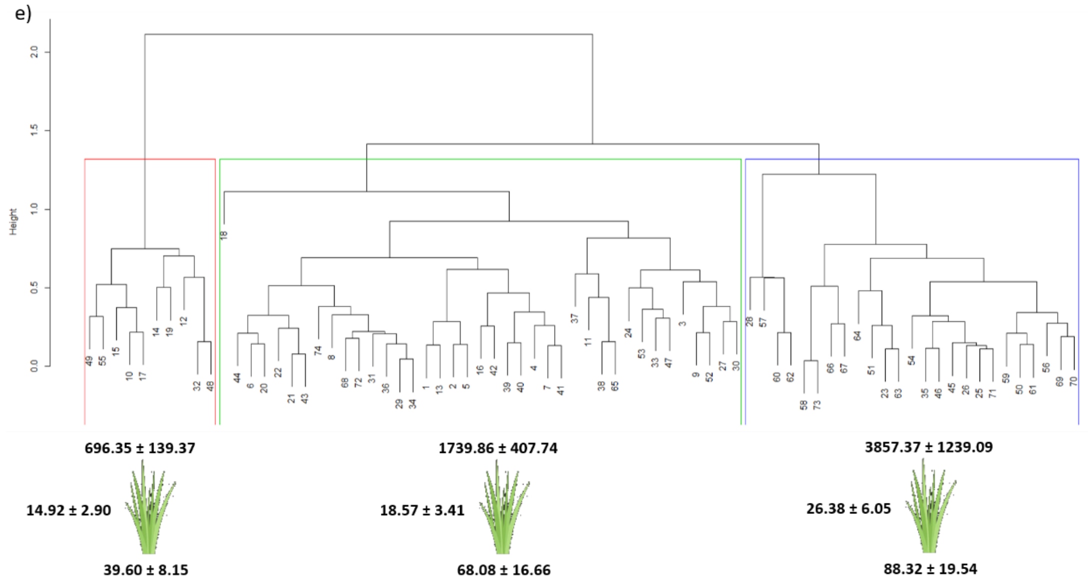

Height
696.35 ± 139.37
14.92 ± 2.90
39.60 ± 8.15
1739.86 ± 407.74
18.57 ± 3.41
68.08 ± 16.66
3857.37 ± 1239.09
26.38 ± 6.05
88.32 ± 19.54

Figure 4. Dendrograms resulting from hierarchical cluster analysis (HCA): a) first period, b) second period, c) third period, d) fourth period and e) fifth period. Tussocks graphic representation bellow each cluster for each period indicate mean ± standard deviation of canopy projection (above tussocks – in cm^2), average canopy height (on the left side of each tussocks - in cm) and basal perimeter (bellow tussocks – in cm).

Each time a significant variation in the values of Euclidean distance is observed for the set of variables considered it is possible to perform a group division. We can observe in Figure B the evolution of clustering throughout the five sample periods. First period is the only with a two-groups division. In other periods we can observe that clustering indicates a three-group formation.

MFA allowed us to create a unique data distribution (dimension 1 x dimension 2). The two principal components together allowed us to create a bidimensional ordination of the data and variables, and a biplot graphical construction (Figure 4). The total amount of information on the original variables, retained by the two main components, was 89.3% (70.3% on Dimension 1 + 19% on Dimension 2).

Figure 5. MFA including all individuals (of the five sampling periods), represented in a two-cluster grouping form. Values within parentheses indicate the data explanation contribution of each axis.

Ordination of individuals in two clusters show the effect of period and FA over clustering. The 16% FA is here represented as “OF_16” and its position in the cartesian plan indicates that most common tussocks of the group (related to larger dimensions) are the closest points near “OF_16”. Also, it can be seen that the first period (that has the highest means to our variables) is the one that is tightly correlated to lower FA.

Discussion

Our findings bring important insights for grassland management focusing on tussock-forming grasses in humid and sub-humid environments, as affected by grazing intensity. Plant's functional traits are sensitive to the growing environment (Dìaz et al. 2004). The Table 2 shows the variation of some of these traits of *A. lateralis*, as affected by the FA. Lower grazing intensities (16% FA) resulted in taller plants, with broader canopy projection and basal perimeter, with intermediate grazing intensities (8-12% and 12% FA) showing a similar response to each other. Conversely, higher grazing intensities (8% FA) resulted on smaller tussocks. These responses are in line to previous patterns of plant functional traits responses to grazing (Díaz et al., 2007).

According to Cornelissen et al. (2003), Grime (2006), Keddy (1989), and Gaudet & Keddy (1995), plant height could be associated with plant fecundity and competitive ability (i.e. light interception), which suggest that plants of 16% FA have higher competitive ability when compared to those submitted to higher grazing intensities. The strong relation of plant height with canopy projection (R^2=0.69; Figure 5), indicates that as grazing intensity increases, the height and, consequently, canopy projection reduce as observed by Díaz et al. (2007), and Fischer et al. (2019).

The decrease of tussock height and canopy projection, and increase in basal perimeter, from late summer to early winter (Table 3), can be associated to increasing rates of herbivory. Azambuja et al. (2020) demonstrated, in the same long-term experimental protocol, that cattle compose their diet from five feeding classes. In that work, author observed that 70% of bites occurred on tussock grasses such as *A. lateralis*; most of the intake of theses tussock-forming species occurs during winter due to the fact that lower strata availability decreases in those periods.

Based on the consumer-resource model of exploitative competition (Grace & Tilman, 1990), we assume that variations on height and canopy projection tend to respond to the same equation of biomass change:

Rate of biomass change = Growth – Loss

or, in our case:

Rate of height (or canopy projection) change = Growth – (Senescence + Herbivory).

The basal perimeter could give us an idea of how plants respond to resource shortages or decrease in nutrient assimilation with time. The increase in the basal perimeter as grazing season progressed (Table 3) might be related to changes in each individual tussock population density as a function of shortage of resources, as suggested by Tilman's (1982) model. Indeed, according to previous studies in periods of lower temperatures, and shorter photoperiods plants tend to reduce tillering rates and increase tiller survival, independently of grazing management (Sbrissia et al., 2010; Silva et al., 2015). Also, Harper (1981), postulated that tillers distribution in space is directly linked to its exploitation capacity. Accordingly, we suggest that plants of *A. lateralis* assume a space-occupation strategy by decreasing tillers density during unfavorable seasons as an attempt to broad its resources capture. This clonal reproduction persistency strategy, proper of bunchgrasses (Briske & Derner, 1998), is driven by three processes (Red/Far Red ratio, hormonal control and resource availability – Tomlinson & O'Connor, 2004) which might be affected regarding de treatment; i.e.: tussocks in 8% FA should have less light competition due to the fact that the canopy structure allows light pass through the leaves layers in canopy. Working with the same species utilized in this study, Zanella (2019),showed that *A. lateralis* individuals managed under higher grazing intensities resulted in plants with lower height and higher SLA. Also, the photosynthetic quality was inversely related to plant height (lower plants, higher light quality).

We suggest that *A. lateralis* adopt a space-occupation strategy in tillering unfavorable seasons as an attempt to broad its resources capture. Accordingly, Giustina Júnior et al. (2019), found that *A. lateralis* managed under rotational stocking and different grazing heights, showed no differences in population stability index (PSI – determined based on tiller survival rates and tiller birth) for treatments. In addition, in the same work PSI didn't showed a seasonal difference, although the mechanisms responsible for keeping the stability might shift (tillering rates *versus.* tiller mortality/longevity). Low heights were related to high tiller birth rates while high heights to increased tiller survival rates, as we suggest having occurred in this study. Grazing method would be irrelevant to set this comparison, given that, in our case FA is a proxy for grazing heights, where changes in defoliation intensity and frequency are verified.

The cluster analysis might indicate how plants are managing and utilizing available resources. Cruz et al. (2010), considered the leaf dry matter content (LDMC) and specific leaf area (SLA) as descriptors of plant functioning of *A. lateralis*, and suggested that it used two resource utilization strategies (acquisition and conservation). Here we define strategy as a mean of how a species sustains its population (Westoby, 1998). Although this definition is traditionally used to compare between species rather than between individuals, we believe that the studied species – which display high phenotypical plasticity – adapts itself to shifts in disturbance intensity and frequency, showing different levels of responses. We propose that for the first period (when HCA resulted in two groups), classification of clusters should be distinguished based on those resource use strategies. Individuals with smaller dimensions (short plants with low basal perimeter and canopy projection) are those using the resource acquisition strategy, as they demand higher tissue production for regrowth after defoliation events (Gastal & Lemaire, 2015). In addition, the other group [represented by individuals with larger dimensions (tall plants with high basal perimeter and canopy projection)] denote a resource conservation strategy (Chapin, Autumn, & Pugnaire, 1993; Westoby, 1998; Grime, 2001). Those results are similar to the ones of Fischer et al. (2019), which argued that for high forage allowances (where plants are less intensively defoliated) individuals invest higher amounts of energy and resources to produce strong leaves (smaller SLA and larger LDMC) and taller heights. From the second to the fifth period, the cluster analysis grouped tussocks in three classes, that we assumed to be indicators of plants with resource acquisition strategy (for plants with lowest mean values to measured variables), resource conservation strategy (plants with highest mean values to measured variables), and intermediate (or mixed) resource utilization strategy (represented by plants with average values for measured traits). We assume that changes in clusters number are connected to the fact that part of the traits (TH and CP) values are decreasing, and differences from plants of high and low FA are increasing, so individuals tend to be more dissimilar to each other.

Conclusions

The FA shift the upper strata *A. lateralis* plants structure (height, canopy projection and basal perimeter) in a time-dependent fashion. Also, we assume that changes in upper strata plants consumption and senescence rates tend to be grater in colder seasons (autumn and winter), as the vegetation growth rate is lower than in warmer seasons (spring and summer), and that grazing animals increase their relative preference for tussocks in colder seasons.

A. lateralis individuals might assume diverse resource utilization strategies, according to the FA applied over the vegetation (plants under higher FA assume a resource maintenance strategy while the ones under low FA assume a resource utilization strategy) and the moment of the year.

References

Adler, P. B., Milchunas, D. G., Lauenroth, W. K., Sala, O. E., & Burke, I. C. (2004). Functional traits of graminoids in semi-arid steppes: a test of grazing histories. Journal of Applied Ecology, 41(4), 653-663.

Allen V.G., C. Batello, E.J. Berretta, J. Hodgson, M. Kothmann, X. Li, J. McIvor, J. Milne, C. Morris, A. Peeters And M. Sanderson (2011) An international terminology for grazing lands and grazing animals. Grass and Forage Science, 66, 2–28.

Anderson, T. M., Ritchie, M. E., & McNaughton, S. J. (2007). Rainfall and soils modify plant community response to grazing in Serengeti National Park. Ecology, 88(5), 1191-1201.

Andrade, B. O., Bonilha, C. L., Overbeck, G. E., Vélez-Martin, E., Rolim, R. G., Bordignon, S. A. L., ... & dos Santos, E. D. (2019). Classification of South Brazilian grasslands: Implications for conservation. Applied Vegetation Science, 22(1), 168-184.

Azambuja Filho, J. C. R., Carvalho, P. C. F., Bonnet, O. J. F., Bastianelli, D., Joiven, M. (2020). Functional classification of feed items in Pampa grassland, based on their near-infrared spectrum. Rangeland Ecology and Management, https://doi.org/10.1016/j.rama.2020.02.001

Araujo, A. A. D. (1971). Principais Gramineas do Rio Grande do Sul. 3 ed. Porto Alegre: Sulina. 255p

Bai, Y., Wu, J., Pan, Q., Huang, J., Wang, Q., Li, F., ... & Han, X. (2007). Positive linear relationship between productivity and diversity: evidence from the Eurasian Steppe. Journal of Applied Ecology, 44(5), 1023-1034.

Benítez, C. A., & Fernández, J. G. (1977). Espécies forrageiras de la pradera natural. Fenologia y respuesta a la frequência e severidad de corte. Instituto Nacional de Tecnologia Agropecuária. Corrientes: Estación Experimental Agropecuária Mercedes, Rep. da Argentina.

Barthram, G. T. (1985) Experimental techniques: the HFRO sward stick. In: The Hill Farming Research Organization Biennial Report 1984/1985. Penicuik: HFRO. p. 29–30.

Bergamaschi, H., de Melo, R.W., Guadagnin, M.R., Cardoso, L.S., da Silva, M.I.G., Comiran, F., Dalsin, F., Tessari, M.L., Brauner, P.C., 2013. Boletins agrometeorológicos da estação experimental agronômica da UFRGS: Série histórica 1970–2012.

Boavista, L. D. R., Trindade, J. P. P., Overbeck, G. E., & Müller, S. C. (2019). Effects of grazing regimes on the temporal dynamics of grassland communities. Applied Vegetation Science, 22(2), 326-335.

Bonnet, O. J., Meuret, M., Tischler, M. R., Cezimbra, I. M., Azambuja, J. C., & Carvalho, P. C. (2015). Continuous bite monitoring: a method to assess the foraging dynamics of herbivores in natural grazing conditions. Animal Production Science, 55(3), 339-349.

Briske, D. D., Derner, J. D., Brown, J. R., Fuhlendorf, S. D., Teague, W. R., Havstad, K. M., ... & Willms, W. D. (2008). Rotational grazing on rangelands: reconciliation of perception and experimental evidence. Rangeland Ecology & Management, 61(1), 3-17.

Bullock, J. M., Franklin J., Stevenson M. J., Silvertown J., Coulson S. J., Gregory S. J., & Tofts R. (2001). A plant trait analysis of responses to grazing in a long-term experiment. Journal of Applied ecology, 38(2), 253-267.

Carvalho, P. C. D. F., Santos, D. D., & Neves, F. P. (2007). Oferta de forragem como condicionadora da estrutura do pasto e do desempenho animal. Simpósio de Forrageiras e Produção Animal, 2(2007), 23-59.

Casadesús, J., Kaya, Y., Bort, J., Nachit, M. M., Araus, J. L., Amor, S., ... & Ouabbou, H. (2007). Using vegetation indices derived from conventional digital cameras as selection criteria for wheat breeding in water-limited environments. Annals of applied biology, 150(2), 227-236.

Cayssials, V., & Rodríguez, C. (2018). The adaptive value of grass traits in response to grazing. Journal of Plant Ecology, 11(2), 248-255.

Chapin III, F. S., Autumn, K., & Pugnaire, F. (1993). Evolution of suites of traits in response to environmental stress. The American Naturalist, 142, S78-S92.

Cingolani, A. M., Posse, G., & Collantes, M. B. (2005). Plant functional traits, herbivore selectivity and response to sheep grazing in Patagonian steppe grasslands. Journal of Applied Ecology, 42(1), 50-59.

Coley, P. D., Bryant, J. P., & Chapin, F. S. (1985). Resource availability and plant antiherbivore defense. Science, 230(4728), 895-899.

Cornelissen, J. H. C., Lavorel, S., Garnier, E., Diaz, S., Buchmann, N., Gurvich, D. E., ... & Pausas, J. G. (2003). A handbook of protocols for standardised and easy measurement of plant functional traits worldwide. Australian journal of Botany, 51(4), 335-380.

Cruz, P., De Quadros, F. L. F., Theau, J. P., Frizzo, A., Jouany, C., Duru, M., & Carvalho, P. C. F. (2010). Leaf traits as functional descriptors of the intensity of continuous grazing in native grasslands in the south of Brazil. Rangeland Ecology & Management, 63(3), 350-358.

Da Trindade, J. K., Pinto, C. E., Neves, F. P., Mezzalira, J. C., Bremm, C., Genro, T. C. M., Tischler, M. R., Nabinger, C., Gonda, H. L., Carvalho, P. C. F., 2012. Forage allowance as a target of grazing management: implications on grazing time and forage searching. Rangel. Ecol. Manag. 65, 382–393.

Da Trindade, J. K., F. P. Neves, C. E. Pinto, C. Bremm, C. C. Mezzalira, L. B. Nadin, T. C. M. Genro, H. L. Gonda, and P. C. F. Carvalho. 2016. Daily forage intake by cattle on natural grassland: Response to forage allowance and sward structure. Rangeland Ecol. Manag. 69:59–67.

Damé, P. R. V., Quadros, F. L. F. D., Kersting, C. E. B., Trindade, J. P. P., & Londero, F. A. A. (1997). Efeitos da queima seguida de pastejo ou diferimento sobre a produção, qualidade, cobertura do solo e sistema radicular de uma pastagem natural. Ciência Rural, 27(1), 133-137.

De Bello, F., Lepš, J. A. N., & Sebastià, M. T. (2005). Predictive value of plant traits to grazing along a climatic gradient in the Mediterranean. Journal of applied Ecology, 42(5), 824-833.

Díaz, S., & Cabido, M. (1997). Plant functional types and ecosystem function in relation to global change. Journal of vegetation science, 8(4), 463-474.

Diaz, S., Hodgson, J. G., Thompson, K., Cabido, M., Cornelissen, J. H., Jalili, A., ... & Band, S. R. (2004). The plant traits that drive ecosystems: evidence from three continents. Journal of vegetation science, 15(3), 295-304.

Diaz, S., Lavorel, S., McIntyre, S. U. E., Falczuk, V., Casanoves, F., Milchunas, D. G., ... & Landsberg, J. (2007). Plant trait responses to grazing–a global synthesis. Global Change Biology, 13(2), 313-341.

Escofier, B., & Pagès, J. (1998). Analyses factorielles simples et multiples. Dunod, Paris.

Gastal, F., & Lemaire, G. (2015). Defoliation, shoot plasticity, sward structure and herbage utilization in pasture: review of the underlying ecophysiological processes. Agriculture, 5(4), 1146-1171.

Gaudet, C.L. & Keddy, P.A. (1995) Competitive performance and species distribution in shoreline plant communities: a comparative approach. Ecology, 76, 280–291.

Gibson, C. W. D., Hambler, C., & Brown, V. K. (1992). Changes in spider (Araneae) assemblages in relation to succession and grazing management. Journal of Applied Ecology, 132-142.

Giustina Junior, L. H. P. D., Zanella, P. G., Baldissera, T. C., Pinto, C. E., Garagorry, F. C., & Sbrissia, A. F. (2019). Grazing height management does not change the persistence pathway of Andropogon lateralis in a natural pasture. Pesquisa Agropecuária Brasileira, 54.

Grace, J., & Tilman, D. (1990). Perspectives on plant competition: some introductory remarks. In Perspectives on Plant Competition (pp. 3-7). Academic Press.

Grime, J. P. (1977). Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. The American Naturalist, 111(982), 1169-1194.

Grime, J. P. (2001). Plant strategies, vegetation processes, and ecosystem properties. Colchester, UK: Wiley.

Grime, J. P. (2006). Plant strategies, vegetation processes, and ecosystem properties. John Wiley & Sons.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). Multivariate data analysis (Vol. 6).

Harper, J. L. (1981). The concept of population in modular organisms. Theoretical ecology: principles and applications, 53-77.

Hui, A. N., & Guoqi, L. I. (2014). Differential effects of grazing on plant functional traits in the desert grassland. Polish Journal of Ecology, 62(2), 239-251.

IUSS, 2006. World Reference Base for Soil Resources 2006 (World Soil Resources Reports No. 103).

Keddy, P.A. (1989) Competition. Chapman & Hall, London, UK.

Laliberté, E., & Tylianakis, J. M. (2012). Cascading effects of long-term land-use changes on plant traits and ecosystem functioning. Ecology, 93(1), 145-155.

Li, W., Xu, F., Zheng, S., Taube, F., & Bai, Y. (2017). Patterns and thresholds of grazing-induced changes in community structure and ecosystem functioning: Species-level responses and the critical role of species traits. Journal of Applied Ecology, 54(3), 963-975.

Milchunas, D. G., Sala, O. E., & Lauenroth, W. (1988). A generalized model of the effects of grazing by large herbivores on grassland community structure. The American Naturalist, 132(1), 87-106.

Mott, G. O., Lucas, H. L. (1952) The design, conduct, and interpretation of grazing trials on cultivated and improved pastures. In: INTERNATIONAL GRASSLAND CONGRESS, 6, 1952, Pennsylvania. Proceedings... Pennsylvania: State College Press, 1952. p.1380-1385.

Overbeck, G. E., Müller, S. C., Fidelis, A., Pfadenhauer, J., Pillar, V. D., Blanco, C. C., ... & Forneck, E. D. (2007). Brazil's neglected biome: the South Brazilian Campos. Perspectives in Plant Ecology, Evolution and Systematics, 9(2), 101-116.

Pakeman, R. J. (2004). Consistency of plant species and trait responses to grazing along a productivity gradient: a multi-site analysis. Journal of Ecology, 92(5), 893-905.

Pinto, C. E., Wallau, M., Boldrini, I. I. (2019). Estrutura da vegetação e composição florística. In *Nativão + de 30 anos de pesquisa em campo nativo* (pp. 16-20). Porto Alegre, RS: VIAPAMPA.

Reich, P. B., Wright, I. J., & Lusk, C. H. (2007). Predicting leaf physiology from simple plant and climate attributes: a global GLOPNET analysis. Ecological Applications, 17(7), 1982-1988.

Sbrissia, A. F., Da Silva, S. C., Sarmento, D. O., Molan, L. K., Andrade, F. M., Gonçalves, A. C., & Lupinacci, A. V. (2010). Tillering dynamics in palisadegrass swards continuously stocked by cattle. Plant Ecology, 206(2), 349-359.

Seath, P. H. A., Sokal, R. R., & Freeman, W. H. (1973). Numerical taxonomy; the principles and practice of numerical classification. Systematic Zoology, 24(2), 263-268.

Da Silva, S. C., Sbrissia, A. F., & Pereira, L. E. T. (2015). Ecophysiology of C4 forage grasses—understanding plant growth for optimising their use and management. Agriculture, 5(3), 598-625.

Tews, J., Brose, U., Grimm, V., Tielbörger, K., Wichmann, M. C., Schwager, M., & Jeltsch, F. (2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of biogeography, 31(1), 79-92.

Tilman, G. D. (1982). Resource Competition and Community Structure. Princeton Univ. Press, Princeton, New Jersey.

Vesk, P. A., Leishman, M. R., & Westoby, M. (2004). Simple traits do not predict grazing response in Australian dry shrublands and woodlands. Journal of Applied Ecology, 41(1), 22-31.

Violle, C., Navas, M. L., Vile, D., Kazakou, E., Fortunel, C., Hummel, I., & Garnier, E. (2007). Let the concept of trait be functional! Oikos, 116(5), 882-892.

Westoby, M. (1998). A leaf-height-seed (LHS) plant ecology strategy scheme. Plant and soil, 199(2), 213-227

CONSIDERAÇÕES FINAIS

Os resultados do presente trabalho indicam que a aplicação de ofertas de forragem distintas por um longo período resulta em diferentes formações fisionômicas de plantas da espécie *Andropogon lateralis* presentes no estrato superior de plantas. Não somente o tratamento aplicado (neste caso, na forma de OF) tem efeito sobre estas formações. O período do ano tem influência direta sobre a dinâmica da vegetação, alterando a taxa em qual processos ocorrem (e.g. aumento da senescência em períodos de menor temperatura e fotoperíodo).

Ofertas de forragem maiores (leia-se menor intensidade de pastejo) acarretam a formação de estruturas de maiores dimensões, enquanto ofertas menores (maiores intensidade de pastejo) tem como resposta a formação de estruturas menores. Essas formações distintas resultaram em diferentes grupos de plantas, os quais acreditamos que estejam diretamente ligados com estratégias de utilização de recursos tróficos disponíveis no ambiente.

As touceiras aqui estudadas são comprovadamente recursos alimentares para os animais em estações de maior escassez de pasto em estruturas do estrato inferior de plantas. Estas plantas de estrutura mais robusta são associadas a composição da dieta dos animais, oferecendo menor valor nutritivo aliado a altas taxas de ingestão (elevação da massa por bocado). Além da função nutricional, estas plantas desempenham um papel ecológico fundamental, sendo muitas vezes ligada à conservação de espécies em suas zonas de ocorrência.

REFERÊNCIAS

ALLEN, V. G. *et al.* An international terminology for grazing lands and grazing animals. **Grass and Forage Science**, Oxford, v. 66, n. 1, p. 2–28, 2011.

ARAÚJO, A. A. **Principais gramíneas do Rio Grande do Sul**. Porto Alegre: Sulina, 1971. 256 p.

BAI, Y. *et al*. Positive linear relationship between productivity and diversity: Evidence from the Eurasian Steppe. **Journal of Applied Ecology**, London, v. 44, n. 5, p. 1023–1034, 2007.

BOLDRINI I. I. A flora dos campos do Rio Grande do Sul. *In*: PILLAR, V. D. *et al.* (ed.). **Campos sulinos**: conservação e uso sustentável da biodiversidade. Brasília: Ministério do Meio Ambiente, 2009. p. 63-77.

BOLDRINI, I. I. Biodiversidade dos campos sulinos. *In*: SIMPÓSIO DE FORRAGEIRAS E PRODUÇÃO ANIMAL, 2006, Porto Alegre. **Anais** [...]. Canoas: Ed. ULBRA; Porto Alegre: Departamento de Plantas Forrageiras e Agrometeorologia da UFRGS, 2006. p. 11-24.

BONNET, O. J. F. *et al.* Continuous bite monitoring: a method to assess the foraging dynamics of herbivores in natural grazing conditions. **Animal Production Science**, Collingwood, v. 55, n. 3, p. 339–349, 2015.

BREMM, C. *et al.* Foraging behaviour of beef heifers and ewes in natural grasslands with distinct proportions of tussocks. **Applied Animal Behaviour Science**, Amsterdam, v. 141, n. 3–4, p. 108–116, 2012. Disponível em: http://dx.doi.org/10.1016/j.applanim.2012.08.008

BRISKE, D. D. *et al.* Recommendations for development of resilience-based state-and-transition models. **Rangeland Ecology and Management**, Lakewood, Colo, v. 61, n. 4, p. 359–367, 2008.

BRISKE, D. D.; BUTLER J. L. Density-Dependent Regulation of Ramet Populations Within the Bunchgrass Schizachyrium Scoparium : Interclonal Versus Intraclonal Interference. **British Ecological Society**, London, v. 77, n. 4, p. 963–974, .

BULLOCK J. F. *et al.* A plant trait analysis of responses to grazing in a long-term experiment diversity, gap colonization, grazer selectivity, long-term study, mesotrophic grassland. **Journal of Applied Ecology**, London, v. 38, n. 2, p. 253–267, 2001.

BUTLER, J. L.; BRISKE, D. D. Population structure and tiller demography of the Bunchgrass Schizachyrium scoparium in response to herbivory. **Oikos**, Nijmegen, v. 51, n. 3, p. 306, 1988.

CALDWELL, M. M. *et al*. Coping with herbivory: photosynthetic capacity and resource allocation in two semiarid Agropyron bunchgrasses. **Oecologia**, Berlin, v. 50, n.11, p. 14-24, 1981.

CARVALHO, P. C. F. *et al*. Produção animal no bioma Campos Sulinos. **Brazilian Journal of Animal Science**, Viçosa, v. 35, p. 156-202. 2006. Suplemento especial. Disponível em: http://www.forragicultura.com.br/arquivos/ProducaoanimanoBiomaCamposSulinos.pdf.

CARVALHO, P. C. F. **Relações entre a estrutura da pastagem e o processo de pastejo com ovinos**. 1997. 150 f. Tese (Doutorado em Zootecnia)- Faculdade de Zootecnia, Universidade Estadual Paulista Júlio de Mesquita Filho, Jaboticabal, 1997.

CAYSSIALS, V.; RODRÍGUEZ, C. The adaptive value of grass traits in response to grazing. **Journal of Plant Ecology**, Oxford, v. 11, n. 2, p. 248–255, 2018.

CINGOLANI, A. M. *et al*. Plant functional traits, herbivore selectivity and response to sheep grazing in Patagonian steppe grasslands. **Journal of Applied Ecology**, London, v. 42, n. 1, p. 50–59, 2005.

COSTANZA, R. *et al.* The value of the world's ecosystem services and natural capital. **Nature**, London, v. 387, n. 6630, p. 253–260, 1997. Disponível em: https://www-nature-com.ezproxy.royalroads.ca/articles/387253a0.pdf.

CRUZ, P. *et al.* Leaf traits as functional descriptors of the intensity of continuous grazing in native grasslands in the South of Brazil. **Rangeland Ecology and Management**, Lakewood, Colo, v. 63, n. 3, p. 350–358, 2010.

CRUZ, P. *et al.* Une nouvelle approche pour caractériser les prairies naturelles et leur valeur d ' usage Présentation * Comment évaluer la valeur des prairies , pour mieux les gérer ? **Fourragees**, Versailles, v. 172, p. 1–15, 2002.

DAMÉ, P. R. V. *et al.* Efeitos da queima seguida de pastejo ou diferimento sobre a produção, qualidade, cobertura do solo e sistema radicular de uma pastagem natural. **Ciência Rural**, Santa Maria, v. 27, n. 1, p. 133–137, 1997.

BELLO, F.; LEPŠ, J.; SEBASTIÀ, M. T. Predictive value of plant traits to grazing along a climatic gradient in the Mediterranean. **Journal of Applied Ecology**, London, v. 42, n. 5, p. 824–833, 2005.

DERNER, J. D. *et al.* Livestock as ecosystem engineers for Grassland Bird habitat in the Western Great Plains of North America. **Rangeland Ecology and Management**, Lakewood, Colo, v. 62, n. 2, p. 111–118, 2009.

DIAZ, S. *et al.* Plant trait responses to grazing: a global synthesis. **Global Change Biology**, London, v. 13, n. 2, p. 313–34, 2007.

DIAZ, S.; CABIDO, M. Plant functional types and ecosystem function in relation to global change. **Journal of Vegetation Science**, London, v. 8, n. 4, p. 463–474, 1997.

DIAZ, S.; NOY-MEIR, I.; CABIDO, M. Can grazing of herbaceous plants be predicted from simple vegetative response traits ?. **Journal of Applied Ecology**, London, v.

38, n. 3, p. 497–508, 2009.

FYNN, R. W. S.; MORRIS, C. D.; EDWARDS, T. J. Long-term compositional responses of a South African mesic grassland to burning and mowing. **Applied Vegetation Science**, London, v. 8, n. 1, p. 5–12, 2005.

GONÇALVES, E. N. *et al.* Plant-animal relationships in pastoral heterogeneous environment: Process of herbage intake. **Revista Brasileira de Zootecnia**, Viçosa, v. 38, n. 9, p. 1655–1662, 2009.

HENDON B. C.; BRISKE D. D. Evaluation of a Herbivory-Sensitive Perennial Bunchgrass : Does It Possess an Achilles Heel? **Oikos**. Lund, v. 80, n. 1, p. 8–17, 1997.

HODGSON, J. **Grazing management: science into practice**. London: Longman Scientific and Technical, 1990.

HUI, A.; LI, G.. Differential effects of grazing on plant functional traits in the desert grassland. **Polish Journal of Ecology**, Washington, v. 62, n. 2, p. 239–251, 2014.

HUTCHINGS, M. J.; DE KROON, H. Foraging in Plants: The Role of Morphological Plasticity in Resource Acquisition. **Advances in Ecological Research**, [S. l.], v. 25, n. C, p. 159–238, 1994.

LACA, E. A.; LEMAIRE, G. Measuring sward structure. *In:* T´MANNETJE, L.; JONES, R.M. (ed.). **Field and laboratory methods for grassland and animal production research**. New York: CABI, 2001. p.103-122.

LALIBERTÉ, E.; TYLIANAKIS, J. M. Cascading effects of long-term land-use changes on plant traits and ecosystem functioning. **Ecology**, Washington, v. 93, n. 1, p. 145–155, 2012.

LAVOREL, S. *et al*. Plant functional types: are we getting any closer to the holy grail? **Terrestrial Ecosystems in a Changing World**, New York, p. 149–164, 2007.

LEITH, H. (ed.). Modeling the primary productivity of the world. *In:* LIETH, H; WHITTAKER, R. R. (ed.). **Primary productivity in the biosphere**. Berlin: Springer-Verlag, Dowden, 1975. p. 300–321. (Ecological studies, v. 14).

LI, W. *et al.* Patterns and thresholds of grazing-induced changes in community structure and ecosystem functioning: species-level responses and the critical role of species traits. **Journal of Applied Ecology**, London, v. 54, n. 3, p. 963–975, 2017.

MILCHUNAS, D. G.; SALA, O. E.; LAUENROTH, W. K. A generalized model of the effects of grazing by large herbivores on grassland community structure. **The American Naturalist**, Chicago, v. 132, n. 1, p. 87–106, 1988.

MORAES, A.; MOOJEN, E. L.; MARASCHIN, G. E. Comparação de métodos de estimativa de taxa de crescimento em uma pastagem submetida a diferentes pressões de pastejo. *In*: REUNIAO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 27., 1990, Campinas. **Anais** [...]. Piracicaba: FEALQ, 1990. 332 p.

MORRIS, M. G. The effects of structure and its dynamics on the ecology and conservation of arthropods in British grasslands. **Biological conservation**, Essex, v. 95, p. 129-142, 2000.

MÜLLER, S. C. *et al.* Plant functional types of woody species related to fire disturbance in forest-grassland ecotones. **Plant Ecology**, Dordrecht, v. 189, n. 1, p. 1–14, 2007.

NABINGER, C.; Produção animal com base no campo nativo: aplicações de resultados de pesquisa. *In:* PILLAR, V. D. *et al.* (ed.). **Campos sulinos**: conservação e uso sustentável da biodiversidade. Brasilia: MMA, 2009. p. 214-228.

OLIVEIRA, J. M.; PILLAR, V. D. Vegetation dynamics on mosaics of Campos and Araucaria forest between 1974 and 1999 in Southern Brazil. **Community Ecology**, Budapest, v. 5, n. 2, p. 197–202,2004.

OVERBECK, G. E. *et al.* Brazil's neglected biome: The South Brazilian Campos. **Perspectives in Plant Ecology, Evolution and Systematics**, Amsterdam, v. 9, n. 2, p. 101-116, 2007.

OVERBECK, G. E. *et al.* Fine-scale post-fire dynamics in southern Brazilian subtropical grassland. **Journal of Vegetation Science**, London, v. 16, n. 6, p. 655–664, 2005.

PALLARÉS, R.O.; BERRETTA, E.J.; MARASCHIN, G.E. The South American Campos Ecosystem. *In*: SUTTIE, J.M.; REYNOLDS, S.G.; BATELLO, C. (ed.) **Grasslands of the world**. Rome: FAO, 2005. p. 171-179.

PILLAR, V. D. P.; VÉLEZ, E. Extinção dos Campos Sulinos em unidades de conservação: Um fenômeno natural ou um problema ético? **Natureza & Conservação**, Rio de Janeiro, v. 8, n. 1, p. 84-86, 2010.

TRINDADE, J. K. *et al.* Forage allowance as a target of grazing management: Implications on grazing time and forage searching. **Rangeland Ecology and Management**, Lakewood, Colo, v. 65, n. 4, p. 382–393, 2012.

TRINDADE, J. K. *et al.* Daily Forage Intake by Cattle on Natural Grassland: Response to Forage Allowance and Sward Structure. **Rangeland Ecology and Management**, Lakewood, Colo, v. 69, n. 1, p. 59–67, 2016. Disponível em: http://dx.doi.org/10.1016/j.rama.2015.10.002. Acesso em: 08/10/2018.

VIOLLE, C. *et al.* Let the concept of trait be functional! **Oikos**, Lund, v. 116, n. 5, p. 882–892, 2007.

WALTER, H. **Vegetation of the earth and ecological systems of the geobiosphere**. New York: Springer-Verlag Press, 1979.

WREGE, M. S. *et al.* **Atlas climático da Região Sul do Brasil**: Estados do Paraná, Santa Catarina e Rio Grande do Sul. Pelotas: Embrapa Clima Temperado; Colombo: Embrapa Florestas, 2011. 336 p.

APÊNDICE

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- Quick checklist for initial submission
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Please ensure that your article fits within the journal's **Aims and Scope** and that you have read our **Editorial Policies** before submitting your article. Initial submissions do not need to be fully formatted to journal style. Please follow our quck checklist for initial submission. For revised manuscripts, please refer to the full **manuscript specifications**.

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Abstract

The abstract must not exceed 350 words and should list the main results and conclusions, using simple, factual, numbered statements. The abstract should outline the purpose of the paper and the main results, conclusions and recommendations, using clear, factual, numbered statements.
Authors should follow a formula in which point 1 sets the context and need for the work; point 2 indicates the approach and methods used; the next 2-3 points outline the main results; and the last point identifies the wider implications and relevance to management or policy. The final point is the most important of all in maximising the impact of the paper. It should synthesise the paper's key messages and should be generic, seminal and accessible to non-specialists, and must carry one of the following subheadings:
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This should state the reason for doing the work, the nature of the hypothesis or hypotheses under consideration, and should outline the essential background.

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State the results and draw attention in the text to important details shown in tables and figures.

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Beers, S. R. , & De Bellis, M. D. (2002). Neuropsychological function in children with maltreatment-related posttraumatic stress disorder. The American Journal of Psychiatry, 159, 483–486. doi:10.1176/appi.ajp.159.3.483

Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003). Theories of developmental dyslexia: Insights from a multiple case study of dyslexic adults. Brain, 126(4), 841–865. doi: 10.1093/brain/awg076

Example of reference with more than 7 authors

Rutter, M., Caspi, A., Fergusson, D., Horwood, L. J., Goodman, R., Maughan, B., … Carroll, J. (2004). Sex differences in developmental reading disability: New findings from 4 epidemiological studies. Journal of the American Medical Association, 291(16), 2007–2012. doi: 10.1001/jama.291.16.2007

- Book edition

Bradley-Johnson, S. (1994). Psychoeducational assessment of students who are visually impaired or blind: Infancy through high school (2nd ed.). Austin, TX: Pro-ed.

- Edited book

Hawkley, L. C., Preacher, K. J., & Cacioppo, J. T. (2007). Multilevel modeling of social interactions and mood in lonely and socially connected individuals: The MacArthur social neuroscience studies. In A. D. Ong & M. Van Dulmen (Eds.), *Oxford handbook of methods in positive psychology* (pp. 559–575). New York, NY: Oxford University Press.

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VITA

Gustavo Haas Heissler, filho de Luiz Ribeiro Heissler e Haigli Haas Heissler, nascido em 16 de junho de 1990, na cidade de Lajeado – RS. Estudou na Escola Madre Bárbara na cidade de Lajeado, onde concluiu o ensino fundamental (2005) e também o ensino médio (2008). Em 2009 ingressou no curso de Agronomia na Universidade Federal do Rio Grande do Sul (UFRGS) – Porto Alegre – RS, atuando como bolsista no Laboratório de Ensino Zootécnico (LEZO/UFRGS) sob orientação da professora Andrea Machado Leal Ribeiro no ano de 2012. No mesmo ano efetuou o trancamento do curso, iniciando, no ano seguinte (2013) o curso de Engenharia Civil na Universidade do Vale do Taquari (UNIVATES) – Lajeado – RS, até o final de 2014 (total de 4 semestres). Durante mesmo período foi estagiário no escritório Nicaretta Arquitetos, tendo como funções o planejamento e execução de projetos, bem como administração das obras realizadas. No início do ano de 2015 foi aprovado, novamente, em processo seletivo para o curso de Agronomia na Universidade Federal do Rio Grande do Sul (UFRGS) – Porto Alegre – RS. No período entre 2015 e 2017 foi bolsista de iniciação científica e voluntário no Grupo de Pesquisa em Ecologia do Pastejo (GPEP) sob orientação do professor Paulo César de Faccio Carvalho. No final do ano de 2017 formou-se Engenheiro Agrônomo na referida instituição. Em abril de 2018 ingressou no Mestrado Acadêmico (Stricto Sensu) pelo Programa de Pós Graduação em Zootecnia na Universidade Federal do Rio Grande do Sul (UFRGS) sob orientação do professor Paulo César de Faccio Carvalho, tendo seu estudo focado em interações ecológicas dentro do ambiente de pastagens naturais representantes do Bioma Pampa.