UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
FACULDADE DE AGRONOMIA
PROGRAMA DE PÓS-GRADUAÇÃO EM ZOOTECNIA

PADRÕES DE INGESTÃO E DESLOCAMENTO DE BOVINOS E OVINOS EM AMBIENTES PASTORIS COMPLEXOS

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Tese apresentada como um dos requisitos à obtenção do Grau de Doutor em Zootecnia
Área de Concentração Plantas Forrageiras

Porto Alegre - RS, Brasil
Novembro de 2010

FOLHA DE HOMOLOGAÇÃO

"Embora ninguém possa voltar atrás e fazer um novo começo, qualquer um pode começar agora e fazer um novo fim."

Chico Xavier

AGRADECIMENTOS

Foram quase quatro anos de convivência dentro do Grupo de Pesquisa em Ecologia do Pastejo e as minhas principais conquistas foram o conhecimento e a amizade. Quanto à isso só tenho que agradecer a todos que de alguma forma colaboraram com a minha formação e com esta tese! Sou grata pelo ótimo trabalho de todos colaboradores do grupo, sendo eles professores, pesquisadores, funcionários, pós-doutorandos, doutorandos, mestrandos, bolsistas e estagiários. Ao Paulo, por todos os ensinamentos e experiências transmitidas, pela sua dedicação com a minha formação, pela oportunidade de convivência, pela confiança e amizade. Obrigada pelo privilégio de ter sido sua orientada! Aos co-orientadores e colaboradores, tanto dentro da instituição (Nabinger, Poli, Vivian) quanto externos (Malcolm, Monica, Picho, Cris, Naylor, Lemaire, André). Ao Emilio, que me proporcionou o privilégio da sua convivência na UCDavis, a qual foi imprensindível para a realização desta tese. Muito obrigada pelas experiências e pelo conhecimento transmitido! À Cris e ao Jairo, que me acolheram em Davis de braços abertos, de uma forma que eu nunca vou esquecer! À todos os colegas de doutorado e mestrado, pelas discussões proporcionadas que certamente me ajudaram a crescer intelectualmente. À Ione, por ser sempre tão atenciosa! Ao CNPq, pela bolsa proporcionada! Às amizades verdadeiras que conquistei dentro do grupo de pesquisa e às amizades antigas que continuaram durante esta caminhada e que continuarão eternamente! Aos meus mestres de formação, professora Marta e professor José Henrique. Muito obrigado por terem me proporcionado a base de conhecimento que me fez chegar até aqui! À minha "equipe de apoio", Jean e Lidi, eu não teria chegado até aqui sem a ajuda de vocês! Espero um dia poder retribuir! À todos na estação experimental, pela ajuda proporcionada com o experimento, principalmente ao Tio Panta e Seu Roberto! Às minhas eternas companheiras de trabalho, Lidi, Gláucia e Dê, não tenho palavras para agradecer tudo que vcs fizeram por mim! Vcs foram realmente meus "braços direitos"! Muito, mas muito obrigada amigas!!! Também quero agradecer profundamente ao Jean, Mônica, Cris, Fê, Tibico, Gabi, Laura, Diego e Dê M.! A ajuda de vcs foi fundamental para esta caminhada! Também agradeço às outras pessoas que colaboraram nas avaliações de campo, pode ter sido em menor freqüência, mas não em menor importância! Às "Meninas" (Zebuzinha, Cascudinha, Miluca e Narizinho; as terneiras) e às "Carolzinhas" (Ovelhas), por terem sido tão compreensivas enquanto colocávamos todas aquelas ensilhas, meu profundo respeito e agradecimento, pois sem sua colaboração seria impossível a realização desta pesquisa. Jaque, Lena e Flávia, pela amizade, por estarem sempre por perto, por ouvirem meus desabafos! Yuri, meu companheiro de todas as horas, sempre ao meu lado. Por já estar a 10 anos me proporcionando alegria, já se formou em Zootecnia, fez mestrado e, agora, doutorado! Ígor, meu amor, muito obrigada pela paciência, cumplicidade, pelo companheirismo, enfim, por estar ao meu lado tanto nas horas boas quanto nas difíceis! À minha família, mãe, pai, Mari, Felipe, Leila, Gabriel e vó, pelo amor, carinho e apoio em toda essa caminhada. Amo muito vocês!!! Essa tese é para vocês!!!

Enfim, à todas as pessoas que contribuíram para a realização deste trabalho. E, sobretudo, à Deus! Meus sinceros agradecimentos!

PADRÕES DE INGESTÃO E DESLOCAMENTO DE BOVINOS E OVINOS EM AMBIENTES PASTORIS COMPLEXOS[1]

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Resumo

O presente trabalho foi desenvolvido na EEA-UFRGS, em Eldorado do Sul/RS, entre novembro e dezembro de 2009, com o objetivo de avaliar as estratégias de pastejo de novilhas e ovelhas, buscando o entendimento das respostas dos animais frente a distintos níveis de cobertura de touceiras em pastagens naturais. Foi utilizado um delineamento experimental de blocos completamente casualizados com quatro repetições. Os tratamentos consistiram de diferentes proporções de cobertura de estrato superior: 0, 25, 50 e 75% de touceiras de capim-annoni-2 (*Eragrostis plana* Nees) em estádio vegetativo, considerado como o item não preferencial da dieta dos animais. O estrato inferior da pastagem era composto principalmente por *Axonopus afinnis, Cynodon dactylon, Paspalum nicorae, Paspalum notatum, Desmodium incanum, Andropogon lateralis, Coelorachis selloana* e *Eleocharis viridans.* A vegetação encontrada dentro das touceiras era composta principalmente por *Desmodium incanum.* Durante as avaliações de pastejo de 45 minutos, a cada 1 minuto foi anotado o estrato pastejado pelos animais, se inferior, superior ou dentro das touceiras. A taxa de ingestão foi medida por meio da técnica de dupla pesagem e para a determinação dos padrões comportamentais dos animais foram utilizados registradores de movimentos mandibulares (IGER). Os resultados mostraram que tanto as novilhas quanto as ovelhas selecionaram dietas com predominância de espécies do estrato inferior da pastagem, mesmo em áreas com predominância de touceiras. No entanto, a partir de 50% de infestação de capim-annoni-2, os animais aparentemente desistem de selecionar o estrato inferior da pastagem e passam a consumir as touceiras. Para as novilhas, as touceiras podem ter agido como uma barreira vertical e/ou horizontal interferindo no processo da formação do bocado e afetando a massa do bocado e conseqüentemente a taxa de ingestão de forragem, enquanto que as ovelhas, independente do nível de infestação de capim-annoni-2, conseguem selecionar *Desmodium* dentro das touceiras e manter a taxa de ingestão constante. Para cada aumento de 1% na proporção de touceiras, as novilhas substituíram 0,6% do pastejo no estrato inferior pelas touceiras, enquanto que as ovelhas reduziram apenas 0,36% do pastejo no estrato inferior. Dessa forma, conclui-se que o entendimento dos padrões de pastejo dos animais possibilita conhecer as estratégias necessárias para um manejo adequado e proporciona habilidade para interferir de forma positiva nos resultados de produção em pastagens naturais.

Palavras-chave: *Eragrostis plana* Nees, percentual de cobertura de touceiras, heterogeneidade, seletividade, taxa de ingestão

[1] Tese de Doutorado em Zootecnia – Plantas Forrageiras, Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre - RS, Brasil, (182 p.), Novembro, 2010.

FORAGING AND MOVEMENT PATTERNS OF CATTLE AND SHEEP IN COMPLEX PASTORAL ENVIRONMENTS[1]

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Abstract

The experiment was carried out at the Research Station of the Federal University of Rio Grande do Sul, Brazil, between November and December 2009, with the objective of evaluating the grazing strategies of beef heifers and ewes for the understanding of the animal's responses under different levels of cover of tussocks in natural grasslands. A complete randomized block design with four replicates was used. The grazing paddocks contained different proportions of tussocks in vegetative phenological stage: 0, 25, 50 and 75% of *Eragrostis plana* Nees, considered as the non-preferred item of the diet. The inter-tussocks areas were predominantly composed of *Axonopus afinnis, Cynodon dactylon, Paspalum nicorae, Paspalum notatum, Desmodium incanum, Andropogon lateralis, Coelorachis selloana a*nd *Eleocharis viridans.* The vegetation intra-tussocks was predominantly composed by *Desmodium incanum.* At 1-minute intervals during grazing activity of 45 minutes, records were taken whether the animals were grazing on tussock, inter-tussock or intra-tussock areas. The short-term intake rate was measured by weighing the heifers pre- and post-grazing corrected for insensible weight losses. Grazing time and jaw movements were recorded using behavior recorders. The results showed that both heifers and ewes selected diets with predominance of inter-tussock areas, even in areas with predominance of tussocks. However, from 50% of tussock's percentage of cover, animals apparently give up to select the inter-tussock stratum and start to graze the tussocks. For heifers, tussocks may act as a vertical and/or horizontal barrier interfering in the process of bite formation and affecting bite mass and short-term intake rate, while for ewes, independent of the tussock's percentage of cover, they could select the *Desmodium* intra-tussock and maintain their short-term intake rate constant. With each increase of tussock's percentage of cover, heifers reduced 0.6% of their grazing time on the inter-tussock areas, while the ewes reduced only 0.36% of grazing inter-tussock areas. Thus, we conclude that the understanding of the grazing patterns permits to know the necessary strategies to an appropriate management and provides the ability to intervene positively on the production's results in natural grasslands.

Key words: *Eragrostis plana* Nees, heterogeneity, selection, short-term intake rate, percentage of cover of tussocks

[1] Doctoral thesis in Forage Science, Faculdade de Agronomia, Universidade Federal do Rio Grande do Sul, Porto Alegre - RS, Brazil, (182 p.), November, 2010.

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RELAÇÃO DE ABREVIATURAS E SÍMBOLOS

Abreviatura	Descrição
BM	bite mass
BR	bite rate
DM	dry matter content
ET	eating time
GJMR	grazing jaw movement rate
ha	hectare
HM	herbage mass
IMID	intra-meal interval duration
IMIN	intra-meal interval number
INT	intra-tussock stratum
IT	inter-tussock stratum
m	meters
m^2	square meters
min	minute
Mg	tones
MW	metabolic weight
N	non-selectivity
NBGJMR	non-biting grazing jaw movement rate
Prob	probability
RIWL	rate of insensible weight loss
S	selectivity
sec	second
SH	sward height
STIR	short-term intake rate
T	tussock stratum
Trat	treatment

1. CAPÍTULO I

1.1 Introdução

A área de pastagens naturais no sul do Brasil vem sendo anualmente reduzida pela expansão da gramínea sul-africana estival perene denominada capim-annoni-2 (*Eragrostis plana* Nees). Essa gramínea é evitada pelos animais, principalmente pela sua baixa palatabilidade e valor nutritivo e, como conseqüência, se torna dominante. Carvalho & Batello (2009) consideram que dentre as tantas ameaças impostas às pastagens naturais, uma das mais relevantes neste momento é o processo de invasão pelo capim-annoni-2, com taxas de expansão anuais de 14.000 ha (Ziller, 2005). Torna-se claro a necessidade de se desenvolver um conjunto de práticas de manejo para a utilização racional destas pastagens, tanto do ponto de vista técnico como econômico (Medeiros & Focht, 2007). Para o uso de forma produtiva e sustentável das pastagens naturais, devem-se compreender e descrever os processos que integram a vegetação e o comportamento, consumo e seleção de dietas realizada por animais sob diferentes estratégias de manejo (Carvalho et al., 2009a).

Em ambientes pastoris complexos, como as pastagens naturais, a seleção de forragem de alta qualidade pode proporcionar um efeito negativo sobre a taxa de ingestão dos animais, visto que estas pastagens são caracterizadas por uma grande variedade espacial e temporal de plantas forrageiras. A resposta funcional da taxa de ingestão é dependente do tipo e grau de heterogeneidade presente na vegetação, sendo que os padrões de reposta podem apresentar uma grande variedade de formas, dependentes da distribuição espacial dos recursos (Drescher, 2003).

Esta tese é composta por cinco capítulos. No capítulo I encontra-se uma revisão bibliográfica do assunto. Nos capítulos II e III estão apresentados os resultados do experimento realizado com novilhas e ovelhas em nível de bocado. Já no capítulo IV estão apresentados os resultados referentes à escala de *patch.* No Capítulo II, o principal objetivo se refere à investigação das interações entre a estrutura do pasto e os padrões de escolha de forragem pelos animais frente ao aumento nos níveis de estrato superior (touceiras de capim-annoni-2). No Capítulo III, a hipótese testada é a de que existe um nível de estrato superior a partir do qual o deslocamento dos animais passa a ser aleatório, ou seja, a partir do qual os animais desistem de selecionar o estrato preferencial de pastejo (estrato inferior da pastagem). Já no Capítulo IV, o objetivo do trabalho está no entendimento e comparação das estratégias de pastejo de novilhas e ovelhas e, principalmente, na definição de níveis de touceiras de capim-annoni-2 que limitam a taxa de ingestão dos animais. O capítulo V corresponde às considerações finais, onde são apresentados os principais resultados observados e sugestões para trabalhos futuros.

1.2 Hipótese de Estudo

Em ambientes pastoris heterogêneos como as pastagens naturais, existe um nível de percentual de cobertura de estrato superior, composto por capim-annoni-2 (*Eragrostis plana* Nees.), a partir do qual os padrões de ingestão e deslocamento de bovinos e ovinos passam a ser alterados.

1.3 Objetivos

Objetivos Gerais

- Avaliar o efeito das touceiras de capim annoni-2 (*Eragrostis plana* Nees) sobre as respostas dos animais com o intuito de se obter recomendações de manejo em pastagens naturais.

Objetivos Específicos

- Avaliar as estratégias de pastejo e os padrões de ingestão e seleção de forragem de bovinos e ovinos sob diferentes percentuais de cobertura de estrato superior na pastagem;

- Identificar o nível de interação entre o estrato superior e o estrato inferior em pastagens naturais que promova a máxima taxa de ingestão de forragem por bovinos e ovinos.

1.4 Modelo Conceitual

O modelo conceitual (Figura 1) propõe que a distinta freqüência de cobertura de estrato superior, em ambientes pastoris heterogêneos como as pastagens naturais, influencia os padrões de comportamento ingestivo dos animais, através dos processos de deslocamento e procura por estações alimentares, ingestão de forragem, desfolhação e seleção de dietas. Como fator central do modelo conceitual temos a composição da comunidade de plantas, formando uma estrutura do tipo mosaico, com espécies de plantas pertencentes ao estrato preferencial da pastagem, ou seja, o estrato inferior, e ainda as touceiras de *Eragrostis plana* Nees pertencentes ao estrato superior, considerado como o estrato não-preferencial pelos animais. Dessa forma, os animais precisam tomar uma série de decisões para explorar de forma positiva a heterogeneidade natural do ambiente pastoril. Para o entendimento dessas ações dos animais frente a este ambiente, é importante a caracterização da composição estrutural do pasto, através do percentual e distribuição espacial das touceiras, altura e massa de forragem tanto do estrato inferior quanto do superior, composição química, estádio fenológico das plantas, entre outros. E, para se poder comparar apenas o efeito do percentual de cobertura de estrato superior, como hipótese deste trabalho, é necessário oferecer uma estrutura ótima aos animais (alturas de estrato inferior de 11,4 cm e 9,5 cm para novilhas e ovelhas, respectivamente; Gonçalves et al., 2009), para que esses tenham a possibilidade de selecionar a comunidade preferencial de plantas. Numa condição de estrato inferior baixo, bovinos têm a sua capacidade seletiva reduzida e, em conseqüência, pastejam vegetações de touceiras, enquanto que os ovinos tendem a pastejar seletivamente as manchas de estrato inferior na pastagem evitando as espécies de touceiras (Grant et al., 1985; Hodgson et al., 1991). Dessa forma, a composição da dieta é decorrente das estratégias de pastejo dos animais, dependendo da espécie animal (bovinos x ovinos). A decisão do animal é organizada de forma hierárquica iniciando, nas condições deste trabalho, no âmbito *patch*, estação alimentar, até chegar ao bocado. As respostas dos animais frente à estrutura do pasto são quantificadas através de variações nas estratégias de busca e apreensão de forragem pelos animais. Os processos de busca envolvem o deslocamento e procura por forragem (entre estações alimentares), enquanto que nos processos de apreensão estão envolvidas a taxa de bocados e a massa do bocado, a qual é determinada pela profundidade e área do bocado. Estes componentes do comportamento ingestivo definem os padrões de ingestão dos animais. Mudanças na exploração dos *patches* são decorrentes de uma reorientação do animal para um novo local com maior abundância e qualidade de forragem, ou seja, uma quebra da seqüência de pastejo (Laca & Ortega, 1995; Bailey et al.,1996; Carvalho & Moraes, 2005; Bailey & Provenza, 2008). A estação alimentar é um semicírculo hipotético, disponível em frente ao animal, que ele alcançaria sem mover as suas patas dianteiras (Ruyle & Dwyer, 1985). O animal troca de estação alimentar para otimizar a seleção da dieta. Quanto maior a oferta de forragem na estação alimentar, maior o tempo de permanência dos animais nela até que o ponto de abandono seja atingido, representado pelo ponto a partir do qual a relação custo-benefício em explorá-la passa a ser menos interessante (Carvalho et al., 1999). Já a menor escala de decisão do animal é o bocado, que significa a ação ou o ato de apreender a forragem com os dentes (Gibb, 1996). O animal utiliza os estímulos de olfato, paladar e tato como motivação para a escolha do local e, posteriormente, da planta e suas partes, onde será realizado um bocado (Bailey at al., 1996). Todas essas estratégias de que os animais dispõem para explorar o ambiente de pastejo são fundamentais na definição da taxa de ingestão, variável principal do modelo conceitual.

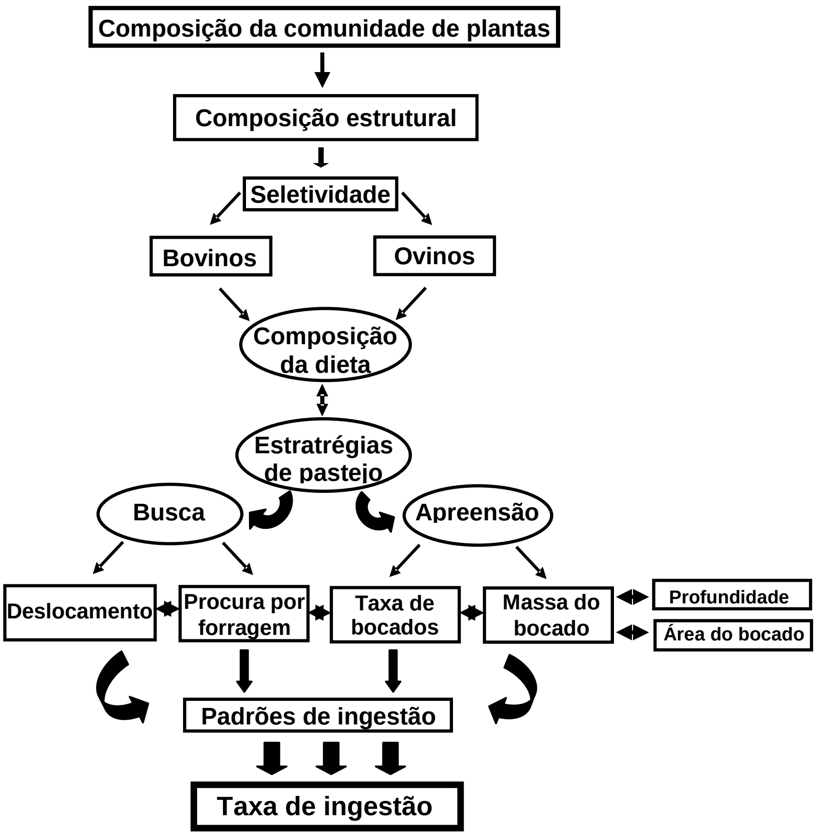

Figura 1 - Modelo conceitual proposto para a tese de doutorado, com as principais variáveis envolvidas no processo de ingestão de animais em pastagens heterogêneas

1.5 Revisão Bibliográfica

1.5.1 Bioma Pampa

O Bioma Campos compreende 500.000 km^2 (latitudes 24° e 35° S), abrangendo o Uruguai, Nordeste da Argentina, Sul do Brasil, e parte do Paraguai (Pallarés et al., 2005). A extensão brasileira do Bioma Campos é atualmente conhecida como Bioma Pampa e compõe um dos seis biomas brasileiros. Abrange a metade sul do estado do Rio Grande do Sul, em área de clima subtropical e representa 2,07% (176.496 km^2) do território brasileiro e cerca de 63% da área do estado (IBGE, 2004).

No Rio Grande do Sul, a área de vegetação nativa é estimada em 72.928 km^2 (41,32% do bioma; MMA, 2007). Esse ecossistema abriga uma ampla diversidade florística, sendo 400 espécies de gramíneas (Poaceae) e 150 de leguminosas (Fabaceae) de interesse forrageiro (Boldrini, 1997), entre outras famílias, constituindo a base alimentar de 14,37 milhões de bovinos e 3,95 milhões de ovinos (IBGE, 2010). Nessas pastagens naturais, tem sido observada constante redução na diversidade de espécies de plantas nativas, assim como queda na produtividade pecuária (Reis, 1993), pelo aumento de plantas invasoras. Pesquisas indicam que o aumento da diversidade de espécies de plantas promove benefícios sobre algumas funções do ecossistema, como a retenção de nutrientes e resistência a invasoras (Sanderson et al., 2004).

No contexto da produção animal, uma planta indesejável é aquela que, embora fazendo parte do ecossistema, ou não integra de forma constante a dieta do animal, ou mesmo fazendo parte da dieta, não contribui com o pleno atendimento dos requerimentos nutricionais dos animais. Além disso, diminui a produção de espécies de interesse forrageiro por competir por recursos nutricionais, água e luz e por diminuir a área de pastejo (Crâncio et al., 2006). Ou seja, por sua freqüência de ocorrência e desenvolvimento individual, ela diminui o rendimento das espécies desejáveis. De acordo com Brady et al. (1989), na interação planta x herbívoro, algumas plantas são rejeitadas enquanto outras têm a sua presença reduzida ou, até mesmo, eliminada da área. Os animais, por intermédio do pastejo seletivo, também alteram a habilidade competitiva das espécies influenciando a estrutura e a composição da vegetação.

As plantas invasoras, como são rejeitadas pelo pastejo animal, tornam-se dominantes e a comunidade passa a assumir o aspecto de "monocultura" (Reis & Coelho, 2000). Esse fato tem sido comumente observado nos últimos anos nas pastagens naturais do Bioma Pampa. Tal bioma encontra-se ameaçado pela extensão anual da área invadida pelo capim-annoni-2 (*Eragrostis plana* Nees). De acordo com Carvalho & Batello (2009), dentre as tantas ameaças impostas às pastagens naturais, uma das mais relevantes neste momento é este processo de invasão por capim-annoni-2.

Nas últimas décadas, vem sendo observada uma expansão dessa espécie em taxas anuais de 14.000 ha (Ziller, 2005). O capim-annoni-2 é uma gramínea sul-africana estival perene, introduzida acidentalmente na década de 1950 (Reis, 1993), apresenta alta tolerância às flutuações do clima, especialmente a geada, e por isto foi multiplicada e suas sementes comercializadas no RS pelo Grupo Rural Annoni, de Sarandi, a partir de 1970. A distribuição de sementes acelerou o processo invasor. Torna-se necessário desenvolver um conjunto de práticas de manejo para a utilização racional destes campos, tanto do ponto de vista técnico como econômico (Medeiros & Focht, 2007).

Nesse contexto, estudos de Medeiros et al. (2004) com capim-annoni-2, mostraram que o aumento da freqüência e cobertura desta espécie invasora provoca redução na freqüência de muitas espécies nativas de bom valor forrageiro e, em conseqüência, o valor nutritivo da pastagem é reduzido. As plantas estabelecidas passam a capturar mais recursos do ambiente (nutrientes, luz, água, etc.) do que as forrageiras nativas, desenvolvendo-se e produzindo grandes quantidades de sementes, a cada estação de crescimento. Estes fatores respondem pela drástica redução na frequência e riqueza de muitas espécies nativas e da heterogeneidade da vegetação do bioma Campos (Medeiros et al., 2004).

Ainda em relação a estudos relacionados ao manejo, Mezzalira et al. (2008) compararam duas das principais espécies da pastagem em questão. O *Paspalum notatum* foi associado diretamente à intensidade de pastejo. Sua maior ou menor presença representa a existência de fisionomias mais homogêneas (maior presença de *P. notatum* = pastagem com um único estrato inferior) ou mais heterogêneas (menor presença de *P. notatum* = pastagem com duplo estrato e formação de touceiras). Já o *Andropogon lateralis*, espécie de elevada plasticidade e principal espécie formadora de touceiras na vegetação em questão (Carvalho et al., 2009b), teve sua presença associada às menores intensidades de pastejo.

Observou-se, nesses tipos de pastagem, que o manejo do pasto com oferta diária de 12 kg de MS/100 kg de peso vivo (intensidade de pastejo moderada) possibilitou um sincronismo entre a emissão de folhas e o intervalo entre desfolha das espécies supracitadas. Isso possibilita que as plantas se regenerem e que o animal tenha disponibilidade de folhas verdes. Permite também a expressão da seletividade, por parte dos animais, por uma forragem de melhor qualidade, bem como garantia à planta de tempo suficiente para prover assimilados para emissão de novas folhas após a desfolha (Carvalho et al., 2010a). Por outro lado, plantas menos tolerantes ao pastejo, ao serem pastejadas à intensidade e frequência acima do ideal, tendem a desaparecer da comunidade.

Mezzalira et al. (2008) ilustra a ascendência da intensidade de pastejo sobre a pastagem, onde, com alterações no ritmo e na intensidade da desfolha, pode-se alterar sua estrutura e sua composição florística, ou seja, toda a diversidade de uma comunidade (Carvalho et al., 2009b). Outros resultados desse protocolo experimental de manejo de campo nativo, que é o mais antigo do Brasil, indicam que intensidades de pastejo moderadas otimizam a produção animal e vegetal (Nabinger, 2006; Carvalho et al., 2007), além de serem capazes de promover o seqüestro de carbono (Salton, 2005), manutenção de elevada taxa de infiltração de água no solo (Bertol et al., 1998), dentre outras variáveis indicadoras de qualidade ambiental (Nabinger et al., 2000).

Neste sentido Nabinger (2006); Carvalho & Batello (2009) e Nabinger & Carvalho (2009) argumentam que a conservação do Bioma Pampa se dê pela valorização de um produto particular, fundamental para remunerar aqueles produtores que sigam boas práticas de manejo.

A decisão do manejador, portanto, tem implicações além da busca pela simples produção animal na comunidade vegetal, visto que o animal e suas relações com o ambiente são alterados a partir de decisões impostas pelo manejo do pasto, e os sincronismos e desequilíbrios nos processos são fruto destas decisões (Carvalho et al., 2010a).

Dessa forma, existe a necessidade de, através do manejo, manipular a estrutura dos pastos visando otimizar a colheita de forragem em pastejo e, conseqüentemente, maximizar a produção animal através da criação de ambientes de pastejo mais favoráveis (Carvalho & Moraes, 2005).

1.5.2 Comportamento ingestivo de animais em pastejo

O consumo diário de forragem é o produto entre o tempo gasto pelo animal na atividade de pastejo e a taxa de consumo de forragem durante o pastejo, que por sua vez, é o produto do número de bocados por unidade de tempo (taxa de bocados) e a quantidade de forragem apreendida em cada bocado (massa do bocado) (Allden & Witthaker, 1970; Forbes, 1988; Hodgson, 1990; Illius, 1997).

O tempo de pastejo diário é composto de refeições. Uma refeição é definida por uma longa seqüência de pastejo (Carvalho et al., 2005). Para este mesmo autor, o número de refeições parece ser um indicador da qualidade do ambiente pastoril. Dessa forma, quando o pastejo se torna eficiente, os animais colhem uma dieta de qualidade superior à média da pastagem, a taxa de ingestão é aumentada e o rúmen se enche mais rapidamente, ocasionando um número maior de refeições e menor duração de cada uma (Carvalho & Moraes, 2005).

Dentre todas as variáveis que descrevem o comportamento ingestivo dos animais, a massa do bocado é a variável que mais se altera de acordo com as características estruturais do pasto (Hodgson 1990; Hodgson et al. 1991), sendo considerada o fator que mais explica as variações na taxa de ingestão (Laca et al., 1994; Ginnett et al., 1999) e consumo diário dos animais (Chacon & Stobbs, 1976; Hodgson, 1981; Mursan et al., 1989).

Há muitos estudos acerca da massa do bocado em resposta à altura do pasto (Black & Kenney, 1984; Wade, 1991; Burlison et al., 1991; Laca et al., 1992; Mitchell et al., 1993, Flores et al., 1993), a densidade (Laca et al. 1991a; Griggs et al., 1991; Laca et al., 1992), a distribuição vertical da forragem nos diferentes estratos do pasto (Black & Kenney, 1984; Black et al., 1989; Burlison et al., 1991; Laca et al., 1991b; Laca et al., 1994), o estado fenológico (Stobbs, 1973; Prache, 1997), o comprimento da folha (Flores et al., 1993), altura de colmos (Ginnett et al., 1999) e densidade dos mesmos (Ganskopp et al., 1993).

A taxa de bocados e o tempo diário de pastejo são considerados mecanismos compensatórios (Chacon & Stobbs, 1976; Hodgson, 1981,1990;

Forbes, 1988; Ungar, 1996), sendo que o animal aumenta a taxa de bocados para manter adequadas taxas de ingestão diante de baixos valores de massa de bocado e tempo de pastejo. Entretanto, existem evidências de que estas “compensações” nem sempre se manifestam (Forbes & Hodgson, 1985; Forbes & Coleman, 1993). Mudanças na massa do bocado e taxa de bocados podem permanecer constantes (Hodgson, 1981; Dougherty et al., 1989a, b; Arias et al., 1990; Hodgson, 1990; Laca et al., 1994; Ginnet al., 1999) e o tempo de pastejo não compensar baixas taxas de ingestão (Chacon & Stobbs, 1976; Hodgson, 1981; Gibb et al., 1997).

Generalizando, Ungar (1996) propôs três situações para explicar a resposta do consumo e comportamento em relação à quantidade de oferta de forragem: a) Em situação de elevada disponibilidade de biomassa por unidade de área a taxa de ingestão e o tempo de pastejo não são afetados pela biomassa presente; b) Em níveis intermediários de disponibilidade de biomassa a taxa de ingestão diminui e o tempo de pastejo aumenta, atuando como um mecanismo de compensação de manutenção do consumo diário; c) em disponibilidade de biomassa por unidade de área baixa a taxa de ingestão diminui e o aumento do tempo de pastejo não é suficiente para atuar como um mecanismo compensatório e manter adequados os níveis de consumo.

Tanto o consumo diário quanto a taxa de ingestão são respostas funcionais que expressam a relação do consumo dos animais e a estrutura do pasto (Laca, 1992), entretanto, os processos que são utilizados para explicá-las são mensurados em diferentes escalas de tempo. A taxa de ingestão geralmente é mensurada em curtos intervalos de tempo e sua resposta é centrada nos mecanismos do processo de ingestão (colheita, manipulação dos bocados). O consumo diário, por sua vez, é calculado normalmente durante grandes períodos de tempo (dias ou semanas) e é medido de acordo com diversas técnicas. Entretanto, essas variáveis têm sido analisadas de forma independente, mas deveriam ser correlacionadas, visto que diminuições no consumo diário podem ser atribuídas às baixas taxas de ingestão (Laca, 1992). Dessa forma, é imprescindível estabelecer uma relação entre estas duas variáveis.

1.5.3 Escalas de decisão dos animais em pastejo

O pastejo pode ser definido como o processo pelo qual animais consomem plantas para adquirir energia e nutrientes, utilizando seus sentidos, cabeça e pernas para alocar bocados potenciais e seu aparato bucal para levar a forragem à boca, apreendê-la entre os dentes, cortá-la com movimentos de cabeça - caracterizando um bocado - para então mastigá-la, formando o bolo alimentar; para, finalmente, degluti-la (Cosgrove, 1997). Esta atividade inclui períodos curtos em que o animal não se encontra efetivamente se alimentando, mas envolvido em atividades diretamente associadas a esse processo, ou seja, selecionando a sua dieta e se movimentando para novos sítios de alimentação.

O processo de pastejo pode ser dividido em uma série de decisões em diferentes escalas espaço-temporais, sendo que as ações de manejo afetam o processo de pastejo diferentemente, segundo a escala em que atuam.

Segundo Carvalho et al. (2010b), é possível identificar ambientes pastoris adequados por meio do comportamento ingestivo dos animais em pastejo, pois, em comunidades vegetais complexas, como as pastagens naturais, os animais retiram uma dieta bem superior à média encontrada no pasto, ou seja, exploram a heterogeneidade vegetal, beneficiando-se dela (Carvalho et al., 2001; Bailey, 2005). Dessa forma, para identificar ambientes pastoris adequados por meio do comportamento ingestivo dos animais em pastejo, devemos entender as escalas de decisão dos animais (Tabela 1).

A menor escala de decisão do animal é o bocado, que significa a ação ou o ato de apreender a forragem com os dentes (Gibb, 1998). Dessa forma o bocado, incluindo os movimentos de manipulação e apreensão, pode ser considerado o elemento básico na taxa de ingestão (Ungar, 1996).

O nível hierárquico de escolhas dos animais posterior ao bocado corresponde à estação alimentar, que é o semicírculo hipotético, disponível em frente ao animal, no qual ele alcançaria sem mover as suas patas dianteiras (Ruyle & Dwyer, 1985). Em situações de elevada disponibilidade de forragem, os animais escolhem poucas estações alimentares, enquanto passam bastante tempo explorando-as (Carvalho, 1997). O deslocamento entre estações alimentares pode ser longo, mas a quantidade de deslocamento total é menor quando comparado a situações de limitação de forragem (Carvalho et al., 2001). Um agregado de estações alimentares corresponde a um *patch*, separado de outros *patches*, nas escolhas dos animais, por uma parada na sequência de pastejo, quando o animal se reorientaria para um novo local (Bailey et al., 1996). Recentemente, um *patch* tem sido definido como uma área onde se observa uma agregação espacial de bocados que se caracterizam por uma taxa de consumo constante (Illius & Gordon, 1999). Para o animal, um *patch* corresponde à escala onde ele percebe descontinuidade no ambiente, e toma decisões que vão definir o seu comportamento (Kotliar & Wiens, 1990).

Um agregado de *patches* é um sítio de pastejo e representa uma área contígua onde os animais pastejariam durante uma refeição (definida como uma interrupção da ação de pastejo para descanso, ruminação, etc.). Um campo de pastejo é um agregado de diferentes sítios de pastejo com um *foci* comum onde os animais buscam água, descanso ou sombra. O nível regional de pastejo é definido por um agregado de campos de pastejo definido por cercas, barreiras, etc. Em muitos casos, a região de pastejo se constitui em um único campo de pastejo (Bailey et al., 1996).

Tabela 1 – Relações planta-animal sob distintas escalas espaciais e temporais de decisões no processo de pastejo

Escala	**Escala espacial**	**Escala temporal**	**Definição comportamental**	**Motivação para movimentação**	**Variável resposta**	**Critérios de seleção envolvidos**	**Mecanismos envolvidos**	**Entidade do pasto**
bocado	0,0001 a 0,01 m^2	1 a 2 segundos	Movimentos mandibulares, de língua e de pescoço	Depleção da forragem, seleção de dietas, estímulos do olfato, paladar e tato	Tamanho do bocado	Concentração de nutrientes e toxinas, tamanho da planta	Consumo, seleção de dietas, efeitos pós-ingestivos	Partes da planta
Estação alimentar	0,1 a 1 m^2	5 a 100 segundos	Posição das patas dianteiras	Depleção da forragem, seleção de dietas, abundância de forragem, bocado	Tempo por bocado	Abundância e qualidade da forragem, espécies de plantas e interações sociais	Frequência de retorno, consumo e trânsito da forragem	Planta inteira
Patch	1 m^2 a 1 ha	1 a 30 minutos	Reorientação do animal para um novo local. Quebra da sequência de pastejo	Depleção da forragem, consumo, composição botânica, estímulo visual e olfatório, interações sociais	Permanência na estação alimentar	Abundância e qualidade da forragem, espécies de plantas, interações sociais e topografia	Trânsito da forragem, consumo, seleção (memória espacial)	Grupo de plantas
Sítio de pastejo	1 a 10 ha	1 a 4 horas	"refeições"	Depleção da forragem, taxas de consumo e digestão	Movimentos durante o pastejo	Topografia, qualidade e abundância da forragem, distância da água, fenologia, predação	Frequência de seleção (memória espacial) e regras práticas	Associação de espécies de plantas
Campo de pastejo	10 a 100 ha	1 a 4 semanas	Áreas centrais próximas onde os animais bebem água e descansam entre refeições	Fenologia, água cobertura depleção da forragem e rebrota	Alocação do tempo diário	Disposição de água, abundância de forragem, fenologia, competição, cobertura	Migração, frequência de seleção (memória espacial)	Unidade de paisagem
Região de pastejo	>1000 ha	1 mês a 2 anos	Dispersão ou migração	Social, reprodução, fenologia competição, água termoregulação	Histórico de vida	Disponibilidade de água, abundância de forragem, fenologia, competição	Transumância migração, dispersão	Paisagem/ região geográfica

Adaptado de Laca & Ortega (1995); Bailey et al*.* (1996); Carvalho & Moraes (2005) e Bailey & Provenza (2008).

Considerar os níveis de escolha dos animais em pastejo ordenados hierarquicamente para descrever o processo de pastejo é de fundamental importância na interpretação das respostas comportamentais dos animais.

A integração entre escalas mediante a consideração dos níveis inferiores e seus níveis imediatamente superiores, surge como necessária para explicar o comportamento dos animais (Bissonette, 1997; Laca, 2000). Em grandes escalas, os padrões espaciais de pastejo são controlados, em sua maior parte, por fatores abióticos, como a distância da água e a topografia do terreno (Senft et al., 1987; Bailey et al., 1996). Por outro lado, esses fatores têm pouca influencia sobre as menores escalas. Desde o bocado até os sítios de alimentação, a quantidade de forragem, estrutura, qualidade e variabilidade espacial se tornam mais relevantes. Assim se espera que os efeitos da heterogeneidade espacial da vegetação sobre a quantidade e a qualidade da resposta ingestiva dos animais se tornem mais relevantes para estas escalas.

1.5.4 Seletividade em ambientes pastoris heterogêneos

Informações detalhadas sobre o processo de ingestão de animais em pastejo têm crucial importância para a criação de modelos de predição de comportamento ingestivo e consumo de forragem, pois permitem o entendimento dos padrões de pastejo tanto em escala de bocado quanto em escala de piquete (Parsons et al., 2001). Parsons et al. (2000) propuseram três teorias sobre o processo de pastejo em escala de bocado: seqüencial (tipo 1), aleatória (tipo 2) e seletiva (tipo 3).

A essência da desfolhação “tipo 1-seqüencial” é que os animais podem sempre selecionar forragem da área mais próxima e gratificante (Ungar, 1996). Por exemplo, quando *patches* são selecionados de onde eles foram primeiramente encontrados, uma seqüência de *patches* pode ser repetida por desfolhações subseqüentes. A probabilidade de animais serem capazes de retornar às estações alimentares em seqüência poderia aumentar se cada estação fosse grande o suficiente e uniformemente desfolhada para permitir que os animais se recordassem da seqüência de *patches* através da memória (Rook et al., 2004). No entanto, para se poder sugerir que animais regularmente usam a desfolhação “seqüencial”, seria necessário um comportamento de pastejo espacial inicial que permitisse a distinção de grandes escalas de *patches*. Considerando o tipo de pastejo conceitualmente mais simples “aleatório-tipo 2”, está claro que os animais não realizam bocados ao acaso em escala de bocado, e em escala de estação alimentar, existe uma forte tendência do animal se mover para a frente ou a virar em pequenos ângulos. A complexidade do deslocamento em pastejo de animais sugere que a probabilidade de reencontro com *patches* poderia ser aleatória. O pastejo “tipo 3-seletivo”, por sua vez, considera as implicações quando os animais encontram áreas aleatoriamente, entretanto, selecionam a área do bocado. Está claro na literatura que tanto bovinos quanto ovinos são capazes de selecionar em pastejo.

A seletividade está relacionada à heterogeneidade e à estrutura do pasto, pois, para consumir determinada fração forrageira, rejeitando outra, o animal deve ser capaz de diferenciá-la e colhê-la. Uma vez que a heterogeneidade pode ser percebida pelo animal, o processo de seleção de dietas pode ocorrer em diversos níveis: em sítios de alimentação dentro de uma pastagem, em espécies dentro de um sítio, ou em órgãos dentro de uma planta. Esse nível de seleção depende não somente das características do pasto, mas também da capacidade de seleção do próprio animal (Galli et al., 1996).

Desta forma, a seletividade pode ser considerada como a expressão da preferência do animal modificada pelas circunstâncias ambientais que operam sobre a oportunidade de escolha (Hodgson, 1979; Newman et al., 1995). A seletividade é difícil de quantificar, porque depende da decisão do animal entre as alternativas alimentares com relação à sua preferência, restrições pelos próprios atributos morfo-fisiológicos do animal e características estruturais e espaciais da vegetação (Laca et al., 2001).

Quando a disponibilidade de forragem é superior à quantidade requerida pelos animais e há variabilidade espacial na quantidade e qualidade da forragem, os animais têm a oportunidade de pastejar de forma seletiva (Grant et al., 1985; Willms et al., 1988). Em ambientes heterogêneos, os animais geralmente selecionam áreas com forragem de maior valor nutritivo, obtendo dietas de maior qualidade que a média da vegetação (Jamieson & Hodgson, 1979; Prache et al., 1998; Prache & Peyraud, 2001; Montossi et al., 2001).

Segundo Stuth (1991), existem espécies de plantas que os animais consomem na proporção em que as encontram. Em geral, são plantas que têm elevada contribuição em massa e frequência, mas de qualidade intermediária.

Por outro lado, as plantas preferidas são, em geral, plantas de elevada concentração de nutrientes e não muito freqüentes, pois sofrem intensidade de pastejo muito superior às outras plantas da comunidade. Elas são identificadas por terem uma presença na dieta do animal bastante superior à sua abundância no pasto. Quando a taxa de lotação é alta em relação à disponibilidade de forragem nos locais preferidos, existe um super-pastejo das espécies preferidas, e algumas espécies de alto valor nutritivo correm o risco de desaparecer. Existem também as plantas que os animais somente pastejam se forçados, como por exemplo, em situações de baixa oferta de forragem. Essas plantas são geralmente entouceiradas ou apresentam algum tipo de fitotoxina. Como são pastejadas menos intensamente, passam a ter vantagem competitiva dentro da comunidade de plantas.

Assim, em ambientes heterogêneos, a seleção da dieta surge como um dos principais determinantes do consumo de forragem. A fim de estabelecer uma relação funcional entre o consumo de animais a pasto e disponibilidade de recursos, é necessário conhecer quais são os mecanismos que controlam e determinam a seletividade.

1.5.5 Relações planta-animal em ambientes pastoris heterogêneos

Em ambientes pastoris heterogêneos, os animais são obrigados a tomar uma série de decisões para colher de forma eficiente os nutrientes necessários aos seus requerimentos diários. Decisões essas que resultam em ações, determinando padrões de comportamento ingestivo que, em conjunto, são conhecidos como estratégia de alimentação ou de forrageamento (Gordon & Illius, 1992). A partir do uso destas estratégias de forrageamento os animais exploram, de forma positiva, a heterogeneidade natural do ambiente pastoril (Laca & Demment, 1991).

Dessa forma, visto que estas modificações estruturais do pasto são complicadoras do processo de busca e encontro da forragem no ambiente pastoril, como o animal responderia ao aumento da freqüência de espécies menos preferidas (Mezzalira, 2009)?

A heterogeneidade da vegetação pode ser considerada como um dos fatores determinantes dos padrões espaciais do pastejo (Bailey et al., 1996; Hirata & Fukuyama, 1997), da resposta funcional dos herbívoros (Laca & Demment, 1990; Laca & Ortega, 1995) e do impacto potencial que o pastejo pode ter como formador das estruturas das comunidades vegetais (Willms et al. 1988; Bailey et al., 1998; Hirata, 1998, 2000; Adler et al. 2001).

Thurow et al. (2009) salientou a importância do conhecimento de como a freqüência de cobertura de espécies indesejáveis afeta o processo de pastejo dos animais em pastagens heterogêneas. Dessa forma, agrupou as principais espécies pertencentes ao estrato superior da pastagem e correlacionou-as com variáveis comportamentais de bovinos, observando alterações no tempo diário de pastejo, número de refeições e de intervalos entre refeições com o aumento no percentual de cobertura do estrato superior. Neste mesmo trabalho, aproximadamente 40% das plantas percententes ao estrato superior apresentaram sinais de pastejo. Neste sentido, estudos de Grant et al. (1985) sobre a composição da dieta e biomassa do pasto mostraram que a quantidade de *Nardus stricta* - espécie perene de hábito cespitoso e fibrosa (Chadwick, 1960) - na dieta de bovinos e ovinos, foi influenciada pela biomassa de forragem verde entre as áreas de touceiras. Esse estudo mostrou que os bovinos ingeriram mais *Nardus* que os ovinos e, também, que a proporção de *Nardus* na dieta de ambas as espécies é inversamente influenciada pela biomassa da vegetação preferida entre touceiras. Na condição de estrato inferior baixo, bovinos têm sua capacidade de seleção reduzida e, em conseqüência, pastejam vegetações de touceiras, enquanto que os ovinos tendem a pastejar seletivamente os *patchs* de estrato baixo na pastagem evitando as espécies de touceiras (Grant et al., 1985; Hodgson et al., 1991; Carvalho et al., 2010a).

Segundo O'Reagain & Schwartz (1995), o animal ao iniciar o pastejo realiza uma avaliação visual da área, buscando estabelecer referências sobre a forragem disponível, tanto em termos qualitativos como quantitativos. Assim, ao alocar uma determinada estação alimentar, ele permanece nesta mesma estação até que a forragem disponível seja inferior à média pré-estabelecida, quando ele passa a deslocar-se em busca de outro local que lhe proporcione um melhor consumo de forragem. No entanto, em pastagens cujo valor nutritivo e disponibilidade não são limitantes, assume-se, muitas vezes, que o tempo de procura por bocados potenciais é insignificante, pois o animal mastiga a forragem enquanto se movimenta de uma estação alimentar para outra (Laca & Demment, 1992; Prache, 1997).

Para comunidades de plantas contendo muitas espécies, é primeiramente necessário adquirir um conhecimento básico dos fatores que afetam o comportamento e as escolhas do animal em pastejo (Gordon, 2000).

Comportamento em pastejo é a área de interface dos cientistas das áreas planta e animal (Gordon & Illius, 1992). Para os cientistas da área animal, a seleção da dieta e a taxa de consumo de nutrientes pelos animais em pastejo são influenciadas pelas condições da pastagem. Por outro lado, para os pesquisadores da área planta, existe uma interação entre as condições da pastagem e do pastejo dos animais que, por sua vez, influencia o consumo de diferentes espécies de plantas (Gordon, 2000).

De fato, o comportamento ingestivo dos herbívoros está intimamente relacionado à estrutura da pastagem, sobretudo às variáveis densidade e altura. A densidade de forragem representa a quantidade de massa da pastagem por unidade de altura, ou seja, a distribuição vertical da massa vegetal. Essa densidade é dependente da arquitetura da planta e da proporção de folhas e colmos (Stobbs, 1973). Para que o animal consiga colher um bocado pesado (condição básica para atingir consumo na capacidade de ingestão), há a necessidade de existir um “perfil” de pastagem com altura e densidade suficientes que permitam a ele a colheita daquela forragem que se está ofertando (Heringer & Carvalho, 2002).

Hodgson et al. (2000) sintetizaram o estado atual de conhecimento sobre o efeito da estrutura da pastagem nas dimensões do bocado: i) A massa do bocado é influenciada fundamentalmente pela resposta da profundidade do bocado à altura do pasto, ou seja, estas variáveis freqüentemente apresentam uma relação de proporcionalidade ao longo de uma ampla variação de alturas de pasto. ii) A área do bocado é menos sensível do que a profundidade do bocado em resposta às características da pastagem. iii) A taxa de bocado, de forma geral, é negativamente relacionada à massa do bocado, indicando o aumento da importância de movimentos mandibulares de manipulação (apreensão e mastigação) à medida que a massa do bocado aumenta. iv) A despeito da associação geralmente negativa entre massa do bocado e taxa de bocado, a taxa de consumo a curto prazo ainda tende a aumentar progressivamente como uma função assintótica da massa do bocado.

Quanto aos parâmetros relacionados à interação planta-animal em ambientes pastoris heterogêneos, Gonçalves et al., (2009) realizou um experimento onde os tratamentos eram compostos por diferentes alturas de manejo do pasto. A taxa de ingestão apresentou resposta quadrática em função da altura, com máximas taxas sendo obtidas com pastos ao redor de 11,4 cm para novilhas e 9,5 para ovelhas, tendendo a diminuir novamente com maiores alturas.

A apreensibilidade da forragem é um atributo do pasto que afeta a velocidade de aquisição de nutrientes pelos animais em pastejo (Carvalho et al., 2005). De forma geral, quanto maior a altura do pasto e maior a massa de forragem, menor é o número de movimentos de apreensão e maior os de mastigação (Penning et al., 1994). Em contrapartida, quanto menor a altura das plantas e mais densa a forragem, menos efetiva é a capacidade dos animais ampliarem a quantidade de forragem trazida até a boca (Laca et al., 1993).

Dessa forma, os animais em pastejo podem empregar diferentes estratégias para aumentar o consumo, seja através da variação da massa do bocado, do aumento da freqüência de bocados ou pelo aumento no tempo de pastejo (Newman et al., 1994). Segundo Hodgson (1990), quando o consumo por bocado é reduzido há uma correspondente queda na taxa de consumo, a menos que haja um aumento compensatório na taxa de bocados. Desse modo, a ingestão diária de forragem também será afetada se qualquer redução na taxa de ingestão não puder ser compensada por um incremento no tempo de pastejo diário (Hodgson, 1990).

Portanto, o animal responde diretamente à estrutura do pasto, obtendo uma velocidade de ingestão elevada quando a massa de forragem é adequada e, como nestas situações uma elevada seletividade lhes é permitida, os animais colhem uma dieta de elevada qualidade de forma rápida (Carvalho & Moraes, 2005).

2. CAPÍTULO II

Grazing choices between different sward strata by cattle and sheep in a native vegetation invaded by *Eragrostis plana Nees*[1]

[1] Artigo elaborado de acordo com as normas da Revista Rangeland Ecology and Management (Apêndice 1).

Grazing choices between different sward strata by cattle and sheep in a native vegetation invaded by *Eragrostis plana Nees*[1]

Abstract

One of the most relevant threats posed to the rangelands of the subtropical regions of South America in this moment is the invasion process of *Eragrostis plana* Nees and, for use the rangelands in a sustainable management, becomes important to understand the interactions among the vegetation and the behavior, intake and diet choices of animals. This study was conducted to understand the impact of tussock's percentages of cover under the grazing choices by heifers and ewes in order to obtain management decisions in rangelands. The grazing paddocks contained different proportions of tussocks in vegetative phenological stage: 0, 25, 50 and 75% of *Eragrostis*, considered as the non-preferred item of the diet. At 1-minute intervals during grazing activity, records were taken whether the animals were grazing on tussock, inter-tussock or intra-tussock strata. The grazing probability of the inter-tussock stratum by heifers decreased from 1.0 to 0.36 from 0% to 100% of tussocks percentage of cover, with proportional increase on tussock's grazing. Ewes reduced their grazing probability of the inter-tussock stratum from 0.95 to 0.52, in the lower to the higher percentage of cover of tussocks; however, they didn't replace all grazing in the inter-tussock stratum by tussocks. Ewes also increased the grazing probability of the intra-tussock stratum, selecting legumes. With 40% and 50% of *Eragrostis* tussock percentage of cover the diet choice by sheep and cattle, respectively, becomes difficult. With 75% of tussock percentage of cover the heifers give up to select the inter-tussock stratum, while ewes were more reluctant to choose the tussocks, independent of the

[1] Parte da tese da primeira autora, como requisito para obtenção do título de Doutor em Zootecnia, área de Concentração Plantas Forrageiras, UFRGS

level of infestation. Finally, cattle and sheep have different spatial scales of perception and selection in heterogeneous vegetations and, therefore, grazing by cattle probably will have a different impact upon rangelands invaded by *Eragrostis plana* Nees.

Keywords: diet selection, percentage of cover of tussocks, grazing behavior, heterogeneity

1. Introduction

The heterogeneity of the rangelands of southern Brazil has been reduced by the annual expansion of the area invaded by *Eragrostis plana* Nees. This tufted perennial grass is avoided by grazing animals, principally by sheep; as a consequence, this specie becomes dominant. *E. plana* has limited palatability and grazing value, high seed production and it's characterized to be a tussocky specie. Carvalho and Batello (2009) consider that among the many threats posed to the rangelands, one of the most relevant in this moment is the invasion process of *E. plana,* with annual expansion rate of 14.000 ha (Ziller, 2005). It is clear that some form of control of this specie should be searched. It is necessary to redirect the focuses exclusively productivist of the researches conducted so far to researches that also have involvement in terms of conservationist and sustainable production. For this, it have been increased the necessity for researching that try to understand the complex interactions between plants and the animals that graze them, as well as how the animal behaves in mosaic pastures. According to Carvalho et al. (2009), for use the rangelands in a productive and sustainable management, should be understood the processes that interact the vegetation and the behavior, intake and diet choices of animals under different management strategies. In this stage, the foraging behavior patterns associated to the vegetation characteristics are primordial to the reorientation of the management strategies that provide high nutrient ingestion by animals, considering that the rangeland has clear economic function.

On plant communities that contain species with different digestibility and preference ranking (e.g., tussocks and intra-tussock strata) it is necessary to acquire a basic knowledge of factors affecting grazing choice or foraging behavior (Gordon, 2000). Grazing cattle have potential to control or reduce non-preferred species and increase the proportion of more nutritious grasses in the community (Armstrong et al., 1997). It has been argued that an increase in cattle and low intensity mixed sheep and cattle grazing may increase the structural diversity of the vegetation, leading to increased biodiversity and the enhanced nature conservation value of hill pastures (Bignal and McCracken, 1996).

The objective of this study was to investigate the interactions between sward composition and foraging behavior in order to understand the factors influencing the impact of tussocks of *Eragrostis plana* Nees on grazing of sheep and cattle.

2. Methods

2.1. Experimental design

The experiment was carried out at the Research Station of the Federal University of Rio Grande do Sul, Brazil (30º05’27’’S, 51º40’18’’W), in a rangeland area invaded by *Eragrostis plana* Nees in southern Brazil, between November and December 2009. The grazing paddocks contained different proportions of tussocks in vegetative phenological stage: 0, 25, 50 and 75% of *E. plana*, considered as the non-preferred item of the diet. Paddocks were 100 m^2 of intra-tussock areas and the area was increased according to the percentage of tussocks of each treatment, taking into consideration that all treatments had the same forage allowance and sward structure of the inter-tussock stratum. The pasture and animal measurements were made on the grazing peaks (during the first and the last grazing meals), that comprised four replicates; two spatial replicates (paddocks) and two replicates in time (measurement periods).

2.2.Botanical composition

The botanical composition of each measurement area was determined prior to the first grazing period. Field observations showed the inter-tussocks areas (IT) to be predominantly composed of grass - *Axonopus afinnis, Cynodon dactylon, Paspalum nicorae, Paspalum notatum, Andropogon lateralis, Coelorachis selloana* and *Dichanthelium sabulorum* - and the legume *Desmodium incanum.* Tussock (T) vegetation was predominantly (>95%) *Eragrostis plana* Nees. The vegetation intra-tussocks (INT) was predominantly composed by *Desmodium incanum.*

2.3.Sward characteristics

In an adjacent area of the experiment, previous grazing tests were performed to define the inter-tussock area of the treatments. During the grazing tests, the sward height of the preferred inter-tussock area was measured every ten minutes using a sward stick. The inter-tussock area of the experimental units was defined as the minimal area necessary to the post-grazing sward height did not reduce more than 10% of the pre-grazing sward height during the 45 minutes of the grazing tests and, as resulting of these tests, the minimal area considered was 100m^2.

Previous grazing were used as adjustments of sward heights several months prior to the start of the experiment. At the experimental units the sward height of the preferred inter-tussock vegetation was controlled, maintaining it at predetermined heights throughout the grazing periods. The sward height and herbage mass were determined separately for the *Eragrostis* tussocks and the inter-tussock areas of the sward. The sward height of the inter-tussock vegetation was estimated by 100 pre- and 100 post-grazing measurements using a sward stick. For the estimation of the tussocks height, there were made pre- and post-grazing measurements according to the percentage of cover of tussocks (e.g. in the treatment with 50% of tussocks the mean tussock height was estimated by 50 pre- and 50 post-grazing measurements using a sward stick).

For the herbage mass measurement, six quadrants (0.5m x 0.5m; three in tussock and three in inter-tussock areas) by paddock were cut at ground level. After harvesting, each sample was weighed to determine total fresh weight and then oven dried at 60°C for 48 h to determine dry matter (DM) content.

2.4.Actual percentage of cover of tussocks

All the area was divided in jointly quadrats of 1m x 1m and thereby, the percentage of cover of tussocks inside each quadrat was visually estimated. Therefore, it was mapped the total percentage area cover by *Eragrostis*, as well as the total percentage area cover by the plants belonging to the inter-tussock stratum of the pasture. After obtaining the actual percentage of cover of tussocks in all experimental area, it was design the position of each experimental unit area, in order to obtain different proportions of tussocks as nearest possible than 0, 25, 50 and 75%. To obtain similar proportions of tussocks to the predetermined values, when necessary, it was removal the excess of tussocks using a hoe.

2.5.Animals

A total of four heifers, crossbred (Angus x Brahman), weighing 286.7 ± 1.2 kg and 12 adult ewes, Suffolk, weighing 51.0 ± 0.72 kg were used. The heifer’s evaluation was proceeded between 16 November and 4 December 2009, while for the ewes it was proceeded between 10 and 18 December 2009. The same group of four heifers grazed in all the experimental units, while for the ewes two groups of six animals were evaluated separately, where each ewe grazed each treatment two times. To increase the number of animals, two ewes were added in each group of four “tester” animals (Penning et al., 1993) to allow no effect of the group size under the grazing time (Carvalho, 1997).

For approximately 30 days prior to the start of the experiment the ewes and heifers grazed separately on areas that had similar sward characteristics as the experimental area. During this period the animals were trained to become familiar to the presence of observers and the behavior equipments.

2.6.Foraging behavior measurements

At 1-minute intervals during grazing activity (total of 45 minutes), records were taken whether the animals were grazing on tussock, inter-tussock or intra-tussock strata. Also it was recorded the exactly location of the animals in the paddock. Two observers recorded the position and the grazed stratum by the animals on a scaled map of the plot. On the grazing periods, at least four animal of the grazing group were using behavior recorders, used to record the grazing time and jaw movements (Rutter et al., 1997). During the grazing evaluations, the animals were non-fasted to ensure their normal behavior activities.

2.7.Selectivity

Selectivity was defined as the ability to exhibit selection of a preferred forage (inter-tussock stratum) when given more options of contrasting vegetation (tussock percentages of cover). Selectivity (S) was considered when the animal chose the smaller tussock percentage of cover available in the surrounding neighbourhood. When the animal did not choose the smaller tussock percentage of cover available in the surrounding neighbourhood, it was considered non-selectivity (N).

2.8.Statistical analysis

Firstly, it was realized nominal logistic analysis of variance by χ^2 test that included the effects of percentage of cover of tussocks at patch level, percentage of cover of tussocks at bite level, the interaction between both levels of evaluation and the animal effect. There were no effect of the interaction between the percentage of cover of tussocks at patch and at bite level (P=0.339). The effect of the percentage of cover of tussocks at bite level (P<0.001) was much larger (6.6 times) than the effect at patch level, therefore, the model fitted included only the effects for tussock percentage of cover at bite level and for differences between the animals of the evaluation group. It was utilized logistic regression to fit the probabilities of grazed stratum and selectivity in relation to the percentage of cover of tussocks (P<0.05). Nominal logistic regression estimates the probability of choosing one of the response levels as a smooth function of the x factor. The grazing probabilities in the sward strata were calculated by the relation between the observed grazed stratum by animal and the available tussock percentage of cover at each 1-minute interval evaluated. The most likely response was based on the computed probabilities of the most likely level of each interval evaluated. A variance homogeneity test (Levene's test) was realized to detect differences between the animal's species for the sward characteristics (P<0.05). Statistical tests were carried out using JMP version 8 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1. Sward characteristics

There were no significant differences (*P*<0.05) between the values of sward height and herbage mass for the inter-tussock and tussock strata among the treatments. The mean sward heights of the inter-tussock and tussock areas grazed by the heifers were 10.3 ± 0.3 and 40.4 ± 1.1 cm and for the ewes were 10.5 ± 0.3 and 44.2 ± 1.3 cm, respectively. The mean herbage mass grazed by the heifers at the inter-tussock and tussock stratum was 2.9 ± 0.2 and 20.4 ± 1.9 Mg DM ha^{-1}, respectively. For ewes the mean herbage mass at the inter-tussock and tussock stratum were 2.3 ± 0.4 and 18.9 ± 1.4 Mg DM ha^{-1}, respectively. The proportion of the total area represented by the tussocks on the four treatments was 2.5 ± 0.3, 26.6 ± 1.7, 45.8 ± 1.6 and 69.8 ± 1.2, respectively (Fig. 1).

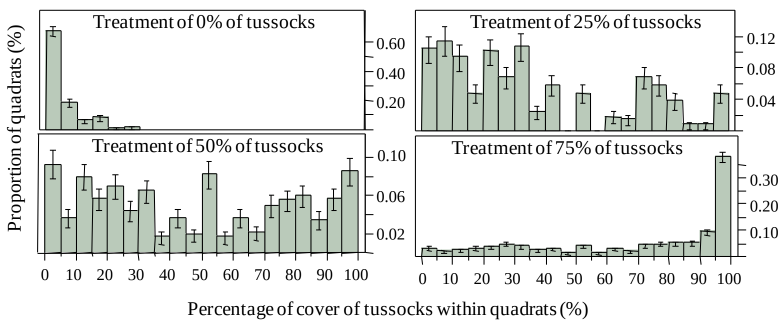

Figure 1. Tussock distribution, expressed in proportion of quadrats (%), in the treatments of 0, 25, 50 and 75% of tussocks of *Eragrostis plana* Nees in relation to the percentage of cover of tussocks within the quadrats

3.2. Foraging strategies

Both heifers and ewes decreased the probability of grazing the inter-tussock stratum and increased the probability of grazing the tussocks with the increase on the tussock percentage of cover. The grazing probabilities of the inter-tussock stratum by heifers fit to the quadratic regression model (Prob[IT] = 1.0 - 0.006x - 4.21e-5x^2; R^2 =

0.955; SE= 0.05; *P*<0.0001; Fig. 2a). For the ewes, besides the inter-tussock and tussock strata, it was observed a third grazed stratum, the legumes inside the tussocks (composed principally by *Desmodium incanum*), with increase on the grazing probability of this stratum with the increase on the tussock percentage of cover. The best polynomial fit were: Prob[IT] = 0.95 - 0.004x - 2.89e-5x^2; R^2 = 0.806; SE = 0.08; *P*<0.0001; Prob[INT] = 0.02 + 0.001x + 5.74e-6x^2; R^2 = 0.595; SE = 0.04; *P*<0.0001 and Prob[T] = 0.02 + 0.003x + 2.31e-5x^2; R^2 = 0.843; SE = 0.05; *P*<0.0001 (Fig. 2b).

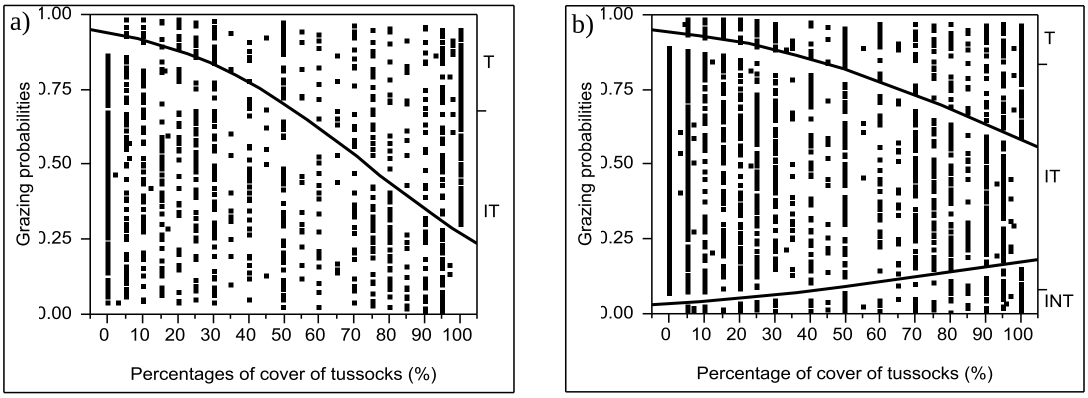

Figure 2. Grazing probabilities of beef heifers (a) and ewes (b) on the tussock (T), inter-tussock (IT) and intra-tussock (INT) strata in relation to the tussock percentages of cover (%; each point correspond to an observation of grazing event within a quadrat)

3.3.Selectivity

There were no significant differences (*P*>0.05) between the values observed for the probability of selection of heifers on the tussock’s percentages of cover (Fig. 3a). In the other hand, the ewes decreased linearly their probability of selection with the increase on the tussock’s percentage of cover (Prob[S] = 0.75 – 0.002x; R^2 = 0.999; SE = 0.002; *P*<0.0001; Fig. 3b).

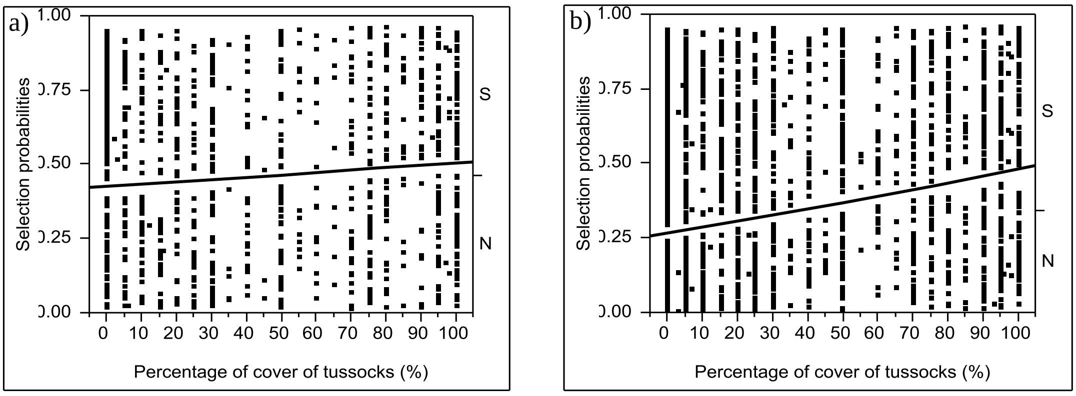

Figure 3. Selection probabilities (S – selectivity; N – non-selectivity) of beef heifers (a) and ewes (b) submitted to different tussock's percentages of cover (%; each point correspond to an observation of grazing event within a quadrat)

3.4.Most likely grazed stratum

With 50% of tussock percentage of cover the beef heifers start to most likely grazed the tussocks (probability of 0.01), and with 75% of tussock percentage of cover the heifers give up to select the inter-tussock stratum (Fig. 4a). On the other hand, ewes perceive the high difficulty in the selection of the inter-tussock stratum when the tussock percentage of cover reaches levels of 40% (probability of 0.01), however, they are more reluctant to the tussock grazing and started to most likely graze the tussocks in lower intensity when comparing with heifers (Fig. 4b).

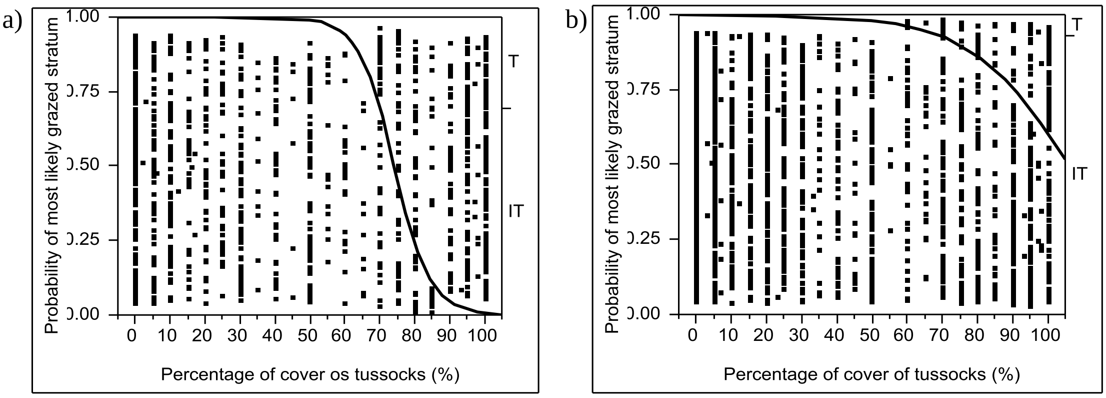

Figure 4. Probabilities of most likely grazed stratum (T – tussock; IT – inter-tussock) of beef heifers (a) and ewes (b) submitted to different tussock's percentages of cover (%;each point correspond to an observation of grazing event within a quadrat)

4. Discussion

4.1. Sward characteristics

In order to the sward height of the inter-tussock stratum be similar among treatments and non-limiting to the animal’s intake rate, it was assumed a predetermined sward height of 11.4 cm to heifers and 9.5 cm to ewes (Gonçalves et al., 2009). The obtained values of sward heights of the inter-tussock stratum in this study were 10.3 and 10.5 for beef heifers and ewes, respectively. Those values can be considered not limiting to the intake rate of both cattle and sheep. According to the equation defined by Gonçalves et al. (2009), in relation to the dry matter intake rate potential of sheep, the sward height observed could provide 99.1% of the potential intake rate. For cattle, the estimated dry matter intake rate to the sward height of 10.3 cm would represent 99.0% of the potential values defined by Gonçalves et al. (2009).

It was made variance homogeneity test to the sward variables in order to test if the heifers and ewes had the same conditions of sward height and herbage mass. For the pre-grazing sward height of the inter-tussock stratum, it was observed variance homogeneity (P>0.05), in other words, both animal species had the same sward characteristics to graze. However, the herbage mass and the post-grazing sward height of the inter-tussock stratum were not homogeneous (P<0.05), which indicate differences in dietary choice between cattle and sheep (Grant et al., 1985, Armstrong et al., 1997, Fraser et al., 2009, Fig. 2). Thus, only the pre-grazing sward height of the inter-tussock stratum could be considered similar between the animal’s species. For the tussock stratum, all sward variables were homogeneous and thereby can be considered similar for the heifers and ewes.

In relation to the tussock distribution, there was a clear variation in the tussock percentage of cover in the treatments 25, 50 and 75% of tussocks, with values ranging between 0% and 100% of tussocks (Fig. 1). It could be expected that animals would graze the tussocks only due to some restriction imposed in the higher tussock percentages of cover, in other words, when the intake rate for the preferred species was constrained. Results of Grant et al. (1996) confirmed the importance of height or mass of the preferred sward component in determining the level of offtake of the non-preferred vegetation. However, the sward height and herbage mass of the inter-tussock stratum - preferred component - was not limiting in this study. Thus, both cattle and sheep could manifest their grazing choices. The considerable variation on the tussock percentage of cover inside the paddocks allowed the manifest of the selectivity by the animals (Fig. 3). This premise is supported by the reports of WallisDeVries et al. (1999) and latter by Gregorini et al. (2009), who argued that the greatest potential for selection appeared to exist in the choice of feeding stations and, in this case, in the choice of a bite.

4.2.Foraging strategies of sheep and cattle

In complex vegetation communities, as rangelands, the animal obtain a diet much superior in nutrients than the average available in the environment, in other words, they explore in a positive form the vegetal heterogeneity (Bailey, 2005). Knowing that the pasture structural modifications are complicating of the animal's foraging strategies, how the animal would react to the increase of the percentage of cover of the less-preferred species, i.e. the tussocks (Mezzalira, 2009)? This work suggested that there were notable differences between foraging strategies of cattle and sheep. In particular, it was suggested that cattle are less selective grazers than sheep, and will consume significant quantities of invasive grasses such as *Eragrostis*, such as *N. stricta* and *M. caerulea* (Grant et al., 1985, Armstrong et al., 1997, Fraser et al., 2009). The grazing probability of the inter-tussock stratum by heifers decreased from 1.0 in the 0% of tussocks to 0.36 in the higher level of tussock percentage of cover. This reduction of grazing in the inter-tussock stratum was totally replaced by the grazing on tussocks. Ewes reduced their grazing probability of the inter-tussock stratum from 0.95 in the lower level of tussock's percentage of cover to 0.52 in the higher percentage of cover of tussocks; however, they didn't replace all grazing in the inter-tussock stratum by the tussocks. With the increase on the tussock percentage of cover, ewes increased the grazing probability of the intra-tussock stratum, which reached the value of 0.13 with 100% of tussock percentage of cover. According to Gong et al. (1996), when sheep encounter feed where a marked heterogeneity in quality exists, selective grazing for high-quality components is their primary strategy. Therefore, the grazing probability of the tussocks by ewes was low (0.34) when comparing with the heifers (probability of 0.64). Results of Grant et al. (1996) comparing cattle with sheep grazing at sward heights maintained at 4.5 cm also confirms the greater readiness of cattle compared with sheep to graze tufted species.

During the current study, there was a clear difference in the response of the two animal species to tussocks, with the sheep having a lower preference for tussocks and selecting more the inter-tussock stratum. Sheep also grazed the intra-tussock stratum, selecting legumes inside the tussocks. This may reflect the greater selective ability of the sheep, as they have the potential to remove plant parts with a higher nutritional value, such as new green shoots and flowerheads, from particular plant species (Fraser et al., 2009).

Cattle are generally unselective grazers within a plant community and will graze tussock vegetation, whereas sheep tend to graze selectively from the base of the sward avoiding the tussock species (Grant et al., 1985, Hodgson et al., 1991, Common et al., 1998, Holland et al., 2008). Indeed, ewes were more selective than heifers. The selection probability of heifers ranged between 0.57 and 0.50 from 0 to 100% of tussocks (P>0.05), while for ewes the selection probability reduced from 0.75 to 0.55 from the lower to the higher percentage of cover of tussocks. The selection choices for both cattle and sheep are difficult in heterogeneous vegetations, with complex structure and a mixture of preferred (inter-tussock) and avoided (tussocks) strata. However, cattle are more affected by the difficult in select the preferred stratum in the higher tussock percentages of cover. Laca et al. (2010), evaluating each level of the grazing hierarchy - patches, paths, feeding stations, bites and intake - observed that smaller herbivores (sheep) exhibit higher selectivity than larger ones (cattle) at all scales of observation.

Foraging theory predicts that selectivity increases with increasing difference in profitability (e.g. nutrient intake) among options (Utsumi et al., 2009). When patch encounter rate declines, selectivity is also expected to decline (Stephens and Krebs, 1986), fact observed for the ewes in this study. Following this thinking, Rutter (2006) suggests the hypothesis that ruminants eat mixed diets in order to balance the supply of nutrients (principally C and N) to the rumen so as to optimize the efficiency of microbial protein synthesis. If this hypothesis is correct, it will have major implications for improving the efficiency of production on-farm by utilising grazing management strategies that facilitate diet choice by livestock. In this work, with 40% and 50% of *Eragrostis* tussock's percentage of cover on pasture the diet choice by sheep and cattle, respectively, becomes difficult. This fact is proved because both heifers and ewes start to most likely graze the tussocks, the non-preferred stratum available in the sward. Probably, from that tussock's percentage of cover the animals perceive the high cost of searching by the preferred stratum (Roguet et al., 1998) and start to graze the tussocks.

With 75% of tussock percentage of cover the heifers give up to select the inter-tussock stratum, when the probability of most likely grazed stratum becomes lower than 0.50. From this level of tussock percentage of cover, the selection of preferred forage becomes constrained by environmental and physiological trade-offs (Parsons et al., 1994). On the other hand, ewes were more reluctant to choose the tussocks and, with 75% of tussock percentage of cover – critical point to the heifers - the probability of most likely grazed the tussocks were still insignificant (0.10). With 100% of tussock percentage of cover, the most likely grazed stratum probability of heifers was 1.0 for tussocks, while ewes still rejected the tussocks, with higher probability of most likely grazed inter-tussock stratum when comparing to the tussocks (0.60 *vs* 0.40).

Finally, cattle and sheep have different spatial scales of perception and selection in heterogeneous landscapes (Laca et al., 2010), and, therefore, grazing by cattle has a different impact upon the vegetation (Hodgson and Grant, 1981). The increased use of the grazing animals as a tool to promote and maintain plant biodiversity is a way to achieve environmental benefits (Rook et al., 2004). However, traditional grazing management schemes are not based on a mechanistic understanding of the grazing process and, therefore, have not evolved to keep up with the changing needs of ecosystem management (Utsumi et al., 2009). Enhancing and maintaining biodiversity is an integral part of conservation and herbivory affects biodiversity by influencing the structure and dynamics of plant and animal communities (Papachristou et al., 2005).

5. Implications

With 40% of tussock's percentage of cover ewes perceive the major difficult in the selection of the inter-tussock stratum and start to most likely graze the tussocks, however, in low intensity. On the other hand, from 50% of tussocks heifers start to most likely graze the tussocks, being the critical point of 75% of tussock percentage of cover. This result implies that beef heifers give up to select the inter-tussock stratum in rangelands with high levels of invasion of *Eragrostis*. As a consequence, where rangelands are grazed by sheep alone, *Eragrostis* will probably become dominant.

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3. CAPÍTULO III

Effects of vegetation heterogeneity on movement patterns of beef heifers and ewes at grazing[1]

[1] Artigo elaborado de acordo com as normas da Revista Ecology (Apêndice 2).

Effects of vegetation heterogeneity on movement patterns of beef heifers and ewes at grazing[1]

Abstract

In heterogeneous vegetations, animals have to take a series of decisions to efficiently obtain the necessary nutrients to their requirements and thereby, their grazing strategies may affect vegetation diversity. The hypotheses of this study were 1) in heterogeneous vegetation, with different percentage of cover of tussocks, the movement patterns of cattle and sheep are distinct and 2) there is an infestation level of tussocks of *Eragrostis plana* Nees from wich the movement strategies of both cattle and sheep change from selective to random. The grazing paddocks contained different proportions of tussocks in vegetative phenological stage: 0, 25, 50 and 75% of *E. plana*, considered as the non-preferred item of the diet. With 50% of tussock percentage of cover, the movement patterns of heifers start to be more correlated with the tussock stratum. On the other hand, ewes continued selecting the inter-tussock and intra-tussock stratum, even in the higher tussock's percentages of cover. Overall, ewes were more reluctant in grazing the tussocks when comparing with heifers. From 0 to 45% and from 0 to 50% of tussocks for sheep and cattle, respectively, the chosen direction by animals had lesser tussock's percentage of cover than the average available on vegetation, in other words, both heifers and ewes presented active selection. However, after values of 45% and 50% of tussock's percentage of cover for ewes and heifers, respectively, the animals start to choose directions with similar percentage of cover of tussocks than the average available, thus, from these tussock's percentages of cover, they presented indifference selection and random grazing process. Although presenting random grazing and low effective encounter rate of the inter-tussock stratum in higher tussock's percentages of

[1] Parte da tese da primeira autora, como requisito para obtenção do título de Doutor em Zootecnia, área de Concentração Plantas Forrageiras, UFRGS

cover, ewes could select the inter-tussock areas available among the tussocks and, furthermore, they were capable to select the legumes in the intra-tussock stratum. Therefore, in a rangeland infested by *Eragrostis plana* Nees, probably the grazing by sheep would decrease the spatial heterogeneity of the vegetation, while the grazing by heifers would probably maintain the vegetation in the same state of infestation, considering that the heifers graze the tussocks in the higher tussock's percentages of cover.

Keywords: *Eragrostis plana* Nees, plant diversity, random search strategies, selectivity, percentage of cover of tussocks

1. Introduction

In rangelands, a grazing ruminant is confronted with a complex food source that is heterogeneous in both spatial and temporal dimensions, and contains many different plant species (Soder et al. 2009). Therefore, the animals are forced to take a series of decisions to efficiently obtain the necessary nutrients to their requirements, identifying patterns of behavior, which are known as feeding or foraging strategy (Gordon and Illius 1992). It is from the use of foraging strategies at their disposal, that the animals exploit in a positive way the natural heterogeneity of the grazing environment (Laca and Demment 1991).

To grazing animals, heterogeneity means spatial variation in available forage mass, its quality and its accessibility on various spatial scales (Drescher 2003), and thereby, the spatial arrangement of plants across scales can strongly affect the foraging behavior of both sheep and cattle (Laca et al. 2010). Although the mechanisms by which herbivores perceive and respond to such patchiness remain uncertain, it is clear that mammalian herbivores demonstrate high variability in spatial patterns of resource use (Bailey et al. 1996, Fryxell et al. 2005).

From a practical or management perspective, an important issue is the relationship between spatial heterogeneity and biodiversity (Adler et al. 2001). Grazing can affect plant diversity by creating environmental heterogeneity at different spatial scales (McNaughton 1983, Sommer 2000), and these responses are dependent of the animal species. Changes in spatial heterogeneity caused by grazing animals can also imply in changes in habitat diversity, and influence the diversity of consumers ranging from insects to birds and mammals (Smith 1940, England and DeVos 1969, Grant et al. 1982, Bock et al. 1984, Dennis et al. 1998). Thus, to use grazing as a management tool for habitat diversity, we must be able to predict when grazing will increase rather than decrease spatial heterogeneity (Adler et al. 2001). For this, it is useful to explore how what we have learned about the smallest scale process in foraging - taking a bite - informs us about foraging at larger scales (Shipley 2007). Selective grazing, for example, can occur at the scale of a bite, feeding station, patch or feeding site (Bailey et al. 1996), and can affect the spatial heterogeneity of vegetation. Thus, the understanding of how cattle and sheep respond to the spatial distribution of heterogeneous vegetation through of their movement patterns can represent an important strategy to improve the forage utilization and, consequently, the vegetation diversity.

We test the hypotheses that 1) in heterogeneous vegetation, with different percentage of cover of tussocks, the movement patterns of cattle and sheep are distinct and 2) there is an infestation level of tussocks of *Eragrostis plana* Nees from wich the movement strategies of both cattle and sheep change from selective to random grazing.

2. Methods

Fieldwork was performed at the Research Station of the Federal University of Rio Grande do Sul, Brazil (30º05’27’’S, 51º40’18’’W), in a rangeland area invaded by *Eragrostis plana* Nees in southern Brazil, from 16 November to 16 December 2009.

2.1.Experimental design

The grazing paddocks contained different proportions of tussocks in vegetative phenological stage: 0, 25, 50 and 75% of *E. plana*, considered as the non-preferred item of the diet. Paddocks were 100 m^2 of intra-tussock areas and the area was increased according to the percentage of tussocks of each treatment, taking into consideration that all treatments had the same forage allowance and sward structure of the inter-tussock stratum. The pasture and animal measurements were made on the grazing peaks (during the first and the last grazing meals), that comprised four replicates; two spatial replicates (paddocks) and two replicates in time (measurement periods).

2.2.Sward

Field observations showed the inter-tussocks areas (IT) to be predominantly composed of grass - *Axonopus afinnis, Cynodon dactylon*, *Paspalum nicorae, Paspalum notatum, Andropogon lateralis, Coelorachis selloana* and *Dichanthelium sabulorum* - and the legume *Desmodium incanum.* Tussock (T) vegetation was predominantly (>95%) *Eragrostis plana* Nees. The vegetation intra-tussocks (INT) was predominantly composed by *Desmodium incanum.*

In an adjacent area of the experiment, previous grazing tests were performed to define the inter-tussock area of the treatments. During the grazing tests, the sward height of the preferred inter-tussock area was measured every ten minutes using a sward stick. The inter-tussock area of the experimental units was defined as the minimal area necessary to the post-grazing sward height did not reduce more than 10% of the pre-grazing sward height during the 45 minutes of the grazing tests and, as resulting of these tests, the minimal area considered was $100m^2$.

Previous grazing were used as adjustments of sward heights several months prior to the start of the experiment. At the experimental units the sward height of the preferred inter-tussock vegetation was controlled, maintaining it at predetermined heights throughout the grazing periods according to Gonçalves et al. (2009). The sward height and herbage mass were determined separately for the *Eragrostis* tussocks and the inter-tussock areas of the sward. The sward height of the inter-tussock vegetation was estimated by 100 pre- and 100 post-grazing measurements using a sward stick. The mean sward heights observed for the inter-tussock areas grazed by the heifers were 9.5, 9.9, 10.0 and 10.7 cm and for the ewes were 9.3, 10.2, 10.7 and 10.3 cm, on treatments 0, 25, 50 and 75% of tussock percentage of cover, respectively. For the estimation of the tussock's height, there were made pre- and post-grazing measurements according to the percentage of cover of tussocks (e.g. in the treatment with 50% of tussocks the mean tussock height was estimated by 50 pre- and 50 post-grazing measurements using a sward stick). The mean sward heights of the tussock areas grazed by the heifers were 37.3, 38.5 and 42.1 cm and for the ewes were 42.5, 46.9 and 43.7 cm, on treatments 25, 50 and 75% of tussock percentage of cover, respectively.

For the herbage mass measurement, six quadrants (0.5m x 0.5m; three in tussock and three in inter-tussock areas) by paddock were cut at ground level using a hedge-trimmer. After harvesting, each sample was weighed to determine total fresh weight and then oven-dried at 60°C for 48 h to determine dry matter (DM) content. The mean herbage mass grazed by the heifers at the inter-tussock and tussock stratum were 2.8 and 0.0, 2.8 and 21.8, 3.1 and 19.3 and 2.7 and 22.4 Mg DM ha^{-1} for treatments 0, 25, 50 and 75% of tussock percentage of cover, respectively. For ewes the mean herbage mass observed for the inter-tussock and tussock stratum were 2.0 and 0.0, 2.5 and 20.7, 2.6 and 16.8 and 2.2 and 19.2 Mg DM ha^{-1}, respectively.

2.3.Actual percentage of cover of tussocks

All the area was divided in jointly quadrats of 1m x 1m and thereby, the percentage of cover of tussocks inside each quadrat was visually estimated. Therefore, it was mapped the total percentage area cover by *Eragrostis*, as well as the total percentage area cover by the plants belonging to the inter-tussock stratum of the pasture. After obtaining the actual percentage of cover of tussocks in all experimental area, it was design the position of each experimental unit area, in order to obtain different proportions of tussocks as nearest possible than 0, 25, 50 and 75%. To obtain similar proportions of tussocks to the predetermined values, when necessary, it was removal the excess of tussocks using a hoe.

2.4.Animals

A total of four heifers, crossbred (Angus x Brahman), weighing 286.7 ± 1.2 kg and 12 adult ewes, Suffolk, weighing 51.0 ± 0.72 kg were used. The heifer's evaluation was proceeded between 16 November and 4 December 2009, while for the ewes it was proceeded between 10 and 18 December 2009. The same group of four heifers grazed in all the experimental units, while for the ewes two groups of six animals were evaluated separately, where each ewe grazed each treatment two times. To increase the number of animals, two ewes were added in each group of four "tester" animals (Penning et al. 1993) to allow no effect of the group size under the grazing time (Carvalho 1997).

For approximately 30 days prior to the start of the experiment the ewes and heifers grazed separately on areas that had similar sward characteristics as the experimental area. During this period the animals were trained to become familiar to the presence of observers and the behavior equipments.

2.5.Grazing movement patterns

Two observers recorded the position and grazed stratum (tussock, inter-tussock and intra-tussock) by the animals on a scaled map of the paddock at 1-minute intervals during grazing activity (total of 45 minutes). During the grazing evaluations, the animals were non-fasted to ensure their normal behavior activities. A digital map measurer was used on these maps to determine the available percentage of cover of tussocks in the directions chosen by animals. However, only movements at one feeding station scale were used in the calculations, in other words, there were not included situations where the animals have moved to locations more distant than 1m. It was used this criterion of evaluation because in situations that the animals had moved to a farter location, it would not possible to define the exact reason for this movement pattern. Thus, the model considered reflects that the decisions of animals to move to a new location are based on visual assessment of the tussock percentage of cover available in a surrounding neighbourhood (Fig. 1).

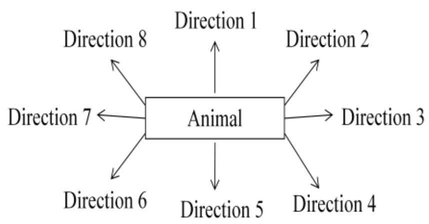

Figure 1. Possible directions chosen by animals in the surrounding neighbourhood locations, according to the position of the animal (the direction 1 was considered when the animal moved forward, direction 5 was to go back, direction 3 was to turn right and direction 7 to turn left)

2.6.Encounter rate of the inter-tussock stratum

The potential encounter rate was calculated according to the forage allowance of the preferred grazed stratum (inter-tussock stratum), considering that in all percentage of cover of tussocks the area cover by the inter-tussock stratum had 100 m^2. Theoretically, it was assumed that with the increase on the percentage of cover of tussocks, animals would have to increase their total displacement to encounter the same area of available preferred stratum. On the other hand, the effective encounter rate corresponds to the relation between the total displacement observed for the animals and the available area of the inter-tussock stratum. Posteriorly, both potential encounter rate and effective encounter rate were expressed in percentage values.

2.7.Statistical analysis

Firstly, it was realized variance homogeneity test (Levene's test) to detect differences in the foraging behavior between the animal's species in the tussock percentages of cover (P<0.05). Statistical tests to determine the effects of movement patterns and animal species were carried out using JMP version 8 (SAS Institute Inc., Cary, NC, USA). When parametric tests were used, assumptions were checked, and transformations were used when necessary. For the variable inter-tussock encounter rate of ewes, it was made log transformation. When transformations were unsuccessful, nonparametric tests were used. Canonical correlations were used to analyse the grazing movement patterns of the animals in the neighbourhood locations. Bivariate fit with smoothing spline equation was used to analyse the chosen direction of animals in relation to the available tussock percentage of cover (P<0.05).

3. Results

3.1.Actual percentage of cover of tussocks

On treatment 0% of tussocks there were observed some locations with percentage of cover of tussocks ranging between 5 and 20%, which determined the mean actual percentage of cover of tussocks of 2.5 ± 0.3. On the other hand, on treatments 25, 50 and 75% of tussocks, there were observed values of tussock percentage of cover ranging from 0 to 100%. On treatment 25% of tussocks, 46% of the paddock's area had tussock percentages of cover between 0 and 25% and only 17% of the area had tussock's percentages of cover ranging between 75 and 100%. For the treatment 50% of tussocks, the area cover by low tussock's percentages of cover (between 0 and 25% of tussocks) decreased to 34%, while the locations with tussock percentages of cover ranging from 0 to 100% increased to 28% of the paddock's area. On treatment 75% of tussocks, only 13% of the paddock's area was cover by tussock percentages of cover between 0 and 25%. On the other hand, there were observed that 61% of the paddock's area was cover by tussock percentages of cover ranging from 75 to 100%. In mean, the actual percentage of cover of tussocks were 26.6 ± 1.7, 45.8 ± 1.6 and 69.8 ± 1.2, respectively for the treatments 25, 50 e 75% of tussocks.

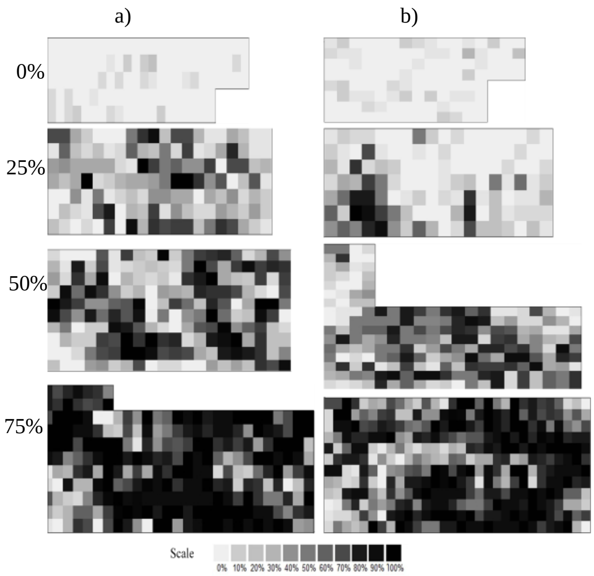

Figure 2. Actual tussock's percentage of cover (%) of the experimental units (a - paddock 1, b – paddock 2) in the treatments 0, 25, 50 and 75% of tussocks of *Eragrostis plana* Nees

3.2.Grazing movement patterns

With 0% of tussock percentage of cover, the heifers did not present a pattern of direction's choice in relation to the available directions in the surrounding neighbourhood (Fig. 3). With 25% of tussock percentage of cover, the animals had preference by the directions 3 and 6, characterized by lower tussock's percentages of cover. With 50% of tussock's percentage of cover, the movement patterns of heifers start to be more correlated with the tussock stratum. In this treatment, the animals had preference by the directions 1, 3 and 7, characterized by intermediary percentages of cover of tussocks. With 75% of tussock percentage of cover, the heifers chose preferably the directions 1 and 6, also characterized by had intermediary percentage of cover of tussocks.

For ewes, on the other hand, on treatment 0% of tussocks the more frequently chosen direction was the direction 1, in other words, the front direction. On treatment 25% of tussocks, ewes did not present a pattern of direction’s choice in relation to the available directions. With 50%, ewes still grazed principally the inter-tussock stratum, being the direction 1 the more frequently chosen direction, characterized by being more correlated with the intra-tussock stratum in this treatment. With 75% of tussock’s percentage of cover, ewes did not present a pattern of direction’s choice, however, they still select the higher percentages of cover of the inter-tussock and intra-tussock strata.

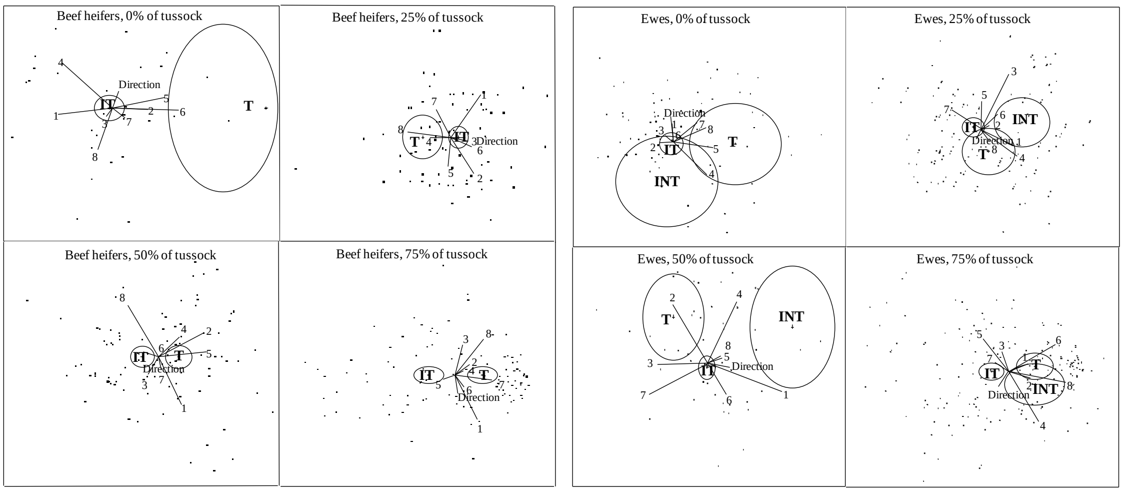

Figure 3. Canonical correlations for the available directions (from 1 to 8), chosen direction and the grazed stratum (IT – inter-tussock, INT – intra-tussock and T – tussock stratum) of heifers and ewes under different tussock’s percentages of cover (0, 25, 50 and 75%) of *Eragrostis plana* Nees

3.3.Encounter rate of the inter-tussock stratum

The solid line, upper in the figure (Fig. 4), represents the potential response considered for the preferred sward stratum in relation to the increase on the percentage of cover of tussocks. To achieve the same level of occupation of the inter-tussock stratum, the animals should increase their displacement proportional to the increase on the percentage of cover of tussocks. However, the effective encounter rate of the inter-tussock stratum presented a linear decrease for both heifers and ewes with the increase on the percentage of cover of tussocks.

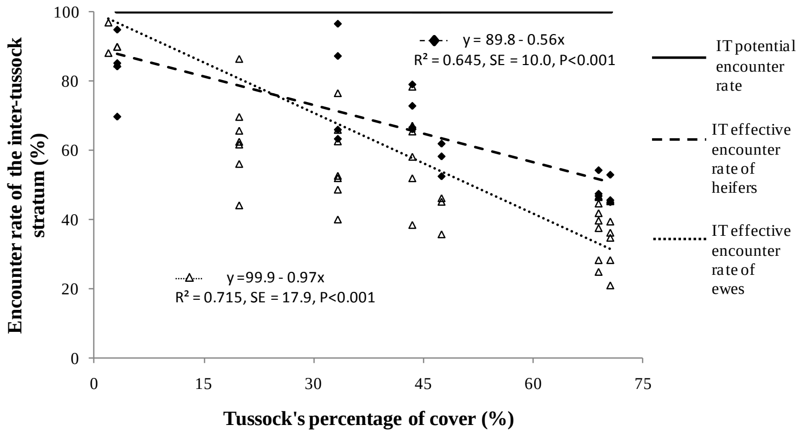

Figure 4. Effective encounter rate of the inter-tussock stratum by heifers and ewes under different tussock's percentages of cover (0, 25, 50 and 75%) of *Eragrostis plana* Nees

3.4.Chosen directions

The chosen directions by heifers and ewes in relation to the average of tussocks available in the surrounding neighbourhood showed that there is a level of tussock percentage of cover from which the grazing choices of both animal species become difficult (Fig. 5). When the percentage of cover of tussocks reaches 50% and 45% for heifers and ewes, respectively, the animals start to choose directions with similar percentage of cover of tussocks than the average available, indicating a random grazing process. The value of percentage of cover of tussocks from which the animals start to graze at random was visually defined, considered when the mean observed values for chosen direction, represented by the fit line, were similar or superior to the available tussock's percentage of cover.

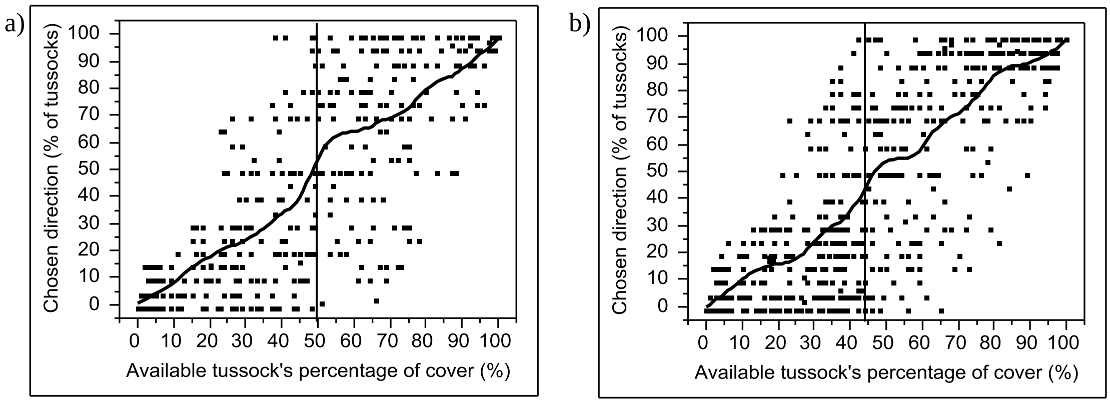

Figure 5. Chosen direction of beef heifers (a) and ewes (b), expressed in percentage of cover of tussocks (%), in relation to the available tussock's percentage of cover (%) of *Eragrostis plana* Nees in the surrounding neighbourhood

4. Discussion

On the lower tussock percentage of cover, the heifers did not present a pattern of preferred direction's choice, in due to the high forrage availability, non-limiting for the utilisation of resources, being that the random movements are efficient to encounter the available resources. According to Knegt et al. (2007), the animal's movement paths become more tortuous in high patch densities, resulting in shorter steps and larger turning angles. With 25% of tussock's percentage of cover, the animals had preference by the directions 3 and 6, characterized by lower tussock percentages of cover. We can observed that the preferred directions were contrary to the directions 4 and 8, in that case, these directions are characterized by grazing on the tussock stratum. This result indicates that in this tussock's percentage of cover, the heifers still present active selection (Parsons et al. 1994) for the inter-tussock stratum. On the other hand, with 50% of tussock's percentage of cover, the movement patterns of heifers start to be more correlated with the tussock stratum. When making grazing decisions in heterogeneous vegetation, one of the rules for animals is to select tall swards (tussocks) over short swards (inter-tussock stratum; Black and Kenney 1984, Arnold 1987, Bazely 1990). In this treatment, the heifers start to move to front and to both sides, perhaps in a strategy of trying to deviate from the available tussocks in their vision angle, however, they grazed a similar structure than the available on the average of the paddocks. As observed on the treatment 50% of tussocks, with 75% of tussock's percentage of cover, the heifers also chose preferably the directions characterized by had intermediary tussock's percentage of cover. The animals did not search for directions with higher inter-tussock percentages of cover. This fact could be observed if the animals had higher displacement for searching the better feeding stations available, since the tussock distribution in the paddocks allowed to the animal encounter some locations with lower tussock's percentages of cover (Fig. 1). When the movement patterns become difficult, straighter and faster movements become more efficient than highly tortuous ones, as they result in high displacement, thereby minimizing the chance of revisiting an already visited resource and increasing the chance of finding new resources (Turchin 1991, Crist et al. 1992, McIntyre and Wiens 1999, Viswanathan et al. 1999, With et al. 1999, Zollner and Lima 1999, Bartumeus et al. 2005). In the higher tussock's percentages of cover, the heifers grazed more proportions of tussocks. According to Bailey (2005), animals rank good, intermediate and poor feeding sites, and use spatial memory to select sites that maximize nutrient intake, minimize travel effort, and maintain comfort (e.g., thermoneutrality, predator avoidance).

For ewes, on the other hand, we can observed that their grazed the intra-tussock stratum in all treatments, what shows a difference between the foraging patterns of cattle and sheep (confirming the hypothesis 1 of this study). Because of their smaller body and mouth size, sheep are able to feed more selectively than cattle (Demment and

Van Soest 1985) and they also can move on more quickly than cattle in search of better quality material (Rook et al. 2004).

On treatment 0% of tussocks, ewes chose more frequently the areas in front of them. On treatment 25% of tussocks, the animals did not present a pattern of preferred direction's choice. The chosen direction presented predominance of inter-tussock stratum, however, ewes did not rejected the areas with low percentage of cover of tussocks. With 50% of tussocks, ewes grazed principally the inter-tussock stratum, being the direction 1 the more commonly chosen, characterized by high correlation with the intra-tussock stratum. With 75%, the animals did not present a pattern of preferred direction's choice, similar to the observed on the treatment with 25% of tussocks. However, ewes continued selecting the inter-tussock and intra-tussock stratum. Overall, ewes were more reluctant in grazing the tussocks when comparing with heifers. Laca et al. (2010), evaluating each level of the grazing hierarchy-patches, paths, feeding stations, bites and intake- observed that sheep perceive or respond to spatial heterogeneity at finer scales compared with cattle.

Hengeveld (2008) demonstrated that animals present a interaction between the grazing environment and the foraging process, adjusting their foraging behavior depending on the available resource. This interaction is one of the most important determinants of the searching efficiency and thereby, this interaction can change some properties of the movement patterns, depending of the availability of the nutrient searched. Thus, patch selection is controlled not only by the characteristics of individual patches but also by the location of the patch in relation to neighbouring patches with different characteristics, carry-over effects of foraging style from patch to patch, and patch encounter rate (Illius et al. 1987, 1992, Demment et al. 1993).

With the increase on the percentage of cover of tussocks, both heifers and ewes decreased the effective encounter rate of the inter-tussock stratum (Fig. 3). However, initially, ewes were more selective than heifers and, from approximately 25% of tussocks, ewes start to search the inter-tussock stratum in lower intensity than heifers. With the increase on the percentage of cover of tussocks, the environment has become more difficult to the movement patterns of sheep, showing that the tussocks provided an increase on the difficult to the animal in exploring the grazing environment (Laca 2008). The linear reductions on the encounter rate of the inter-tussock stratum by ewes and heifers could indicate similar strategies between both animal species, however, it was not observed. With the increase on the percentage of cover of tussocks, heifers start to graze both the inter-tussock and the tussock stratum. On the other hand, ewes also grazed the intra-tussock stratum, in addition to the inter-tussock and tussock strata (Fig. 2). With the increase on the complexity of the environment, spatial memory and visual cues are efficient in helping animals to localize the preferred areas in the plot, and thereby, these mechanisms are involved in foraging efficiency at large scales (Garcia et al. 2005). On the other hand, at patch scale, the modulation of path sinuosity has been involved in the improvement of foraging efficiency by ruminants (Gross et al. 1995, Bailey et al. 1996), enabling to the animal occupy small areas of inter-tussock stratum among the tussocks. However, with the increase on the tussock's percentage of cover, the distance between preferred patches will increase and the movement between patches will probably limit the intake of the animal (Hengevel 2008).

Thus, patchiness across a foraging landscape can force herbivores to trade-off preference and diminishing rewards at a current patch undergoing depletion against the travel cost of searching for a new undepleted patch (Charnov 1976, Dumont et al. 1998). In this study, from 0 to 45% and from 0 to 50% of tussocks for sheep and cattle, respectively, the chosen direction by animals had lesser tussock's percentage of cover than the average available in the surrounding neighbourhood (Fig. 5). In other words, both heifers and ewes presented active selection (Parsons et al. 1994). If the animals would graze the same proportion as was offered in each level of infestation of tussocks, it would indicate that they were grazing at random (Rutter 2006). Indeed, after values of 45% and 50% of tussock percentage of cover for ewes and heifers, respectively, animals began to choose directions with similar percentage of cover of tussocks than the average available in the in the surrounding neighbourhood. Thus, they presented indifference selection (Parsons et al. 1994) and random grazing process (Parsons et al. 2000), confirming the hypothesis 2 of this study. Probably in major tussock's percentages of cover, the animals perceive the increase on the cost of searching by the preferred stratum (Roguet et al. 1998) and start to graze at random. Likewise, the relative strength of the visual cues will determine the grazing decisions (i.e. patch choice) of herbivores which will determine their nutrient intake rate, and thus the efficiency of use of the forage resource (Hutchings et al. 2002). Although presenting random grazing from 45% of tussock's percentage of cover (Fig. 5) and low effective encounter rate of the inter-tussock stratum (Fig. 4), the ewes could select the inter-tussock areas available among the tussocks and, furthermore, they were capable to select the legumes in the intra-tussock stratum (Fig. 3). Thus, independent of the tussock level of infestation, ewes presented the 'type 3-selective' grazing (Parsons et al. 2000), when animals encounter bite sized areas at random but select whether or not to bite from them. Therefore, in a rangeland infested by *Eragrostis planna*, probably the grazing by sheep would decrease the spatial heterogeneity of the vegetation, because grazing would affect negatively the abundance of the selected resource in the vegetation (Adler et al. 2001), and *Eragrostis plana* would probably become dominant. On the other hand, Jefferies et al. (1994)

reviewed studies from tundra ecosystems in which herbivores selected for high nutrient content, early successional vegetation, and maintained the vegetation in that state, at least over ecological time scales. Probably the grazing by heifers would maintain the vegetation in the same state of infestation, considering that the heifers graze the tussocks in the higher tussock's percentages of cover. According to Rook et al. (2004), the differences in bite dimensions and movement patterns between sheep and cattle can explain how marked differences in sward structure and heterogeneity are initiated and can be sustained. The differences are in keeping with the widely observed greater heterogeneity found in pastures grazed (notably continuously grazed) by cattle compared to those grazed by sheep (Gibb et al. 1997).

Finally, the information on the foraging behavior variables studied here have crucial importance on the understanding of the spatial patterns of grazing choices and their impact under the sward heterogeneity and productivity and, in particular, in allowing scaling-up from bite scale to field scale processes (Schwinning and Parsons 1999, Parsons et al. 2001). However, although the detailed comparative forage utilisation results obtained during short-term experiments complement those from longer-term systems studies quantifying the impact of different grazing regimes on vegetation dynamics and livestock performance (Critchley et al. 2008, McLean et al. 2008), and informed the development of models predicting the wider implications of different management scenarios (Gardner et al. 2005, Waterhouse et al. 2006), the effects of spatial heterogeneity and plant diversity in rangelands invaded by *Eragrostis plana* Nees still need to be tested on long-term grazing behavior.

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4. CAPÍTULO IV

Foraging behaviour of beef heifers and ewes in natural grasslands with different proportions of tussocks[1]

[1] Artigo elaborado de acordo com as normas da Applied Animal Behaviour Science (Apêndice 3).

Foraging behaviour of beef heifers and ewes in natural grasslands with different proportions of tussocks[1]

Abstract

In natural vegetation mosaics, sheep exhibit higher partial selectivity compared with cattle, considering that the preferred grazing species are intermixed with less-preferred species. The hypothesis was tested that heifers and ewes have different foraging strategies in a mosaic natural grassland infested by *Eragrostis plana* Nees and that there is a level of infestation of *Eragrostis* that constraint the animal's intake rate. The grazing paddocks contained different proportions of tussocks in vegetative phenological stage: 0, 25, 50 and 75% of *Eragrostis plana* Nees, considered as the non-preferred item of the diet. The inter-tussocks areas were maintained on a non-limiting herbage allowance, both in sward height as in space. At 1-minute intervals during grazing activity, records were taken whether the animals were grazing on tussock, inter-tussock or intra-tussock areas. The short-term intake rate was measured by weighing the heifers pre- and post-grazing corrected for insensible weight losses. With each increase of tussock's percentage of cover, heifers reduced 0.6% of their grazing time on the inter-tussock areas, while ewes reduced only 0.36%. Virtually all reduction in grazing inter-tussock areas by heifers was replaced by grazing the tussocks. However, the ewes were more selective and try to find the preferred food in the intra-tussock stratum. Independent of the tussock percentage of cover, ewes could adjust their foraging strategies and maintain the short-term intake rate constant. For heifers, the maximization of the short-term intake rate occurred in 34% of tussocks. Bite mass, on the other hand, decreased when the percentage of cover of tussocks reaches 48%. With the increase on the tussock percentages of cover, the heifers were exposed to a clear

[1] Parte da tese da primeira autora, como requisito para obtenção do título de Doutor em Zootecnia, área de Concentração Plantas Forrageiras, UFRGS

trade-off between quantity and quality. Tussocks may act as a vertical and ⁄or horizontal barrier interfering in the process of bite formation and affecting bite mass and, consequently, heifers failed to maximize their short-term intake rate when they grazed in high percentages of cover of tussocks.

Keywords: *Eragrostis plana* Nees; percentage of cover of tussocks; grazing behaviour; mosaic grassland; short-term intake rate

1. **Introduction**

In natural vegetation mosaics, spatial heterogeneity is generally high and preferred grazing species may be intermixed with less-preferred species. In these systems, the spatial interactions between the various processes associated with the presence of grazing animals are more complex (Oom et al., 2008), especially with cattle and sheep. Sheep have a slightly different foraging strategy than cattle, focusing on higher quality options at a finer grain even at scales much greater than those where mouth size and morphology are relevant (Gregorini et al., 2007; Shipley, 2007; Laca et al., 2010). According to Illius and Gordon (1987), larger animals may be restricted to taller, lower quality food options because, for example, larger species can utilize more fibrous foods, while smaller species are more capable of selecting less abundant food items of higher quality.

Foraging decisions at a patch can be viewed as a cycle of events comprising four key phases that can be considered as approach, appraisal, ingestion and defoliation (Griffiths et al., 2003). On the other hand, foraging decisions can be interpreted in terms of an overall objective of maximising efficiency of feeding behavior, often equivalent to maximising intake rate (Baumont et al., 2004). According to Drescher (2003), the mechanisms that could cause a decrease in the forage intake rate likely involve (i) a decreasing mass of cropped forage units and (ii) increasing handling efforts per unit forage through selection against low quality forage parts. Selectivity patterns often agree with the intake rate maximisation hypothesis (Pyke, 1984; Stephens and Krebs, 1986), which predicts both a matching of patch selection and intake rate (Distel et al., 1995), and behavioral strategies to overcome the constraints impose by spatial heterogeneity on preferences (Edwards et al., 1994; Dumont et al., 2000).

Plant structure determines the accessibility and size of plant organs, hence influencing the two central components of the intake rate: bite mass and bite frequency (Spalinger and Hobbs, 1992). For example, the effects of plant architecture on bite mass, measured at small level, are strongly linked to the differential defoliation of plant species (Utsumi et al., 2009), in other words, seems to be more sensitive to the structural effects of local sward attributes, while behaviors at higher levels in the hierarchy (i.e. patches, feeding sites, home ranges) are more dependent on changes in feeding motivation driven by integrated responses to large scale biotic and abiotic heterogeneity (Bailey et al., 1996; Laca, 2008).

The choice among different alternatives sources of forage is substantially influenced by potential intake rate, which is mainly controlled by the sward height and volume, vertical and horizontal distribution of the different components of plants and pasture (Allden and Whittaker, 1970; Stobbs, 1973, 1975; Hodgson, 1985b, 1990; Burlison et al., 1991; Laca and Demment, 1991; Laca et al., 1992), and by the previous feedback of the grazing animal (Newman et al., 1992).

The hypotheses of this study were that heifers and ewes have different foraging strategies in a mosaic natural grassland infested by *Eragrostis plana* Nees and that there is a level of infestation of *Eragrostis* that constraint the animal’s intake rate.

2. **Materials and methods**

2.1. Sward

The experiment was carried out at the Research Station of the Federal University of Rio Grande do Sul, Brazil (30º05’27’’S, 51º40’18’’W), in a area of natural grassland invaded by *Eragrostis plana* Nees in southern Brazil, between November and December 2009.

Field observations showed the inter-tussocks areas (IT) to be predominantly composed of *Axonopus afinnis*, *Cynodon dactylon*, *Paspalum nicorae*, *Paspalum notatum, Desmodium incanum, Andropogon lateralis, Coelorachis selloana, Dichanthelium sabulorum* and *Eleocharis viridans.* Tussock (T) vegetation was predominantly (>95%) *Eragrostis plana* Nees. The vegetation intra-tussocks (INT) was predominantly composed by *Desmodium incanum.*

2.2. Animals

A total of four heifers, crossbred (Angus x Brahman), weighing 286.7 ± 1.2 kg and 12 adult ewes, Suffolk, weighing 51.0 ± 0.72 kg were used. The heifer’s evaluation was proceeded between November 16th and December 4th of 2009, while for the ewes it was proceeded between December 10th and December 18th of 2009. The same group of four heifers grazed in all the experimental units, while for the ewes two groups of six animals were evaluated separately, where each ewe grazed each treatment two times. To increase the number of animals, two ewes were added in each group of four “tester” animals (Penning et al., 1993) to allow no effect of the group size under the grazing time (Carvalho, 1997).

For approximately 30 days prior to the start of the experiment the ewes and heifers grazed separately on areas that had similar sward characteristics as the experimental area. During this period the animals were trained to become familiar to the presence of observers and the behaviour equipments.

2.3. Experimental design

The grazing paddocks contained different proportions of tussocks predetermined in vegetative phenological stage: 0, 25, 50 and 75% of *Eragrostis plana* Nees, considered as the non-preferred item of the diet. The actual proportions of tussocks in the four treatments were 2.5 ± 0.3, 26.6 ± 1.7, 45.8 ± 1.6 and 69.8 ± 1.2, respectively. They were visually estimated using a quadrat (1m x 1m), positioned successively at different areas along all experimental area and it was visually estimated the percentage of cover of tussocks inside the area delimited by the quadrat. Approximately one year before the beginning of the experiment, there were chosen two close areas each other, one with high and other with low percentages of cover of tussocks. All the area was divided in jointly quadrats of 1m x 1m and thereby, the percentage of cover of tussocks inside each quadrat was visually estimated. Therefore, it was mapped the total percentage area cover by *Eragrostis*, as well as the total percentage area cover by the plants belonging to the inter-tussock stratum of the pasture. After obtaining the actual percentage of cover of tussocks in all experimental area, it was design the position of each experimental unit area, in order to obtain different proportions of tussocks as nearest possible than 0, 25, 50 and 75%. To obtain similar proportions of tussocks to the predetermined values, when necessary, it was removal the excess of tussocks using a hoe.

Paddocks were 100 m^2 of inter-tussock areas and the area was increased according to the percentage of tussocks of each treatment, taking into consideration that all treatments had the same forage allowance and sward structure of the inter-tussock stratum. The pasture and animal measurements were made on the grazing peaks (during the first and the last grazing meals), that comprised four replicates; two spatial replicates (paddocks) and two replicates in time (measurement periods).

2.4. Sward measurements

In an adjacent area of the experiment, previous grazing tests were performed to define the inter-tussock area of the treatments. During the grazing tests, the sward height of the preferred inter-tussock area was measured every ten minutes using a sward stick. The inter-tussock area of the experimental units was defined as the minimal area necessary to the post-grazing sward height did not reduce more than 10% of the pre-grazing sward height during the 45 minutes of the grazing tests and, as resulting of these tests, the minimal area considered was 100m^2.

Previous grazing were used as adjustments of sward heights several months prior to the start of the experiment. At the experimental units the sward height of the preferred inter-tussock vegetation was controlled, maintaining it at predetermined heights throughout the grazing periods according to Gonçalves et al. (2009). The sward height and herbage mass were determined separately for the *Eragrostis* tussocks and the inter-tussock areas of the sward. The sward height of the inter-tussock vegetation was estimated by 100 pre- and 100 post-grazing measurements using a sward stick. For the estimation of the tussock's height, there were made pre- and post-grazing measurements according to the percentage of cover of tussocks (e.g. in the treatment with 50% of tussocks the mean tussock height was estimated by 50 pre- and 50 post-grazing measurements using a sward stick).

For the herbage mass measurement, six quadrants (0.5m x 0.5m; three in tussock and three in inter-tussock areas) by paddock were cut at ground level using a hedge-trimmer. After harvesting, each sample was weighed to determine total fresh weight and then oven-dried at 60°C for 48 h to determine dry matter (DM) content.

Samples of herbage (three in tussock and three in inter-tussock areas), estimated as representative of the sward strata grazed by the animals, were collected by hand from each treatment paddock before and after the time that short-term intake rate measurements were being made with the animals. Samples were placed directly into pre-weighed and then oven-dried at 60°C for 48 h to determine DM content.

2.5. Foraging behaviour patterns

The animals were submitted to grazing periods of 45 minutes, during the grazing peaks - the first and the last grazing meals – and they were non-fasted to ensure their normal behavior activities. At 1-minute intervals during grazing activity, records were taken whether the animals were grazing on tussock (T), inter-tussock (IT) or intra-tussock (INT) strata. These observations were used for the determination of the grazing time in each sward stratum, expressed in percentage of the total grazing time.

The number of grazing jaw movements (biting and non-biting jaw movements) was counted automatically using behavior recorders (Rutter et al., 1997). The term 'non-biting jaw movement' refers to those movements that are not identified as bites during grazing, and therefore includes movements which are masticatory or manipulative in function. In calculating short-term intake rate (STIR) and grazing jaw movement rates (GJMR), the time base employed was eating time, rather than grazing time, since the latter would have lead to inclusion of intra-meal intervals (Gibb et al., 1999). The eating time was calculated as the sum of the periods of grazing jaw movements, excluding intervals of jaw inactivity >3 sec, while the grazing time was the sum of the periods of grazing jaw movement, including any periods of jaw inactivity <5 min (Gibb et al., 1999).

The rate of insensible weight loss (RIWL), due to evaporative and gaseous losses, and STIR were measured at two times of day, during the grazing peaks. The

STIR was measured by weighing the animals pre- and post-grazing corrected for insensible weight losses measured after the STIR measurement over 45 minutes (Gibb et al., 1999). RIWL and STIR were measured by weighing the animals before and after each 45 minutes period using an electronic balance with accuracy of 10g, according to Gibb et al. (1997). DM short-term intake rate was calculated as the product of fresh weight intake rate and DM content of the herbage consumed by the animals (determined from hand-plucked samples). Bite mass (BM) was calculated by the ratio between STIR and number of bites.

For the determination of the foraging behaviour variables exclusively on the tussock stratum, it was analyzed the output from the software Graze in short spaces of time when the animals had grazed exclusively the tussocks (grazing periods were determined through the synchronization of the visual observation and the behavior recorders). It was assumed that the values for bite mass and bite rate in the inter-tussock stratum on the treatments 25, 50 e 75% of tussocks were the same that those observed on the treatment 0% of tussocks, and thereby, with the number of grazing jaw movements exclusively on tussocks, it was possible to calculate the BM and STIR proportional to the grazing on the tussock stratum.

2.6. Statistical analysis

Firstly, it was realized variance homogeneity test (Levene's test) to detect differences in the foraging behavior between the animal's species in the tussock percentages of cover (P<0.05). In all analyses the paddock group of four "tester" animals was used as the experimental unit. Dependent variables were analyzed by ANOVA using a MIXED (SAS Inst. Inc., Cary, NC). The model used to analyze the dependent variables included the fixed effects of time of day (paddocks) and treatments, and the random effects of measurement periods and the interaction treatments x measurement periods. The measurement periods were considered the repeated measures. It was used regression analysis, where the relationships between the foraging behaviour variables (y) and the actual tussock percentage of cover (x) were established by linear (y_{ij} = a + bx + $€_{ij}$), quadractic (y_{ij} = a + bx + cx^2 + $€_{ij}$) and broquen line equations (y_{ij} = L + U (R - x) + $€_{ij}$). The fits were compared using the coefficient of determination (R^2) and the probability value (*P*=).

3. **Results**

3.1. ***Sward characteristics***

There were no significant differences (*P*>0.05) between the values of sward height and herbage mass for the inter-tussock and tussock stratum among the treatments (Table 1). The mean sward heights of the inter-tussock areas grazed by the heifers were 9.5, 9.9, 10.0 and 10.7 cm and for the ewes were 9.3, 10.2, 10.7 and 10.3 cm, on treatments 0, 25, 50 and 75% of tussock's percentage of cover, respectively. According to results of Gonçalves et al. (2009), these obtained values of sward heights of the inter-tussock stratum did not limit the intake rate of beef heifers and sheep. The maximum variation predetermined, of 10%, for the difference between the sward heights of the inter-tussock stratum pre and post-grazing in the experimental units was obeyed in all treatments, therefore, at mean, the sward structure was unchanged by the grazing tests.

The mean sward heights of the tussock areas grazed by the heifers were 37.3, 38.5 and 42.1 cm and for the ewes were 42.5, 46.9 and 43.7 cm, on treatments 25, 50 and 75% of tussock percentage of cover, respectively.

The mean herbage mass grazed by the heifers at the inter-tussock and tussock stratum were 2.8 and 0.0, 2.8 and 21.8, 3.1 and 19.3 and 2.7 and 22.4 Mg DM ha^{-1} for treatments 0, 25, 50 and 75% of tussock percentage of cover, respectively. For ewes the mean herbage mass at the inter-tussock and tussock stratum were 2.0 and 0.0, 2.5 and 20.7, 2.6 and 16.8 and 2.2 and 19.2 Mg DM ha^{-1}, respectively.

Table 1 - Sward characteristics of a mosaic natural grassland - inter-tussock and tussock areas - grazed by beef heifers and ewes

Sward characteristics	Percentage of cover of tussocks (%)				Mean ± *S.E.*	T effect *(P=)*
	0	25	50	75		
Beef heifers						
Inter-tussock areas						
Pré-grazing sward height (cm)	10.0	10.3	10.4	10.8	10.3 ±0.3	0.747
Post-grazing SH sward height (cm)	9.0	9.4	9.5	10.5	9.5 ± 0.4	0.580
Mean of sward height (cm)	9.5	9.9	10.0	10.7	9.9 ± 0.3	0.640
Herbage mass (Mg DM ha^{-1})	2.85	2.83	3.09	2.74	2.9 ± 0.2	0.893
Tussocks						
Pre-grazing sward height (cm)	-	38.3	40.2	42.7	40.4 ± 1.1	0.341
Post-grazing sward height (cm)	-	36.4	36.8	41.5	38.2 ± 1.1	0.177
Mean of sward height (cm)	-	37.3	38.5	42.1	39.3 ± 1.1	0.253
Herbage mass (Mg DM ha^{-1})	-	21.84	19.30	22.38	20.4 ± 1.9	0.534
Ewes						
Inter-tussock areas						
Pré-grazing sward height (cm)	9.6	10.5	11.3	10.4	10.5 ±0.3	0.124
Post-grazing sward height (cm)	9.1	9.9	10.1	10.1	9.8 ± 0.2	0.291
Mean of sward height (cm)	9.3	10.2	10.7	10.3	10.1 ± 0.2	0.193
Herbage mass (Mg DM ha^{-1})	1.98	2.50	2.60	2.22	2.3 ± 0.4	0.401
Tussocks						
Pre-grazing sward height (cm)	-	41.6	47.8	43.2	44.2 ± 1.3	0.233
Post-grazing sward height (cm)	-	43.5	46.0	44.1	44.5 ± 1.3	0.686
Mean of sward height (cm)	-	42.5	46.9	43.7	44.4 ± 1.2	0.380
Herbage mass (Mg DM ha^{-1})	-	20.70	16.82	19.20	18.9 ± 1.4	0.642

*3.2. **Grazed stratum by beef heifers and ewes***

According to the variance homogeneity test, the grazing times in the inter-tussock, intra-tussock and tussock strata were not homogeneous to heifers and ewes (*P*>0.10). Therefore, the grazing time in the sward strata cannot be consider similar and are presented separately for each animal species (Figure 1).

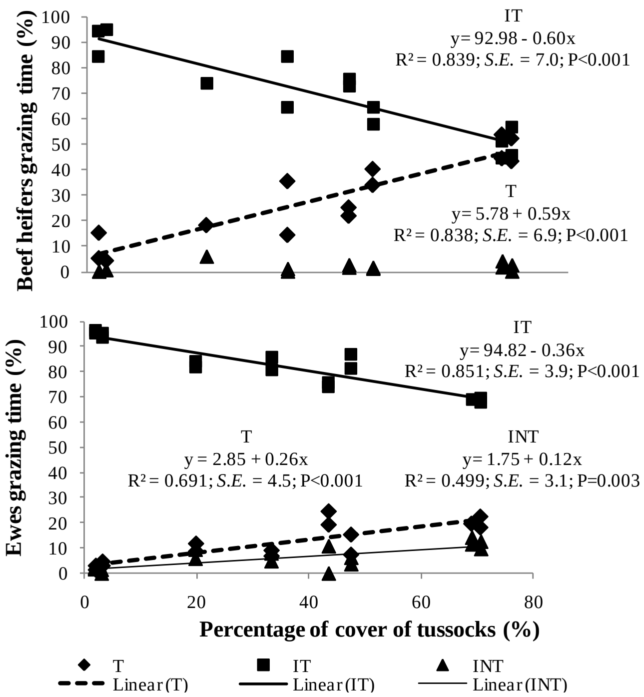

Figure 1. Relationship between the percentage of cover of tussocks (*Eragrostis plana* Nees.) and the grazing time of beef heifers and ewes on the different strata of a mosaic natural grassland

The regression models evidenced that for each increase of 1% of tussocks percentage of cover, heifers reduced 0.6% of their grazing time on the IT areas, while the ewes reduced only 0.36% of grazing IT areas. Virtually all reduction in grazing IT areas by heifers was replaced by grazing the tussocks, while ewes increased the grazing tussocks in only 0.26%, also increasing in 0.12% the legumes selection inside the tussocks. In situations where ewes were exposed to 70% of tussocks, they spent more than 10% of grazing time selecting forage in the INT stratum.

*3.3. **Foraging behaviour patterns***

The variance homogeneity test presented non-homogeneity between the foraging behavior variables of heifers and ewes and thereby, the results are presented separately for each animal species (Table 2).

For heifers, the STIR adjusted better to the quadratic equation, with maximization in 34% of tussocks percentage of cover. After these values, the STIR was reduced, which shows some forage restrictions to the animals. For bite mass, the best fit was the broquen line equation, with stabilization of the values until 48% of tussock percentage of cover, and posterior decrease on bite mass. For bite rate, it was observed a linearly increase with the tussock levels and, consequently, the NBGJMR was reduced, considering that the GJM remained constant (*P*>0.05). The variables IMIN and IMID also were decreasing with the increase on the tussock percentage of cover, however, the variables RIWL and ET did not be fitted to any regression model (*P*>0.05).

On the other hand, for ewes, all the foraging behaviour variables did not adjust to any regression model (*P*>0.05), which shows that sheep succeeded in maintain their foraging behavior responses constant with the increase on the tussock's percentage of cover.

Table 2. Foraging behaviour responses of beef heifers and ewes on a natural grassland with different percentage of cover of tussocks (*Eragrostis plana* Nees.)

Foraging behaviour variables	Percentage of cover of tussocks (%)				Model			*S.E.*	R^2	*P*
	0	25	50	75	a	b (x)	c (x^2)			
Beef heifers										
STIR (g DM min^{-1} kg MW^{-1})	0.35	0.59	0.51	0.29	0.33	0.01	-0.0002	0.06	0.777	0.001
*BM (mg DM kg MW^{-1})	9.1	8.9	9.4	6.7	-	-	-	1.01	0.590	0.006
RIWL (g min^{-1} kg MW^{-1})	0.56	0.58	0.70	0.38	-	-	-	0.19	-	0.448
BR (per min)	41.9	48.6	49.2	55.6	42.5	0.18	-	3.5	0.628	0.003
NBGJMR (per min)	33.0	25.1	24.8	19.9	32.4	-0.18	-	4.9	0.502	0.009
GJMR (per min)	74.2	72.1	73.8	70.7	-	-	-	10.5	-	0.544
ET (min)	48.9	48.5	50.7	51.5	-	-	-	0.6	-	0.239
IMIN	7.3	1.5	3.4	2.3	7.06	-0.08	-	1.9	0.544	0.004
IMID (sec)	25.5	3.0	11.8	4.4	23.6	-0.30	-	5.8	0.638	0.001
Ewes										
STIR (g DM min^{-1} kg MW^{-1})	0.25	0.20	0.24	0.23	-	-	-	0.01	-	0.724
BM (mg DM kg MW^{-1})	4.3	3.8	4.3	3.5	-	-	-	0.2	-	0.384
RIWL (g min^{-1} kg MW^{-1})	0.12	0.12	0.18	0.13	-	-	-	0.03	-	0.882
BR (per min)	62.6	52.3	55.2	56.1	-	-	-	1.4	-	0.274
NBGJMR (per min)	55.6	62.1	61.2	66.9	-	-	-	1.6	-	0.518
GJMR (per min)	119	114	118	123	-	-	-	1.6	-	0.574
ET (min)	46.6	45.5	45.7	45.7	-	-	-	0.3		0.133
IMIN	4.9	10.0	6.4	5.2	-	-	-	1.0	-	0.125
IMID (sec)	6.0	9.0	10.0	11.8	-	-	-	0.9	-	0.493

BR = bite rate
NBGJMR = Non-biting grazing jaw movement rate
ET = Eating time
IMIN = Intra-meal interval number
IMID = Intra-meal interval duration
* Broquen line Equation: y = 9.2 + 0.12 (47.5-x)

4. Discussion

With each increase of tussock’s percentage of cover, heifers reduced 0.6% of their grazing time on the IT areas, while the ewes reduced only 0.36% of grazing IT areas. Virtually all reduction in grazing IT areas by heifers was replaced by grazing the tussocks. However, the ewes were more selective. As the percentage of cover of tussocks increased, ewes try to find preferred food in the INT stratum. With each increase of 1% of percentage of cover of tussocks, the ewes increased the grazing tussocks in only 0.26%, also increasing in 0.12% the legumes selection inside the tussocks. Cattle and sheep have different biting styles. Probably the use of the tongue by cattle to gather herbage into the mouth was an obstacle to the selection of the legumes inside the tussocks. Laca et al. (2010) also observed that sheep exhibited much higher partial selectivity compared with cattle at the path and feeding-station levels, indicating that sheep have a more acute ability, or drive, to discriminate at these scales, regardless of the landscape distribution of forages.

Independent of the difference on the amount of the grazed stratum by heifers and ewes, both species rejected the tussocks. These results suggest that the animals do not graze at random. The animals perceive and react to the grazing environment. Both cattle and sheep searched for a diet with predominance of inter-tussock stratum even in areas with predominance of tussocks. With 75% of tussocks, the grazing time in the tussock stratum of heifers and ewes was only 50% and 22%, respectively. On the other hand, with the increase on the tussock percentage of cover becomes increasingly costly to search for inter-tussock stratum, even in a non-limiting forage allowance, and thereby, both heifers as ewes grazed the tussocks, agreeing with the optimal foraging theory (Pyke, 1984), in which the costs of obtaining food modify dietary choices.

With respect to the comparison of the foraging behavior responses of beef heifers and ewes, heifers presented distinct responses with the increase on the percentage of cover of tussocks. On the other hand, independent of the tussock percentage of cover, ewes could adjust their foraging strategies and maintain the STIR constant (Agreil et al., 2005). The differences observed on the foraging strategies of heifers and ewes were confirmed by earlier experiments which generated comparative information for cattle and sheep grazing a range of pasture types (Grant et al., 1985, 1987; Armstrong et al., 1997; Fraser et al., 2009).

Indeed, differences in mouth morphology of both species can influence bite mass and intake on different types of vegetation (Shipley, 2007). Mean calculated bite mass for heifers was double times superior that observed for ewes. Likewise, the STIR was greater for cattle, as expected because cattle took larger bites (Laca et al., 2010). The grazing jaw movement rate of ewes was 63% major that for heifers. It was observed principally by the greater values in the non-biting grazing jaw movement rate. For sheep bites and chews are mutually exclusive, with sheep spending greater time masticating (Penning et al., 1991). Sheep thus need to pause from biting, and so terminate the grazing bout, in order to process the harvested food and appear to use this time to move on to a new area (Rook et al., 2004) and thereby, select the preferred sward stratum. Thus, sheep could maintain their foraging behavior responses constant with the increase on the percentage of cover of tussocks. According to Laca et al. (2010), differential utilization of forage resources by herbivores of differing body size (cattle *vs* sheep) can result from scale-dependent limitations on foraging selection among resource patches, in addition to differences in bite-scale behaviors, such as bite mass or bite depth.

For heifers, the maximization of the STIR occurred in 34% of tussocks. After these values, STIR started to reduce, what shows some forage restrictions to the animals. Bite mass, the most critical factor determining intake rate (Stobbs, 1973), decreased when the percentage of cover of tussocks reaches 48%. Tussocks may act as a vertical and ⁄or horizontal barrier interfering in the process of bite formation and affecting bite mass and STIR, effect already observed with stems by Benvenutti et al. (2008).

For the variable STIR, however, it was expected a similar response to bite mass, with stabilization by 48% of tussocks, and posterior decrease in the values with higher percentages of cover of tussocks. To explain this result, let’s resume the principal factors determining the intake rate of ruminants (Fig. 2).

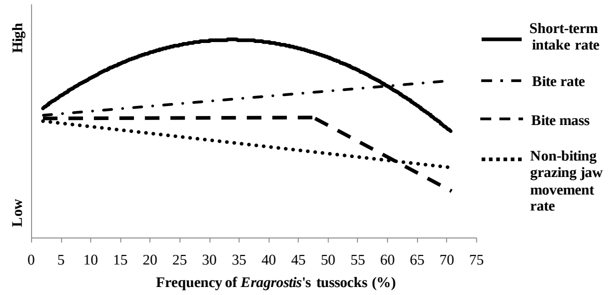

Figure 2. Response’s model of the factors determining intake rate of beef heifers grazing a natural grassland with different percentage of cover of tussocks (*Eragrostis plana* Nees.)

The forage daily intake, or the STIR in smaller scale, is the result of the product between the time spent by animal in the grazing activity and the forage intake rate during grazing, which in turn, is the product of the bite’s number per time (bite rate) and the obtained forage per bite (bite mass; Allden and Witthaker, 1970; Forbes, 1988; Hodgson, 1990; Illius, 1997). The hypothesis that the bite mass is the most mechanism on determination of the STIR (Allden and Whittaker, 1970) was discarded to explain the smaller values on 0% of tussock’s percentage of cover, since as the bite mass was constant until 48% of tussock’s percentage of cover. According to Laca et al. (1994a), structural characteristics of single plants within a patch can affect the functional response of intake rate through effects on bite mass and handling time. Thus, the explanation would be on bite rate and NBGJMR, as the feeding time was practically constant among the treatments (Table 2). Indeed, it is observed that the response of the bite rate in relation to the increase on the tussock percentage of cover was linear increasing, while the NBGJMR was linear decreasing (Fig. 2). This response is commonly observed, which there is an inverse relationship between bite mass and bite rate because of the competition between chewing and cropping processes (Spalinger and Hobbs, 1992). These results suggest that the increase on the bite rate and reduction on NBGJMR was the factor determining of the increase on the intake rate between 0 and 34% of tussock's percentage of cover.

Thus, it is plausible mentioning why the animals execute more bites and less masticatory and manipulative movements with the increase on the tussock's percentage of cover. With 0% of tussocks, the lesser values of bite rate, with the higher values of number and duration of intra-meal intervals characterize a situation of more searching activity and selectivity. Although herbivores cannot crop and chew bites efficiently at the same time, they can search for new food items or patches while chewing bites from previous patches or food items (Laca et al. 1994b; Shipley and Spalinger, 1995; Ginnett and Demment 1997; Hobbs et al. 2003) and thereby select the forages that maximize their rate of energy intake, as predicted by optimal patch choice models (Pyke, 1984; Roguet et al., 1998). However, with the increase on the tussock's percentages of cover, the heifers were exposed to a clear trade-off between quantity and quality, whereby more restrictive foraging conditions would motivate lower selectivity for the preferred forage in order to achieve maximum daily intake or intake rate (Fryxell, 1991).

With 34% of tussock's percentage of cover, heifers grazed the tussock stratum during 26% of their total grazing time. Probably they had chose a forage that could be ingested more quickly (Illius and Gordon, 1990; Laca and Demment, 1991; Illius et al., 1992; Demment et al., 1993; Laca et al., 1993), even if this resulted in a diet of smaller digestibility (Gordon and Lascano, 1993). The hypothesis would be that, on beginning of the grazing period, when the animals grazed the tussocks, they perceived the smaller bites obtained in this stratum and thereby, they increased the number of bites as a strategy to increase the STIR. Indeed, with the grazing on tussocks, with smaller bite mass, the heifers increased the bite rate in 16% in relation to the smaller percentage of cover of tussocks (Fig. 2). Furthermore, they probably increased the bite mass in the inter-tussock stratum as a form of stabilize the average bite mass during the grazing periods, considering that heifers grazed by 26% of their total grazing time in the tussock stratum (Fig. 2), with smaller values of bite mass (Table 3.). Agreil et al. (2005), studying the dynamics of behavioural intake response of ewes in heterogeneous vegetation, observed that animals use an increasingly wider range of bite masses with modifications on sward structure, consequently, the variation in bite mass range had a major effect on intake rate. These authors also observed that animals were able to achieve adjustments of day-to-day feeding behaviour that led to a stabilisation of daily average digestibility and bite mass.

Table 3. Foraging behaviour variables of beef heifers grazing the inter-tussock (IT) or the tussock (T) stratum of a natural grassland infested by *Eragrostis plana* Nees

Foraging behavior variables	Sward stratum				
	IT	T	Mean	*S.E.*	Effect (*P*=)
Short-term intake rate (g DM min^{-1} kg MW^{-1})	0.35a	0.26b	0.32	0.02	0.044**
Bite mass (mg DM kg MW^{-1})	9.1a	4.8b	7.4	1.08	0.019**
Bite rate (per min)	42.1b	57.7a	48.2	3.6	0.046**
Non-biting grazing jaw movement rate (per min)	31.9b	39.8a	36.9	2.3	0.073*
Grazing jaw movement rate (per min)	75.4b	85.7a	81.1	2.4	0.012**

(* P<0.10; ** P<0.05)

From 48% of tussock's percentage of cover, even with the increase on bite rate, the major time grazing the tussock stratum (35% of the total grazing time), with smaller bite mass (corresponding to only 53% of the bite mass obtained by heifers when they graze exclusively the inter-tussock estratum; Table 3), provides a reduction on the average BM and STIR. Following Charnov's marginal value theorem (Charnov, 1976), we hypothesized that cattle adopt a foraging strategy that maximizes intake rate, however, selectivity for preferred species will be constrained by the spatial heterogeneity of forage. However, in the higher tussock's percentages of cover, heifers failed to maximize their STIR. This occurred because when heifers selected the tussocks, the smaller forage density and major leaf dispersion on the highest grazing horizon provided reduction on BM and, consequently, on STIR. In these situations, animals are forced to ingest less leaf per bite, or even individual leaves, providing reduction on bite mass (Carvalho et al., 2007). On the other hand, when heifers grazed the tussocks, their presented major BR, NBGJMR and GJMR ($P<0.10$). Higher values for NBGJMR were observed when the animals grazed the tussocks probably because the tussocks were the most fibrousness stratum available. Indeed, fibrousness of the forage can affect how long an animal continues to chew when leaving the previous bite or patch (Shipley and Spalinger, 1992). With the higher values of both NBGJMR and BR, consequently, the GJMR was superior when the animals grazed the tussock stratum. One of the first behavioural adjustments to compensate for a decrease in bite mass is the increase in bite frequency (Allden and Whittaker, 1970; Spalinger and Hobbs, 1992), however, in this study, the increase on bite rate in the tussock stratum was not sufficient to compensate for a low bite mass and, as a result, intake rate was significantly lower than in the inter-tussock stratum.

5. **Conclusions**

Both cattle and sheep reject the tussocks, independent of the difference on the amount of the grazed stratum for both species and of the tussock's percentage of cover. Sheep can select the legumes intra-tussocks and maintain their intake rate constant, independent of the tussock levels, however, for cattle, the intake rate and bite mass are substantially reduced when the percentage of cover of tussocks is superior to 34 and 48%, respectively, suggesting that animal's response can be constrained in natural grasslands with predominance of tussocks.

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5. CAPÍTULO V

CONSIDERAÇÕES FINAIS

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O capim-annoni-2 é uma planta tão competitiva que tomou conta dos campos naturais do Bioma Pampa, causando uma situação de desequilíbrio vegetacional. Nas últimas décadas, incansáveis foram as tentativas de combater esta planta, no entanto, sem sucesso. Dessa forma, meios de produzir e conviver com essa planta devem ser buscados, com o objetivo de reduzir os prejuízos desta invasora à economia e à biodiversidade das pastagens naturais. O estudo das relações entre animais e o seu ambiente é um dos mais importantes no âmbito ecológico, e proporciona respostas do uso do espaço pelos animais, das interações entre os animais e das relações entre os animais e seu habitat. Estudos do comportamento ingestivo a curto prazo são essenciais para o entendimento das respostas dos animais em pastejo, entretanto, para o caso do capim-annoni-2, devem ser realizados estudos também a longo prazo para verificar se as mesmas respostas reproduzem, visto que um dos principais objetivos quando se trata de capim-annoni-2 é a manutenção da diversidade vegetacional das pastagens naturais.

Cabe ressaltar que em experimentos de curta duração, as avaliações devem ser realizadas com muito cuidado, tentando ao máximo minimizar possíveis erros. A pastagem, os animais, os avaliadores, tudo deve ser controlado ao máximo. Neste estudo, imaginamos que o mapeamento da área a cada $1m^2$ e que a caracterização do comportamento dos animais a cada 1 minuto seria mais do suficiente para o entendimento das estratégias de deslocamento dos animais à medida em que se aumentou o nível de touceiras. No entanto, como o bocado ocorre em uma escala temporal de 1 a 2 segundos e ocupa uma área de até 0,01m^2, o mapeamento realizado não foi suficiente para responder algumas questões. Poderia se considerar que a avaliação ocorrreu em escala de estação alimentar, pois esta ocorre entre 5 e 100 segundos e numa área de 0,1 a 1m^2. Neste caso, este estudo proporcionou respostas muito interessantes e inéditas. Esta escala de avaliação á a base para o entendimento das questões que envolvem as escolhas de pastejo dos animais em ambientes pastoris heterogêneos. Entretanto, para estudos futuros que visem o entendimento das relações planta-animal em pequena escala, proponho uma caracterização ainda maior, em escala ainda menor, tanto em termos animal quanto vegetacional.

A seguir, estão apresentadas as principais respostas observadas nesta tese, composta por três artigos. No artigo 1, observou-se ovinos selecionando leguminosas (*Desmodium sp.)* dentro das touceiras. Fator evidente de que as ovelhas foram mais seletivas que as novilhas neste ambiente pastoril heterogêneo. A probabilidade de seleção das novilhas não variou entre os níveis de touceiras, enquanto que para as ovelhas, a probabilidade de seleção reduziu de 0,75 para 0,55 do menor para o maior nível de touceiras, o que reforça a tese da seletividade relativa à espécie animal. Com 40 e 50% de frequência de touceiras na pastagem, as escolhas em pastejo por ovelhas e novilhas, respectivamente, se tornam dificultadas. Com 40% de frequência de touceiras, as ovelhas percebem a maior dificuldade em selecionar o estrato inferior e passam a pastejar as touceiras, entretanto, em baixa intensidade. Por outro lado, as novilhas passam a pastejar as touceiras a partir de 50% de percentual de touceiras, sendo o ponto crítico em

75%. No artigo 2 observou-se que a partir de 50% de touceiras, os padrões de movimento das novilhas passaram a ser mais correlacionados com as touceiras. Neste momento, os animais passaram a se deslocar mais freqüentemente tanto para frente quanto para ambos os lados, tentando desviar das touceiras disponíveis no seu ângulo de visão e assim, aumentando a possibilidade de encontro de melhores estações alimentares de estrato inferior. No entanto, pastejaram uma estrutura semelhante à disponível na média do piquete. Com 75% de percentual de touceiras, as novilhas também escolheram preferencialmente direções caracterizadas por possuir níveis intermediários de touceiras. Por outro lado, com 75% de frequência de touceiras, as ovelhas não apresentaram um padrão de escolha de direção. Entretanto, elas seguiram selecionando estações alimentares com maiores percentuais de estrato inferior e dentro das touceiras. Com o aumento no percentual de touceiras, tanto as novilhas quanto as ovelhas reduziram a taxa de encontro efetiva do estrato inferior, demonstrando que nestes níveis de infestação, qualquer estratégia adotada pelos animais é insuficiente para minimizar os efeitos negativos das touceiras sobre seus padrões de busca. No artigo 3, observaram-se respostas em nível de *patch*. Com o aumento no percentual de touceiras, as novilhas reduziram em 0,6% o seu tempo de pastejo no estrato inferior, enquanto que as ovelhas reduziram somente 0,36% do tempo de pastejo no estrato inferior. A cada aumento de 1% de touceiras, as ovelhas aumentaram o pastejo nas touceiras em somente 0,26%, também aumentando em 0,12% a seleção das leguminosas dentro das touceiras. Para as novilhas, a maximização da taxa de ingestão ocorreu em 34% de touceiras.

A massa do bocado, fator determinante da taxa de ingestão de maior importância, diminuiu quando o nível de touceiras atingiu valores de 48%. Para a taxa de ingestão, entretanto, esperava-se uma resposta semelhante à observada para a massa do bocado, com estabilização inicial até certo nível de infestação de touceiras, e posterior decréscimo nos valores com maiores percentuais de touceiras. No entanto, o aumento na taxa de bocados e redução na taxa de movimentos de manipulação e mastigação foi o fator determinante para o aumento na taxa de ingestão entre 0 e 34% de touceiras. E, a partir de 48% de touceiras, mesmo com o aumento na taxa de bocados, o maior percentual de pastejo nas touceiras (35%), que proporciona valores muito inferiores de massa do bocado (correspondendo a apenas 53% da massa de bocado alcançada pelas novilhas quando consomem apenas estrato inferior) proporcionou redução na taxa de ingestão das novilhas. Por outro lado, as ovelhas, independente do nível de touceiras, conseguiram manter a taxa de ingestão constante.

Enfim, os resultados observados neste trabalho mostram a importância da manutenção do estrato inferior da pastagem em uma situação não limitante aos animais, pois, de outra forma, as respostas observadas provavelmente teriam sido diferentes. Também, observa-se a importância de se avaliar diferentes espécies animais, pois, cada espécie, em decorrência dos seus padrões de ingestão, seletividade e deslocamento, apresenta distintas respostas de escolha frente às variações na estrutura do pasto em ambientes heterogêneos.

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7. APÊNDICES

Apêndice 1. Normas utilizadas para redação do capítulo II

Rangeland Ecology and Management Style Manual

Updated June 7, 2010

Note: The style of papers in *Rangeland Ecology & Management* should follow CBE 7th edition for all style points except those listed below. Spelling should be from Webster's 10th edition.

Manuscript Categories

Research Papers report original findings on all rangeland topics and must be based on a sound conceptual framework and a rigorous test of experimental hypotheses. The experimental design should be clearly described, analyzed with appropriate statistical procedures, and conclusions limited to the appropriate inference space. Papers that are descriptive (e.g., characterize landscape patterns or classify vegetative communities) or that are based on quantitative models are also appropriate.

Forum Papers are conceptual in nature and provide an informative summary of contemporary topics or alternative views of contentious issues. They also address comments and rebuttals related to manuscripts previously published in REM.

Synthesis Papers combine data and hypotheses from multiple published sources to provide an integrated, comprehensive presentation of a concept or model. Proposals for synthesis papers must be approved by the Editor-in-Chief prior to submission.

Research Notes are short papers reporting experimental research of immediate interest. Notes are intended to foster communication addressing research topics and concepts that may not be fully replicated over time and/or space.

Technical Notes are short papers reporting original experimental and analytical techniques, including those that are either conceptual or quantitative. A technical note requires a thorough description of the theoretical base of the instrument or procedure and a comprehensive comparison to existing techniques, procedures, or models. Notes are limited to 3000 words (title through literature cited) and a total of three tables, figures, or photos in any combination.

Apêndice 1 (Continuação). Normas utilizadas para redação do capítulo II

Manuscript Organization

Manuscript Files: Authors should submit all manuscript text in Microsoft Word. Please note, however, that at this time we cannot accept Microsoft Word 2007 due to potential formatting problems. Microsoft Word 2007 documents should be submitted in earlier formats. (If a file ends in .docx, open the file and Save As, selecting Microsoft Word 2003 (.doc format) from the file type choices.) The manuscript will not move through the peer-review process until the appropriate manuscript files have been uploaded.

Page/Line Numbers and Spacing: Page and line numbers should be on all submitted manuscripts. Line numbers can be either sequential throughout the manuscript or repeated on each page. Text should be double spaced throughout.

Title page

The title page is the first page, and includes these three components:

1) **Title:** Titles should be as brief as possible (15 word maximum) while conveying the broad contribution of the manuscript.

2) **Authors and affiliations:** One author should be designated as the corresponding author and his/her complete contact information should be provided, including business phone and email address.

3) **Support/Grant Information:** Include funding sources only; individuals who provided assistance with data collection or analyses and reviewers may be referenced in Acknowledgments. Use this format: “Research was funded by the Wyoming Abandoned Lands Program, University of Wyoming.” or “A.L.H. was funded by Grant TA-MOU-94-C13-149 from the US Agency for International Development.”

If the information on the title page is missing or incomplete, the authors may be charged later for fixing it at the proof stage. See next page for formatting example.

Apêndice 1 (Continuação). Normas utilizadas para redação do capítulo II

Abstract

The Abstract constitutes the second page and it is limited to a 300-word maximum. It includes a brief summary of the hypotheses, methods, conclusions, and management implications of the research. The Abstract must identify the relevance of the manuscript to the rangeland profession. It should include numerical data and a measure of variation, as well as both common and scientific names of organisms studied. The authority for scientific names should be listed. Citations to references, figures, and tables are not to be included in the Abstract.

Resumen

A Spanish translation of the one-paragraph abstract will be requested by the Editor-in-Chief, if one is not provided at the time of submission.

Key Words

Include four to six high impact words not used in the title for indexing and abstracting purposes. Key words should be alphabetical with comma separators, no period at the end

Introduction

The Introduction presents the rationale, justification, and hypotheses for the investigation. It should provide an appropriately detailed background for a broad readership to determine the potential contribution of the manuscript. This background information should be supported with peer-reviewed literature. It is the authors' responsibility to convey the importance of the work to the broadest potential audience. The Introduction provides the framework for the subsequent Discussion and Implications sections.

Methods

This section should clearly delineate the study location, experimental design, and specific statistical analyses used. Sufficient detail must be provided to permit the reader to evaluate the proper application of the analyses and to repeat the experiments. Standard methods or techniques should be referenced and modifications of standard techniques should be clearly stated. Novel analytical methods should be clearly described and referenced. It is the authors' responsibility to describe the appropriateness and limitations of the experimental design and to acknowledge these constraints while drawing inferences.

Apêndice 1 (Continuação). Normas utilizadas para redação do capítulo II

Results

The Results describe all of the relevant findings of the manuscript supported by critical tables and figures. The central tendencies of the data as well as the variability observed should be emphasized. Estimates of variability must accompany statistical analyses in data-based papers. Data comparisons to other published literature should not be included in this section.

Discussion

The Discussion should place the research results in the broadest possible scientific or management context. It should highlight the important contributions of the work and relate these contributions to published knowledge. The Discussion should clearly state the importance of the work to rangeland ecology or management.

Implications

All manuscripts should conclude with a brief section (maximum of two paragraphs) that highlights the broad implications of the research. The implications can be either scientific or managerial and reference any aspect of the rangeland profession.

Acknowledgments

The Acknowledgments section immediately precedes Literature Cited and is used to acknowledge individuals who provided assistance with data collection, analyses, and reviews. Grant information is footnoted on the title page, rather than in this section.

Literature Cited

List the citations of all published papers referenced in the text. The majority of citations should be from the peer-reviewed scientific literature. Citations from non–peer-reviewed sources should be limited to general databases (e.g., NOAA climate), manuals (e.g., SAS manuals) or to generic descriptions of study sites. It is the author's responsibility to ensure that all citations are correct and correctly cited in the text. Incorrect citations caught at the proof stage may result in extra charges for alterations.

Figures and Tables

Figures must be uploaded separately from the manuscript text. However, figure captions should be listed on a separate page following the Literature Cited. Tables (in their entirety) should follow the figure captions. See Appendix A for more information about figure files.

Apêndice 1 (Continuação). Normas utilizadas para redação do capítulo II

Supplemental Files

Supplemental files offer additional information to the reader but are not vital to understanding the paper. These files may be tables, figures, appendices, etc., that are too lengthy to print, or non-traditional elements such as spreadsheet tools or audio or video files. Supplemental files are not copy edited or typeset, but posted as submitted directly onto the journal web site when the paper is published. Therefore, please ensure supplemental files are ready to be published when they are submitted. Make sure to cite supplemental files in text using a separate numbering system from regular tables and figures (i.e., Tables S1, S2; Figs. S1, S2; etc.), and use the journal site URL to direct readers to the supplemental data: (Table S1, available at www.srmjournals.org).

Basic Formatting Rules (see Appendix B for specific information)

Headings

FIRST ORDER HEADING (Head #1)

All manuscripts should begin with the first order heading of Introduction. Heading should be all uppercase and centered. Insert a single line of space between Head #1 and text. Text following the heading is flush with the left margin and is not indented. Subsequent paragraphs in the section are indented.

Second Order Heading (Head #2)
Heading should be capitalized and bold, and should be flush with the left margin. The next line of text follows immediately and should be flush with the left margin.

Third Order Heading (Head #3). Heading should be capitalized and bold, but should be indented with a period at the end of the heading. Text begins on the same line.

Fourth Order Heading (Head #4). Heading should be indented and italicized with a period at the end of the heading. Text begins on the same line.

Internal and Technical Style

See Appendix B for specific style instructions. Make sure that all abbreviations used in the text are defined, scientific names (including authorities) are provided for plant and animal species, and complete sources of materials are listed. If these items are missing at the proof stage authors may be charged for providing them.

In-Text Footnotes

Material should be footnoted very rarely. Use superscript numerals.

Apêndice 1 (Continuação). Normas utilizadas para redação do capítulo II

Citations in Text

1. Place citations in chronological order (oldest first), then alphabetical order with semicolon separators.
2. Use et al. with three or more authors
3. EXAMPLES:
   Johnson (2000), (Eliel 2003a, 2003b)
   Johnson and Lewis (2001, 2002)
   (Eliel 1999; Crews and Gartska 2000; Gardos et al. 2002a, 2002b)
4. Provide the date for personal communications. EXAMPLE: (J.T.C. Renner, personal communication, March 2001)
5. Avoid citing unpublished data

Literature Cited

1. Use #1 head style listed above; LITERATURE CITED
2. Citations should be strictly alphabetical by author, then chronological within same author(s). If an agency-author's name has been abbreviated in citations in the text, list the abbreviation first in the Literature Cited: [WRCC] Western Regional Climate Center. 2007….
3. Use city postal codes for USA locations. EXAMPLE: New York, NY, USA
4. Use city and country for countries outside the USA. EXAMPLE: Paris, France
5. Use the full name of journals; journal issue numbers are not necessary. Include information such as "Volume 1." and "2nd ed." with book titles
6. Except for proper names that occur in the titles of papers or books, **capitalize only** the first word in a title, and lowercase the first word after a colon or dash. The only exception is when the paper is published in a different language that typically capitalizes nouns
7. Author rules:
   A. Schuman, G. E. (first/middle initials go after the last name for first authors only), T. Booth, and E. R. Roos
   B. Schuman, G. E., III (1st author), G. E. Schuman III (other authors)
   C. Engle, D. M., Jr. (1st author), D. M. Engle, Jr. (other authors)

Apêndice 1 (Continuação). Normas utilizadas para redação do capítulo II

Figures and Tables

Figure and table callouts in text:

1. All figures and tables must be called out in text, in the order they should appear in the article.
2. Figure, Table spelled out always in text. Use Fig. and Table in parentheses. If citing a figure or table from another work, use lowercase letters.
   EXAMPLES
   (Figs. 10A and 10B); (Figs. 4B–4D)
   Figures 3–5; (Figs. 3–5)
   Figures 1 and 2; (Figs. 1 and 2)
   (Fig. 7; Tables 2 and 3)
   (Johnson et al. 2007, fig. 1)

Figure captions (see Appendix A for information about figure files):

1. Figure captions should be listed on a separate page following the Literature Cited, since the figures will be uploaded separately from the manuscript text.
2. Caption style: **Figure 1.** Description that enables the reader to interpret the figure without referring to text. Refer to different panels in the figure as **A,** Text. **B,** More text. **C,** Final text.
3. Define all abbreviations used in the figure. Style for explanations: NS indicates not significant; ND, not done; and NA, not applicable.
4. When showing mean separations, either capital or lowercase letters are permitted, but should be consistent throughout the manuscript.

Tables:

1. Heading style: **Table 1.** Description that enables the reader to interpret the table without referring to the text. If needed: **Table 1.** Continued.
2. All footnotes are designated and use superscripted numerals. Place a period at end of each footnote. EXAMPLE: [1]TNC indicates total nonstructural carbohydrates; KNF, Kaibab National Forest.
3. Letter designation for statistical significance should be lowercase not superscript.
4. Redefine all abbreviations used in the table. Use the same style for explanations as in figure captions.
5. Abbreviate “number”. EXAMPLE: No. of animals
6. For continued tables, repeat the column headings.
7. All horizontal lines dividing the table should be solid, but lines designating the measurement units should be dashed.

Apêndice 2. Normas utilizadas para redação do capítulo III

Ecology

Submission Instructions:

Consult recent issues for examples of journal style. For purposes of review, submitted manuscripts need not adhere to journal style in every detail; however, preparation of final revisions of manuscripts accepted for publication will be easier if ESA style is followed from the outset. But be sure to abide by the following minimum formatting requirements for submitted manuscripts:

* **The entire manuscript must be double-spaced** (text, quotations, figure legends, literature cited) at three lines per inch (12 lines/10 cm) with a 12-point font, Times New Roman. Choose the "double-spacing" option for line spacing. Leave a 1 inch (2.4-cm) margin on all sides of each page. Do not justify the right margin.

* Assemble the parts of the manuscript in this order: title page, abstract, key words, text, acknowledgments, literature cited, tables (one table per page), figure legends (on separate page preceding the first figure), figures (one figure per page; label each figure, i.e., Figure 1, Figure 2, etc.). Appendices for *Ecological Archives* should be in a separate file.

* Number all pages (including tables, and figures), starting with the title page.

* All pages of text should have line numbers as well.

Specify the manuscript type. Check the length limits for each type by clicking on the links in the table below. Note particularly that length limits for *Ecology* have become more stringent. **Length limits include the entire manuscript meant for ink (including Literature Cited, tables and figures)**.

Articles. While a Report is a concise scientific statement on a single simple topic, an Article tells a more complicated story with distinct components. The greater length of Articles relative to Reports must be justified by their greater complexity. We are asking authors to submit shorter, better-organized pieces that make use of *Ecological Archives* for digital publication of appendices and supplements.*The target length for Articles is 20-30 manuscript pages (double-spaced, 12-point font, including* **everything** *from Title Page through the last figure). Longer Articles (those between 30 and 50 manuscript pages) should be accompanied by a detailed justification for the length in the cover letter at the time of submission.* The abstract can have a maximum of 350 words. Manuscripts longer than 50 pages may be considered for *Ecological Monographs*, at the editor's discretion.

Apêndice 3. Normas utilizadas para redação do capítulo IV

APPLIED ANIMAL BEHAVIOUR SCIENCE

Guide for Authors

Preparation of manuscripts

1. Manuscripts should be written in English. *Language Editing*: Elsevier's Authors Home provides details of some companies who can provide English language and copyediting services to authors who need assistance *before* they submit their article or *before* it is accepted for publication. Authors should contact these services directly. For more information about language editing services, please email authorsupport@elsevier.com.

Please note that Elsevier neither endorses nor takes responsibility for any products, goods or services offered by outside vendors through our services or in any advertising. For more information please refer to our terms & conditions http://www.elsevier.com/termsandconditions.

In addition, the International Society for Applied Ethology can help members with the preparation of manuscripts for publication in *Applied Animal Behaviour Science* (and other English-language journals). Non-members of this Society will first need to join to gain access to this service: contact the Membership Secretary, Moira Harris, e-mail: mharris@harper-adams.ac.uk. Members should requests for assistance to Dr Lindsay Matthews, Ruakura Agricultural Centre, Private Bag, Hamilton, New Zealand, tel.: + 64 7 838 5569; fax: + 64 7 838 5727; e-mail: lindsay.matthews@agresearch.co.nz. Include the paper title, authors, contact address (including fax and e-mail if possible), key words and the journal to which the paper will be submitted. Do not send the manuscript. You will be sent the details of someone who will help you with the English of your paper. The helper should be acknowledged in your paper, but will not expect to be included as an author.

2. Manuscripts should have **numbered lines**, with wide margins and **double spacing** throughout, i.e. also for abstracts, footnotes and references. **Every page of the manuscript, including the title page, references, tables, etc., should be numbered.** However, in the text no reference should be made to page numbers; if necessary one may refer to sections. Avoid excessive usage of italics to emphasize part of the text.

3. Manuscripts in general should be organized in the following order:
Title (should be clear, descriptive and not too long)
Name(s) of author(s) - we would like to publish full first names rather than initials, and would appreciate it if you would provide this information
Complete postal address(es) of affiliations
Full telephone, Fax No. and e-mail address of the corresponding author
Present address(es) of author(s) if applicable
Complete correspondence address including e-mail address to which the proofs should be sent
Abstract
Keywords (indexing terms), normally 3-6 items. Please refer to last index (Vol. 50/3-4).
Introduction
Material studied, area descriptions, methods, techniques
Results
Discussion
Conclusion
Acknowledgment and any additional information concerning research grants, etc.
References
Tables
Figure captions
Tables (separate file(s))
Figures (separate file(s)).

Apêndice 3 (Continuação). Normas utilizadas para redação do capítulo IV

4. Titles and subtitles should not be run within the text. They should be typed on a separate line, without indentation. Use lower-case letter type.

5. SI units should be used.

6. Elsevier reserves the privilege of returning to the author for revision accepted manuscripts and illustrations which are not in the proper form given in this guide.

Abstracts

The abstract should be clear, descriptive and not longer than 400 words. All online users have access to abstracts free-of-charge, and often use it as a basis to decide whether to access the full text article; therefore, the abstract needs to be a carefully written summary of the article and should summarise it so that it is understandable on its own, without reference to the full text. It should begin with a clear statement of the objective of the paper, and end by pointing out important conclusions.

Introduction

The introduction should explain why the research was done, and specify the hypothesis that is being tested. Involved discussions of literature should not be included in the introduction, but in the discussion. The introduction should not normally be more than 750 words (approximately 3 pages).

Materials and Methods

All procedures should be clearly explained, or referred to by means of the original reference. Any modifications to procedures must be explained. The information provided should be sufficient that a reader could repeat exactly the experiments reported, if desired.

Results

This section should include only results that are relevant to the hypotheses outlined in the Introduction and considered in the Discussion. Present results in tabular or graphical form (see following sections) wherever possible. Text should explain why the experiment was carried out, and elaborate on the tabular or graphical data. Sufficient data should be presented so that the reader can interpret the results independently.

In particular, statistical analyses should be complete and appropriate, and full details should be given either in the text, or in the Figures or Tables legends. Include the type of test, the precise data to which it was applied, the value of the relevant statistic, the sample size and/or degrees of freedom, and the probability level. Any assumptions that have been made should be stated. In doubt, a statistical expert should be consulted.

Discussion

The discussion should interpret the results, and set them in the context of what is already known in the appropriate field. The discussion should be focused and limited to the actual results presented, and should normally not exceed about 1500 words. Results already described in the Results section should not be repeated here. Any necessary extensive discussion of the literature should be placed in the Discussion, and not in the Introduction.

Conclusion

The conclusion should be one or two sentences long only, and should present the take-home message that can be derived from the results presented.

Apêndice 3 (Continuação). Normas utilizadas para redação do capítulo IV

Tables

1. Authors should take notice of the limitations set by the size and lay-out of the journal. Large tables should be avoided. Reversing columns and rows will often reduce the dimensions of a table.
2. If many data are to be presented, an attempt should be made to divide them over two or more tables.
3. Tables should be numbered according to their sequence in the text. The text should include references to all tables.
4. Each table should occupy a separate page of the manuscript. Tables should never be included in the text.
5. Each table should have a brief and self-explanatory title.
6. Column headings should be brief, but sufficiently explanatory. Standard abbreviations of units of measurement should be added between parentheses.
7. Vertical lines should not be used to separate columns. Leave some extra space between the columns instead.
8. Any explanation essential to the understanding of the table should be given as a footnote at the bottom of the table.

Illustrations

• Illustrations should be designed with the format of the page of the journal in mind. Illustrations should be of such a size as to allow a reduction of 50%
• Produce images near to the desired size of the printed version
• Each illustration should have a caption. The captions to all illustrations should be typed on a separate sheet of the manuscript
• Produce images near to the desired size of the printed version
• References should be made in the text to each illustration
• Only use the following fonts in your illustrations: Arial, Courier, Helvetica, Times, Symbol
• Lettering should be big enough to allow a reduction of 50% without becoming illegible. Any lettering should be in English
• Use the same kind of lettering throughout and follow the style of the journal
• Number the illustrations according to their sequence in the text
• Use a logical naming convention for your artwork files
• Save text in illustrations as "graphics" or enclose the font
• Provide all illustrations as separate files
• Provide captions to illustrations separately
• Explanations should be given in the figure legend(s). Drawn text in the illustrations should be kept to a minimum
• Photographs are only acceptable if they have good contrast and intensity
• If a scale should be given, use bar scales on all illustrations instead of numerical scales that must be changed with reduction
• Explanations should be given in the figure legend(s). Drawn text in the illustrations should be kept to a minimum.

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Apêndice 3 (Continuação). Normas utilizadas para redação do capítulo IV

Formats

Regardless of the application used, when your electronic artwork is finalised, please "save as" or convert the images to one of the following formats (Note the resolution requirements for line drawings, halftones, and line/halftone combinations given below.):
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TIFF: Colour or greyscale photographs (halftones): always use a minimum of 300 dpi.
TIFF: Bitmapped line drawings: use a minimum of 1000 dpi.
TIFF: Combinations bitmapped line/half-tone (colour or greyscale): a minimum of 500 dpi is required.
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• Supply files that are optimised for screen use (like GIF, BMP, PICT, WPG); the resolution is too low
• Supply files that are too low in resolution
• Submit graphics that are disproportionately large for the content

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References

1. All publications cited in the text should be presented in a list of references following the text of the manuscript. The manuscript should be carefully checked to ensure that the spelling of authors' names and dates are exactly the same in the text as in the reference list.
2. In the text refer to the author's name (without initial) and year of publication, followed, if necessary, by a short reference to relevant pages. Examples: "Since Peterson (1988) has shown that..."; "This is in agreement with results obtained later (Kramer, 1989, pp. 12-16)".
3. If reference is made in the text to a publication written by more than two authors, the name of the first author should be used followed by "et al.". This indication, however, should never be used in the list of references. In this list, names of first author and all co-authors should be mentioned.
4. References cited together in the text should be arranged chronologically. The list of references should be arranged alphabetically on authors' names, and chronologically per author. If an author's name in the list is also mentioned with co-authors, the following order should be used: publications of the single author, arranged according to publication dates - publications of the same author with one co-author - publications of the author with more than one co-author. Publications by the same author(s) in the same year should be listed as 1974a, 1974b, etc.
5. Use the following system for arranging your references:
a. *For periodicals*
Mastrota, F. M., Mench, J. A., 1994. Avoidance of dyed food by the northern bobwhite. Appl. Anim. Behav. Sci. 42, 109-119.
b. *For edited symposia, special issues, etc. published in a periodical*
Thompson, K.V., 1991. Flehmen and social dominance in captive female sable antelope, *Hippotragus niger*. In: Mungal, E.C. (Ed.), Ungulate Behavior and Management. Appl. Anim. Behav. Sci. 29, 121-133.
c. *For relevant papers within books*
Alcock, J., 1975. Animal Behavior. Sinauer Associates, Sunderland, MA, pp. 173-204.
d. *For relevant pages within multi-author books*
Challis, J., Olson, D., 1988. Parturition. In: Knobil, E., J. (Ed), The Physiology of Reproduction, Vol. 2. Raven Press, New York, pp. 2177-2216.

Apêndice 3 (Continuação). Normas utilizadas para redação do capítulo IV

6. Abbreviate the titles of periodicals mentioned in the list of references in accordance with BIOSIS Serial Sources, published annually by BIOSIS. The correct abbreviation for this journal is: Appl. Anim. Behav. Sci.
7. In the case of publications in any language other than English, the original title is to be retained. However, the titles of publications in non-Latin alphabets should be transliterated, and a notation such as "(in Russian)" or "(in Greek, with English abstract)" should be added.
8. Work accepted for publication but not yet published should be referred to as "in press".
9. References concerning unpublished data and "personal communications" should not be cited in the reference list but may be mentioned in the text.
10. Web references may be given. As a minimum, the full URL is necessary. Any further information, such as Author names, dates, reference to a source publication and so on, should also be given.
11. Articles available online but without volume and page numbers may be referred to by means of their Digital Object identifier (DOI) code.

Formulae

1. Give the meaning of all symbols immediately after the equation in which they are first used.
2. For simple fractions use the solidus (/) instead of a horizontal line.
3. Equations should be numbered serially at the right-hand side in parentheses. In general only equations explicitly referred to in the text need be numbered.
4. The use of fractional powers instead of root signs is recommended. Powers of e are often more conveniently denoted by exp.
5. In chemical formulae, valence of ions should be given as, e.g. Ca^{2+} , not as Ca^{++} .
6. Isotope numbers should precede the symbols e.g. ^{18}O.
7. The repeated use of chemical formulae in the text is to be avoided where reasonably possible; instead, the name of the compound should be given in full. Exceptions may be made in the case of a very long name occurring very frequently or in the case of a compound being described as the end product of a gravimetric determination (e.g. phosphate as P_2O_5).

Footnotes

1. Footnotes should only be used if absolutely essential. In most cases it will be possible to incorporate the information in normal text.
2. If used, they should be numbered in the text, indicated by superscript numbers, and kept as short as possible.

Nomenclature

1. Authors and Editors are, by general agreement, obliged to accept the rules governing biological nomenclature, as laid down in the *International Code of Botanical Nomenclature*, the *International Code of Nomenclature of Bacteria*, and the *International Code of Zoological Nomenclature*.
2. All biotica (crops, plants, insects, birds, mammals, etc.) should be identified by their scientific names when the English term is first used, with the exception of common domestic animals.
3. All biocides and other organic compounds must be identified by their Geneva names when first used in the text. Active ingredients of all formulations should be likewise identified.
4. For chemical nomenclature, the conventions of the *International Union of Pure and Applied Chemistry* and the official recommendations of the *IUPAC-IUB Combined Commission on Biochemical Nomenclature* should be followed.

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1) 215 239 3804 or + 44(0)1865 843830, fax + 44(0)1865 853333, e-mail

Apêndice 4. Output do JMP referente à probabilidade de pastejo das novilhas (Capítulo II)

Polynomial Fit Degree=2

Prob[IT] 2 = 1.0305337 - 0.0065236*Touceiras (Peq) - 4.2149e-5*(Touceiras (Peq)-45.5035)^2

Summary of Fit

RSquare	0.955262
RSquare Adj	0.955182
Root Mean Square Error	0.054784
Mean of Response	0.67699
Observations (or Sum Wgts)	1130

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	72.223587	36.1118	12031.93
Error	1127	3.382499	0.0030	**Prob > F**
C. Total	1129	75.606086		0.0000*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.0305337	0.003191	322.91	0.0000*
Touceiras	-0.006524	4.613e-5	-141.4	0.0000*
(Touceiras -45.5035)^2	-4.215e-5	1.798e-6	-23.44	<.0001*

Apêndice 5. Output do JMP referente à probabilidade de pastejo das ovelhas (Capítulo II)

Polynomial Fit Degree=2

Prob[IT] = 0.9518 - 0.0043474*%Touceiras - 2.8874e-5*(%Touceiras-36.7474)^2

Summary of Fit

RSquare	0.806473
RSquare Adj	0.806298
Root Mean Square Error	0.088464
Mean of Response	0.753721
Observations (or Sum Wgts)	2217

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	72.203530	36.1018	4613.122
Error	2214	17.326512	0.0078	**Prob > F**
C. Total	2216	89.530042		0.0000*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.9518	0.002986	318.81	0.0000*
%Touceiras	-0.004347	6.65e-5	-65.37	0.0000*
(%Touceiras-36.7474)^2	-2.887e-5	2.171e-6	-13.30	<.0001*

Apêndice 5 (Continuação). Output do JMP referente à probabilidade de pastejo das ovelhas (Capítulo II)

Polynomial Fit Degree=2
Prob[INT] = 0.0244062 + 0.0012766*%Touceiras + 5.7388e-6*(%Touceiras-36.7474)^2

Summary of Fit

RSquare	0.594699
RSquare Adj	0.594333
Root Mean Square Error	0.041963
Mean of Response	0.078936
Observations (or Sum Wgts)	2217

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	5.7205267	2.86026	1624.305
Error	2214	3.8986659	0.00176	**Prob > F**
C. Total	2216	9.6191926		0.0000*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0244062	0.001416	17.23	<.0001*
%Touceiras	0.0012766	3.154e-5	40.47	<.0001*
(%Touceiras-36.7474)^2	5.7388e-6	1.03e-6	5.57	<.0001*

Polynomial Fit Degree=2
Prob[T] = 0.0237938 + 0.0030708*%Touceiras + 2.3135e-5*(%Touceiras-36.7474)^2

Summary of Fit

RSquare	0.843211
RSquare Adj	0.843069
Root Mean Square Error	0.055978
Mean of Response	0.167343
Observations (or Sum Wgts)	2217

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	37.311307	18.6557	5953.446
Error	2214	6.937767	0.0031	**Prob > F**
C. Total	2216	44.249073		0.0000*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0237938	0.001889	12.59	<.0001*
%Touceiras	0.0030708	0.000042	72.97	0.0000*
(%Touceiras-36.7474)^2	2.3135e-5	1.374e-6	16.84	<.0001*

Apêndice 6. Output do JMP referente à probabilidade de seleção das novilhas (Capítulo II)

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	1.53817	1	3.076349	0.0794
Full	658.86179			
Reduced	660.39996			

RSquare (U)	0.0023
Observations (or Sum Wgts)	957

Converged by Gradient

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-0.2972688	0.1032586	8.29	0.0040*
Touceiras	0.00310834	0.0017738	3.07	0.0797

Apêndice 7. Output do JMP referente à probabilidade de seleção das ovelhas (Capítulo II)

Linear Fit

Prob[S] = 0.7344822 - 0.0021014*%Touceiras

Summary of Fit

RSquare	0.9991
RSquare Adj	0.9991
Root Mean Square Error	0.002299
Mean of Response	0.657261
Observations (or Sum Wgts)	2217

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	12.994482	12.9945	2458799
Error	2215	0.011706	5.285e-6	**Prob > F**
C. Total	2216	13.006188		0.0000*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.7344822	6.935e-5	10591	0.0000*
%Touceiras	-0.002101	1.34e-6	-1568	0.0000*

Apêndice 8. Output do JMP referente à probabilidade de estrato preferencialmente pastejado por novilhas (Capítulo II)

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	562.19722	1	1124.394	<.0001*
Full	134.72357			
Reduced	696.92079			

RSquare (U)	0.8067
Observations (or Sum Wgts)	1130

Converged by Gradient

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	14.4935015	1.3575738	113.98	<.0001*
Touceiras	-0.1954082	0.017761	121.05	<.0001*

Apêndice 9. Output do JMP referente à probabilidade de estrato preferencialmente pastejado por ovelhas (Capítulo II)

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	206.83059	1	413.6612	<.0001*
Full	370.40000			
Reduced	577.23059			

RSquare (U)	0.3583
Observations (or Sum Wgts)	2217

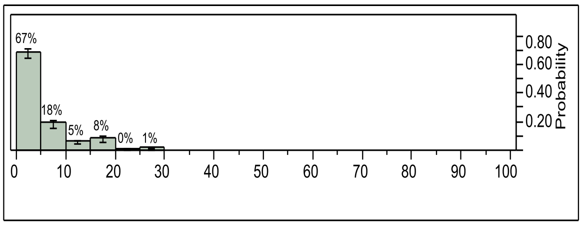
Converged by Gradient

Parameter Estimates

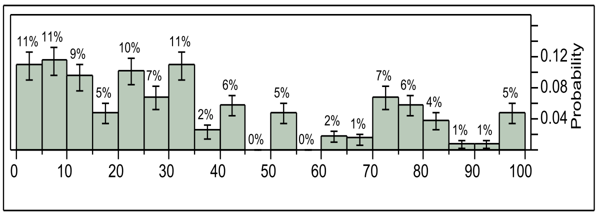
Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	7.41158105	0.5446127	185.20	<.0001*
%Touceiras	-0.0698462	0.0060895	131.56	<.0001*

Apêndice 10. Output do JMP referente à distribuição de touceiras nos tratamentos (Capítulo III)

Mean	2.9318182
Std Dev	5.1391493
Std Err Mean	0.3464814
Upper 95% Mean	3.6146829
Lower 95% Mean	2.2489535
N	220
Sum Wgt	220
Sum	645
Variance	26.410855
Skewness	1.9422554
Kurtosis	3.4269905
CV	175.28881

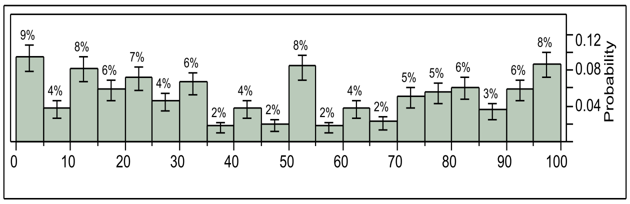


Mean	26.63043
Std Dev	28.79968
Std Err Mean	1.6544984
Upper 95% Mean	36.886235
Lower 95% Mean	30.374625
N	303
Sum Wgt	303
Sum	10190.02
Variance	829.42156
Skewness	0.7360389
Kurtosis	-0.664458
CV	85.635775

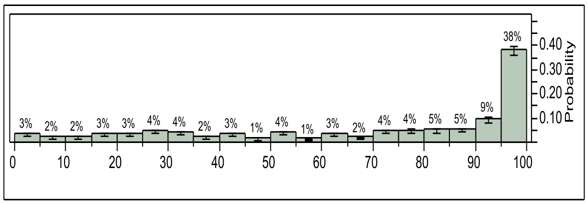


Mean	45.828205
Std Dev	32.177256
Std Err Mean	1.6293587
Upper 95% Mean	48.931656
Lower 95% Mean	42.524754
N	390
Sum Wgt	390
Sum	17834
Variance	1035.3758
Skewness	0.1391993
Kurtosis	-1.378015
CV	70.366322

Apêndice 10 (Continuação). Output do JMP referente à distribuição de touceiras nos tratamentos (Capítulo III)



Mean	69.807205
Std Dev	31.681802
Std Err Mean	1.2026248
Upper 95% Mean	71.86843
Lower 95% Mean	67.145979
N	694
Sum Wgt	694
Sum	48238
Variance	1003.7366
Skewness	-0.813037
Kurtosis	-0.796532
CV	45.580602



Apêndice 11. Output do JMP referente à taxa de encontro de novilhas (Capítulo III)

Summary of Fit

RSquare	0.644933
RSquare Adj	0.626245
Root Mean Square Error	9.966484
Mean of Response	66.52634
Observations (or Sum Wgts)	21

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3428.0011	3428.00	34.5110
Error	19	1887.2852	99.33	**Prob > F**
C. Total	20	5315.2864		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	89.84165	4.525667	19.85	<.0001*
Touceiras	-0.55582	0.094614	-5.87	<.0001*

Apêndice 12. Output do JMP referente à taxa de encontro de ovelhas (Capítulo III)

Summary of Fit

RSquare	0.715809
RSquare Adj	0.712414
Root Mean Square Error	17.93487
Mean of Response	62.48853
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	28697.894	28697.9	89.2182
Error	46	14796.340	321.7	**Prob > F**
C. Total	47	43494.233		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	99.942266	4.735429	21.11	<.0001*
Touceiras	-0.971773	0.102882	-9.45	<.0001*

Apêndice 13. Output do JMP referente à direção escolhida por novilhas (Capítulo III)

Smoothing Spline Fit, lambda=1000

R-Square	0.647811
Sum of Squares Error	212855.9

Summary of Fit

Root Mean Square Error	22.14706
Mean of Response	42.31263
Observations (or Sum Wgts)	467

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	386003.46	386003	786.9716
Error	465	228078.89	490	**Prob > F**
C. Total	466	614082.36		<.0001*

Apêndice 14. Output do JMP referente à direção escolhida por ovelhas (Capítulo III)

Smoothing Spline Fit, lambda=1000

R-Square	0.729402
Sum of Squares Error	316779.7

Summary of Fit

Root Mean Square Error	19.41968
Mean of Response	35.29162
Observations (or Sum Wgts)	895

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	844041.1	844041	2238.100
Error	893	336771.8	377	**Prob > F**
C. Total	894	1180812.9		<.0001*

Apêndice 15. Output do SAS referente à homogeneidade de variâncias para as características da pastagem (Capítulo IV)

Levene's Test for Homogeneity of preITSH Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	7	3.9217	0.5602	1.90	0.1183
Error	22	6.4894	0.2950		

Levene's Test for Homogeneity of posITSH Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	7	6.1115	0.8731	2.59	0.0415
Error	22	7.4196	0.3373		

Levene's Test for Homogeneity of mediaITSH Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	7	4.8277	0.6897	2.33	0.0615
Error	22	6.5205	0.2964		

Apêndice 15 (Continuação). Output do SAS referente à homogeneidade de variâncias para as características da pastagem (Capítulo IV)

Levene's Test for Homogeneity of HMIT Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	7	1347258	192465	3.91	0.0065
Error	22	1084202	49281.9		

Welch's ANOVA for preITSH

Source	DF	F Value	Pr > F
animal*trat	7.0000	0.83	0.5886
Error	8.8476		

Levene's Test for Homogeneity of preTSH Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	5	38.2070	7.6414	3.42	0.2255
Error	17	37.9853	2.2344		

Levene's Test for Homogeneity of posTSH Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	5	34.3663	6.8733	1.53	0.2336
Error	17	76.4860	4.4992		

Levene's Test for Homogeneity of mediaTSH Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	5	32.8566	6.5713	2.12	0.1122
Error	17	52.6192	3.0952		

Apêndice 15 (Continuação). Output do SAS referente à homogeneidade de variâncias para as características da pastagem (Capítulo IV)

Levene's Test for Homogeneity of HMT Variance
ANOVA of Absolute Deviations from Group Means

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
animal*trat	5	46724320	9344864	2.14	0.1099
Error	17	74232063	4366592		

Welch's ANOVA for preTSH

Source	DF	F Value	Pr > F
animal*trat	5.0000	2.19	0.1603
Error	7.5143		

Welch's ANOVA for posTSH

Source	DF	F Value	Pr > F
animal*trat	5.0000	3.65	0.0557
Error	7.4956		

Welch's ANOVA for mediaTSH

Source	DF	F Value	Pr > F
animal*trat	5.0000	3.42	0.0657
Error	7.4143		

Welch's ANOVA for HMT

Source	DF	F Value	Pr > F
animal*trat	5.0000	0.93	0.5119
Error	7.1252		

Apêndice 16. Output do SAS referente às características da pastagem para as novilhas (Capítulo IV)

The Mixed Procedure

Model Information

Data Set	WORK.A1
Dependent Variable	preITSH
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.42	0.7472
Ciclo	1	2	0.74	0.4809
Ciclo*trat	3	2	0.69	0.6377

--------------------- Effect=trat   Method=Tukey-Kramer(P<0.10)   Set=1 ---------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	10.8600	0.4931	0.1	9.8087	11.9113	A
2	_	50	10.4000	0.4931	0.1	9.3487	11.4513	A
3	_	25	10.3514	0.6506	0.1	8.9644	11.7384	A
4	_	0	9.9695	0.6506	0.1	8.5825	11.3564	A

Model Information

Data Set	WORK.A1
Dependent Variable	posITSH
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Apêndice 16 (Continuação). Output do SAS referente às características da pastagem para as novilhas (Capítulo IV)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.74	0.5801
Ciclo	1	2	0.58	0.5268
Ciclo*trat	3	2	0.46	0.7393

--------------------- Effect=trat   Method=Tukey-Kramer(P<0.10)   Set=1 ---------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	10.5100	0.6714	0.1	9.0786	11.9414	A
2	_	50	9.5175	0.6714	0.1	8.0861	10.9489	A
3	_	25	9.3916	0.8676	0.1	7.5421	11.2412	A
4	_	0	9.0434	0.8676	0.1	7.1939	10.8929	A

Model Information

Data Set	WORK.A1
Dependent Variable	mediaITSH
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.62	0.6401
Ciclo	1	2	0.66	0.5024
Ciclo*trat	3	2	0.56	0.6919

--------------------- Effect=trat   Method=Tukey-Kramer(P<0.10)   Set=1 ---------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	10.6825	0.5725	0.1	9.4621	11.9029	A
2	_	50	9.9575	0.5725	0.1	8.7371	11.1779	A
3	_	25	9.8759	0.7475	0.1	8.2825	11.4694	A
4	_	0	9.4914	0.7475	0.1	7.8980	11.0849	A

Apêndice 16 (Continuação). Output do SAS referente às características da pastagem para as novilhas (Capítulo IV)

Model Information

Data Set	WORK.A1
Dependent Variable	preTSH
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	3	1.57	0.3408
Ciclo	1	2	1.19	0.3889
Ciclo*trat	2	2	0.01	0.9883

--------------------- Effect=trat   Method=Tukey-Kramer(P<0.10)   Set=1 ---------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	42.6550	1.5544	0.1	38.9970	46.3130	A
2	_	50	40.1600	1.5544	0.1	36.5020	43.8180	A
3	_	25	38.3129	1.9850	0.1	33.6414	42.9844	A

Model Information

Data Set	WORK.A1
Dependent Variable	posTSH
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	3	3.26	0.1767
Ciclo	1	2	4.87	0.1579
Ciclo*trat	2	2	0.47	0.6805

Apêndice 16 (Continuação). Output do SAS referente às características da pastagem para as novilhas (Capítulo IV)

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	41.4875	1.5131	0.1	37.9265	45.0485	A
2	_	50	36.8000	1.5131	0.1	33.2390	40.3610	A
3	_	25	36.4383	1.7572	0.1	32.3029	40.5737	A

Model Information

Data Set	WORK.A1
Dependent Variable	mediaTSH
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	3	2.25	0.2526
Ciclo	1	2	2.22	0.2750
Ciclo*trat	2	2	0.09	0.9172

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	42.0700	1.5485	0.1	38.4258	45.7142	A
2	_	50	38.4850	1.5485	0.1	34.8408	42.1292	A
3	_	25	37.3174	1.8965	0.1	32.8543	41.7804	A

Model Information

Data Set	WORK.A1
Dependent Variable	HMIT
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Apêndice 16 (Continuação). Output do SAS referente às características da pastagem para as novilhas (Capítulo IV)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.20	0.8927
ciclo	1	2	0.03	0.8814
ciclo*trat	3	2	0.83	0.5868

--------------------- Effect=trat   Method=Tukey-Kramer(P<0.10)   Set=1 ---------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	3093.33	335.21	0.1	2378.72	3807.94	A
2	_	0	2854.11	418.12	0.1	1962.74	3745.48	A
3	_	25	2832.66	418.12	0.1	1941.29	3724.03	A
4	_	75	2740.00	335.21	0.1	2025.39	3454.61	A

Model Information

Data Set	WORK.A1
Dependent Variable	HMT
Covariance Structure	Toeplitz
Subject Effect	trat*bloco
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Between-Within

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	3	0.78	0.5343
ciclo	1	1	27.14	0.1207
ciclo*trat	2	1	0.13	0.8880

-------------------- Effect=trat   Method=Tukey-Kramer(P<0.10)   Set=1 ----------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	22380	1648.94	0.1	18499	26261	A
2	_	25	21859	1958.56	0.1	17249	26468	A
3	_	50	19297	1958.56	0.1	14688	23906	A

Apêndice 17. Output do SAS referente às características da pastagem para as ovelhas (Capítulo IV)

Model Information

Data Set	WORK.A1
Dependent Variable	preITSH
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	7	2.72	0.1241
bloco	1	7	4.93	0.0619
grupo	1	7	0.11	0.7545
grupo*trat	3	7	0.48	0.7058

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	11.3525	0.4421	0.1	10.5150	12.1900	A
2	_	25	10.5425	0.4421	0.1	9.7050	11.3800	A
3	_	75	10.4175	0.4421	0.1	9.5800	11.2550	A
4	_	0	9.5700	0.4421	0.1	8.7325	10.4075	A

Model Information

Data Set	WORK.A1
Dependent Variable	posITSH
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Apêndice 17 (Continuação). Output do SAS referente às características da pastagem para as ovelhas (Capítulo IV 3)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	7	1.52	0.2917
bloco	1	7	1.22	0.3064
grupo	1	7	0.06	0.8190
grupo*trat	3	7	0.55	0.6633

------------------------- Effect=trat   Method=Tukey(P<0.10)   Set=1 ------------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	10.1175	0.3841	0.1	9.3898	10.8452	A
2	_	50	10.0925	0.3841	0.1	9.3648	10.8202	A
3	_	25	9.9150	0.3841	0.1	9.1873	10.6427	A
4	_	0	9.1125	0.3841	0.1	8.3848	9.8402	A

Model Information

Data Set	WORK.A1
Dependent Variable	mediaITSH
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	7	2.07	0.1933
bloco	1	7	3.06	0.1238
grupo	1	7	0.08	0.7802
grupo*trat	3	7	0.34	0.7970

Apêndice 17 (Continuação). Output do SAS referente às características da pastagem para as ovelhas (Capítulo IV)

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 ------------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	10.7200	0.4009	0.1	9.9604	11.4796	A
2	_	75	10.2675	0.4009	0.1	9.5079	11.0271	A
3	_	25	10.2275	0.4009	0.1	9.4679	10.9871	A
4	_	0	9.3425	0.4009	0.1	8.5829	10.1021	A

Model Information

Data Set	WORK.A1
Dependent Variable	preTSH
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	5	1.98	0.2331
bloco	1	5	2.48	0.1760
grupo	1	5	0.01	0.9239
grupo*trat	2	5	0.04	0.9581

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 ------------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	47.7700	2.2842	0.1	43.1673	52.3727	A
2	_	75	43.2550	2.2842	0.1	38.6523	47.8577	A
3	_	25	41.5575	2.2842	0.1	36.9548	46.1602	A

Model Information

Data Set	WORK.A1
Dependent Variable	posTSH
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Apêndice 17 (Continuação). Output do SAS referente às características da pastagem para as ovelhas (Capítulo IV)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	5	0.41	0.6857
bloco	1	5	3.95	0.1036
grupo	1	5	0.51	0.5072
grupo*trat	2	5	1.15	0.3879

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	46.0125	2.0722	0.1	41.8369	50.1881	A
2	_	75	44.1425	2.0722	0.1	39.9669	48.3181	A
3	_	25	43.4575	2.0722	0.1	39.2819	47.6331	A

Model Information

Data Set	WORK.A1
Dependent Variable	mediaTSH
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	5	1.18	0.3798
bloco	1	5	3.43	0.1233
grupo	1	5	0.09	0.7763
grupo*trat	2	5	0.32	0.7378

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	46.8900	2.0838	0.1	42.6910	51.0890	A
2	_	75	43.7000	2.0838	0.1	39.5010	47.8990	A
3	_	25	42.5075	2.0838	0.1	38.3085	46.7065	A

Apêndice 17 (Continuação). Output do SAS referente às características da pastagem para as ovelhas (Capítulo IV)

Model Information

Data Set	WORK.A1
Dependent Variable	HMIT
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	1.26	0.4012

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	50	2600.00	250.40	0.1	2066.19	3133.81	A
2	25	2500.00	250.40	0.1	1966.19	3033.81	A
3	75	2220.00	250.40	0.1	1686.19	2753.81	A
4	0	1980.00	250.40	0.1	1446.19	2513.81	A

Model Information

Data Set	WORK.A1
Dependent Variable	HMT
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	2	3	0.51	0.6428

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	25	20700	2729.05	0.1	14278	27122	A
2	75	19200	2729.05	0.1	12778	25622	A
3	50	16820	2729.05	0.1	10398	23242	A

Apêndice 18. Output do SAS referente ao tempo de pastejo nos estratos por novilhas (Capítulo IV)

Dependent Variable T

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	48.4850	5.3880	0.1	36.9985	59.9715	A
2	_	50	30.4000	5.3880	0.1	18.9135	41.8865	AB
3	_	25	18.8635	6.1049	0.1	5.8488	31.8783	B
4	_	0	6.4567	6.1049	0.1	-6.5580	19.4715	B

Dependent Variable IT

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	0	93.1308	5.1952	0.1	82.0554	104.21	A
2	_	25	77.7958	5.1952	0.1	66.7205	88.8712	AB
3	_	50	67.8550	4.5103	0.1	58.2397	77.4703	BC
4	_	75	49.6150	4.5103	0.1	39.9997	59.2303	C

Dependent Variable INT

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	25	3.3316	1.5175	0.1	0.09662	6.5667	A
2	_	75	2.0225	1.4974	0.1	-1.1698	5.2148	A
3	_	50	1.6525	1.4974	0.1	-1.5398	4.8448	A
4	_	0	0.2579	1.5175	0.1	-2.9772	3.4929	A

The REG Procedure
Model: MODEL1
Dependent Variable: T

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2959.70315	2959.70315	61.97	<.0001
Error	12	573.16209	47.76351		
Corrected Total	13	3532.86524			

Root MSE	6.91111	R-Square	0.8378
Dependent Mean	29.22214	Adj R-Sq	0.8242
Coeff Var	23.65027		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	5.78458	3.50379	1.65	0.1247
Touceiras	1	0.59175	0.07517	7.87	<.0001

Apêndice 18 (Continuação). Output do SAS referente ao tempo de pastejo nos estratos por novilhas (Capítulo IV)

The REG Procedure
Model: MODEL1
Dependent Variable: IT

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	3072.54456	3072.54456	62.67	<.0001
Error	12	588.32072	49.02673		
Corrected Total	13	3660.86529			

Root MSE	7.00191	R-Square	0.8393
Dependent Mean	69.10286	Adj R-Sq	0.8259
Coeff Var	10.13259		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	92.98303	3.54982	26.19	<.0001
Touceiras	1	-0.60293	0.07616	-7.92	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: INT

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	2.21628	2.21628	0.76	0.3998
Error	12	34.89887	2.90824		
Corrected Total	13	37.11515			

Root MSE	1.70536	R-Square	0.0597
Dependent Mean	1.57500	Adj R-Sq	-0.0186
Coeff Var	108.27658		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.93364	0.86458	1.08	0.3014
Touceiras	1	0.01619	0.01855	0.87	0.3998

Apêndice 19. Output do SAS referente ao tempo de pastejo nos estratos por ovelhas (Capítulo IV)

Dependent Variable T

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 ------------------

Obs	trat	grupo	turno	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	75	_		25.0875	2.8428	0.1	19.9350	30.2400	A
2	50	_		16.5975	2.8428	0.1	11.4450	21.7500	AB
3	25	_		8.9550	2.8428	0.1	3.8025	14.1075	BC
4	0	_		2.7775	2.8428	0.1	-2.3750	7.9300	C

Dependent Variable IT

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 ------------------

Obs	trat	grupo	turno	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	0	_		95.2800	2.8699	0.1	90.0784	100.48	A
2	25	_		83.0650	2.8699	0.1	77.8634	88.2666	B
3	50	_		79.3075	2.8699	0.1	74.1059	84.5091	B
4	75	_		63.1600	2.8699	0.1	57.9584	68.3616	C

Dependent Variable INT

------------------------ Effect=trat Method=Tukey(P<0.10) Set=1 -------------------

Obs	trat	grupo	turno	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	75	_		11.7550	1.4508	0.1	9.1254	14.3846	A
2	25	_		6.8800	1.4508	0.1	4.2504	9.5096	AB
3	50	_		5.0675	1.4508	0.1	2.4379	7.6971	BC
4	0	_		1.3425	1.4508	0.1	-1.2871	3.9721	C

Apêndice 19 (Continuação). Output do SAS referente ao tempo de pastejo nos estratos por ovelhas (Capítulo IV)

The REG Procedure
Model: MODEL1
Dependent Variable: T

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1030.09093	1030.09093	25.15	0.0002
Error	14	573.50867	40.96490		
Corrected Total	15	1603.59959			

Root MSE	6.40038	R-Square	0.6424
Dependent Mean	13.35438	Adj R-Sq	0.6168
Coeff Var	47.92724		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.75996	2.81183	0.63	0.5414
Touceiras	1	0.32129	0.06407	5.01	0.0002

The REG Procedure
Model: MODEL1
Dependent Variable: IT

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	1949.60616	1949.60616	41.02	<.0001
Error	14	665.36699	47.52621		
Corrected Total	15	2614.97314			

Root MSE	6.89393	R-Square	0.7456
Dependent Mean	80.20313	Adj R-Sq	0.7274
Coeff Var	8.59558		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	96.15400	3.02865	31.75	<.0001
Touceiras	1	-0.44201	0.06901	-6.40	<.0001

Apêndice 19 (Continuação). Output do SAS referente ao tempo de pastejo nos estratos por ovelhas (Capítulo IV)

The REG Procedure
Model: MODEL1
Dependent Variable: INT

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	172.18698	172.18698	17.62	0.0009
Error	14	136.77759	9.76983		
Corrected Total	15	308.96458			

Root MSE	3.12567	R-Square	0.5573
Dependent Mean	6.26125	Adj R-Sq	0.5257
Coeff Var	49.92090		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.52089	1.37318	1.11	0.2867
Touceiras	1	0.13136	0.03129	4.20	0.0009

Apêndice 20. Output do SAS referente às variáveis do comportamento ingestivo de novilhas (Capítulo IV)

Dependent Variable ET

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	3	2.46	0.2398
Ciclo	1	1	0.00	0.9565
Ciclo*trat	3	1	21.66	0.1564

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	51.4880	0.8424	0.1	49.5054	53.4705	A
2	_	50	50.6875	0.7989	0.1	48.8074	52.5676	A
3	_	0	48.8750	0.8424	0.1	46.8924	50.8576	A
4	_	25	48.5000	1.1298	0.1	45.8411	51.1589	A

Dependent Variable RIWL

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	1.09	0.4479
Ciclo	1	1	0.77	0.5409
Ciclo*trat	3	1	0.27	0.8512

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	0.000699	0.000114	0.1	0.000456	0.000941	A
2	_	25	0.000584	0.000135	0.1	0.000295	0.000873	A
3	_	0	0.000555	0.000135	0.1	0.000266	0.000844	A
4	_	75	0.000379	0.000135	0.1	0.000090	0.000668	A

Apêndice 20 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de novilhas (Capítulo IV)

Dependent Variable NBGJMR

----------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -------------------

Obs	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	0	32.9607	3.1089	0.1	27.1795	38.7419	A
2	25	25.1367	3.1089	0.1	19.3555	30.9179	AB
3	50	24.8333	3.1089	0.1	19.0521	30.6145	AB
4	75	19.9104	3.1089	0.1	14.1292	25.6916	B

Dependent Variable BR

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	55.6126	2.3999	0.1	50.9492	60.2761	A
2	_	50	49.2214	1.9919	0.1	45.3508	53.0921	AB
3	_	25	48.6172	1.9919	0.1	44.7466	52.4879	AB
4	_	0	41.9481	1.9919	0.1	38.0775	45.8188	B

Dependent Variable GJMR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	1194.43	0.1201
Ciclo	1	1	0.76	0.5445
Ciclo*trat	3	1	0.09	0.9580

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	0	74.2146	0.04957	0.1	74.1089	74.3203	A
2	_	50	73.8099	0.03506	0.1	73.7351	73.8846	A
3	_	25	72.1321	0.04957	0.1	72.0265	72.2378	A
4	_	75	70.7004	0.04957	0.1	70.5947	70.8061	A

Apêndice 20 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de novilhas (Capítulo IV)

Dependent Variable IMIN

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	0	7.2667	1.2570	0.1	4.9625	9.5709	A
2	25	3.8333	1.2570	0.1	1.5291	6.1375	AB
3	50	3.4000	1.0886	0.1	1.4045	5.3955	AB
4	75	2.2667	1.2570	0.1	-0.03752	4.5709	B

Dependent Variable IMID

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	0	25.1020	3.9373	0.1	16.7084	33.4957	A
2	_	50	11.8250	3.7479	0.1	3.8351	19.8149	AB
3	_	25	9.0248	3.9373	0.1	0.6311	17.4185	AB
4	_	75	3.9660	3.9373	0.1	-4.4277	12.3597	B

Dependent Variable STIR

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	Ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	25	0.5880	0.01415	0.1	0.5547	0.6213	A
2	_	50	0.5061	0.01001	0.1	0.4825	0.5296	B
3	_	0	0.3473	0.01398	0.1	0.3144	0.3803	C
4	_	75	0.2909	0.01398	0.1	0.2580	0.3238	C

Dependent Variable BM

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	50	9.3807	0.6703	0.1	8.1108	10.6505	A
2	0	9.0870	0.6703	0.1	7.8172	10.3568	AB
3	25	8.9400	0.8209	0.1	7.3848	10.4952	AB
4	75	6.7373	0.6703	0.1	5.4675	8.0072	B

Apêndice 20 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de novilhas (Capítulo IV)

The REG Procedure
Model: MODEL1
Dependent Variable: IMIN

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	46.24556	46.24556	13.13	0.0040
Error	11	38.74213	3.52201		
Corrected Total	12	84.98769			

Root MSE	1.87670	R-Square	0.5441
Dependent Mean	4.13077	Adj R-Sq	0.5027
Coeff Var	45.43227		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	7.05910	0.96125	7.34	<.0001
touceiras	1	-0.07841	0.02164	-3.62	0.0040

The REG Procedure
Model: MODEL1
Dependent Variable: IMID

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	659.53970	659.53970	19.36	0.0011
Error	11	374.82953	34.07541		
Corrected Total	12	1034.36923			

Root MSE	5.83741	R-Square	0.6376
Dependent Mean	12.59231	Adj R-Sq	0.6047
Coeff Var	46.35699		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	23.65103	2.98992	7.91	<.0001
touceiras	1	-0.29611	0.06731	-4.40	0.0011

Apêndice 20 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de novilhas (Capítulo IV)

The REG Procedure
Model: MODEL1
Dependent Variable: NBGJMR

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	248.06423	248.06423	10.09	0.0099
Error	10	245.82100	24.58210		
Corrected Total	11	493.88523			

Root MSE	4.95803	R-Square	0.5023
Dependent Mean	25.71025	Adj R-Sq	0.4525
Coeff Var	19.28427		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	32.38849	2.54324	12.74	<.0001
touceiras	1	-0.18297	0.05760	-3.18	0.0099

The REG Procedure
Model: MODEL1
Dependent Variable: BR

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	189.25658	189.25658	15.18	0.0036
Error	9	112.20728	12.46748		
Corrected Total	10	301.46386			

Root MSE	3.53093	R-Square	0.6278
Dependent Mean	48.35940	Adj R-Sq	0.5864
Coeff Var	7.30144		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	42.49625	1.84337	23.05	<.0001
touceiras	1	0.17554	0.04506	3.90	0.0036

Apêndice 20 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de novilhas (Capítulo IV)

The REG Procedure
Model: MODEL1
Dependent Variable: STIR

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	0.00868	0.00434	15.89	0.0011
Error	9	0.00246	0.00027325		
Corrected Total	11	0.01114			

Root MSE	0.01653	R-Square	0.7793
Dependent Mean	0.10703	Adj R-Sq	0.7302
Coeff Var	15.44414		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.08381	0.01048	8.00	<.0001
touceiras	1	0.00325	0.00064817	5.02	0.0007
touceiras	1	-0.00004892	0.00000880	-5.56	0.0004

Nonlinear Fit

Response: BM, Predictor: Model L (3P) 2

Parameter	Estimate	Low	High
theta1	9.1715254256	5e+9	1.5e+10
theta2	0.1228013696	0.75	2.25

Solution

SSE	DFE	MSE	RMSE
9.2274591399	9	1.0252732	1.0125578

Parameter	Estimate	ApproxStdErr
theta1	9.1715254256	0.35789857
theta2	0.1228013696	0.03412824

Summary of Fit

RSquare	0.589926
RSquare Adj	0.544363
Root Mean Square Error	1.012558
Mean of Response	8.499467
Observations (or Sum Wgts)	11

Apêndice 21. Output do SAS referente às variáveis do comportamento ingestivo de ovelhas (Capítulo IV)

Dependent Variable ET
Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	3.41	0.1333
grupo	1	3	0.83	0.4299
grupo*trat	3	3	0.35	0.7925

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	0	46.6265	0.2961	0.1	45.9952	47.2578	A
2	_	50	45.7000	0.2152	0.1	45.2413	46.1587	A
3	_	75	45.6750	0.2152	0.1	45.2163	46.1337	A
4	_	25	45.5000	0.2152	0.1	45.0413	45.9587	A

Dependent Variable RIWL
Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.21	0.8816
grupo	1	4	2.04	0.2262
grupo*trat	3	4	2.05	0.2493

------------------------- Effect=trat Method=Tukey(P<0.10) Set=1 -----------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	0.000178	0.000062	0.1	0.000044	0.000311	A
2	_	75	0.000125	0.000062	0.1	-8.57E-6	0.000258	A
3	_	0	0.000118	0.000062	0.1	-0.00001	0.000251	A
4	_	25	0.000117	0.000062	0.1	-0.00002	0.000250	A

Apêndice 21 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de ovelhas (Capítulo IV)

Dependent Variable NBGJMR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.89	0.5179
grupo	1	3	14.10	0.0330
grupo*trat	3	3	46.83	0.0051

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	66.9050	4.8850	0.1	56.4910	77.3190	A
2	_	25	62.0675	4.8850	0.1	51.6535	72.4815	A
3	_	50	61.2525	4.8850	0.1	50.8385	71.6665	A
4	_	0	55.6215	4.9028	0.1	45.1696	66.0734	A

Dependent Variable BR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	1.88	0.2744
grupo	1	3	3.65	0.1519
grupo*trat	3	3	0.70	0.6131

------------------ Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ------------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	0	62.6147	3.3383	0.1	55.4980	69.7315	A
2	_	75	56.1375	2.8698	0.1	50.0195	62.2555	A
3	_	50	55.1650	2.8698	0.1	49.0470	61.2830	A
4	_	25	52.3400	2.8698	0.1	46.2220	58.4580	A

Apêndice 21 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de ovelhas (Capítulo IV)

Dependent Variable GJMR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.76	0.5740
grupo	1	3	3.98	0.1400
grupo*trat	3	3	1.36	0.4024

----------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ------------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	123.04	4.1053	0.1	114.29	131.79	A
2	_	0	119.22	4.4052	0.1	109.83	128.61	A
3	_	50	117.83	4.1053	0.1	109.08	126.58	A
4	_	25	114.41	4.1053	0.1	105.66	123.16	A

Dependent Variable STIR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.46	0.7244
grupo	1	2	0.02	0.8911
grupo*trat	3	2	2.63	0.2875

----------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 -------------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	0	0.2496	0.03393	0.1	0.1772	0.3219	A
2	_	50	0.2371	0.02953	0.1	0.1742	0.3001	A
3	_	75	0.2258	0.03393	0.1	0.1535	0.2981	A
4	_	25	0.2002	0.02953	0.1	0.1372	0.2632	A

Apêndice 21 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de ovelhas (Capítulo IV)

Dependent Variable BM

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	3	1.45	0.3836
grupo	1	1	0.03	0.8966
grupo*trat	3	1	0.72	0.6758

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	50	4.3205	0.2725	0.1	3.6792	4.9619	A
2	_	0	4.2650	0.3854	0.1	3.3581	5.1720	A
3	_	25	3.8299	0.3623	0.1	2.9773	4.6824	A
4	_	75	3.4523	0.3623	0.1	2.5998	4.3049	A

Dependent Variable IMIN

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	3.58	0.1250
grupo	1	2	0.91	0.4398
grupo*trat	3	2	5.22	0.1650

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	25	10.0000	1.1890	0.1	7.4652	12.5348	A
2	_	50	6.4083	1.4597	0.1	3.2964	9.5201	A
3	_	75	5.2500	1.1890	0.1	2.7152	7.7848	A
4	_	0	4.8839	1.4597	0.1	1.7721	7.9957	A

Apêndice 21 (Continuação). Output do SAS referente às variáveis do comportamento ingestivo de ovelhas (Capítulo IV)

Dependent Variable IMID

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	3	4	0.96	0.4935
grupo	1	3	4.29	0.1301
grupo*trat	3	3	5.38	0.1002

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	grupo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	75	11.7975	2.4431	0.1	6.5892	17.0058	A
2	_	50	10.0475	2.4431	0.1	4.8392	15.2558	A
3	_	25	8.9850	2.4431	0.1	3.7767	14.1933	A
4	_	0	5.9915	2.5216	0.1	0.6158	11.3673	A

Apêndice 22. Output do SAS referente à comparação do comportamento ingestivo de novilhas entre estrato superior e inferior da pastagem (Capítulo IV)

Dependent Variable STIR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	1	2	21.31	0.0439
ciclo	1	2	1.36	0.3641

------------------ Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ------------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	IT	0.3514	0.01296	0.1	0.3135	0.3892	A
2	_	T	0.2587	0.01534	0.1	0.2139	0.3035	B

Dependent Variable BM

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	1	2	49.48	0.0196
ciclo	1	2	0.10	0.7787

------------------ Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ------------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	IT	9.0544	0.3927	0.1	7.9077	10.2011	A
2	_	T	4.7751	0.4647	0.1	3.4184	6.1319	B

Dependent Variable BR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	1	2	20.35	0.0458
ciclo	1	2	0.33	0.6225

Apêndice 22 (Continuação). Output do SAS referente à comparação do comportamento ingestivo de novilhas entre estrato superior e inferior da pastagem (Capítulo IV)

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	T	57.7500	2.6495	0.1	50.0136	65.4864	A
2	_	IT	42.1000	1.7345	0.1	37.0353	47.1647	B

Dependent Variable NBGJMR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	1	4	5.84	0.0730
ciclo	1	4	3.96	0.1175

-------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 ---------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	T	39.8000	2.1151	0.1	35.2910	44.3090	A
2	_	IT	31.8800	2.5026	0.1	26.5449	37.2151	B

Dependent Variable GJMR

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trat	1	4	18.67	0.0124

--------------------- Effect=trat Method=Tukey-Kramer(P<0.10) Set=1 --------------

Obs	ciclo	trat	Estimate	Standard Error	Alpha	Lower	Upper	Group
1	_	T	85.7000	1.5433	0.1	82.4100	88.9900	A
2	_	IT	75.3700	1.8260	0.1	71.4772	79.2628	B

Apêndice 23. Animais com os equipamentos para os testes de pastejo.

8. VITA

Carolina Bremm é filha de Sérgio Adalberto Bremm e Zuleica Dummer Bremm, nasceu em 09 de abril de 1982 no município de Santa Cruz do Sul, Rio Grande do Sul. Cursou os ensinos fundamental e médio no Colégio Mauá, em sua cidade natal, sendo o segundo grau finalizado no ano de 1999. Em 2000 ingressou no Curso de graduação em Zootecnia pela Universidade Federal de Santa Maria (UFSM). Durante o curso de graduação, desenvolveu estágio extracurricular no setor de Forragicultura do Departamento de Zootecnia de 2002 a 2004, quando foi bolsista Fapergs. Concluiu a Faculdade de Zootecnia em dezembro de 2004. Em 2005 ingressou no curso de Mestrado junto ao Programa de Pós-graduação em Zootecnia da Universidade Federal de Santa Maria, sendo bolsista CAPES. Em fevereiro de 2007 obteve o grau de Mestre em Zootecnia. Em março de 2007 ingressou no curso de Doutorado junto ao Programa de Pós-graduação em Zootecnia pela Universidade Federal do Rio Grande do Sul (UFRGS), na área de concentração Plantas Forrageiras, com bolsa pelo CNPq.