UNIVERSIDADE FEDERAL DO PARANÁ

DELMA FABÍOLA FERREIRA DA SILVA

RESÍDUOS DE LAVOURAS AFETAM A INGESTÃO DO PASTO POR OVINOS EM SISTEMAS INTEGRADOS DE PRODUÇÃO AGROPECUÁRIA?

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Tese apresentada ao Curso de Pós-Graduação em Agronomia, área de concentração, Produção vegetal em Sistemas integrados. Departamento de Fitotecnia e Fitossanitarismo, Setor de Ciências Agrárias, Universidade Federal do Paraná, como requisito para obtenção do título de Doutor em Ciências.

Orientador: Prof. Dr. Paulo César de Faccio Carvalho
Co-orientador: Prof. Dr. Aníbal de Moraes e Dra. Carolina Bremm.

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Curitiba, 28 de Abril de 2017.

PAULO CÉSAR DE FACCIO CARVALHO
Presidente da Banca Examinadora (UFRGS)

ANIBAL DE MORAES
Avaliador Interno (UFPR)

Carolina Bremm
CAROLINA BREMM
Avaliador Externo (UFRGS)

Ana Luisa Palhano Silva
ANA LUISA PALHANO SILVA
Avaliador Externo (UTP)

LEONARDO DEISS
Avaliador Externo (UTP)

Aos meu pais Eloy Martins da Silva e Elifas Ferreira da Silva,

Aos meus padrinhos Leonor Ferreira de Oliveira e Humberto Pinto de Oliveira (*in memorian*)

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"Nenhum olho está capacitado a ver o Sol enquanto, de certa maneira, não for ele mesmo um sol".

Filósofo romano Plotino

RESUMO

Em sistemas integrados de produção agropecuária (SIPA), a rotação de culturas inclui na fase pastagem a presença de resíduos de lavouras antecessoras. Além disso, há diversas formas e estratégias de arranjos de cultivo de lavouras. O objetivo geral desta Tese foi estudar o processo de pastejo de animais em pasto de azevém (*Lolium multiflorum* Lam.) em áreas de culturas antecessoras de soja e milho (*Glycine max* L. *Merril e Zea mays* L.). O primeiro capítulo da Tese é a revisão bibliográfica sobre manejo do pasto num contexto histórico e atual. O segundo capítulo tem como objetivo avaliar os efeitos dos resíduos da lavoura antecessora de soja e milho nos padrões de comportamento ingestivo de cordeiros em azevém. O terceiro capítulo quantifica os mecanismos pelos quais a taxa de ingestão do azevém é determinada em diferentes alturas de resíduos de lavoura antecessora soja e milho. O quarto capítulo, investigou a influência dos resíduos de soja e milho, suas características de diâmetro, altura e espaçamento entre plantas no processo de ingestão de azevém. Concluiu-se que há influência das culturas antecessoras na estrutura do pasto de azevém levando a mudanças nos padrões de comportamento ingestivo animal. Além disso, resíduos de colheita da cultura antecessora milho acima de 30 cm reduzem a taxa de ingestão de curto prazo e a massa de bocados. A soja, como lavoura antecessora, pode ser considerada como alternativa para melhorar o desempenho animal. Um determinado tipo de bocado é realizado em maior número, de acordo com a maior quantidade de matéria seca capturada por este. O espaçamento entre as plantas e a altura dos resíduos regulam a massa de bocado total. Os resíduos de colheita de lavoura antecessora na fase pastagem participam como estrutura vertical no processo de seleção, em que o animal adapta os bocados.

Palavras chave: Integração lavoura-pecuária; Estrutura do pasto; Comportamento ingestivo; Taxa de ingestão.

ABSTRACT

In integrated crop-livestock systems (ICLS), crop rotation includes in the pasture phase the presence of residues from predecessor crops. In addition, there are several ways and strategies of crop cultivation arrangements. The objective was to study the ingestive behavior of the animals in Italian ryegrass (*Lolium multiflorum* Lam.) in areas of predecessor crops soybean and maize (*Glycine max* L*. Merril e Zea mays* L.). The first chapter of the thesis is the bibliographical review on pasture management in a historical and current context. The second chapter evaluates the effects of crop predecessors (maize or soybean) and their residues on ingestive behavior patterns of lambs grazing Italian ryegrass in the subsequent pasture phase. The third chapter quantifies the mechanisms by which the intake rate of Italian ryegrass is determined in different contrasting heights of predecessor soybean and maize crop residue. The fourth chapter investigated the influence of crop residues and their characteristics of diameter, height and spacing in between plants in intake process on Italian ryegrass. It was possible to conclude that the influence of predecessor crops may alter the structure of Italian ryegrass pasture leading to changes in animal ingestive behavior patterns. Thus, maize crop residues above 30 cm reduce the short-term intake rate. Predominant soybean farming may be considered as an alternative to improve the animal performance. A certain type of bite is carried out in greater number, according to the greater amount of dry matter captured by it.Maize residues reduce the bite mass (BM). The spacing between the plants and the height of the residues regulate the total BM. The residues participate as a vertical structure in the selection process, in which the animal adapts the bites.

Key-words: Mixed crop-livestock systems; Sward structure; Ingestive behavior; Short-term intake rate.

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LISTA DE ABREVIATURAS

Abreviatura	Descrição
ANOVA…………………...…	Variance analysis
BM………………………...	Bite mass
BR………………………...	Bite rate
cm…………………………	Centímetro
DM…………………….....	Dry matter
DMM……………………...	Dead material mass
E……………..……….…...	Energia digestível
ET…………………………	Effective eating time
ETL	Extended tiller length
g……………………………	Grama (medida)
H……………………………..	Tempo necessário para cortar e mastigar a massa do bocado
ha……………………………	Hectare
HM……………………......	Herbage mass
HPCR………………………	Height of predecessor crops residue
IAF…………………………..	Índice de área foliar
ICLS…………………………	Integrated crop-livestock systems

IM……………………………	Inflorescence mass
IMID…………………………	Intra-meal interval duration
Kg…………………………	Kilograma
LM…………………………	Leaf mass
m^2……………………………	Metros quadrados
m^3……………………………	Metros cúbicos
MB…………………………	Massa de bocado
mm…………………………	Milimetros (medida)
N-BJMR……………………	Non-biting jaw movements rate
NBR…………………………	Non-biting rates
NIMI…………………………	Number of intra-meal interval of grazing
PMC…………………………	Predecessor maize crops
P_P ……………………………	p-value for predecessor crop
P_{PXR} …………………………	p-value for interaction between predecessor crop and residue height
P_R ……………………………	p-value for crop residue height
PSC…………………………	Predecessor soybean crops
PSM……….………………	Pseudostems and sheaths mass
P-Value…………………......	Probability Value
SBP……………………….....	Spacing between plants
sd……..……………………...	Standard deviation
SIPA…………………………	Sistemas de integração em produção agropecuária
SIPA…………………………	Systems of integration in agricultural production
SSH…………………………	Sward surface height
STIR…………………………	Short-term herbage intake rate
TJM…………………………	Total jaw movements rate
TSB…………………………	Time spent for bite
UFRGS……………………	University of Rio Grande do Sul
W……………………………	Animal's weight

SUMÁRIO

1. INTRODUÇÃO GERAL

O Sistema Integrado de Produção Agropecuária (SIPA) é reconhecido como alternativa para intensificação sustentável (FAO, 2010). É caracterizado como sistema planejado para explorar sinergismos, resultado de interações entre os diferentes compartimentos, que se integram em diferentes escalas espaço-temporais (Moraes et al., 2014).

Como característica deste sistema, nas regiões subtropicais da América do Sul como Brasil, Argentina, Uruguai e Paraguai, tem–se alternância de lavouras e pastos cultivados em rotação na mesma área, com relevância para a soja (*Glycine max*L. *Merril*) e o milho (*Zea mays* L.) nos cultivos de verão, e azevém (*Lolium multiflorum* Lam.) e aveia (*Avena Sativa*) como pastos de inverno (Carvalho et al., 2010; Barth Neto et al., 2013).

Em SIPA que utiliza semeadura direta, a rotação de cultivos na mesma área resulta na presença de resíduos verticais e horizontais (Figura 1). Estes atuam na estruturação e proteção física do solo e ciclagem de nutrientes. Resíduos horizontais podem ser aqueles que se encontram na superfície paralela ao solo, derivados de lavouras ou pasto (e.g Azevém). Os resíduos verticais (Figura 1) são compostos, em sua maioria, por colmos e/ou hastes, ainda enraizadas, que não foram arrancadas e não sofreram deformação após o processo da colheita, e que ficam perpendicular ao solo. Neste trabalho, será abordado os resíduos verticais de lavoura que permanecem no solo até a fase pastagem (e.g. soja e milho).

Nestas condições, compreender a utilização do ambiente de pastejo pelo animal é fundamental para o manejo de pasto (Provenza et al., 2013). Considerando que condições passadas podem trazer consequências atuais (Provenza et al., 2013), a interação planta- animal deve abranger a relação de tempo e espaço (Bailey e Provenza, 2008). Assim, o processo anterior (escolha de lavoura), e o presente, no manejo da colheita de lavoura pelo homem e de pasto pelo animal, pode levar a efeitos diretos e indiretos no comportamento animal. Assim, se faz importante a visão sistêmica em SIPA.

É sabido que resíduos horizontais de soja e milho podem alterar as condições de pasto do azevém, devido a efeitos físicos e químicos, de curto prazo, dos resíduos vegetais sobre o meio ambiente local (Barth Neto et al., 2013). Desta forma, esta Tese tem como hipótese que resíduos verticais de lavouras antecessoras de soja e milho afetam o comportamento ingestivo dos animais na fase pastagem, trazendo mudanças na ingestão de pasto.

Para melhor compreensão da hipótese deste trabalho, a Figura 2 apresenta o modelo conceitual de comportamento ingestivo animal, em pasto de azevém anual, após seu estabelecimento por ressemeadura natural, em área de lavoura antecessora de soja e milho. Como domínio de conhecimento central do modelo está a interface planta-animal contextualizada num SIPA. Neste contexto, a planta é representada pela estrutura do pasto e pelos resíduos de lavouras antecessoras. No modelo conceitual ainda é possível observar os parâmetros avaliados nesta Tese.

Este manuscrito foi elaborado na forma de capítulos. No Capítulo I consta a revisão de literatura. Os Capítulos II, III e IV, são apresentados na forma de artigos científicos. O Capítulo II, tem como objetivo avaliar os efeitos dos resíduos de lavoura antecessora de soja e milho, nos padrões de comportamento ingestivo em pastejo de cordeiros em azevém. O Capítulo III quantifica os mecanismos pelos quais a taxa de ingestão de azevém (*Lolium multiflorum* Lam.) é determinada em diferentes alturas de contraste entre resíduos de lavoura antecessora de soja e milho. O Capítulo IV investigou a influência dos resíduos de colheita de soja e milho, suas características de diâmetro, altura e espaçamento entre plantas, no processo de ingestão de azevém (*Lolium multiflorum* Lam.). O trabalho é concluído no Capítulo V, com as considerações finais.

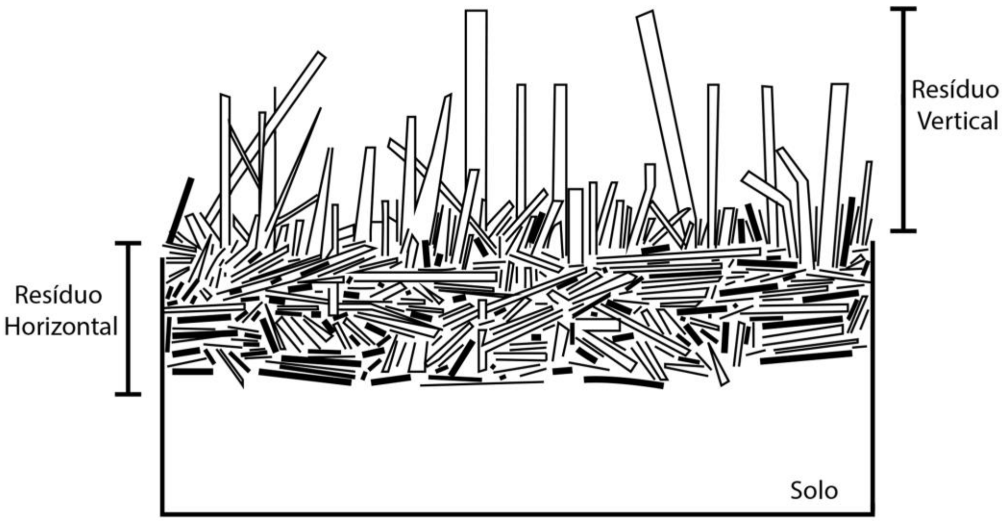
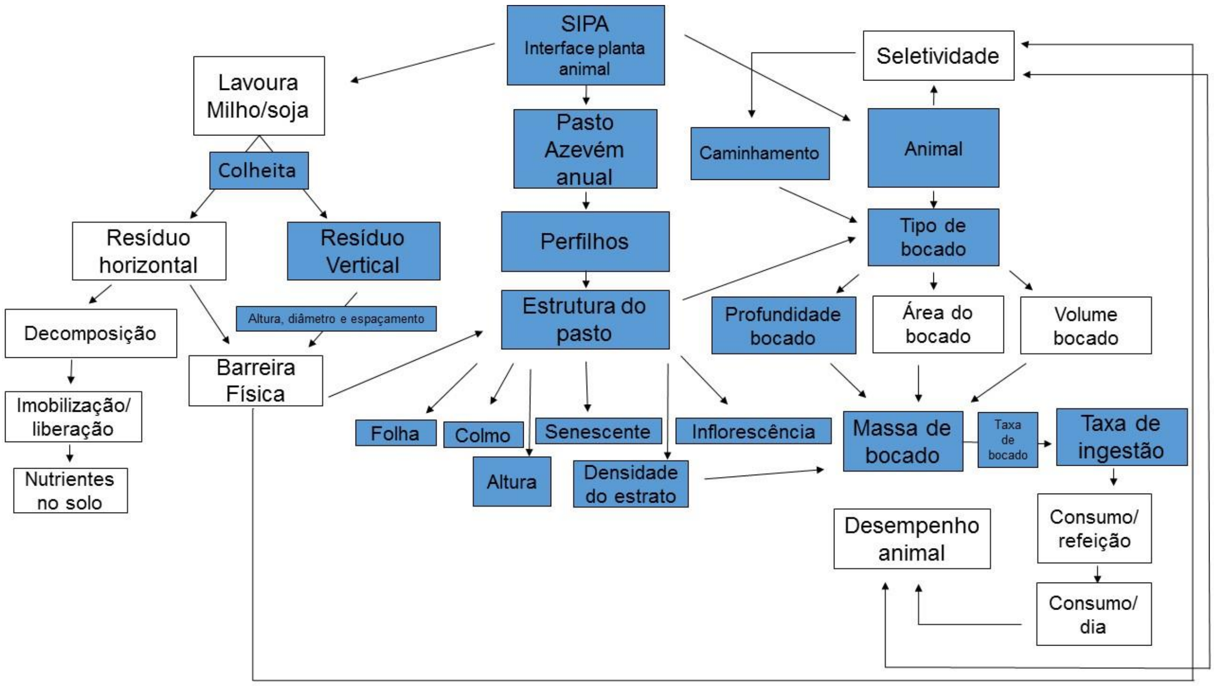


Figura 1: Resíduos horizontais e verticais acima do solo.



*Quadros em coloração azul: parâmetros avaliados no experimento. Quadros em branco: parâmetros não avaliados no experimento.

Figura 2: Modelo conceitual da relação entre a estrutura das plantas e seus resíduos e o processo de pastejo num sistema integrado de produção agropecuária.

2.0 CAPITULO I

REVISÃO DE LITERATURA: PASTEJO ANIMAL SOB PERSPECTIVA: PLANTA, ANIMAL E SISTEMA INTEGRADO DE PRODUÇÃO AGROPECUÁRIA.

2.1 Manejo do pasto em busca da maior eficiência de utilização da planta

O manejo do pasto tem grande impacto na estrutura e no crescimento vegetal. Em particular, no tamanho e densidade dos perfilhos (Gastal e Lamaire, 2015). Provavelmente por isso, a abordagem há muito tempo utilizada do manejo de pastagens era focada na planta, basicamente, determinada pela produtividade do pasto e utilização, focada na relação entre o índice de área foliar (IAF) e taxa de crescimento. Isso porque os determinantes para o acúmulo de biomassa no pasto dependem: (a) da eficácia com que a luz é interceptada pelas folhas do dossel; (b) da eficiência fotossintética. A interceptação luminosa é função da quantidade de folhas do pasto para um dado IAF, que é definido como a relação entre a quantidade de área foliar verde e unidade de área de solo (Hogson, 1990). Plantas com IAF menor, a taxa de crescimento líquido é limitada pela intercepção da luz, enquanto em IAF superior é limitada pela respiração (dos órgãos sombreados) e pela perda de material vegetal através de senescência. Além disso, a ingestão pelos animais de partes de plantas senescentes é limitada (Hogson et al., 1977). Portanto, em IAF extremamente alto, não só a produtividade, mas também a utilização de pasto, são restritas.

A taxa de acúmulo de pasto máxima é considerada onde praticamente toda a luz incidente é interceptada (IAF crítico). De modo geral, isso ocorre em IAF de 3 a 5 (Lemaire e Chapman, 1996). Na Figura 1 visualiza-se a relação de IAF e interceptação luminosa em que, com o aumento no índice de área foliar, ocorre aumento na interceptação luminosa.

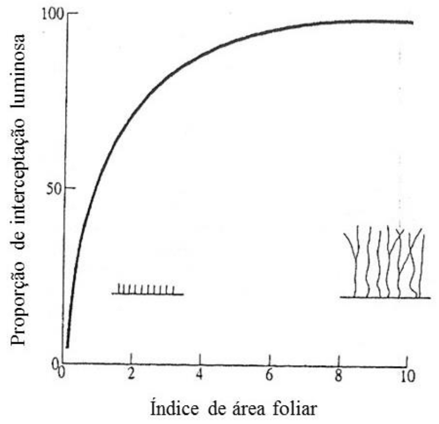


Figura 1: Relação entre índice de área foliar e interceptação luminosa pelo pasto (Hogson, 1990).

Desde 1968, Brown & Blaser já concluíram que o IAF, relacionado à interceptação de luz, parece uma forma útil para entender a produção de pasto e o desenvolvimento de melhores variedades e práticas de manejo. Esta informação permaneceu, até pouco tempo, como a base no manejo de pasto.

Ficou amplamente reconhecido que quando o pasto intercepta 95% da luz incidente, atingiria um valor de IAF dito crítico, no qual a taxa de crescimento da cultura estaria próxima de um valor máximo. Assim, devido ao alto grau de associação, em diversos trabalhos, relacionou-se os 95% de interceptação luminosa com a altura do dossel (e.g. Carnevalli, 2003). Sendo, portanto, vinculado com as metas de pasto e apoio a novas estratégias de manejo (e.g. Silva et al., 2012; Montagner et al., 2012.). É ainda considerado uma estratégia valiosa para se estabelecer a frequência de desfolhações (Pontes et al., 2014).

Portanto, até aqui, a busca pela eficiência máxima tem sido interpretada como produzir o máximo e consumir o máximo de biomassa (Figura 2), basicamente em função da curva de crescimento do pasto. Deste manejo decorre a ideia de não desperdício (Serviço de Inteligência em Agronegócios, comunicação oral 2016).

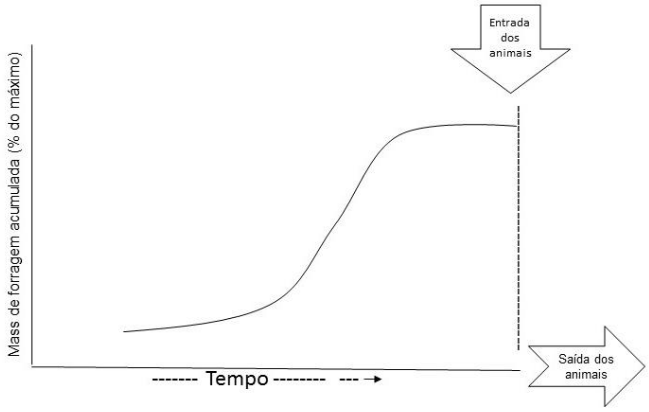


Figura 2: Curva de crescimento do pasto de acordo com a massa de forragem acumulada pelo tempo, com respectivos momentos de manejo de entrada e saída dos animais a pasto (Adaptado de Hogson, 1990).

No entanto, esta análise anterior deve ser adaptada às condições a longo prazo, onde as adaptações da estrutura do dossel modificam as relações fotossíntese-respiração-senescência. Humphreys apud Kichel et al. (1997) já mencionava que o uso do conceito de IAF, no manejo de pastagens, poderia ter algumas limitações, devido a mudanças nas características fotossintéticas, na arquitetura e composição botânica do pasto. Como demonstrado no trabalho de Pontes et al. (2014), que encontraram diferentes alturas a 95% de interceptação luminosa, de acordo com as espécies e as estações. Além disso, em estudo específico com azevém anual, índices de interceptação luminosa dessa magnitude têm resultado em alturas de pasto demasiadamente altas, com maior proporção de colmos no dossel e menor relação folha:colmo (Amaral et al., 2013).

Na utilização do pasto, tem-se a ideia de manejo como um problema a resolver piquete a piquete, enquanto os animais são forçados a resolver suas exigências, diárias, bocado a bocado (Parsons & Chapman, 1998). Uma nova compreensão de manejo de pasto (Carvalho, 2013) propõe nova perspectiva desta questão, ou em outras palavras, é possível não desperdiçar produção animal, ao invés de não desperdiçar pasto? Ou ainda, achar o nível ótimo entre produção animal e vegetal? Com isso, estudos para a compreensão dos processos subjacentes na interface planta-animal resultaram em melhorias recentes na produção animal de pastagens (Carvalho et al., 2013a). A interface planta-animal baseia-se no comportamento de pastejo e tornou-se poderosa ferramenta no manejo de pasto, onde, de modo geral, os animais selecionam plantas e componentes morfológicos, de modo a otimizar o consumo de nutrientes e de energia (Carvalho et al., 2013a).

2.2 Manejo do pasto para minimizar perdas de produção através do conhecimento do comportamento animal

O fundamento básico do processo comportamental de consumo a pasto está na otimização, ou seja, o custo de aquisição de pasto (e.g., energia) é sempre contraposto ao benefício em obtê-la (Prache et al.,1998). Os componentes comportamentais do pastoreio compreendem como os animais procuram alimento e como é o processo de colheita pelo pastejo dos diferentes tecidos de planta, em diferentes escalas espaço-temporais do processo de pastejo (Carvalho, 2013).

Para se compreender melhor esta perspectiva é preciso revisar alguns conceitos comportamentais do animal, definidos por escalas, onde: (a) O bocado: A menor escala de decisão do animal, o átomo do pastejo. Ação ou o ato de apreender a pasto (Gibb, 1996; Laca e Ortega, 1996). (b) Estação alimentar: Semicírculo hipotético, disponível em frente ao animal, que ele alcançaria sem mover as suas patas dianteiras (Ruyle & Dwyer, 1985). (c) *Patch*: agregado de estações alimentares separado de outros *patches* por uma parada na seqüência de pastejo, quando o animal se reorientaria para um novo local (Bailey et al., 1996). (d) Sítio de pastejo: agregado de *patches* em área adjacente onde os animais pastejariam durante uma refeição. (e) Campo de pastejo: agregado de diferentes sítios de pastejo. (f) Região de pastejo: agregado de campos de pastejo. Em muitos casos, a região de pastejo se constitui em um único campo de pastejo (Bailey et al., 1996).

O manejo, em nível de bocado, pode trazer maior eficiência no uso do pasto (Carvalho et al., 2004), pois o bocado é o átomo do pastejo (Laca e Ortega, 1996). Assim, o animal a pasto reúne milhares de bocados ao longo do dia, o que, em última análise, define o consumo de matéria seca e o desempenho animal (Figura 3). A apreensão do pasto, por meio do bocado, pode atingir 35.000 ações diárias, ao ritmo de um bocado a cada 1 - 2 segundos. Portanto, assim se mostra a importância do conceito de taxa de consumo e do processo de pastejo, como sendo tempo-dependente (Carvalho et al., 2001). O comportamento em pastejo é estreitamente ligado à maximização da taxa instantânea de energia digestível ingerida, mais do que a taxa diária (Babin et al., 2011).

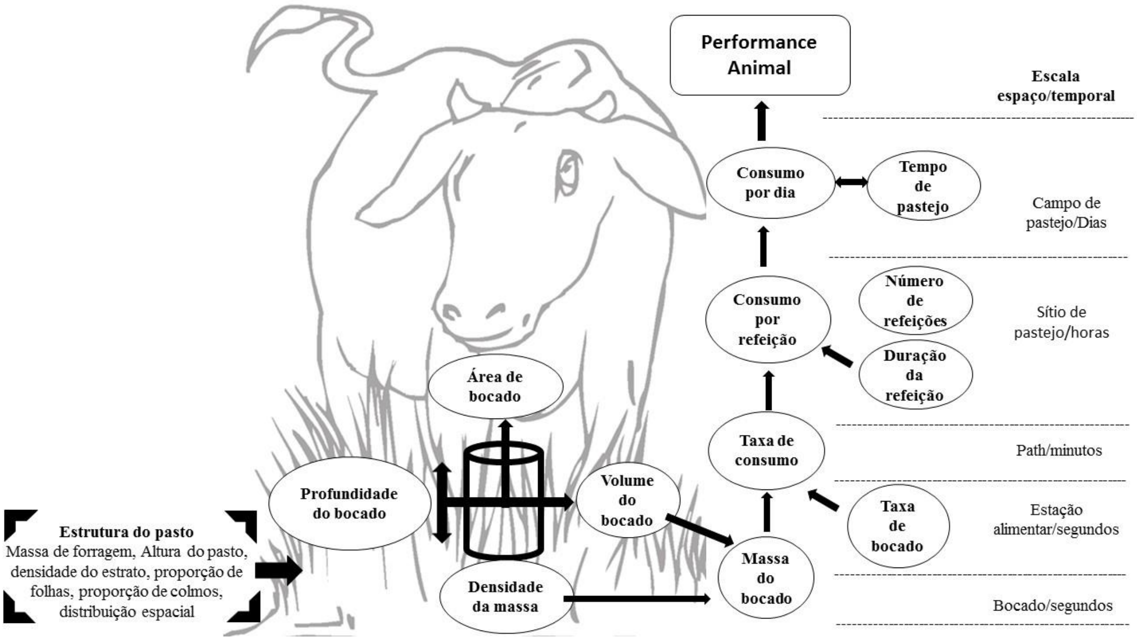


Figura 3: Escalas espaciais e temporais de pasto (adaptado de Bailey et al. 1996; Cangiano et al 1999; Bailey e Provenza, 2008; Carvalho et al., 2013).

Portanto, procedimentos de manejo para a aquisição de pasto, pelo animal, de forma mais rápida é importante. Por isso, estudos de taxa de consumo, em curto prazo, vem sendo considerados de importância para determinar metas de manejo. Nesse contexto, a nova perspectiva de manejo consiste na intenção de “construir estruturas” de pasto visando a otimização do processo de ingestão pelo animal em pastejo (Carvalho et al., 2001).

2.2.1 Comportamentos inerentes ao animal que podem influenciar o processo de pastejo

O processo de pastejo tem relação com a estrutura do pasto. Mas inerente ao animal há sua preferência (discriminação exibida entre os componentes do dossel, se disponíveis sem restrição), e seleção (reflete a preferência, com as inevitáveis limitações a exercê-la que ocorrem em nível de campo) (Hogson, 1990). Em outras palavras, a seletividade é a capacidade do animal selecionar alimentos, quando administradas duas ou mais opções de qualidades diferentes (Laca et al., 2010). Segundo Prache et al. (1998), é a ação de explorar a heterogeneidade dos recursos, na escolha de dieta de melhor qualidade.

De acordo com Dumont (1997), quando a espécie preferida, ou partes de uma determinada espécie, já não estão disponíveis, os animais mudam sua dieta, escolhendo outras espécies. Assim, utilizam o deslocamento para a busca de novos locais de alimentação para garantir melhor consumo de nutrientes (Carvalho e Moraes, 2005). Portanto, ao escolher a estação alimentar, o animal permanece nela até que o consumo de nutrientes diminua a quantidades inferiores à média pré-experimentada, considerando todo o ambiente alimentar, quando se deslocam em busca de novos locais de alimentação, para garantir melhor consumo de nutrientes (Carvalho e Moraes, 2005).

Na determinação dos componentes escolhidos do dossel, os sensores de gosto e cheiro são provavelmente os mais importantes, porém, a visão e toque influenciam a aproximação inicial, além de fornecer estimativa de valores dos componentes. A característica da superfície da planta tem efeito direto nos receptores táteis do focinho, lábios e língua, e consequentemente na preferência. Portanto, partes grosseiras, pontiagudas e pilosas tendem a ser evitadas. Por isso, a possibilidade do componente preferido ser pastado é menor quando se encontra na base do dossel (Hogson, 1990). Além disso, considerando que a restrição de forragem pode trazer mudanças no comportamento de preferência, Laca e Demment, (1991) utilizaram o valor de referência de 700 kg de forragem.ha^{-1} onde praticamente não existe seleção animal, devido à dificuldade de seleção.

Prever a seleção de dieta animal é ainda mais complicado em situações complexas, em ambiente difícil para o animal perceber, levando a limitações na procura. Ainda, herbívoros menores (ovelhas, cabras e filhotes) são limitados por relações de escala alométrica e pelo fato de percebem seus ambientes, ou "foodscape" (Searle et al., 2007), em escalas mais finas. Assim, a seletividade deve ser mais pronunciada na escala ótima (tamanho) para cada espécie.

Além disso, há a influência do meio ambiente, e fatores abióticos (distância para água, abrigo, microclima e a topografia) que determinam o "valor percebido local (global)" (Bailey, 1996). Por conseguinte, a densidade dos componentes do habitat influencia na presença ou ausência de um animal. Assim, animais de rebanho, quando em ambiente natural, evitam florestas, onde os movimentos e contatos visuais são difíceis (Pratt et al.,(1986) e Jarman P.J., (1974), citado por Roguet et al., (1998).

A verificação do valor percebido do local, onde haja risco de predador, é fator importante. É influenciador do comportamento animal, que pode limitar a maximização da taxa de ingestão através de: 1) custo de tempo / energia da vigilância, 2) até 95% do tempo de pastejo; 3) a perda de precisão na seletividade entre os diferentes locais. Isto porque a capacidade do animal para tratar simultaneamente os diversos componentes do meio ambiente pastoril é limitada (Dukas R. e Ellner S., (1993) e Underwood R., (1983), apud Roguet et al., (1998). Porém, a busca e vigia, podem não ser atividades mutuamente excludentes, ou seja, os animais podem procurar por predadores ao mastigar sua comida (Illius e FitzGibbon 1994), o que lhes permite reduzir o risco de predação, e podendo manter a taxa de ingestão (Fortin et al 2004b;. Blanchard e Fritz 2007).

Para algumas espécies, a maximização no comportamento de pastejo deve envolver troca entre adquirir alimento e evitar predadores (Lima e Dill 1990; McLoughlin et al., 2005; Dussault et al., 2012). A alocação de risco de predação prevê que, se não houver variação temporal, elevando o risco de predação, o animal deve exibir comportamento anti-predação (Bednekoff e Lima 2004). Assim, muitos animais alteram seus movimentos e padrões de seleção, no habitat, em resposta a padrões espaço-temporais de risco (Latombe et al 2014). Quando há fortes padrões espaciais no risco de mortalidade, o animal pode aumentar a sua aptidão, maximizando a relação entre os ganhos de energia e o risco de mortalidade (Sih, 2005). Fortin et al. (2015) propõem um modelo que considera a relação entre a taxa de ingestão instantânea e o risco de predação. Os animais, que são considerados como presas (herbívoros de maneira geral), podem apresentar mudanças rápidas na escolha de alimentos e uso de habitat devido ao risco de predação (Fortin et al., 2015).

Considerações sobre o efeito do risco de predação podem ser feitas quando os animais deixam de selecionar plantas preferidas em locais onde são mais suscetíveis a encontrar predadores (Fortin e Fortin 2009), presumivelmente devido a realocação de tempo para detecção do predador (diminuição da seleção; Hochman e Kotler 2007). Portanto, mudanças no comportamento de pastejo acontecem não apenas devido a princípios de maximização de energia (VanGils et al., 2013).

2.2.2 Memória animal: processo do comportamento em pastejo

A memória atua no comportamento animal e pode influenciar o processo de pastejo. A memória espacial é a capacidade do animal em lembrar-se de ter pastejado em algum local e usar essa informação para determinar onde irá realizar novo pastejo

(Domjan Burkhard, 1982). Quando o animal encontra áreas com baixa oferta de nutrientes, quando comparada a áreas visitadas anteriormente, eles tendem a voltar nas área de maior qualidade (Merkle et al. 2014).

A memória espacial é representada em duas partes: trabalho (curto prazo) e referência (longo prazo; Honig 1978, Staddon 1983). A memória de trabalho é mantida apenas o tempo suficiente para completar uma tarefa particular, após o qual a informação é descartada porque não é mais necessária, ou porque pode interferir na conclusão bem sucedida da próxima tarefa. Em contraste, a memória de referência é retida por mais tempo, porque é necessária para completar tarefas sucessivas.

A memória de trabalho opera em nível de bocados, de modo que os animais evitam áreas pobres de pasto, e procuram permanecer dentro de sítios preferenciais de maior qualidade. Memória de referência atua na busca de locais onde variam os níveis de nutrientes, atuando no que pode ser visitado ou evitado na escala diária (Bailey, 1995).

Embora muitos modelos de pastejo ignorem as habilidades cognitivas dos animais, é possível que muitos paradigmas surjam por desconsiderar a memória espacial (por exemplo, busca aleatória). O reconhecimento da memória animal pode ser importante ferramenta no entendimento de processos ingestivos dos animais. Pode prever, com precisão, os padrões de distribuição de pastejo de herbívoros, considerando que os animais podem aprender, reter e reagir a experiências anteriores de pastejo. Portanto, animais podem lembrar de áreas que produzem pasto de alta qualidade, e procurá-los (Howery et al.,1996). Inversamente, podem lembrar e evitar áreas com pasto de baixa qualidade (Bailey, 1995).

Deste modo, o pastejo envolve as interações entre as características dos animais e dos alimentos no ambiente. Assim, decisões de pastejo devem considerar as restrições comportamentais dos animais que envolve processos cognitivos (aquisição do conhecimento que se dá pela memória).

2.3 Manejo do pasto considerando aspectos de interface planta - animal: Estrutura do Azevém *(Lolium multiflorum* Lm.) no comportamento ingestivo

Ruminantes preferem pasto que possa ser consumido com alta taxa de ingestão em curto prazo (Utsumi et al., 2009). Para maximizar seus ganhos de energia de curto prazo, os animais procuram otimizar o processo de pastejo (E / H), que corresponde à energia digestível (E) de um bocado, dividido pelo tempo necessário para cortar e mastigar a massa obtida em cada bocado (H) (Fortin et al., 2015).

Portanto, para fins de taxa de ingestão em curto prazo, a estrutura do pasto é assumida como fator determinante (Fonseca et al., 2012a) e o principal elo de ligação entre a composição das plantas e comportamento ingestivo dos animais (Hodgson, 1985). A estrutura do pasto determina a produtividade das pastagens, a disposição das folhas e colmos, e a acessibilidade pelo animal. Pode ser influenciada pelo manejo, estádio fenológico e interação entre eles (Hodgson, 1985; Camargo et al, 2012). Além disso, a estrutura do pasto, influencia diretamente duas variáveis mais ligadas à taxa de ingestão, que são a massa e a taxa de bocados (Agreil et al., 2006). Tendo a massa do bocado um papel primordial na taxa de ingestão e, consequentemente, no consumo diário de pasto (Drescher, 2003).

O primeiro componente importante na estrutura do pasto é a massa de forragem, pois pode condicionar diferentes estruturas. No manejo de pasto de azevém anual (*Loliumum multiflorum* Lam.), massas de pasto entre 1100 e 1800 kg.ha^{-1} de matéria seca (MS) possibilitam bons ganho de pesos em cordeiras (Roman et al., 2007). Além disso, intensidades e métodos de pastejo, com lotação rotativa ou contínua, podem fazer variar os valores de massa de azevém, por exemplo entre 3160 e 2330 kg de MS ha^{-1} (Barbosa et al., 2010). Diferentes métodos de implantação de azevém podem levar a valores de 990 a 1410 (kg de MS ha^{-1}) (Silva et al., em tramitação).

A massa de forragem tem relação direta com a massa do bocado (McGilloway et al., 1999). A quantidade de forragem removida ao longo do rebaixamento pelo pastejo afeta significativamente a massa do bocado e a taxa de bocados (Prache & Peyraud, 2001). É importante frisar que diferentes níveis de ingestão podem ser obtidos com a mesma massa de forragem. Isto acontece devido a forma como é oferecida ao animal e por meio de distintas combinações, entre altura e densidade de pasto (Fonseca et al., 2011 e Carvalho, 1997). Porém, a ingestão de forragem é um parâmetro nem sempre fácil de se obter, o que pode tornar relativamente complexa a gestão do pastejo, bem como a tomada de decisão nas áreas pastoris. Isso levou a tentativas importantes no desenvolvimento de indicadores que os agricultores possam aplicar em sua gestão do dia-a-dia (Chapman et al., 2012).

Depreende-se que, dentre os atributos do pasto, a altura seja o de maior importância para determinar mudanças nas variáveis do comportamento ingestivo. A altura, para os animais, significa quantidade de biomassa disponível (Carvalho, 2004). Segundo Hodgson (1990), os animais respondem mais consistentemente a variações em altura do dossel do que em massa de forragem. Em adição, a altura é um indicador simples de ser aplicado pelos gestores de pasto.

Recentes pesquisas realizadas em experimentos de escala de curto prazo têm estudado estruturas de pasto ótimas (como critério a altura do pasto) onde os animais maximizem a taxa de ingestão. Em pastoreio rotativo, as alturas de pré e pós-pastejo de 15 e 10 cm, respectivamente, foram consideradas ideais para azevém (Amaral et al., 2013). Em outro estudo dessa natureza, a taxa de ingestão não foi afetada pelo método de estabelecimento do pasto (semeadura direta na palha e preparo convencional) e é maximizada em altura de 18,5 cm (Silva, 2013). Segundo Kunrath et al. (2014), o gerenciamento de pastos mistos de aveia + azevém anual, em altura de 20 cm sob a pastoreio contínuo, tende a benefícios no sistema planta-animal, com equilíbrio ideal entre a produção de pasto e o desempenho animal.

Altura baixa de pasto é fator limitante a massa do bocado e, consequentemente, a taxa de ingestão de matéria seca (Gonçalves et al., 2009), principalmente por afetar a profundidade do bocado (Laca et al 1992;. Gregorini et al 2011). Pastos altos limitam o consumo por imporem maior dificuldade à formação do bocado (Gordon & Benvenutti, 2006), em parte devido a maior presença de colmos em relação a folhas (Fonseca et al., 2011). Aliado a altura, ocorre mudança em outra variável importante, que é a densidade volumétrica do pasto, a qual é reduzida no estrato superior nos pastos manejados em maiores alturas (e.g. em sorgo: 60, 70 e 80 cm), dificultando a apreensão do pasto, diferentemente do que ocorre em alturas intermediárias (e.g. em sorgo 30, 40 e 50 cm; Fosenca et al., 2011). Já nos estratos inferiores, mais próximos ao solo, ocorre aumento da proporção de colmos em relação a folhas e, assim, incremento na densidade volumétrica da forragem (Barrett et al., 2001; Fonseca et al., 2012). De maneira inversa, a densidade volumétrica de lâminas concentra-se nos estratos superiores do pasto (Fonseca et al., 2012).

2.3.1 Estrutura do pasto considerando folhas e colmos no comportamento ingestivo

O que se considera como altura ideal de manejo do pasto tem como principal objetivo permitir que os animais colham grandes quantidades de tecido foliar de qualidade, antes que esse material entre em senescência (Pedreira et al., 2001). Estes componentes são importantes em satisfazer as necessidades nutricionais dos animais (Stobbs, 1973). Folhas na estrutura do dossel, em período vegetativo, contêm alta qualidade, chegando a 36% de proteína bruta. A digestibilidade *in vitro* da matéria orgânica pode atingir 81% para pasto de azevém anual (Pedroso, 2002). Assim, na seleção pelo animal, as folhas se tornam as partes da estrutura do dossel preferidas, e por isso o animal tenta capturar altas quantidades de massa foliar (Ginnett et al., 1999; Drescher et al., 2006). A massa de lâminas foliares, de acordo com manejo em pastoreio rotativo com ovinos, pode alcançar média inicial de 1100 kg MS ha^{-1} (Schons et al., 2015), semelhante ao encontrado por Amaral et al. (2013), onde a massa pré-pastejo atingiu 1087 (kg MS ha^{-1}). Porém, valores menores, entre 829 a 535 (kg MS ha^{-1}) podem ocorrer de acordo com o método de estabelecimento (Silva, 2013).

A seletividade dos animais por folhas pode levar a um decréscimo no consumo, quando há alta participação de colmos na estrutura do dossel (Benvenutti et al., 2006; Drescher et al., 2006). Além disso, os colmos podem levar a limitação física, formando barreira horizontal, diminuindo a acessibilidade das folhas (Benvenuti et al., 2006; Gregorini et al., 2009a). Em alturas próximas as indicadas como ideais, os colmos podem atingir valores de 455 kg MS ha^{-1} (Schons, 2015), podendo variar de 124 a 576 kg MS ha^{-1} dependendo do método de semeadura (Silva, 2013). Segundo Savian et al. (2014), as massas de colmo podem variar entre 484 e 610 kg MS ha^{-1}, de acordo com a intensidade e o método de pastoreio .

Em alturas baixas ocorre decréscimo na severidade de desfolha em diversas espécies forrageiras (e.g. Mezzalira et al., 2013; Fonseca et al., 2013). Isto é devido ao fato de que, aproximadamente, 90% de todo o colmo dos pastos encontra-se presente a partir da base em até 50% da altura do pasto (Zanini et al., 2012). Por isso, reduções em consumo a partir desse momento, no rebaixamento, podem ser atribuídas a dificuldades em manipulação e apreensão do pasto (Zanini et al., 2012). Os colmos exigem maior gasto de energia para colheita, causam maior impedimento à profundidade de bocado e, por consequência, reduzem a massa do bocado (Barret et al., 2006).

Esta análise está de acordo com Baumont et al. (2004), onde o animal em pastejo prioriza o consumo (bocado) da porção superior equivalente a 50% da altura do pasto. Essa característica é relatada como constante de proporcionalidade entre altura do pasto e profundidade do bocado (Gonçalves et al., 2009; Carvalho et al., 2013a). É, este, o principal fator determinante do desempenho individual dos animais. Neste sentido, Baumont et al. (2004) sugerem que os animais pastejam em horizontes, ou seja, removem camadas sucessivas de pasto equivalentes à metade da altura de cada camada acessada (Figura 4).

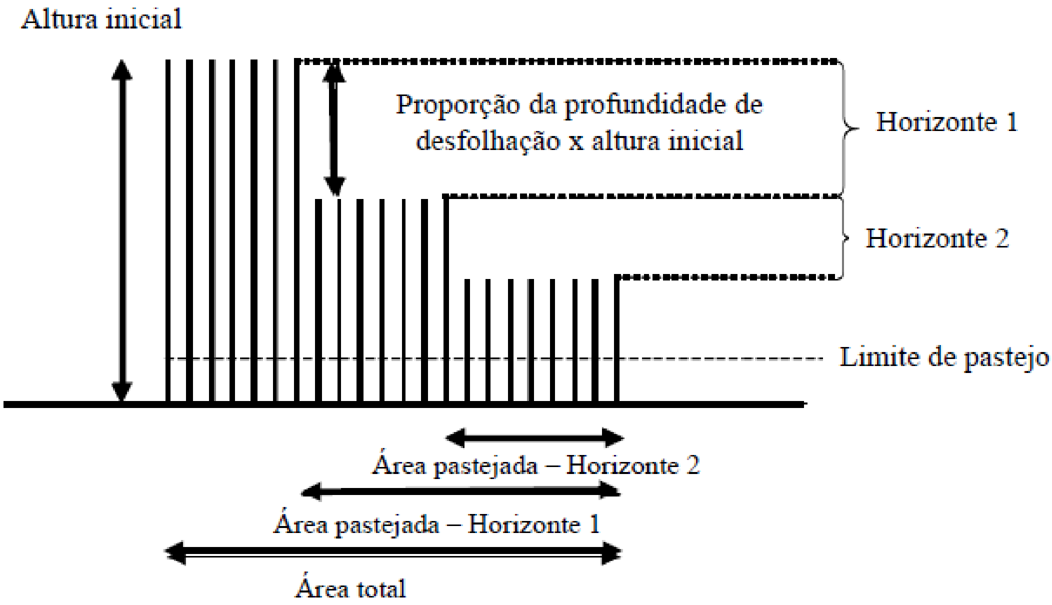


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Figura 4: Representação do processo de pastejo por horizonte do pasto (Baumont et al., 2004).

Porém, o animal não vai procurar todas as folhas do primeiro horizonte, pois leva em consideração o custo de colheita (e.g., energia) que é sempre contraposto ao benefício em obtê-la (Prache et al.,1998). Ou seja, ele não perde tempo procurando todas as folhas do primeiro horizonte, o que seria muito custoso energeticamente, visto que o consumo final corresponde à soma do consumo obtido em cada horizonte de pastejo (Carvalho et al., 2009).

Portanto, se ocorrer rebaixamento além de 40% da altura inicial, o animal começará a consumir o segundo horizonte do pasto e o consumo irá cair, como observado por Fonseca et al. (2013) (Figura 5). O mesmo ocorre com azevém anual, provavelmente pelo excesso de colmos nos estratos inferiores (Amaral, 2009). Portanto, é importante disponibilizar uma camada superficial de lâminas foliares e manejar o pasto até esta altura limite de 40% da altura de entrada.

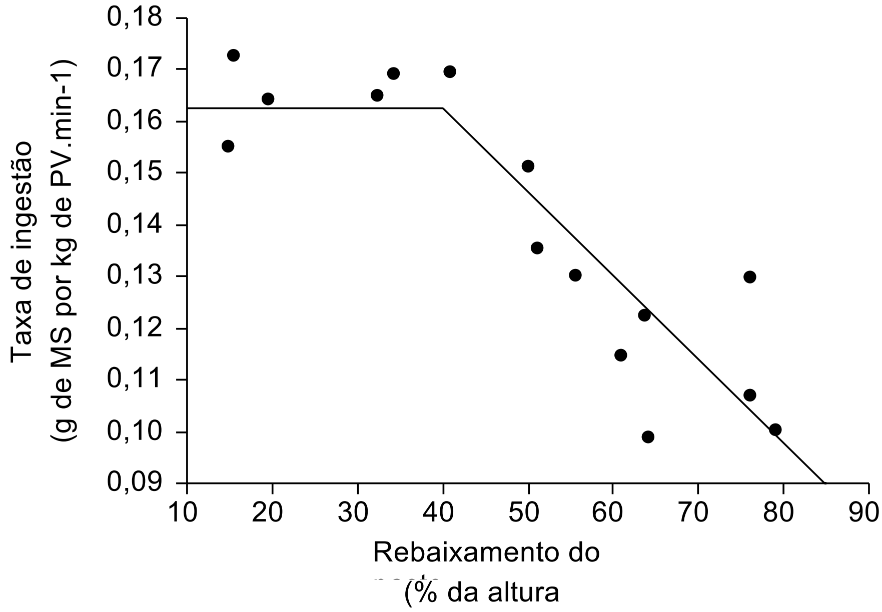

Figura 5: Taxa de ingestão de acordo com o rebaixamento da altura de entrada em pasto de Sorgo (Fonseca et al., 2012)

2.4 Aplicação do manejo do pasto em Sistemas Integrados de Produção Agropecuária

Sistemas integrados de produção agropecuária (SIPA) é importante elemento no uso sustentável da terra em nível global (Bell e Moore, 2012). Algumas premissas são necessárias para o bom funcionamento do sistema, sendo elas: Correção da acidez e fertilidade do solo (rendimento das pastagens e das culturas vegetais); Sistema de plantio ou semeadura direta; Rotação de culturas (qualidade e a conservação do solo, menor incidência de pragas, doenças e plantas daninhas); Uso de genótipos melhorados (rendimento e de rusticidade); Manejo correto da pasto (adubação e altura da pasto). Assim, o SIPA impõe-se como alternativa para intensificação sustentável (FAO, 2010) devido a sua característica em praticar a rotação de culturas na mesma área do cultivo de pastagens anuais ou perenes, destinadas à alimentação animal, com os de culturas destinadas à produção vegetal, sobretudo grãos (Balbinot Jr et al., 2009). Por isso, compreender a utilização da paisagem pelo animal a pasto é fundamental para o manejo do pasto (Provenza et al., 2013), em SIPA.

Nas regiões sul da América do Sul, compreendendo Brasil, Argentina, Uruguai e Paraguai, a soja (*Glycine max* L. *Merril*) e o milho (*Zea mays* L.) na safra de verão são geralmente cultivados em sucessão na mesma área com azevém (*Lolium multiflorum* Lam) (Carvalho et al., 2010). Como estes componentes utilizam o mesmo espaço, porém, em tempos diferentes, é comum que resíduos deixados em uma fase do SIPA interfira no outro, como é observado nas pastagens de inverno que integram os sistemas de semeadura direta (Carvalho et al., 2010), na forma de forragem residual de cobertura do solo para a cultura seguinte (Kunrath et al., 2014). Além disso, algo semelhante acontece com os resíduos das lavouras das safras de verão sobre a pasto subsequente. Como visto no trabalho Barth Neto et al. (2014), a safra de soja afetou positivamente a formação de pastagens, tanto em termos de densidade de perfilhos e forragem, quanto no final do estabelecimento do pasto. Portanto, diferenças nas lavouras antecessoras de milho ou soja podem ser refletidas no pasto, o que provavelmente levem a diferenças de comportamento de consumo pelos animais em pastejo.

Com isso, levanta-se a necessidade de se abranger a relação entre planta e animal ao longo do tempo e espaço (Bailey e Provenza, 2008). Comportamentos atuais dos animais são muitas vezes consequência de condições passadas (Provenza et al., 2013). Dentro deste contexto onde existam resíduos antecessores, o trabalho de Silva et al., (em tramitação) avaliou o comportamento animal com e sem palha (horizontal) no consumo de azevém e não detectou diferenças inerentes aos resíduos. Porém, nada se sabe quanto a influência dos resíduos verticais (palha em pé) após colheitas de lavouras, e como possam interferir no comportamento animal. Esta é uma área de absolutamente descoberta na literatura. Kemp e Michalk (2007) afirmaram que a obtenção de resultados desejáveis no manejo de pasto, visando satisfazer objetivos múltiplos (pastagens multifuncionais), exigirá novas áreas de pesquisa que busquem soluções viáveis para os agricultores e para a sociedade.

3.0 CAPÍTULO II

DO CROP RESIDUES INFLUENCE THE SUCCEEDING PASTURE PHASE OF AN INTEGRATED CROP-LIVESTOCK SYSTEM?[1]

[1] Elaborado de acordo com as normas da Agricultural Systems (Anexo II-A)

Do crop residues influence the succeeding pasture phase of an integrated crop-livestock system?

D. F. F. Silva[1,a], C. Bremm[b], V. Sehaber[c], V . L. Souza[d], N. M. S. Gonzales[a], B. M. Campos[a], A. M. S. Bolzan[e], A. L. G. Monteiro[a], A. Moraes[a], P. C. F. Carvalho[e]

[a] *Center of Technological Innovation in Agriculture, Federal University of Paraná, Curitiba, PR, 80035050, Brazil*

[b] *State Foundation for Agricultural Research, Porto Alegre, RS, 90130-060, Brazil*

[c] *Department of Statistics, Federal University of Paraná, Curitiba, PR, 81531990, Brazil*

[d] *Department of Animal Science, University of São Paulo (ESALQ- USP), Piracicaba, São Paulo, 13418-900, Brazil*

[e] *Grazing Ecology Research Group, Federal University of Rio Grande do Sul, Porto Alegre, RS, 90040-060, Brazil*

[1]Corresponding author: Delma Fabíola Ferreira da Silva

Email: delmafsilva@gmail.com

Postal address: 1540, Funcionarios street, Cabral, 80035050, Curitiba, PR, Brazil.

Short title: Lamb grazing in an integrated crop-livestock system

Abstract

Integrated crop-livestock systems are characterized by rotations of crops and pastures. The objective of the present study was to evaluate the effects of crop predecessors (maize or soybean) and their residues on ingestive behavior patterns of lamb grazing Italian ryegrass (*Lolium multiflorum* Lm.) in the subsequent pasture phase. Treatments consisted of two-residue heights (0 and 15 cm) and two predecessor crops (maize or soybean). Texel lambs grazing on Italian ryegrass pasture preceded by either maize or soybean crops, we measured short-term intake rate, grazing behavior (bite mass, bite rate, residence time), and sward characteristics (pre- and post-grazing canopy height, herbage mass, distribution of grass morphological components). Lambs displayed higher short-term intake rates when grazing pastures with predecessor soybean crop (PSC) than with predecessor maize crop (PMC) ($p = 0.008$). This result may be associated with a higher bite mass in PSC pastures ($p = 0.001$) given that bite rate was not different ($p > 0.05$) between treatments. In PSC pastures, pseudostem and sheath development increased the leaf mass (kg $DM.ha^{-1}$) and thus the bite mass. More than 50% of the sward stratum in PMC pastures was composed of weeds and inflorescences, which may have contributed to decrease in leaf accessibility and consequently lower bite mass compared to PSC pastures. This sward characteristic also increased walking time ($p < 0.001$) and decreased ($P < 0.001$) residence time at each feeding station. Under the conditions of the present study, predecessor crops may have influenced sward structure of the subsequent Italian ryegrass pasture. In particular, PMC may negatively impact the ingestive behavior patterns of lamb grazing Italian ryegrass.

Keywords: Predecessor crop; Harvest; Ingestive behavior; Short-term intake rate.

1. Introduction

Integrated crop-livestock systems (ICLS) are planned systems based on positive interactions between soil, plants and animals in areas that combine crop, forestry and livestock activities at distinct spatio-temporal scales, whether concurrently or sequentially in rotation or succession (Moraes et al., 2014; Lemaire et al., 2014). ICLS are considered a key alternative technology that could contribute to sustainable intensification of agriculture, as well as improve the food security of consumers through benefits from product quality and production processes (FAO, 2010).

ICLS have an important role in many countries, covering 25 million square kilometers (Bell and Moore, 2012) and accounting for approximately 50% of the world's food production. In the Brazilian context, these systems are usually characterized by associations between livestock and crops of soybeans, maize, beans, rice, eucalyptus or cotton, among others (Carvalho and Moraes, 2011). Soybeans and maize are currently the most widespread crops in ICLS, accounting for 10.561.372 and 3.927.826 ha, respectively (Brazilian Institute of Geography and Statistics, 2014).

Successful ecological intensification of agriculture will require diversification at all levels of organization, including the field, landscape, region, continent, and farm. (Lemaire et al., 2014). At the farm level, where management decisions are made, the main concern in ICLS is that pastures should play into system synergisms (Moraes et al., 2002), above all with their predecessor crops. The crop harvest is an important factor for subsequent pasture management, as crop residue is also part of the grazing environment (Barth Neto, 2014). Better understanding of herbivore feeding preferences, including knowledge about ideal grazing environments for ruminant animals, is essential to optimize forage use and pasture management (Favreau et al., 2010).

Ingestive behavior patterns of lamb establish the rate of voluntary intake, and consequently the effective dry matter intake. The latter can be heavily influenced by small changes in intake per bite (bite volume versus bulk density). Through grazing behavior and selectivity, animals reflect the characteristics of their pasture environment (Campana et al., 2015). Diet selection is a complex process (Ralphs and Provenza, 1999) and is influenced by many factors such as forage availability (Papachristou et al., 2005), animal physiological conditions and feed chemical characteristics (Provenza, 1996).

Italian ryegrass is considered an excellent forage for use in integrated systems due to its high nutritional value and capacity for natural reseeding. This type of forage is frequently used for lambs to supply adequate nutrient requirements for growth, maintenance and overall productivity. To date, few studies have evaluated the effects of the presence of predecessor crop residues on sward characteristics and grazing behavior of lamb. This knowledge is useful to increase productivity and management efficacy in integrated crop-livestock systems. The objective of this study was to evaluate the effects of maize and soybean crop predecessors and their residues on ingestive behavior patterns of lamb grazing on Italian ryegrass.

2. Materials and Methods

2.1. Experimental area

The present study is part of a long-term research trial for an ICLS begin in 2003 at the Research Station of the Federal University of Rio Grande do Sul (UFRGS) in southern Brazil (30°05' S; 51°39'). The 2014 management protocol called for rotation on the same land of Italian ryegrass pasture grazed by lamb (winter) and soybean and soybean-maize grain crops (summer). The Italian ryegrass pasture has been established by self-seeding since 2005, a common practice in this system.

The area’s climate (Cfa according to the Köppen classification system; Köppen and Geinger, 1928) is characterized by marked seasonal temperature variation and homogeneous repartition of precipitation throughout the year. Data were recorded for grazing animals during a 10-day experimental period. The daily temperature during the evaluation period averaged 7.5°C (maximum 22°C and minimum 5°C; Accuweather, 2015). The soil is classified as Typic Paleudult (USDA, 1999) with 15.2% clay. Four paddocks of Italian ryegrass (150 m² each) were delimited using wire electro-plastic fencing.

2.2. Treatments

Treatments consisted of two predecessor crop types (maize or soybean) with or without residues (height = 0 or 15 cm), corresponding to a 2 × 2 factorial design. The experimental design was a randomized complete block with four replicates, and blocking was based on time of day in which the grazing session was performed (morning or afternoon).

Italian ryegrass sward height was kept at 18.5 cm during the experimental period as recommended for the vegetative stage (Silva et al., unpublished data). The experimental area was scaled to maintain consistent sward height at the bite level throughout the grazing period. Similar sward structure was thus available for each animal from the beginning to the end of the grazing test.

2.3. Area management

Soy (BRX Power RR) and maize (hybrid DKB290) predecessor crops were sown from 25th to 27th November, 2013 and established during summer and autumn (2013/2014). Both crops were established using direct seeding on the line with row spacing of 43 cm. In winter 2014, Italian ryegrass pasture was established via self-seeding. After the grazing period, glyphosate (2 liter per ha) was used as a broad-spectrum systemic herbicide.

The experimental areas were managed manually for both predecessor crop treatments using costal mowing at either 0 cm (close to the ground) or 15 cm. Maize plants were removed from the area to reduce horizontal residues (stubble). The leaves of maize and soybean crops that fell off prior to harvest were left in paddocks. The subsequent Italian ryegrass received urea fertilizer at 75 kg per ha.

2.4. Sward measurements

Three pasture samples per experimental unit were taken to determine post-grazing herbage mass and density. Sward strata were cut from the top to the botton every 5 cm using a 0.1089 m² quadrat. All samples were separated into leaf lamina, pseudostem, dead material, Inflorescence and weed mass before weighing. Total herbage mass was determined as the sum of the mass of each component. To determine the sward height, a sward stick was used to measure 150 points per experimental unit (one point per m²) both pre and post-grazing (Barthram, 1985).

After Italian ryegrass emergence, sward height was monitored daily to achieve the target height of 18.5 cm.

Dry matter content was determined using four forage samples from each experimental unit, two pre- and two post-grazing (Halls, 1954), by drying at 65 °C for 72 h. Samples were harvested in the uppermost stratum of the sward due to the 50% proportional relationship between herbage removed with each bite and sward height (Cangiano et al., 2002; Gonçalves et al., 2009; Laca et al., 1992).

2.5. Animal measurements

Experimental procedures were adapted from Penning and Hooper (1985). For 60 days before the beginning of the evaluation period, animals were adapted to their environment (human observer, recording equipment, experimental procedures) in an adjacent paddock with Italian ryegrass sward. Four Texel lambs (6 ± 1 months and 35 ± 2.6 kg of body weight) were allocated into two groups kept in individual, side-by-side paddocks to avoid the effects of group size on lamb grazing time (Penning et al., 1993). Each lamb group was allowed 45 minutes of grazing in the morning and afternoon, i.e. at peak grazing times (Hodgson, 1990). Lambs were not kept in fasting prior to grazing periods to prevent unrelated increases in intake rate (Gregorini et al., 2009a) and decreases in diet selectivity (Newman et al., 1994).

At dawn, all animals (n = 4) were placed in a weighing area and fitted with feces and urine collection bags. Lambs were fitted with IGER Behavior Recorders (Rutter et al., 1997) to identify and characterize jaw movements, e.g. biting (bite severing) or non-biting (manipulation, ingestive mastication), and to determine eating time. Eating time was defined as the time for which lambs were head down and completely involved in severing, manipulating, and masticating bites (grazing time = eating +

searching times). Lambs were then weighed and returned to their treatment paddock to measure individual grazing behavior.

After the grazing period, each animal was removed from the paddock, re-weighed and kept for 45 minutes in a non-vegetated area without access to water or feed to estimate insensible weight loss (e.g. due to water evaporation, loss of CO_2 and CH_4; Gibb et al., 1999). The body weight data was taken using a balance with a precision of 10 g. All procedures were similar in both morning and afternoon periods of evaluation.

Short-term herbage intake rate (STIR) was calculated as in equation 1:

(1) $$STIR = \frac{(W2-W1)}{t2-t1} + \frac{(W3-W4)}{t4-t3}\ x\ \frac{(t2-t1)}{ET}$$

where:

- $W1$ and $W2$ are animal weights before and after grazing;
- $t1$ and $t2$ are the time before and after grazing;
- $W3$ and $W4$ are animal weights before and after insensible weight losses;
- $t2$ and $t4$ are the time before and after insensible weight losses; and
- *ET* is the effective eating time.

STIR was calculated as the product of fresh weight intake rate and DM content of the herbage consumed by the animal (determined by hand-harvested samples). Bite mass (DM in mg per bite) was calculated as the ratio between STIR and number of bites. The bite rate (bites per minute) was determined by dividing the total number of bites by the eating time. JM rates (movements per minute) were calculated by summing the chewing and seizing movements (bites) recorded by the IGER. Non-biting jaw movements were identified using bites during grazing and included movements that had a masticatory or manipulative function, and non-biting jaw movement rates (movements per minute) were calculated as the number of non-biting jaw movements per effective eating time (the total grazing time excluding intervals of jaw inactivity of more than 3 seconds, Gibb, 1999). The number of intra-meal intervals (NIMI) was considered intervals of jaw inactivity, until 300 s (Gibb et al., 1999).

Animal movement was monitored from the paddock perimeter, with positions identified through a square meter grid simulating the area on a Cartesian plane and using numbers and letters on the x- and y-axes. The location (quadrant within the paddock) and head position of the animal was measured every minute using a beeping sound to track elapsing minutes. Each minute in sequence that an animal remained in the same quadrant was considered residence time. Every interval that lambs walked between quadrants was considered walking time, and total distance walked by each animal was measured.

2.6. Statistical analysis

IGER data was analyzed using the Graze software (Rutter et al., 1997). Bite mass, bite rate, non-biting jaw movement rate, and total jaw movements (JM) per gram of ingested herbage DM were calculated. The effect of period (morning or afternoon) was used as a covariate in the statistical model due to changes in ingestive behavior patterns with time of day (Rutter, 2006).

Data were analyzed using R software (R Development Core Team, 2016). Linear mixed-effects models were fitted using functions of the Ime4 package in R (Bates et al., 2015). Response variables were normalized using on Box-Cox (Box and Cox, 1964) transformation. Paddock and animal group were considered experimental units.

Fixed effects were the type of predecessor crop (soybean or maize), their residue height (0 or 15 cm), and the interaction between residue height and predecessor crop. Random effects were paddock and animal. The distance walked variable was log-transformed to obtain normality or residuals.

Statistical probabilities were described as: P_P = p-value for predecessor crop; P_R = p-value for crop residue height; P_{PXR} = p-value for interaction between predecessor crop and residue height (Savian et al., 2014).

3. Results

3.1. Ingestive behavior patterns

Lambs grazing on pastures with predecessor soybean crops (PSC) showed higher short-term herbage intake rate (P_P = 0.008; Figure 1A) and bite mass (P_P < 0.05; Figure 1B) compared to predecessor maize crops (PMC). The number of intra-meal interval of grazing (NIMI) was higher for PMC than PSC (P_P < 0.001; Figure 1C).

No differences in bite rate, total jaw movement rate, non-biting jaw movement rate, time per bite and time of intra-meal interval were observed between predecessors or residue heights (P_P and P_R > 0.05). On the other hand, animal walking time (Figure 1D) and distance walked (Figure 1F) were higher for PMC than PSC (P_P < 0.001). In addition, residence time at feeding stations increased for animals grazing in PSC pastures (P_P < 0.001; Figure 1E).

No interaction effects (P_{PXR} > 0.10) on the ingestive behavior of lambs were observed among predecessors and residue heights.

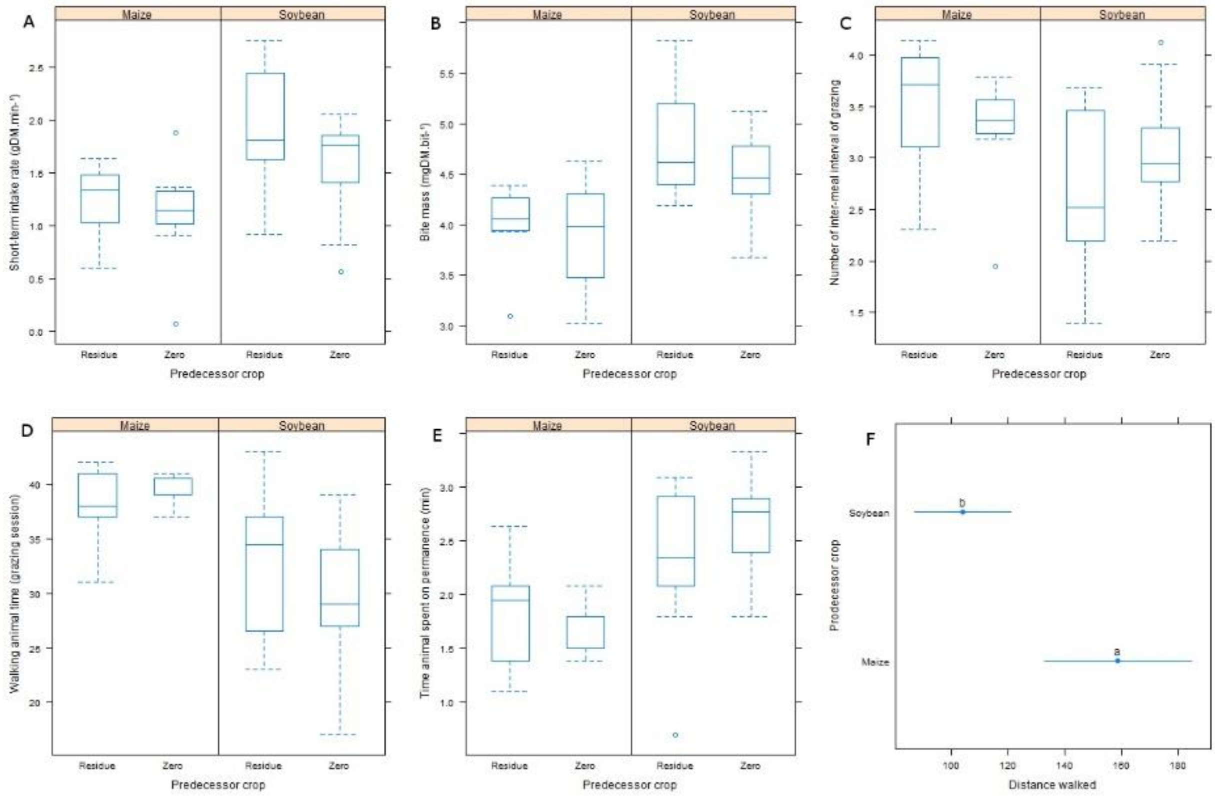

Figure 1: Ingestive behaviour patterns of Italian ryegrass grazed by lambs in paddocks with two different predecessor crops (soybean or maize).

3.2. Sward characteristics

Sward height was similar (P_R > 0.05) between treatments both with or without crop residues (Table 1). Each paddock showed a difference of less than 10% between pre- and post-grazing sward height, which may indicate that all bites during the grazing tests were taken in a similar area of the sward profile for all treatments.

Predecessor crops had detectable effects on herbage, leaf, pseudostem and sheath, weed and inflorescence mass (Pp < 0.05), and residue height influenced leaf and weed mass (Table 1). Residue height had no effect on herbage mass (P_R > 0.05).

Bulk density of the morphological components of the Italian ryegrass as a factor of its predecessor crop is shown in Table 2. There were no differences in the bulk density of herbage mass, leaf mass, pseudostem and sheath mass, and dead material mass among predecessor crops and residue heights (P_P and P_R > 0.05). Weed mass decreased in PSC compared to PMC at the 0 cm residue height (P_P < 0.05). Inflorescence mass was higher in PMC compared to PSC (P_P < 0.001).

Table 1

Sward morphological characteristics of Italian ryegrass grazed by lambs in paddocks with two different predecessor crops (soybean or maize)

Morphological variables	Predecessor crops[1]				Mean ± SD[2]	P_P[3]	P_R[4]	P_{PXR}[5]
	Soybean		Maize					
	Zero	Residue	Zero	Residue				
Pre-grazing sward height (cm)	19.7	18.4	16.6	19.5	18.8 ± 7.2	0.470	0.982	0.809
Post-grazing sward height (cm)	18.1	16.8	14.4	18.5	17.1 ± 7.1	0.377	0.345	0.304
Herbage mass (kg DM.ha^{-1})	1509.9a	1665.2a	1357.1b	1378.8b	1438.0 ± 159.1	0.008*	0.214	0.298
Leaf mass (kg DM.ha^{-1})	928.1aA	1124.9aB	854.3bA	801.3bB	927.1± 183.5	0.010*	0.016*	>0.001
Pseudostem and sheath mass (kg DM.ha^{-1})	499.0a	457.2a	314.44b	393.1b	415.9 ± 79.4	0.002*	0.725	>0.001
Dead material mass (kg DM.ha^{-1})	72.8b	55.1b	135.9a	104.3a	92.01 ± 35.6	>0.001	0.276	0.619
Weed mass (kg DM.ha^{-1})	17.3	27.8	46.8	11.9	26.1 ± 19.1	0.010*	0.006*	0.003*
Inflorescence mass (kg DM.ha^{-1})	3.5b	1.9b	10.9a	20.0a	8.46 ± 6.4	0.001*	0.134	>0.001

[1] Predecessor crop column represents the mean effects of sward characteristics considering the factors Zero and Residue in Soybean and Maize crops. Lowercase letters differ for predecessor crop; Capital letters differ for predecessor crop residue based on Tukey Test ($P<0.05$).
[2] SD= standard deviation.
[3] P_P= Probability level for predecessor crops.
[4] P_R= Probability for predecessor crop residues.
[5] P_{PXR}= Probability for interaction between predecessor crop and residue height.
* $P < 0.05$.

Table 2

Bulk density of the morphological components of Italian ryegrass grazed by lambs in paddocks with different predecessor crop (soybean or maize)

Bulk density	Predecessor crop[1]				Mean ± SD[2]	P_P[3]	P_R[4]	P_{PXR}[5]
	Soybean		Maize					
	Zero	Residue	Zero	Residue				
Herbage mass (g per m³)	1361.1	1604.7	1150.0	1303.8	1354.9 ± 316.3	0.185	0.328	0.794
Leaf mass (g per m³)	1187.0	1405.9	930.1	1144.1	1166.8 ± 297.4	0.161	0.252	0.988
Pseudostem and sheath mass (g per m³)	195.4	197.3	144.9	124.3	165.5 ± 82.12	0.067	0.763	0.798
Dead material mass (g per m³)	11.1	34.5	63.6	30.0	34.8 ± 25.4	0.069	0.720	0.659
Weed mass (g per m³)	0bB	11.7bA	38.8aA	7.8aB	21.0 ± 22.2	<0.001*	0.024*	<0.001*
Inflorescence mass (g per m³)	26.7b	11.1b	51.4a	35.6a	34.1 ± 18.2	0.001*	0.352	0.384

[1] Predecessor crop column represents the mean effects of sward characteristics considering the factors Zero and Residue in Soybean and Maize crops. Lowercase letters are significantly different for predecessor crop; Capital letters are significantly different for residue height based on Tukey Test (P<0.05).
[2] SD= standard deviation.
[3] P_P= Probability for predecessor crop.
[4] P_R= Probability for residue height.
[5] P_{PXR}= Probability for interaction between predecessor crop and residue height.
* P < 0.05.

4. Discussion

4.1. Animal behavior

Sward height is the most important variable affecting ingestive behavior of herbivores by altering bite dimensions and thus DM herbage intake. A sward height of 18.5 cm, recommended for Italian ryegrass based on the optimal STIR, was adopted in the present study (Laca et al., 1992; Gonçalves et al., 2009; Amaral et al., 2012; Fonseca et al., 2013; Silva et al., unpublished data).

The greater STIR and bite mass (BM) for PSC found in this study may be due to the morphological traits of Italian ryegrass. Sward structures have been described as a concomitant cause and effect in the grazing process (Carvalho et al., 2009a). In addition, animal selectivity in searching for ideal sward can cause changes in BM and STIR (Benvenutti et al., 2008b; Laca et al., 2001).

The higher STIR found in the PSC treatment may be due to greater bite mass (Figure 1B), as bite rate was similar between PSC and PMC and, in any case, bite mass tends to have a larger influence on STIR than bite rate (Parsons et al., 1994; Beaumont et al., 2004). In our study, a higher leaf mass for PSC may have also contributed to greater selectivity and bite mass.

The leaf is the preferred part of the sward structure for grazing, and most animals try to capture the largest possible amount of leaf mass (Ginnett et al., 1999; Drescher et al., 2006). This behavior can explain the positive correlation between bite mass and proportion of leaf mass consumed by animals raised on pasture (Stobbs, 1973; Gregorini et al., 2009a).

The high weed and inflorescence mass in PMC pastures, making up more than 50% of sward strata, may also have contributed to a decrease in leaf accessibility and consequently reduced the bite mass (Gregorini et al., 2009a). Because weeds and inflorescences are low-quality sward, animals seeking a high-quality diet under these conditions would have to increase their selectivity while taking smaller bites, thus decreasing the bite mass (Benvenutti et al., 2008b; Laca et al., 2001). Bite mass is a function of bite depth, bite area, and bulk density of the grazed sward stratum (Laca et al., 1992), suggesting that weeds and inflorescences are non-preferred parts of the sward and act both as a vertical barrier to deep bites (Ginnett et al., 1999; Drescher et al., 2006) and a horizontal barrier to large bite areas (Benvenutti et al., 2006).

In PSC, pseudostem and sheaths increased the amount of leaf mass (kg DM $.ha^{-1}$) and were associated with an increase in bite mass. This probably may offset any difficulty in apprehension of pasture (Benvenutti et al., 2006). On the other hand, other studies have shown that high pseudostem and sheath mass may be related to decreases in bite mass (Prache, 1997; Benvenutti et al., 2008b; Gregorini et al., 2009a; Fonseca et al., 2013). The Italian ryegrass used in our study was grazed during the vegetative stage, and instead of stems it contained pseudostem. According to Benvenutti et al. (2009), the presence of pseudostem and sheath mass did not decrease animal consumption of certain plant groups. Therefore, it is possible that there is no barrier for bite mass and bite rate from pseudostem and sheath mass in Italian ryegrass (Moore et al., 1991; Benvenutti et al., 2009).

Bulk densities (upper 50% sward stratum) of pasture principally composed of leaf and pseudostem were similar between predecessor crops, and consequently did not alter the bite rate. Similar herbage masses between predecessor crop treatments agrees with previous results reported by Barth Neto et al. (2014).

4.2. Sward structure

When the production area is well managed, a positive synergistic effect between crops and pastures is possible (Lemaire et al., 2015). The predecessor crop may interfere with herbage accumulation during sward establishment, as well as forage mass at the end of the pasture phase (Barth Neto et al., 2014). Our results suggest that differences among treatments in herbage accumulation during the initial phase may remain intact over time, resulting in total herbage mass – among other modifications in sward structure – that depends on predecessor crop.

Greater leaf mass, pseudostem, and sheath mass for Italian ryegrass under PSC may reflect the positive long-term effects of using legumes to increase soil nitrogen and benefit yield for the following crop (Krupinsky et al., 2006). Our study was conducted according to the long-term ICLS experimental protocol ongoing at the Federal University of Rio Grande do Sul since 2003. Consistently lower leaf mass in PMC may have limited the tillering potential of perennial Italian ryegrass over time. Each leaf is theoretically capable of producing new tillers that pass through four growth periods described as growth, elongation, reproduction, and seed maturation (Moore et al., 1991). The vegetative growth period is characterized by the appearance of leaves and tillers (Waller et al., 1985). In our study, this period may have been reduced under PMC. Also, during the elongation and reproduction periods (Waller et al., 1985) maize emits more inflorescences compared to soybean.

In PMC the horizontal residue was removed during harvesting (isolation of factors). Thus, there was no effect of physical coverage on the germination rate and seedling survival of weeds. In contrast, in PSC the leaves fell before harvesting and were not removed from the grazing areas. Consequently, residues in PSC may have acted as a physical barrier weed growth in the short term (Monquero et al., 2009).

4.3. Animal selectivity

Lambs are efficient in forage selection within a feeding-station and have an accurate ability to discriminate feed quality regardless of the distribution landscape (Laca et al., 2010). Small herbivores have a tendency to focus on high quality feed, meaning they would have to search longer for quality bites in pastures with high proportions of weeds and inflorescences. The higher number of grazing intervals for PMC may thus represent difficulty in forage selection by lambs, mainly due to sward structure and bulk density composed of more weeds and inflorescences.

Herbivore grazing behavior is characterized by search time for feeding stations and time spent at each feeding station (Stuth, 1991). In our study, searching for feeding stations can be represented by the time spent walking, residence time at each feeding station and distance walked (Figure 1). Thus, longer walking times for the PMC treatment suggested that animals were looking for high-nutrient sward. Similarly, herbivores tend to remain at a feeding station until consumption of nutrients dips below the pre-existing average (Carvalho and Moraes, 2005), after which they move to another location (Roguet et al., 1998). In the present study, this point was reached more quickly in PMC, resulting in a higher NIMI (Figure 1C).

Our study also indicated that the bite mass decreased in PMC due to low leaf mass and higher proportions of senescent material and inflorescences in the sward structure, which may have increased the overall number of feeding stations (Baggio et al., 2009). In addition, more time spent walking resulted in longer total distances walked (Figure 1F) and less time spent at feeding stations (Figure 1C). Animals displaying these behaviors are attempting to maintain their level of nutrient consumption, even though by doing so they are decreasing STIR (Figure 1A).

There was insufficient evidence to demonstrate an effect of residue height on ingestive behavior patterns of lamb grazing Italian ryegrass. Further studies are recommended to evaluate the effect of crop residue particle size on grazing behavior patterns of Texel lambs. Furthermore, our study was limited to evaluating short-term grazing behavior on a scale of minutes; cumulative and long-term effects remain unknown.

5. Conclusion

Changes in sward structure of Italian ryegrass pastures and changes in the ingestive behavior patterns of Texel lambs occurred due to the influence of predecessor crops. The predecessor soybean crop was less detrimental to the development of Italian ryegrass compared to maize, and can thus be considered as an alternative to improve the performance of Texel raised on pasture in integrated crop-livestock systems.

6. Competing interests

The authors declare that they have no competing interests.

7. Authors' contributions

Delma Silva, Paulo Carvalho, Alda Monteiro, Anibal de Moraes and Carolina Bremm performed the project, conducted the trials in the farm, and wrote the draft. Breno Menezes and Anderson Bolzan conducted the trials at farms and helped in laboratory analysis. Vanessa Sehaber helped with statistical analysis. Natália Gonzales and Veridiana Souza helped finalize the manuscript. All authors read and approved the final manuscript.

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4.0 CAPÍTULO III

THE HEIGHT OF CROP RESIDUES INFLUENCES INTAKE RATE OF ANIMALS IN INTEGRATED CROP-LIVESTOCK SYSTEMS[1]

[1] Artigo elaborado de acordo com as normas da Livestock Science (Anexo II-B)

THE HEIGHT OF CROP RESIDUES INFLUENCES INTAKE RATE OF ANIMALS IN INTEGRATED CROP-LIVESTOCK SYSTEMS

Delma Fabíola Ferreira da Silva[1,a*], Carolina Bremm[b], Vanessa Sehaber[c], Natália Marcondes dos Santos Gonzales[a], Breno Menezes de Campos[a], Anibal de Moraes[a], A. M. S. Bolzan[d], Alda Lucia Gomes Monteiro[a], Paulo César de Faccio Carvalho[d]

[a] *Center of Technological Innovation in Agriculture, Federal University of Paraná, Curitiba, PR, 80035050, Brazil*

[b] *State Foundation for Agricultural Research, Porto Alegre, RS, 90130-060, Brazil*

[c] *Department of Statistics, Federal University of Paraná, Curitiba, PR, 81531990, Brazil*

[d] *Grazing Ecology Research Group, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, 90040-060, Brazil*

[1]Corresponding author: Delma Fabíola Ferreira da Silva

Email: delmafsilva@gmail.com

Short title: Ingestive Behavior in integrated crop-livestock systems.

Abstract

In southern Brazil, the crops that stand out are soybean and maize (*Glycine max* L. and *Zea mays* L.), in integrated crop-livestock systems (ICLS) based on no-tillage are composed by agricultural and livestock activities in succession, which leads to crop residues. The aim of this study is to quantify the mechanisms by which the intake rate of animals grazing Italian ryegrass (*Lolium multiflorum* Lam.) is determined in different sward heights according to contrasting predecessor soybean or maize crop residues (PSCR, PMCR). We hypothesized that the predecessor vertical crop residues in the sward surface may change the intake rate of grazing animals due to change in patterns of grazing. Indeed, it is possible that there is an ideal residue height of the predecessor crop for maximum intake rate. The work was carried out in two different experiments, both using Italian ryegrass (*Lolium multiflorum* Lam.) as the pasture species. The residue was manually cut in four different heights (0, 15,30 and 45) of residues of PSCR and PMCR were standardized in the pasture. Bite mass and intake rate were estimated by the double-weighing technique with correction for insensible losses. Time spent per bite, non-biting jaw movements rate and intra-meal interval duration were measured with behaviour recorders. Was observed the bite rate was the main variable determining intake rate. In experiment 1, short-term intake rate was higher for the PSCR of 14 cm (p = 0.003), due to the pasture structure with a higher amount of leaf mass. The PSMR has no marked effect. In experiment 2, the STIR was higher on PMCR with residue height of 15 cm (p = 0.0115), a result that seems to be driven by the increase in bite rate (p = 0.0163). In addition, higher residue height provoked increase in non-biting jaw movements rate (p = 0.0175) showing great selectivity performed by ewe lambs. Time spent per bite was higher in PMCR at 45 cm, (p = 0.0162), which was related to time spent on searching. The reduction in bite rate with

increasing PMCR residue height is discussed as the cause of changes in non-biting jaw movements rate. Furthermore, the spatial dispersion of forage on PMCR can be the feature that generates a high time spent per bite.

Keywords: Predecessor crop; Mixed crop-livestock systems; Ingestive behavior; Short-term intake rate.

1. Introduction

Integrated crop-livestock systems (ICLS), opposite unilateral monoculture systems, of commonly use integrated agricultural and livestock activities, at different spatial-temporal scales, concurrently or sequentially in rotation or succession (Moraes et al., 2014; Lemaire et al., 2014). Thus, rotation occurs in the same area, leading to residues of the predecessor crop at the pasture phase (Giller et al., 2015). Concerning crops, in Southern Brazil, soybean and maize (*Glycine max L. and Zea mays L.*) are the most prominent cultures (Brazilian Institute of Geography and Statistics, 2014). Italian ryegrass pastures are usually used in the winter period as an option to rotate with those summer crops (Carvalho et al., 2010). Italian ryegrass is an annual pasture that produces persist viable in the soil, ensuring its return by natural reseeding in the following year (Carvalho et al., 2005). Thus, soon after crop harvest the pasture in formation and some crop residues remain vertically on the soil. Consequently, crop harvesting is an important process in the subsequent pasture management, as the crops residues will be part of the grazing environment (Barth Neto et al., 2014).

Despite the advantages of using pastures in ICLS, there is no information on how the vertical residues may affect the grazing process during the pasture phase, and how it interferes in secondary productivity of ICLS by modifying the grazing environment and/or constraining animal intake rate.

Furthermore, grazing animals have the ability to change their intake rate as a consequence of behavioral decisions (Newman, 1994). Thus, modifications on grazing environment and sward surface structure can affect the grazing process: bite mass (BM), bite rate (BR), and non-biting rates (NBR). Consequently, it affects the daily herbage intake (Yayota et al., 2015), leading to changes in animal production. Foraging preferences and dispersion of food items in the foodscape seem to be undirected connected to ingestive behavioral decisions and short-term herbage intake rate (STIR).

The aim of this study was to quantify the mechanisms by which intake rate is determined in different heights of contrasting predecessor soybean and maize crop residues (PSCR and PMCR, respectively), and the importance of animal selection in the interaction between grazing and residues. Therefore, this address to the following question: Can the predecessor crop vertical residues act as a physical determent to grazing? Then we proposed the following hypotheses: (1) Changes in the grazing environment due to the presence of the vertical crop residues can alter patterns of grazing at the bit level; (2) Considering, ICLS, where there will be crop residue in the subsequent pasture. There is an ideal cut-off time of the predecessor crop, where the intake rate remains at its maximum; (3) Predecessor crop residues may modify the displacement process by the animals, in the search for food.

2. Material and methods

2.1 Experimental area

This study is part of a long-term experimental protocol of ICLS initiated in 2003 at the experimental farm of the Federal University of Rio Grande do Sul (UFRGS), in the South of Brazil (30◦05′ S; 51◦39′ W). The ICLS protocol consisted in the rotation, on the same area, of an Italian ryegrass pasture grazed by ewe lambs during the winter and a soybean and soybean / maize grain crops rotation cultivated during the summer. Italian ryegrass pasture is established each year by self-seeding since 2005, with complements of failures in the area, by manual seeding. This process, which is the common practice in the region.

The region is classified as subtropical humid (Cfa classification, Köppen and Geinger, 1928). It is characterized by a seasonality of temperature and a homogeneous repartition of precipitation along the year. The soil at the experimental site is determined as a Typic Paleudult (USDA, 1999) with 15.2% clay. This experimental protocol was conducted from November 2013 to August 2014.

Four paddocks of 150 m^2 of Italian ryegrass, previously delimited and surrounded with electro-plastic fences were used.

The climatic conditions were similar in temperature during the evaluation period. Mean daily temperature variation was 7.5°C. The maximum temperature was 22 °C (July 13th, 2014) and a minimum of 5 °C (July 19th and 07th, 2014) (Accuweather, 2014).

2.2 Treatments

Experiment 1 consisted of four heights of predecessor soybean crop residues (PSCR: 0, 7, 14 and 21 cm). Experiment 2 consisted of four heights of predecessor maize crop residues (PMCR: 0, 15, 30, 45 cm). In both experiments, the experimental design was a completely randomized block with four replicates, and the blocking criterion was the time of the day for the evaluation (morning and afternoon).

The Italian ryegrass sward surface height (SSH) was maintained at 18.5 cm during the experimental period, which is the recommended SSH for grazing when this plant species is on its vegetative stage (Silva, unpublished data). The experimental area was accompanied by measurements of daily heights so that the SSH of Italian ryegrass remained relatively constant over the grazing period, and the same sward surface structure was available for the animal both at the beginning and at the end of the grazing test. Thereby, the aim was to maintain the sward surface structure, at the bite level, to remain constant, and not limiting to intake, over the entire grazing test.

2.3 Management practices

The sowing of summer crops were, for experiment 1 and 2, held on November 25th and 27th of 2013 respectively (soy-BRX Power RR and maize hybrids DKB290), by direct seeding on the line, with row spacing of 43 cm.

The experimental area was manually prepared using brushcutters after crops harvest (May 23th, 2014) according to the intended treatments, which were close to the ground and 7, 14 and 21 cm from the ground (experiment 1/soybean residue) or close to the ground, 15, 30, and 45 cm (experiment 2/maize residue).

Table 1: Predecessor crop residues height per treatment.

Experiment	Treatment Height (cm)				*P-Value*
Predecessor maize crop residue	Zero	15	30	45	
(cm)	2.0 ± 1.9	15.2 ± 1.5	30.2 ± 2.9	45.1 ± 1.9	< 0.001
Predecessor soybean crop residue	Zero	7	14	21	
(cm)	0 ± 0	7.1 ± 1.15	14.4 ± 2.3	21.0 ± 2.5	< 0.001

sd=Standard deviation; p = significance level.

After harvesting, weeds were removed manually and stubble and crop residues (spikes and seeds) were removed from the experimental paddocks in order to control potential bias. The Italian ryegrass received application of 75 kg ha^{-1} of nitrogen (urea), on July 7th.

2.4 Sward measurements

In both experiments, Italian ryegrass pastures were considered in vegetative stage, because less than 0.5% of the tillers had inflorescences (Tables 2 and 4). Three samples per experimental unit were collected through cut, in order to determine the post-grazing herbage mass and herbage density. Strata was cut every 5 cm using a 0.1089 m^2 square. All samples were separated into leaf lamina, pseudo-stems+ stems + sheaths, dead material, weed mass and inflorescence and then weighed. Samples were then dried at 65 °C for at least 72 h to determine the dry matter (DM) content. The total herbage mass was determined as the sum of the mass of each component (leaf lamina, pseudo-stems + sheaths and dead material). To determine the SSH of Italian ryegrass, a sward stick was used to measure 150 points per experimental unit (≈ one point by m^2) pre- and post-grazing (Barthram, 1985). After the emergence of the Italian ryegrass, SSH were measured daily within the paddocks to monitor their development until reaching the pre-grazing SSH of 18.5 cm. The grazing tests started on July 9th for PSCR paddocks and on July 14th for PMCR paddocks.

The DM content of simulated grazing samples was estimated by cutting four samples from each experimental unit, two pre-and two post-grazing (Halls, 1954). The samples were harvested in the superior stratum of the sward surface because there is a 50% proportional relationship between the herbage removed with each bite and the SSH (Cangiano et al., 2002; Gonçalves et al., 2009; Laca et al., 1992). Then samples were dried at 65 °C for at least 72 h to determine the dry matter (DM) content.

2.5 Animal measurements

In both experiments, approximately 60 days before the grazing tests, the animals were familiarized with observers, recording equipment, and the experimental procedures and remained in an adjacent paddock with Italian ryegrass sward.

Six Texel ewe lambs were used in each experiment, consisting of four “tester” animals (6 ± 1 months and 35 ± 2.6 kg of body weight), and two additional “peer” animals. Each group consisted of three animals consisting of two testers and an additional “peer” animal, which remained in paddocks side by side. This procedure was lead to prevent any effect of group size during lambs grazing time (Penning et al., 1993). Each group of three ewe lambs was placed side by side in the morning or in the afternoon according to its block. The animals were allowed to graze in periods of 45 min during peak grazing times, the first and the last grazing meals, respectively (Hodgson, 1990). The animals were not fasted prior to the grazing periods because this may increase intake rates (Gregorini et al., 2009a) and reduce diet selection

(Newman et al., 1994). The experimental procedure was adapted from Penning and Hooper (1985).

At dawn, the animals were taken to a weighing area, and the four “tester” animals were fitted with feces and urine collecting bags. They were also fitted with IGER Behaviour Recorders (Rutter et al., 1997), to identify and characterize jaw movements [biting (bite severing), non-biting jaw movements (manipulation + ingestive mastication)], and to determine the eating time [time at which ewe lambs were head down and completely involved in severing, manipulating, and masticating bites (grazing = eating + searching times)]. These data were used to calculate bite mass (BM), bite rate (BR), non-biting jaw movements (N-BJMR), and total jaw movements (TJM) per gram of herbage dry matter intake (DMI).

After approximately 45 min of grazing, the animals were removed from the paddock, reweighed and then kept in a non-vegetated area without access to water and food to determine the rate of insensible weight loss (evaporation of H_2O, and gaseous losses; Gibb et al., 1999) during another 45 min. This entire procedure was repeated in the afternoon. Data were analyzed with the Graze software (Rutter et al., 1997). The effect of period of day (morning and afternoon) was blocked in the analysis due to changes in the preferences of animals over the course of the day (Rutter, 2006).

All animals’ weights (pre- and post-grazing and pre- and post-insensible weight losses) were taken on a balance with an accuracy of 10 g. The short-term intake rate was calculated by the equation:

$$STIR = \frac{(W2 - W1)}{t2 - t1} + \frac{(W3 - W4)}{t4 - t3}\ x\ \frac{(t2 - t1)}{ET}$$

Where: STIR=short-term herbage intake rate; W1 and W2=animal's weight after and before grazing; t1 and t2=time pre- and post-grazing; W3 and W4=animals’ weight pre- and post-insensible weight losses; t3 and t4=time pre- and post-insensible weight losses; and ET=effective eating time. The STIR was corrected for the DM content. STIR was calculated as the product of the fresh weight intake rate and the DM content of the herbage consumed by animals (determined from hand-plucked samples).

For calculating effective eating time (ET, the total grazing time excluding intervals of jaw inactivity of more than 3 s; Gibb, 1998). Time spent for bite was calculated ET/total number of bites. The BM was calculated as the ratio between STIR and the number of bites. The BR was determined by dividing the total number of bites by the eating time. The TJM was calculated by adding the chewing and seizure movements (bites) recorded by the IGER. The N-BJMR refers to those movements that are not identified as bites during grazing and therefore include movements that have a masticatory or manipulative function. These were calculated as the number of N-BJMR divided by the ET. The intra-meal interval of grazing was considered intervals of jaw inactivity from 3 until 300 s. The number of intra-meal interval of grazing (NIMI) was the total amount of intervals given during the evaluation (Gibb, 1998).

The evaluation of the movements performed by the animals were placed on the perimeter of the paddock, identified by numbering and lettering each square meter from the zero point, with a x and y axis simulation in an area forming a cartesian plane. This allowed identifying the location of the animal inside the paddock. There was a beep at every minute, so the evaluator assessed the location within a paddock of tester animals and the position of their heads in the quadrant. Each minute in sequence that animals remained in the same quadrant was considered permanence time. Every interval that the animals were moving between quadrants was considered walking time. Moreover, it was possible to evaluate the distance walked by each meter count.

2.6 Data analysis

For both experiments the statistical analyzes were similar. Data were subjected to analysis through R software for statistical computing version 3.1.3 (R Development Core Team, 2015) and through R studio. Mixed linear models were used and developed with the nlm4 package.

All variables (behavioral and sward) showed a normal distribution, checked by MASS package with the Box-Cox test ($p > 0.05$). In all analysis, paddock and test group were used as experimental unit. The structure of these models were selected based on interaction between time of day (morning and afternoon) and grazing test day, to create a variable named "parcel", which included the effects of repetition and paddock. This procedure was performed in order to include more variables in the randomized model.

Data were subjected to variance analysis (ANOVA) at 5% level of significance. The model included the fixed effects for treatment heights according to the experiment (1 or 2), and random effects of parcel and animal. If any significance was detected it was then compared by the Tukey test ($p < 0.05$).

3. Results

3.1 Predecessor soybean crop experiment – Experiment 1

The actual SSH was similar to the target SSH (Table 1). Vertical distribution of herbage mass and morphological components of sward surface (leaf, pseudo-stems + sheaths, dead material mass and inflorescence) are shown in Table 2.

Table 2: Residue diameter of predecessor soybean crop (experiment 1), pre-grazing sward surface heigth (SSH), post-grazing SSH, herbage mass (HM), leaf mass (LM), pseudostems and sheaths mass (PSM), dead material mass (DMM), inflorescence mass (IM) of Italian ryegrass (*L. multiflorum* Lam.) grazed by ewe lambs as a function of different predecessor soybean crop residue heights.

	Predecessor soybean crop residue (cm)					
	0	7	14	21	Mean ± sd	*p* - value
Residue diameter (mm)	—	6.9	6.8	6.0	6.6 ± 1.9	<0.001
Pre-grazing SSH (cm)	19.8	20.1	18.4	21.7	20.1 ± 2.1	0.532
Post-grazing SSH (cm)	18.1	18.3	16.8	22.6	19.2 ± 2.5	0.116
HM (Kg DM ha^{-1})	1509.9	1362.8	1783.5	1250.0	1483.9 ± 341.2	0.174
LM (Kg MS ha^{-1})	928.1 ab	936.4 ab	1221.0 a	794.1 b	971.0 ± 257.5	0.018*
PSM (Kg DM ha^{-1})	499.1	379.5	479.3	400.1	445.5 ± 127.0	0.475
DMM (Kg DM ha^{-1})	72.9	40.0	54.8	46.6	55.20 ± 34.7	0.388
IM (Kg DM ha^{-1})	1.9	3.0	0.3	3.0	2.02 ± 3.0	0.412

sd = Standard deviation; *p* = significance level.

There was no difference for any of the variables BR, N−BJMR, TSB and total jaw movements rate − TJM under PSCR (Table 3).

Table 3: Short-term intake rate (STIR), bite mass (BM), bite rate (BR), non-biting jaw movements rate (N-BJMR), time spent for bite (TSB), total jaw movements rate (TJM), number of intra-meal interval of grazing (NIMI), and Intra-meal interval duration (IMID) for ewe lambs grazing Italian ryegrass (*Lolium multiflorum* Lam.) as a function of different predecessor soybean crop residue heights .

	Predecessor soybean crop residue (cm)					
Animal behaviour variables	0	7	14	21	Mean ± sd	*p* - value
STIR (g $DM.min^{-1}$)	5.1 ± 1.9 b	5.4 ± 2.1 b	8.3 ± 4.5 a	5.4 ± 2.1 b	6.2 ± 3.2	0.005*
BM (mg $DM.min^{-1}$)	88.5 ± 34.9	99.7 ± 34.3	144.6 ± 88.2	94.2 ± 36.9	107.8 ± 58.6	0.055
BR ($bite.min^{-1}$)	60.9 ± 14.9	55.4 ± 14.0	58.9 ± 12.6	58.7 ± 18.9	58.9 ± 14.3	0.486
N-BJMR ($no.min^{-1}$)	68.1 ± 18.8	65.4 ± 18.4	67.0 ± 16.3	72.0 ± 23.4	67.9 ± 18.2	0.782
TSB ($sec.bite^{-1}$)	1.1 ± 0.3	1.14 ± 0.3	1.5 ± 0.2	1.1 ± 0.3	1.1 ± 0.3	0.835
TJM ($no.min^{-1}$)	128.9 ± 9.6	120.7 ± 6.8	125.9 ± 12.9	130.5 ± 6.9	126.7 ± 10.1	0.809
NIMI (nº)	18.3 ± 5.7 b	33.1 ± 14.9 a	18.2 ± 13.5 b	21.8 ± 6.7 ab	21.9 ± 11.8	0.025*
IMID (min.)	0.2 ± 0.1 b	0.3 ± 0.1 a	0.2 ± 0.1 ab	0.2 ± 0.1 ab	0.2 ± 0.08	0.027*

sd = Standard deviation; *p* = significance level.

STIR was significant in the 14 cm residue height (p = 0.003) under PSCR (Figure 1). There is a tendency for high BM, in 14 cm residue (p= 0.052).

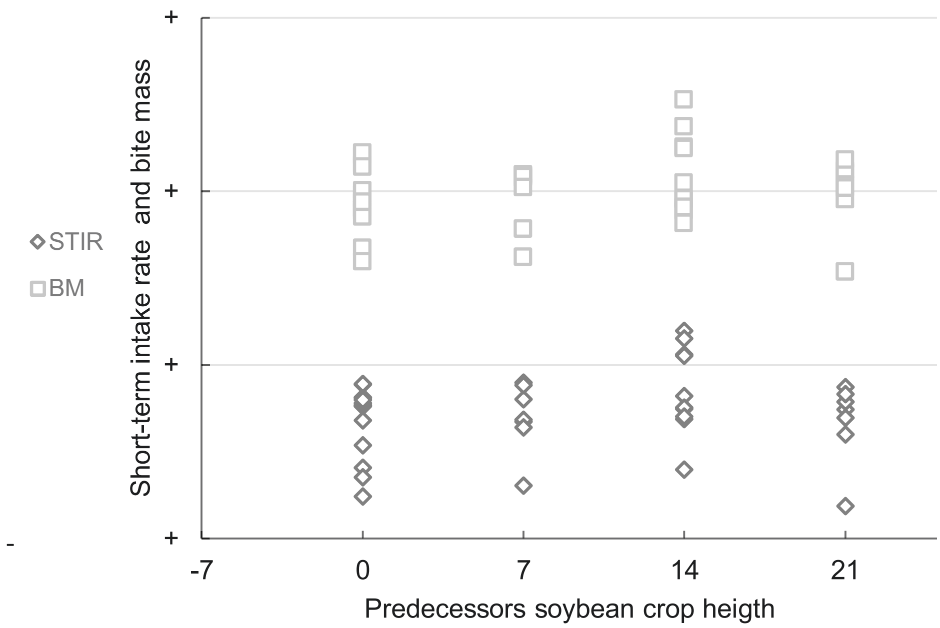

Figure 1: Distribution of short-term intake rate (STIR, g DM.min^{-1}) and bite mass (BM, mg DM.min^{-1}) by ewe lambs grazing Italian ryegrass (*Lolium multiflorum* Lam.), as a function of different predecessor soybean crop residue heights.

3.2 Predecessor maize crop – Experiment 2

There was no significant difference between the mean of pre- and post-grazing SSH in treatments (p = 0.626).

Table 4: Residue diameter of predecessor maize crop, pre-grazing sward surface heigth (SSH), post-grazing SSH, herbage mass (HM), leaf mass (LM), pseudostems and sheaths mass (PSM), dead material mass (DMM), inflorescence mass (IM) of Italian ryegrass (*Lolium multiflorum* Lam.) grazed by ewe lambs as a function of different predecessor maize crop residue heights.

	Predecessor maize crop residue (cm)					
	0	15	30	45	Mean ± sd	*p*-value
Diameter of residue (cm)	—	18.1	18.6	19.5	18.8 ± 3.17	<0.001
Pre-grazing SSH	16.7 b	19.5 a	21.1 a	21.6 a	20.1 ± 2.8	0.001*
Post-grazing SSH	14.4 b	18.5 a	19.2 a	20.5 a	18.6 ± 3.3	0.002*
HM (kg DM ha^{-1})	1357.1	1343.1	1416.2	1532.7	1439.0 ± 259.7	0.640
LM (Kg MS ha^{-1})	854.2	745.3	982.9	970.0	919.5 ± 201.5	0.337
PSM (Kg DM ha^{-1})	314.5	395.1	317.4	412.9	369.3 ± 100.5	0.193
DMM (Kg DM ha^{-1})	135.9	99.9	76.3	110.0	105.0 ± 36.36	0.377
IM (Kg DM ha^{-1})	31.0	9.3	11.2	6.2	8.7 ± 3.9	0.208

Sd = Standard deviation; *p* = significance level; Means followed by lowercase letters on the same line differ based on comparisons multiple contrasts (P < 0.05).

Higher STIR were observed for PMCR for 15 cm of height (p = 0.0115; Figure 2A). The mean value was 3.015 ± 0.94 g DM min^{-1}. There was no difference ($p > 0.005$) for the PMCR residues height concerning BM. The mean was 48.5 mg DM $bite^{-1}$, with ranges about 22.1 to 80.5 mg DM $bite^{-1}$. Higher values of BR (Figure 2B) were observed under PMCR for 15 cm of height ($p = 0.0163$) and lower values in 45 cm height. The mean was 61.56 g DM min^{-1}. The TSB, presented higher values for the 45 cm ($p = 0.0162$; Figure 3A), and lower in 15 cm. The mean was 1.0 g DM min^{-1}. The N-BJMR was lower for 45 cm ($p = 0.0175$, Figure 3 B). The mean value was 58.63 g DM min^{-1}. There was no significant difference for the PMCR for TJM ($p > 0.005$), remaining constant.

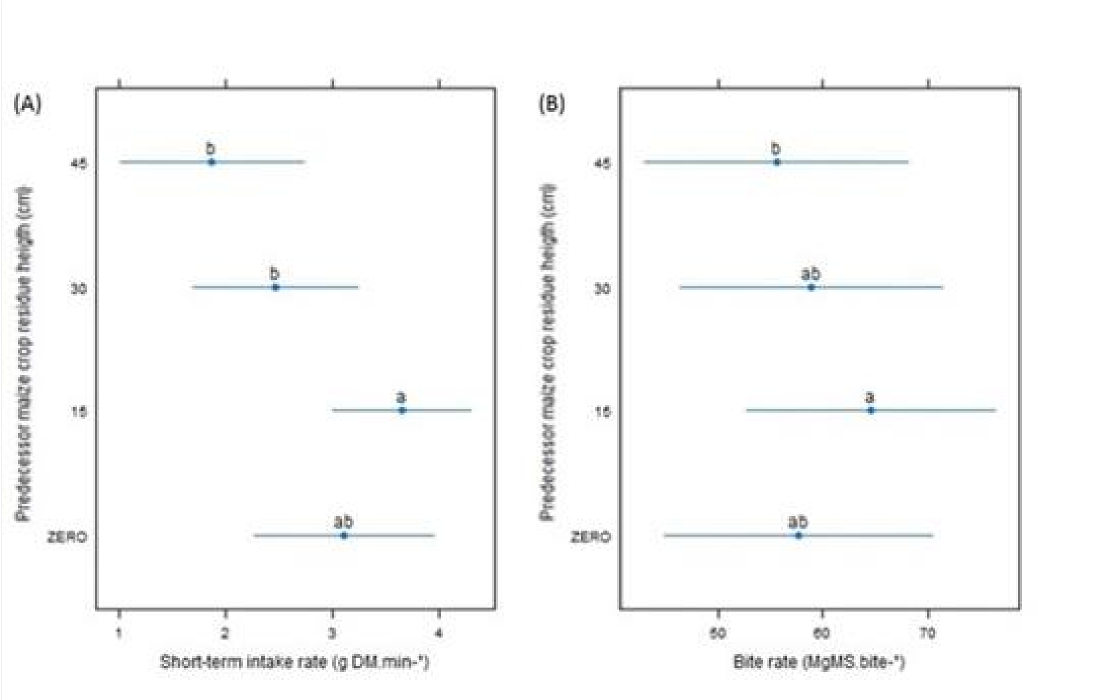

Figure 2: Short-term intake rate (STIR, A) and bite rate (BR, B), for ewe lambs grazing Italian ryegrass (*Lolium multiflorum* Lam.) as function of different PMCR heights.

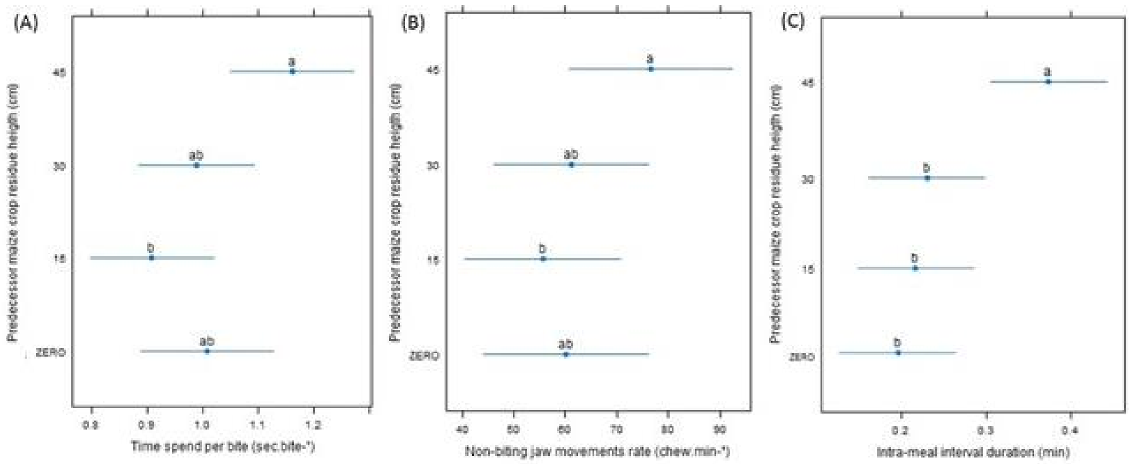

Figure 3: Time spent per bite (A), non-Biting jaw movements rate (B) and intra-meal interval duration (C), for ewe lambs grazing Italian ryegrass (*Lolium multiflorum* Lam.) as a function of different PMCR heights.

4.0 Discussion

4.1 Predecessor soybean crop – Experiment 1

Bite Rate, N-BJMRs and BM determine STIR (Yayota et al., 2015), as shown in experiment 1, in which there was no difference in variables BR, N-BJMRs among treatments. It is worth noting the trend (p = 0.055) for the treatment of BM 14 cm (Table 3), and even the behavior of similar data for STIR in Figure 1. The difference in STIR for PSCR at 14 cm was effective because of the higher leaf mass in that treatment. The amount of dead material mass and inflorescence mass did not differ between treatments. Thus, the animals did not need to avoid undesirable structures and could capture the preferred component of the canopy in abundance (Fonseca et al., 2012). Therefore, concerning the animal grazing behavior there was no influence of residues on PSCR, however, results were influenced by sward structure.

In this context, it is likely that the animals did not perceive PSCR as an opponent to grazing behavior. Due to the row spacing (43 cm), ewe lambs were possibly able to bite between the spacing. In addition, PSCR is fragile compared to those other residues such as corn. During the assessment of animals displacement it was noticeable that animals break the residues in the line. When returning to the same grazing site, it would not have residues "preventing the grazing" anymore. In addition, the residue diameter of 6.6 mm on PSCR seems to not be a barrier for grazing.

Foraging decisions can be interpreted in terms of an overall objective of maximizing the efficiency of feeding (Baumont et al., 2004), which in this study we assume as the equivalent to STIR maximization. For harvesting the herbage up to the mouth, grazing ruminants use jaw movements (Ungar and Rutter, 2006). Thereby, the animals try to maintain the maximum STIR by controlling the type of ingestive jaw movements (Baumont et al., 2004). In this context, it was not observed in experiment 1 an alteration on jaw movements according to the treatments.

Table 3 revealed that ewes lambs essentially exhibited similar patterns of N-BJMRs, TSB and TJM, regardless of the remarkable differences in residues heights (Table 2). Similar results were reported by Yayota et al. (2015). It can be inferred that ewe lambs did not need to perform more harvesting movements or manipulate the harvested material since these variables remained constant. This pattern was expected because sward structure did not varied as reported by Fonseca et al. (2013), where important differences in sward height provoked marked differences on jaw movements. Besides that, the TSB did not increase in the time spent capturing and harvesting herbage, regardless of treatment (Benvenutti et al., 2009). Therefore, it is possible to suggest that the animals avoided places where bites could contain residue.

When the animal harvest the herbage, there is a proportional relationship between the herbage removal depth and SSH, of about 50% SSH (e.g., Laca et al., 1992). Thus, the sward height of 18.5 and 7 cm of residue height seems to define a very close limit in relation to the potential proportionality, with a potential reduction in bite depth and bite area. In addition, 7 cm residue was not easily perceived in the pasture, possibly hindering the bite selection process, leading to higher NIMGI and IMID. It can be considered that the high NIMG was a reflection of the great selection of sites in the feeding station for maximum bite potential, related to a greater IMID. In other treatments, due to the sward structure, the animals possibly had selection facilitated, and could discriminate the residue (Edwards et al., 1994).

4.2 Predecessor maize crop – Experiment 2

The pre and post grazing height of the Italian ryegrass did not varied significantly in any of the treatments. Therefore, it is reasonable to consider that the same sward structure was presented to the grazing animal all along the grazing tests. However, the zero residue treatment had a lower sward height compared to the other treatments, and the magnitude of that sward height may constrain intake (Silva, unpublished data).

The BR was higher for the PMCR of 15 cm, leading to a higher STIR. This relationship of BR and STIR was observed in Yayota et al., (2015). Moreover BR includes the time spent searching (locomotion, recognition and decision) and handling (Prache, 1997).

The PMCR may have acted as a vertical barrier interfering with the process of bite formation and affecting BR and STIR at 30 and 45 cm. Barrier effects on ingestive behavior at the bite level were discussed previously by Benvenutti et al. (2009) and Fonseca et al. (2013). The effect of the vertical barrier was previously observed with stems + sheaths for some plant species by Benvenutti et al. (2008). Furthermore, it is difficult to keep the bites when there is an impediment factor. Moreover, it is possible to suggest that it happens because of the dispersion of food items in the foodscape increases, due PMCR, such as bites becoming farther apart. The BR depends on the dispersion of food, which determines the encounter rate. When bites remain close, the animals may increase BR. However, if bites are farther apart (i.e., with the distribution of PMCR within a sward surface, bites become more dispersed), animals may not increase BR because they are limited by encounter rate with acceptable bites (Searle et al., 2007).

The dispersion of food, due to PMCR, can bring changes in TSB, in which time spent on searching, especially when the height of the residue was higher (45 cm), may have been the main factor to lead to a significant difference, as evidenced by the intra-meal interval duration (Figure 3. C). This occurs due to the selectivity of food, in which the TSB is related to the time spent by the animal on searching and manipulating the sward surface (Figure 3. A; Prache, 1997). Thus, it may not be related to BM (Prache, 1997; Benvenutti, 2006). The manipulation, in addition of mastication time, is dependent of the apprehension time, which is considered independent of BM (Parsons et al., 1994). Furthermore, TSB is related to the gradual decrease of STIR in the treatments 30 and 45 cm (Figure 2). STIR is determined (in addition BM) by the relationship of TSB (eating time per total number of bites) to BR (Laca et al., 1992). Thus, more time per bite results in lower STIR (Mezzalira et al. 2014). Indeed, TSB can bring limiting factors leading to a decrease in STIR (Benvenutti et al., 2009).

Other characteristic related to bites was that N-BJMR increased in the greater residue height, similar to BR. The animals were able to avoid PMCR, which occurred possibly due to the increased N-BJMR, mainly in the 45 cm treatment. The N-BJMR refers to the movements that are not identified as bites during eating time and therefore it includes movements that have a masticatory or manipulative function (Amaral et al., 2012). Ewe lambs use manipulative movements to maintain their foraging preferences and to avoid non-preferred items (Bremm et al., 2012). Moreover, ewe lambs are animals that exhibit great selectivity in patches and feeding-station levels, indicating acute ability to discriminate the landscape distribution types (Laca et al., 2010).

The ability to discriminate can be seen in the intra-meal interval, which are the “non-activity” or “other-activity” between two main grazing events (Gibb, 1998), in this study represented by the variable IMID (P=0,005). Probably the IMID activities were the residues deviation by the animal and reorientation to a grazing site. Thus, searching activity was affected by differences in the pasture area occupied by the predecessor crop residues.

The vision plays an important role in environmental perception (Baldwin, 1979). Classic studies with goats (Baldwin, 1979), and more recently with ewe lambs (Sugnaseelan et al., 2013), demonstrated an ability to visually discriminate different objects. Thereby, ewe lambs are able to discriminate food items (Edwards et al, 1994), such as Italian ryegrass from maize residues. In addition, aspects related to height of PMC may have influenced the IMID (Figure 3 - C). In 45 cm of PMC, the displacement could impair the return to the preferred sites. There may be a relationship with spatial memory, which is the animal ability to remember sites with good grazing profitability, and tend to return in the same area (Merkle et al., 2014).

Furthermore, the IMID can be related to the non-alimentary environment, inherent to PMC . An example is the degree of habitat openness that can difficult flock movements and visual contacts (Averós et al., 2014 and Roguet et al., 1998). In addition, it can reflect a higher restlessness levels by the animals (Averós et al., 2014), which may affect IMID. As discussed in experiment 1, the investigated residues were not contrasting enough to lead differences in animals' ingestive behavior. On the contrary, in experiment 2 the higher heights residues constrained bite formation, increasing masticatory activity or manipulative function and IMID, presumably leading to a decrease in the amount of bites. The consequence of these behaviors was the decrease in STIR.

5. Conclusion

Significant changes in the animal's grazing pattern can occur due to the presence of predecessor maize crop residues, that influence short-term intake rate.

If there is predecessor maize crop residues, it should be lower than 15 cm to allow for higher levels of intake rate.

Predecessor soybean crop residues do not influence grazing patterns, nor the short-term intake rate.

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5.0 CAPÍTULO IV

CROP RESIDUES AFFECT BITE FORMATION? A REDUCIONISTIC EXPERIMENT SIMULATING RESIDUES ON MICROSWARDS [1]

[1] Artigo elaborado de acordo com as normas da Plos one (Anexo II-C)

Do crop residues affect bite formation? A reducionistic experiment simulating residues on microswards

D. F.F. Silva[1,a*], L. S. Szymczak [a], C. Bremm[b], V. Sehaber[c], J. V. Kivel[a] , L.F. Nascimento[a], A.L.G. Monteiro[d] , A. Moraes[a], P. C. F. Carvalho[e]

[a] *Center of Technological Innovation in Agriculture, Federal University of Paraná, Curitiba, PR, 80035050, Brazil*

[b] *State Foundation for Agricultural Research, Porto Alegre, RS, 90130-060, Brazil*

[c] *Department of Statistics, Federal University of Paraná, Curitiba, PR, 81531990, Brazil*

[d] *Sheep and Goat Production and Research Center, Pinhais, PR, 83.327-000, Brazil*

[e] *Grazing Ecology Research Group, Federal University of Rio Grande do Sul, Porto Alegre, RS, 90040-060, Brazil*

[1]Corresponding author: Delma Fabíola Ferreira da Silva

Email: delmafsilva@gmail.com

Short title: Crop residues on microswards.

Keywords: Ingestive behavior; Sheeps; Predecessor crop.

Abstract

Integrated crop-livestock systems are characterized by rotations of crops and pastures. This study was aimed to investigate the influence of crop residues and their characteristics of diameter (RD), height (RH) and spacing in between plants (SBP) on bite formation of sheep grazing Italian ryegrass (*Lolium multiflorum* Lam.). Treatments consisted of triple factorial, two RD (6 and 18 mm), four RH (zero, 15, 30 and 45 cm) and three SBP (zero, 7 and 30 cm). Microswards were built to simulate the intended treatments. Polyvinyl chloride and wood were used to simulate residues from maize and soybean, respectively. Suffolk sheep grazed on microswards in a 30 bites grazing session duration. Sward characteristics were assessed pre- and post-grazing sessions, being sward height, extended tiller height, pseudostem and herbage mass. Bite characteristics were assessed by a bite coding grid which identified types of bites, bite mass and bite depth. The most frequent bite type was the BA-bite (p < 0.001). The 18 mm RD influenced the formation of the BA-bite type, observed at the reduction of the BM in this treatment (p = 0.004). The allocation of Ba-bite type in 7 cm SBP was impaired suggesting a biokinetic explanation such as the animal capacity to recognize and exploit the degree of aggregation at multiple levels. Less amounts of the BA-bite type in 45 cm residue height (P<0.001) reduce BM and possibly the reversal of preference. The lower extended tiller height post grazing on SBP 30 cm (P<0.001) derived from succeeding bite depths at tiller level (P=0.003), possibly due to the low density of residues. The interaction between RH and SBP (P = 0.007) is related to a higher bite depth in the same SBP and a larger number of BA-bite type

(P= 0.047). Larger RD are detrimental to the BM. The SBP and the RD regulate total BM.

1. Introduction

New strategies are being explored for the reintegration of livestock and agricultural production into modern production systems to improve ecological function and economic performance (CSANR, 2017, Duru and Therond, 2015). Ways of this system be ecological are the increase of diversity and environmental sustainability (Duru et al., 2015). The economic performance is associated to the greater flexibility in integrated crop-livestock systems (ICLS), and production intensification (Lemaire et al., 2013).

The intensification of livestock in ICLS can be achieved by new strategies within the production environment, based on the animal-system relationship in order to maintain high levels of intake and consequently production. Thus, it is possible among pasture, crops and animal production to be in synergisms in ICLS (Moraes et al., 2002).

The characteristic of rotation of agricultural and livestock activities leads to predecessor crop residues in pasture (Moraes et al., 2014; Lemaire et al., 2014). The main crops that stand out in rotation in ICLS are soybean and maize (Brazilian Institute of Geography and Statistics, 2014). Characteristics of the harvested plants, planting spacing, besides crop residues are important for the subsequent pasture management (Barth Neto et al., 2014).

It is known that residues of predecessor crop in ICLS can lead to changes in animal ingestive behavior (Silva et al., this thesis). Accordingly, animal foraging decisions are important to base new management strategies.

Herbage intake is central to the understanding and prediction of animal performance in grazing studies (Bonnet et al., 2011). The categorization of bites into different types by the bite coding grid method (Bonnet et al., 2011) promotes refinement of the information about the grazing process. Therewith, bite mass is assumed determinant for the daily intake, hence important for the performance of grazing animals (Gordon and Benvenutti, 2006; Fonseca et al., 2013).

This study was aimed to investigate the influence of crop residues and their characteristics of diameter (RD), height (RH) and spacing in between plants (SBP) on bite formation of sheep grazing Italian ryegrass (*Lolium multiflorum* Lam.).

2. Material and methods

2.1. Experimental area

This study was conducted in November 2016 at the Sheep and Goat Production and Research Center of the Experimental Farm of the Federal University of Paraná - UFPR, located in Pinhais, State of Paraná, in southern Brazil (25º25' S, 49º8'). The climate (Cfa according to the Köppen classification system; Köppen and Geinger, 1928) is characterized by humid subtropical climate (mesothermal) with rainfall of 1500 mm annual average. Temperature were recorded during the 10-day experimental period. The daily temperature averaged 7.5°C (maximum = 25.8°C and minimum = 13.7°C; Accuweather, 2016).

2.2. Treatments

Treatments consisted of the simulation of maize (*Zea mays*) or soybean (*Glycine max*) crop residues. The polyvinyl chloride and wood were used to simulate maize and soybean residues, respectively. They were placed on microswards boxes cultivated with Italian ryegrass (*Lolium multiflorum* Lam.) to mimic pastures succeeding crops. Different simulated residues arrangements were investigated according to diameter (RD, 0, 18 and 6 mm), height (RH, 0, 15, 30 and 45 cm) and spacing between plants (SBP, 0, 7 and 30 cm) (Figure 1). The definition of RD treatment was made with prior 300 measurements of real crop residues in the field that resulted in averages of 6 mm and 18 mm, respectively for soybean and maize. The experimental design was a randomized complete block with three replicates, and blocking was based on the time of day in which the grazing session was performed (morning or afternoon).

Italian ryegrass was sown in 122 microswards (boxes), each measuring 0.5 m X 0.4 m X 0.2 m (Figure 1). Along grazing sessions, 48 simulated soybean residues and 48 simulated maize residues, totaling 96 microswards. Remaining ones were used to animals practice. The swards were sown on August 2016 with a seed density equivalent of 80 kg ha^{-1}. The microswards were fertilized with 68 kg ha^{-1} of nitrogen in a single application. Italian ryegrass was tested in the vegetative stage. The pre-grazing height was 18.1 ± 1.0 cm, according to proposed by Silva et al. (unpublished data), and post-grazing to no more than 40 % depletion (Fonseca et al., 2012).

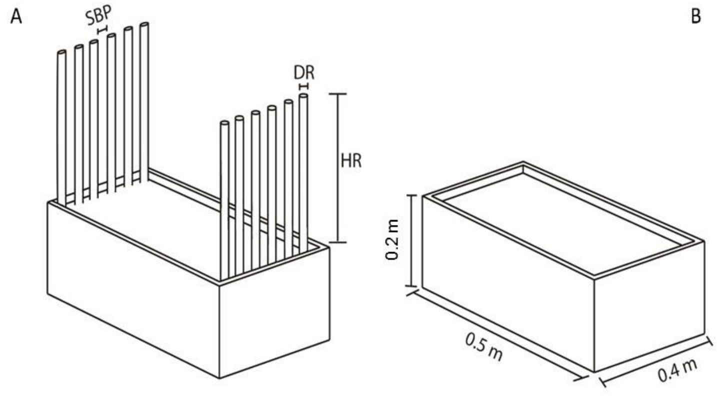

Figure 1: Representation of the boxes with simulated crop residues (soybean or maize) and without residues (control treatment) offered to the sheep. Boxes were cultivated with Italian ryegrass (*Lolium multiflorum* Lam.) to mimic pastures succeeding crops. DR: residues diameter; HR: residues height; SBP: spacing between plants.

2.3. Sward measurements

A sward stick (Barthram, 1985) was used to determine sward surface height (SSH). Ten points were measured per microsward in each grazing session. After Italian ryegrass emergence, the sward height was measured every day within each box for monitoring the targeted SSH of 18.5 cm. Herbage mass was determined using samples that were cut on the ground and splited into top 50% and a bottom 50% of the SSH, using a metallic quadrat of 0.01 m^2. Pseudostem was measured from 6 assessments pre- and post-grazing. In each microsward the evaluation of the extended tiller length (ETL) and height of the pseudostem (HP) was performed in five tillers and measured pre- and post-grazing sessions by determining the height of the ligule of the last expanded leaf.

2.4. Animal measurements

Three Suffolk sheep (*Ovis aries*; 19 ± 1.1 month old, 53.9 ± 3.0 kg live weight) were used. Thirty days before the beginning of the evaluation period, the animals were adapted to the environment (human observer, recording equipment, experimental procedures) in an adjacent paddock with Italian ryegrass sward. Prior to the experimental procedure, sheep and evaluators were trained to the experimental protocol using the remaining microswards. Sheeps were not kept in fasting prior to grazing periods to prevent unrelated increases in intake rate (Gregorini et al., 2009a) and decreases in the diet selectivity (Newman et al., 1994).

During the grazing session the microsward was placed in front of the animals on the floor surface (outside the platform). The animal stood on platforms at a height of 20 cm, so the hoof could stay at the same level of Italian ryegrass base in the microsward, mimicking the real situation at feeding station level. The microswards were offered to each animal and remained until 30 bites were reached.

2.4.1 Bite mass estimations

Immediately before and after each grazing session, the micro-sward boxes were weighed to an accuracy of ± 20 g with a digital scale in a windproof area to measure the herbage intake by weight difference. The bite mass (BM) was calculated as the difference of pre- and post-grazing microsward mass, divided by the number of bites taken in each grazing session (30 bites per session; 29.8 ± 4.9), and was corrected for the herbage dry matter (DM) content. The DM content was estimated by samples used to determine the herbage mass of the top 50%.

A micro-sward control was weighed immediately before and after each grazing session for correcting evapotranspiration losses during the grazing session.

The bite depth was measured according to the method of Fortin et al. (2002), the average difference of samples per microsward, between pre- and post-grazing ETL.

2.4.2 Design of the bite-coding grid

The bite-coding grid corresponded to a number of bite categories that allowed the observer to record in real time a detailed description of the main bites taken by the animal. They were categorized regarding to mass that were visually assessed (Agreil and Meuret, 2004). The design followed three codes: BO-bite type in the middle of the microsward; BA-bite type on the sides; RE-bite type when two or more bites were consecutive in the same place. Bite types were converted to BM by a destructive procedure. Bites were first recognized and then manually collected by hand plucking (Bonnet et al., 2011). The samples were dried at 65 °C for at least 72 h to determine the DM content. A digital scale (model Bel Mark 720, 0.001 g of accuracy) was used to weigh the herbage samples. Prior to data collection, the observer was trained for 3 days with animals and microswards. Sheep actions were transferred to the JWatcher® software, which makes quantitative observational analysis. The bites were later checked with video track, when necessary (Bonnet et al., 2011).

2.5. Statistical analysis

Previously, an electronic data sheet (Microsoft Excel software, 2013) was used to evaluate the biological coherence of the original data. Dataset were analyzed using R software (R Development Core Team, 2016). All linear mixed-effects models were fitted using functions of lme4 package (Bates et al., 2015). Response variables of each model were normalized based on Box-Cox (Box and Cox, 1964) transformation. In addition, paddock and animal group were considered as experimental unit.

The statistical models included fixed effects of predecessor residues heights (0, 15, 30 and 45 cm), diameter of residue (6 and 18 mm), spacing in between plants (7 and 30 cm) and interaction between theirs, the random effects of animal. Blocking effect for evaluator and day period. For bite mass, there was corrected by the dry mass content. The effects tested using analysis of variance and significant differences between the means were carried out by using the Tukey test at 5% probability.

3. Results

3.1 Sward characteristics

The mean of ETL post-grazing (cm) was 14.8 ± 3.1 (Table 1), significant for SBP, with relationship bite depth (Table 2). The average herbage mass was

1480 ± 647.0 (Table 1), and significant for RD. Other characteristics were not significant for RD, RH or SBP.

Table 1: Pre-grazing sward surface height (SSH - cm), post-grazing sward surface height (SSH - cm), extended tiller length (ETL - cm) pre-grazing, extended tiller length (ETL - cm) post-grazing, pseudostem (HP - cm) pre-grazing and pseudostem (HP - cm) post-grazing and herbage mass (HM - kg MS ha^{-1}) of Italian ryegrass (*Lolium multiflorum* Lam.), in different dimeters of residues diameter (RD - mm), residues height (RH - cm), and spacing between plants (SBP - cm).

Sward variable	RD (mm)		RH (cm)				SBP (cm)				
	6	18	0	15	30	45	7	30	P_{RD}	P_{RH}	P_{SBP}
Pre-grazing SSH	18.7±0.9	19.5±1.8	19.2 ± 1.2	18.6±1.0	19.6±1.9	18.9±1.0	19.1±1.6	18.9±1.1	0.057	0.256	0.333
Post-grazing SSH	13.6 ± 2.0	13.6 ± 2.1	13.0±1.2	14.3±1.0	13.7±1.9	13.4±1.0	13.8 ± 2.2	13.3 ± 1.7	0.729	0.156	0.445
ETL pre-grazing	21.0 ± 2.9	21.9 ± 2.7	21.8 ± 2.7	22.4 ± 2.6	22.2 ± 2.11	21.1 ± 3.4	22.0 ± 2.4	21.8 ± 3.1	0.969	0.431	0.8579
ETL post-grazing	15.0 ± 2.3	14.7 ± 3.6	15.9 ± 2.7	15.2 ± 2.6	14.6 ± 2.1	13.6 ± 3.4	16.3 ± 3.3 a	13.5 ± 2.3 b	0.519	0.171	<0.001*
HP pre-grazing	6.2 ± 1.0	6.3 ± 1.0	6.2 ± 1.0	6.0 ± 0.9	6.4 ± 1.0	6.3 ± 0.8	6.3 ± 0.9	6.1 ± 1.0	0.263	0.287	0.248
HP post-grazing	6.2 ± 1.1	6.3 ± 1.1	6.1 ± 1.0	6.2 ± 1.0	6.4 ± 1.0	6.3 ± 0.7	6.2 ± 1.1	6.3 ± 1.1	0.708	0.862	0.640
HM	1145.4 ± 352.6 b	1795.3 ± 703.4 a	1643.9 ± 842.4	1369.6 ± 646.2	1412.6 ± 490.9	1514.6 ± 591.5	1375.6 ± 725.0	1587.0 ± 543.2	0.002 *	0.477	0.922

P_{RD}= Probability level for residue RD of residues crops; P_{RH}= Probability residues height; P_{SBP}= Probability for spacing between plants.
Means followed by lowercase letters on line differ by Tukey test (P < 0.05).
[a] Difference (%) between extended tiller height pre-grazing and post-grazing.

3.2 Bite activity

BO and BA-bite type had significant isolated in RD, RH, and SBP. RE-bite type was significant for RD and SBP. BM, Bo-bite type was significant only for the RD. BA-bite type was significant for all treatments. RE-bite type, unlike the number of bites, is significant in RH. From extended tiller height (cm), the bite depth was significant only for SBP (Table 2).

Table 2: Number of bites types, bite type mass (g DM bite^{-1}) and bite depth (cm) of Italian ryegrass (*Lolium multiflorum* Lam. pastures grazed by sheep in different residues diameter (RD - mm), residues height (RH - cm), and spacing between plants (SBP - cm).

Bite type	RD (mm)		RH (cm)				SBP (cm)					
	6	18	0	15	30	45	7	30	Mean ± sd	P_{RD}	P_{RH}	P_{SBP}
nº BO	10.3 ± 3.0 b	11.5 ± 3.2 a	12.3 ± 3.13 a	10.6 ± 3.4 b	10.3 ± 3.0 b	10.7 ± 3.0 b	11.1 ± 3.2 a	10.8 ± 3.1 b	10.9 ± 3.2	<0.001*	<0.001*	<0.001*
nº BA	14. 5 ± 4.5 a	13. 6 ± 4.3 b	14.8 ± 3.6 a	14.2 ± 5.0 a	14.9 ± 4.2 a	12.3 ± 4.5 b	13.5 ± 4.1 b	14.7 ± 4.7 a	14.1 ± 4.4	<0.001*	<0.001*	<0.001*
nº RE	4.6 ± 3.2 b	5.1 ± 4.1 a	4.4 ± 4.78	4.8 ± 3.30	5.2 ± 3.6	5.1 ± 3.0	5.2 ± 4.2 a	4.4 ± 3.0 b	4.5 ± 3.7	<0.001*	0.096	0.031*
BO mass	0.5 ± 0.2 b	0.6 ± 0.2 a	0.6 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.045*	0.157	0.554
BA mass	0.8 ± 0.3 a	0.7 ± 0.2 b	0.8 ± 0.2 a	0.8 ± 0.3 ab	0.8 ± 0.2 a	0.7 ± 0.2 b	0.7 ± 0.2 b	0.8 ± 0.3 a	0.8 ± 0.2	0.005*	0.047*	0.004*
RE mass	0.2 ± 0.2	0.2 ± 0.2	0.2 ± 0.2 b	0.2 ± 0.2 ab	0.3 ± 0.2 ab	0.3 ± 0.1 a	0.2 ± 0.2	0.2 ± 0.1	0.2 ± 0.2	0.915	0.015*	0.637
Bite depth	7.0 ± 4.3	7.2 ± 3.6	6.0 ± 3.4	7.2 ± 3.4	7.6 ± 3.8	7.4 ± 4.8	5.9 ± 3.5 b	8.3 ± 4.0 a	7.1 ± 3.9	0.860	0.520	0.003*

In Figure 1, there was interaction between RD, RH and SBP for BA-bites type (P = 0.004), with a greater number of BA-bites type for RD 6 mm. In RD 18 cm and SBP 30 cm the highest value was in zero cm and the smallest in 30 cm of RH. In RD 18 cm and SBP 7 cm, the highest value was in RH zero cm, in the others there was no difference.

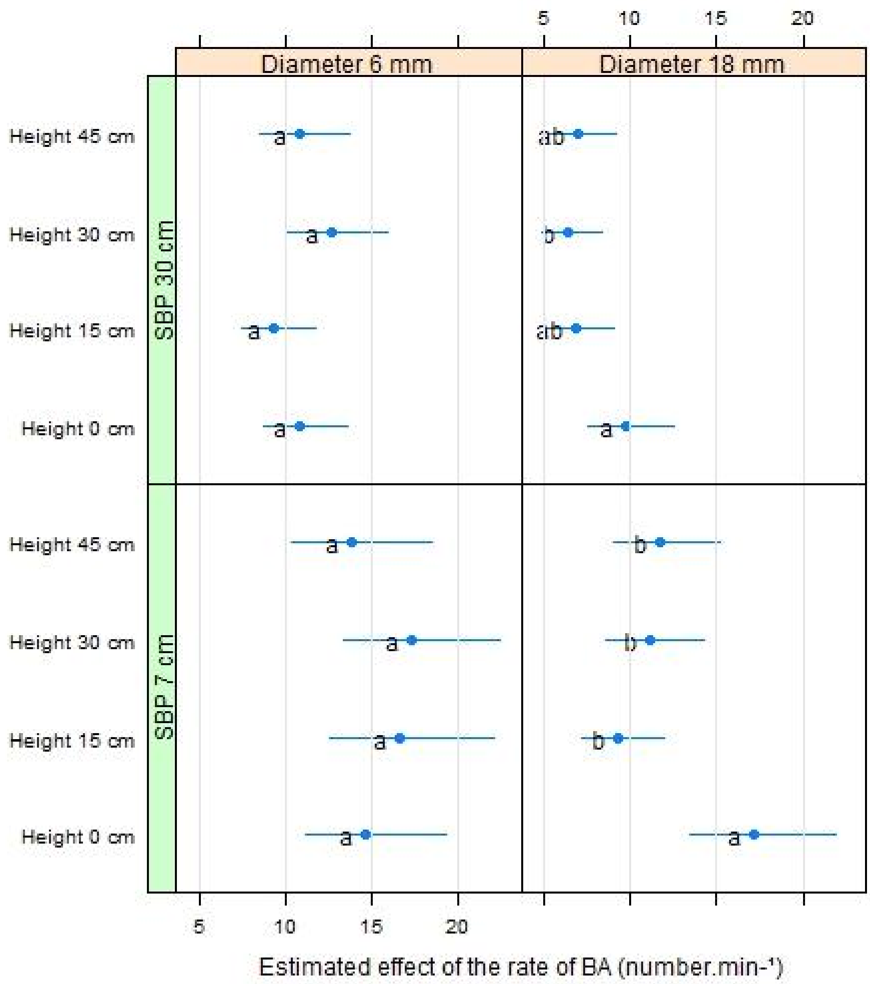

Figure 2: Interaction of number of BA-bite type, between residues diameter (RD - mm), and residues height (RH - cm).

There was interaction between RD, SBP and RH, for RE-bite type (P = 0.0005). Highest number of RE-bite type for residue RD 6 mm in 15 cm height. The lowest rates of this type of bite stayed in a height of zero cm in deep 7 cm.

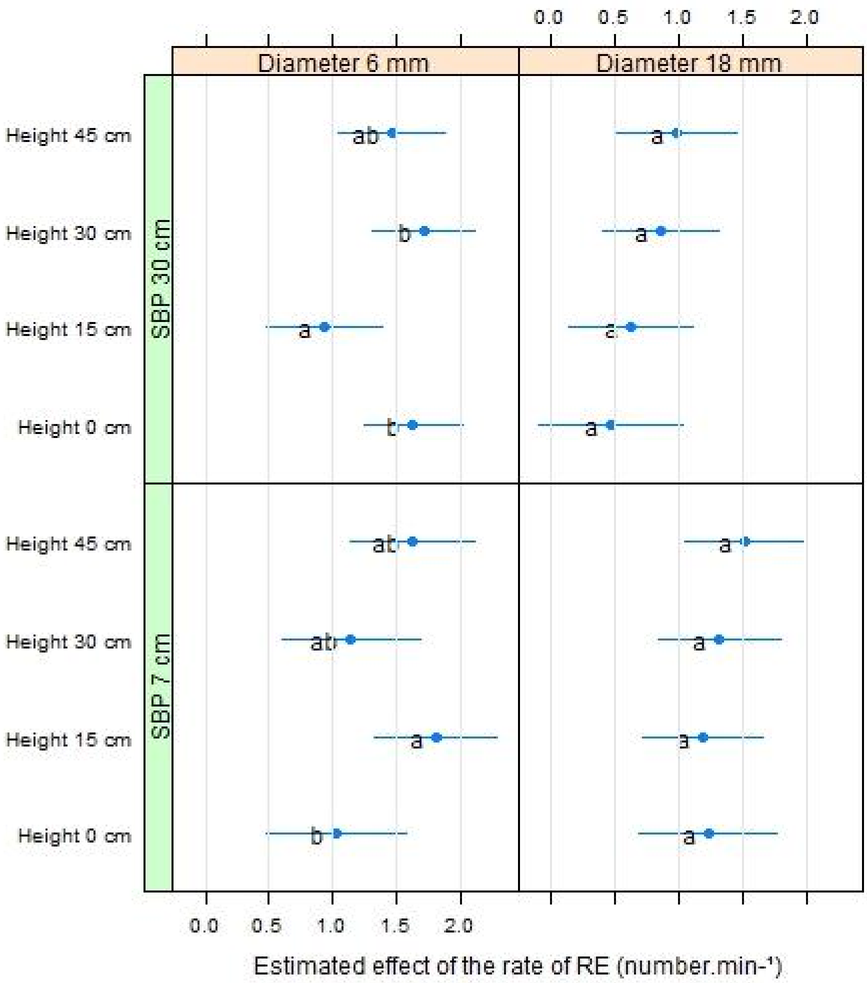

Figure 3: Interaction of number of RE-bite type, between residues diameter RD of residues (mm), residues height (RH - cm) and spacing between plants (cm).

3.3 Bite mass (BM)

There was a BM interaction between residue height and spacing between plants (P = 0.007). There was no single effect or other interaction effects between the remaining variables.

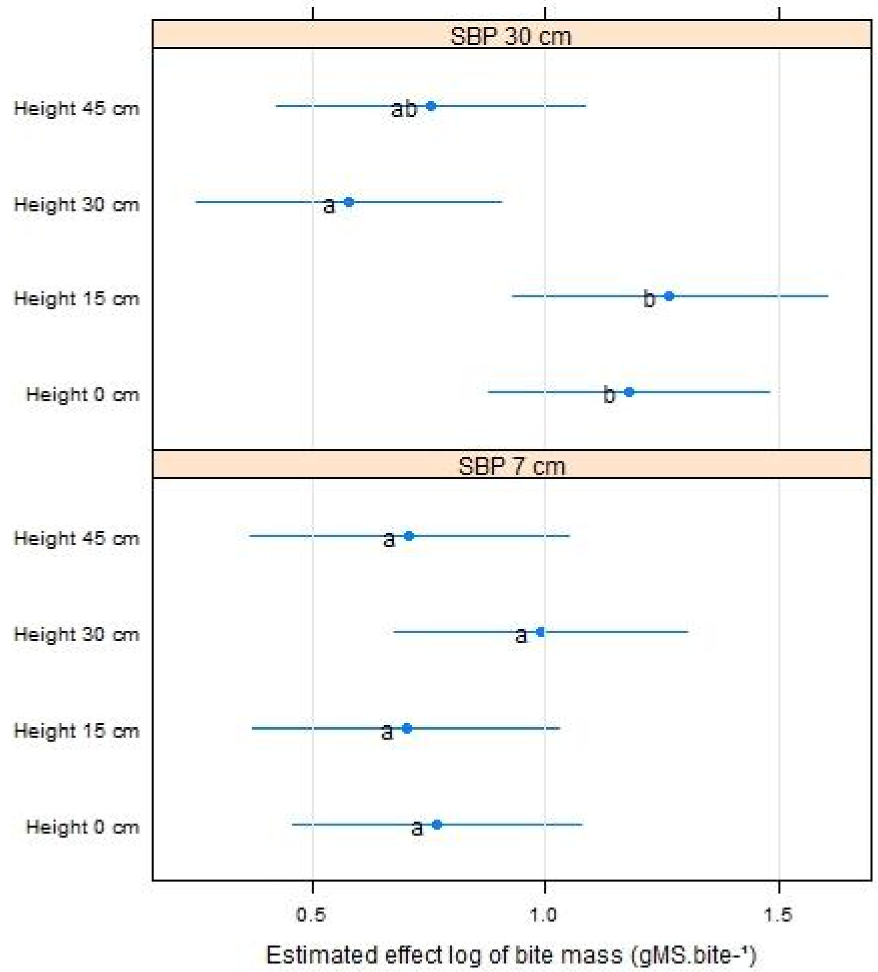

Figure 4: Effect of interaction of bite mass (BM - g MS bite^{-1}) between residues diameter (RD - mm) and spacing between plants (SBP - cm).

4. Discussion

Bite behavior seems to be sensitive to structural effects of local attributes, in feeding station, which includes the sward structure, and crop residues, which we call the “local grazing environment”.

The main type of bite practiced by the animals was BA-bite type, this is due to the dry mass seized by this type of bite (Table 2), because foraging decisions are established starting from an overall objective of maximizing the efficiency of feeding behavior (Beaumont et al., 2004). Therefore, in this paper the food efficiency corresponds in greater numbers of BA-bite type. As in, Hirata et al., (2014), the dry matter affected the number of bites positively.

Despite the higher HM presented in RD of 18 mm (Table 1) do not correspond to the BA-bite type, as shown by the lower number in this treatment (Table 2). In Figure 2, the RD 18 mm influenced the formation of the BA-bite type, observed at the reduction of the BM for BA-bite type in this treatment (Table 2). The smallest number of BA-bite type in 30 cm of RH and 30 cm SBP (Figure 2), contrary to expectations because were the highest values in bite number and BM isolated (Table 2). It is possible the restriction of the bite formation process (Benvenutti et al., 2008b). The of BA-bite type mass declined with increasing RD by a behavioral possibly reduction bite area, unrelated to proximate sward (Mezzalira et al., 2014). Animal ingestive behavior in pastures with residues are not explored in the literature, therefore explanations at pasture level, must be considered for the local grazing environment. Such as, modifications of the formation of the bite, when in selection by animal, they find impediments, like stems. It is known that the animal decreases the bite area to avoid stem (Benvenutti et al., 2009) or to avoid stems with high tensile strength (Benvenutti et al., 2008b). Thus, the animal uses mechanisms, such as reducing the bite area, to avoid unwanted structures, in this work, the crop residues (Table 2). Furthermore, the reduction of bite area may reduce BM (Drescher, 2003). In this work, it is likely that the animal performing BA-bite type, in larger RDs (18 mm) may find reduction of the bite area. With this, the animals stopped forming BA-bite type and began to explore BO-bite type (probably without bite area restriction) as indicated by the greater number of these in treatments with 18 mm RD (Table 2). The BO-bite type mass in 18 mm was still greater than 6 mm guaranteed by herbage mass (Tabela 1), and that led to larger masses of this bite (Table 2) in larger residue RD.

In addition, the allocation of BA-bites type in 7 cm SBP (Table 2), was impaired in the areas, suggesting a biokinetic explanation that the neck angle does not allow the formation of the bite between the residues in these conditions (Jiang and Hudson,1993). Furthermore, in an inverse relationship of BA-bite type, in SBP 7 cm, the sheep performed higher BO-bite type and in SBP 30 cm the animals reduced BO-bite type. The animals are able to recognize and exploit degree of aggregation at multiple levels, bypassing empty space or in this case, occupied by crop residues and concentrating efforts on areas where food is actually found (Laca, 2000). As in the case of SPB of 30 cm, in a lower degree of aggregation where food can be more easily found and harvested, by the BA-bite type.

Less amount of the BA-bite type in 45 cm RH (Table 2), may check the reversal of a particular preference, in specific, in reducing this BM in treatment of 45 cm (Table 2; Parsons et al., 1994a). The vertical structure being decisive in the diet selection by grazing animals and thus bringing changes in an ingestive behavior in high residues. (Gregorini et al., 2009). As shown by the largest amount of BO-bite type was in treatment Zero cm RH even not having difference of the BO-bite type mass of this between HR (Table 2). Beyond that, although the crop residues are not part of the animal feed and consequently ingestion, the height of the residues acts on the selectivity behavior, which is the relative proportion of a selected forage divided by the relative availability of that forage in the landscape (Senft, 1989). Relative availability may be impaired by the vegetative structure (including residues), of the local grazing environment. Furthermore, in the behavior sheep, there is need for vigilance (Sugnaseelan et al., 2013). For this the retina of sheep, designed for scanning their surroundings when they are grazing (Shinozaki et al., 2010). Thus, it is suggested that the larger the residue, the smaller the field of projection of scanning of its environment, making surveillance difficult and thus bringing costs to the ingestive behavior.

The ingestive behavior, re-grazing was recognized in this work, by the RE-bite type. Knowing, top grazing stratum is the vertical section of the pasture that is grazed by the animals for the first time. A new grazing stratum is formed every time the animal re-grazing the same area (Benvenutti et al., 2015). Considering that BA-bite type made it possible for the top stratum to be reduce due to the higher dry matter in the bite, it is possible that the RE-bite type significance (Table 2) comes from the values obtained in BA-bite type. The animals practice re-grazing, when the strata above its grazing became highly reduced (Benvenutti et al., 2015).

The Interaction of number of RE-bite type (Figure 3) between the SBP, RD and RH. Leading the importance 15 cm RH, resembling Silva, (2017), wherein the authors find the higher bite rate for the predecessor maize crop of 15 cm, leading to a higher short term intake rate. At this point intermediary, the residues possibly stimulated the animal to need to be more efficient and to do so by increasing the re-grazing feature (as discussed below from Figure 4). In addition, 6 mm of RD possibly did not hinder the formation of bites, showing in number of BA-bite type (Figure 2). Thus, the animals could express the attempt to be more efficient. SBP of 30 cm and 30 cm RH (as well as in zero cm RH in both SBP), led to lower RE, possibly due to the lower stimulus to grazing efficiency in the largest HR, the highest bite mass (Figure 4) and number of BA-type bites (Figure 2).

The selection process is seen by significance of 30 cm SBP, for ETL post-grazing (Table 1), that is, the bite depth is maximized (Table 2). Possibly, due to low density of residues, provides more bite depth. Thus, with less of barrier effect, improving the efficiency of harvesting by the bite. It is known that the bite depth is the constant proportion of grass height (Laca et al., 1994), but in this study there was no change in the sward height (Table 1) the creation of a barrier with residues, can be considered physical changing of the feeding station (Flores et al., 1993). This physical changing is most pronounced in SBP 7 cm, can cause changes in the biting process, as interference in bite depth, due to the density increases of the residues in this treatment, acting as a horizontal barrier that is possibly affected the bite depth (Benvenutti et al., 2006). There was no significant difference between HP pre- or post-grazing (Table 1), indicating that the animals did not present interference of this pasture structure, and dead material existing lower grazing horizons, which constraint the process of bite formation (Benvenutti et al., 2006; Heuermann et al., 2011).

The largest BM 30 cm SBP (Figure 4) is related, to higher bite depth in this same spacing (Table 2). This being one of the variables that makes up the mass of the morsel (Gordon and Lascano, 1993). There is influence of the largest number of main bites (<u>BA</u>-bite type) with higher value of dry matter, in SBP 30 cm (Table 2). Following this, the largest <u>BA</u>-bite type mass, is at SBP 30 cm and RH 30 cm, (as in zero cm RH; Figure 2). Knowing that the mass of the bite is the sum of <u>BA</u>, <u>BO</u> and <u>RE</u>-bite type mass, and this last one was lower in Zero cm RH (Table 2), this affected the BM at this point.

The BM is considered to have a larger influence in short-term herbage intake rate (Benvenutti et al., 2006). Efficiency of foraging is been equated with short-term dry matter intake rate (Roguet et al., 1998). Therefore, it is important to manage the pasture according to the bite behavior, in order to potentiate the mass of the bite, more precisely, increase the number of bites with the highest DM value.

5. Final considerations

The animal increases the bites type number with the highest dry matter value. Larger diameter maize residues RD (18 mm) reduce the BM, of main type-bite. The SBP and the RH regulate total BM. The RE-bite type mass can influence the total BM. It seems that residues participate like vertical structure in the process of selection, in which the animal adapts the bites to the characteristics present in the place. There is an opportunity for the succeeding pasture phase managers in ICLS, through managements of the predecessor crop: Farming area should have their plan of planting, with higher SBP (30 cm); The harvest should recommend lower RH (until 30 cm); Or, it is necessary to practice the cutting of the residues in the pasture phase. In addition, plant RD should be considered as a factor in the ingestive composition at the bite level.

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5. CAPÍTULO V

CONSIDERAÇÕES FINAIS

5.1 Principais Contribuições

Muitos estudos levaram a algumas premissas de SIPA, que permitem ser um sistema sustentável. Para isso, é necessário a obtenção de produções economicamente viáveis. Para se elevar o rendimento econômico na pecuária, estudos do comportamento de consumo são essenciais, para que seja possível fornecer a alimentação mais próxima do ideal, sob o ponto de vista do colhedor, ou seja, do animal. Manejos de pasto em que as metas de alturas são baseadas no comportamento animal, encontra-se, recentemente, no pastoreio "rotatínuo", baseado na maximização da velocidade de ingestão de forragem. Nesta nova maneira de se conduzir o manejo de pasto, é possível observar o desempenho superior, como resultado do pastejo exclusivo de folhas proporcionado pelo rotatínuo (Schons et al., 2015).

SIPA são sistemas complexos com muitas interações. O entendimento de processos que envolvam interações solo-planta-animal, foi estudado de forma inovadora nesta TESE. Além de relacionar o pasto e animal, trata-se do ambiente de pastejo: animal - planta forrageira - planta lavoura, e suas interações. Indo mais a fundo, o animal como importante instrumento de resposta dos estudos das relações; a lavoura sob novo ponto de vista, observando as consequências do que elas deixam na área de pasto após sua colheita e o pasto, propriamente, como variável de fundamental importância nas interações.

Assim, este trabalho envolve a pecuária de precisão em SIPA, ou seja, a integração dos conhecimentos de comportamento animal, a tecnologia eletrônica e os sistemas de decisão aplicados ao pastoreio (Laca, 2008). Vale lembrar que o papel dos herbívoros domésticos em SIPA vão além da conversão em produto animal, pois a eles são exigidos compromissos com serviços ecossistêmicos (Carvalho et al., 2009).

O conjunto de informações geradas por esta Tese poderá auxiliar pesquisadores, técnicos e produtores, como subsídio para o planejamento das ações a serem desenvolvidas nas propriedades. Informações estas pertinentes aos espaçamentos entre plantas nas lavouras, nas alturas de corte de colheita, principalmente em relação a lavoura antecessora de milho, devido aos resultados aqui discutidos. Além disso, é possível estar mais próximo de uma previsão real de produção vegetal e consequente produção animal, quando se tem lavoura antecessora de soja ou milho. Assim, é possível oferecer um ambiente de pasto que propicie aumento na eficiência da colheita de pasto pelo animal, podendo alcançar seu máximo potencial em SIPA.

- Observação pertinente 1

Nos capítulos 2 e 3, o animal a campo estava na presença de resíduo reais de colheita. Os animais nas áreas experimentais com resíduos de lavoura antecessora de soja, permaneciam visivelmente calmos, sem interação com os resíduos e com pouca locomoção, porém não foi possível através dos dados coletados demostrar este comportamento.

Nas pastagens com resíduos de lavouras antecessoras de milho, foi observado inquietação dos animais durante as avaliações, notadamente os animais estavam em busca de algo além de pasto, visto à grande locomoção. Suspeita-se que estavam em busca de resíduos de grãos e espigas de milho, oriundos da colheita. Como dito no material e métodos dos artigos I e II, na área experimental, não havia resíduos horizontais de milho, devido ao cuidado com as exclusões destes, porém era possível encontrar fora. Os animais quando não estavam em teste de pastejo, tinham contato com a área fora do perímetro experimental.

Durante as avaliações, em alguns momentos, era possível perceber os animais mordendo e tirando lascas dos resíduos verticais de milho. Não havia interesse dos animais, através do bocado, em morder ou quebrar os resíduos de lavoura antecessora de milho.

- Observação pertinente 2

Vale a pena mencionar, nos capítulos II e III, havia visualmente grande diferença entre os campos experimentais com resíduos de lavouras de soja, comparado com os de milho. Os resíduos de milho eram muito mais evidentes, destacando-se no pasto (Apêndice, Figura1). Além disso, os resíduos, principalmente os mais altos de soja, eram frágeis e se quebravam com facilidade no deslocamento dos animais e dos pesquisadores, na colheita de amostras.

- Observação pertinente 3

O experimento do micropasto era realizado com simulador de resíduos de lavoura de milho (com canos de PVC, diâmetro 18mm) e da lavoura de soja (com hastes de madeira, diâmetro 6mm). Foi observado que os animais se interessavam pelos simuladores dos resíduos de soja, em busca de mordiscar e quebrar, o que não acontecia com os canos de PVC. Diferentemente do observado a campo, em que o interesse maior em manipular os resíduos foi observado na lavoura antecessora de milho. Esta ação foi denominada pelo código do grid “TO”, que não foi apresentado no trabalho pela não significância.

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5.2 Novas abordagens sobre resíduos em pasto

Resíduos de lavouras em área de pasto se faz presente em SIPA, com algumas particularidades. Além do resíduo vertical, durante a colheita, é sabido ser possível existir resíduos horizontais, oriundos dos verticais, como em caso de determinadas manobras, na condução dos implementos agrícolas de colheita, em espaçamento entre linhas reduzido, ou, quando após a colheita da cultura, os produtores entram com semeadura das pastagens anuais de inverno (podendo ser com semeadora ou a lanço). O ato de semear pode destruir/derrubar as estruturas verticais ou as estruturas ficarem frágeis (em função do intemperismo) durante o processo de germinação/emergência até a entrada dos animais para o pastejo. Outros estudos devem ser realizados para verificar a interação dos animais com estes tipos de resíduos horizontais.

Durante a colheita principalmente na cultura do milho, existem os resíduos da colheita oriundas dos maquinários, que ao colher liberam palhada, sementes e restos de espigas, que contribuirão para camada horizontal de resíduos. Podem ocasionar maior quantidade de resíduos horizontais. Desta forma, estamos levantando a questão da estrutura do resíduo de lavouras, que somando com a estrutura do pasto, resulta no processo de pastejo. Assim o ciclo relação causa-efeito, têm mais algumas variáveis a serem consideradas em SIPA. A construção de metas de plantabilidade e manejo de lavouras, para alcançar o potencial de produção animal em SIPA, não devem ser descartadas.

Seguindo o raciocínio sobre resíduos horizontais, manejos de pasto, com uso de roçadeiras para o corte do pasto, a fim de uniformizá-lo, são comuns em regiões do Paraná. Esta técnica deixa resíduo de palha, que dificultam o rebrote do pasto permeando resíduos horizontais. Portanto, estudos que esclareçam a relação do animal com resíduos horizontais no pasto pode ser o próximo passo, na condução da pesquisa da relação do comportamento de ingestão animal e ambiente de pastejo.

5.3 O Cientista – ponto de vista filosófico

A base sólida de um conhecimento intelectual verdadeiro e de uma compreensão autêntica dos processos científicos de causa e efeitos, perde sua força, se o pesquisador contentar-se com o “palpite certo”, num extremo pontuado em base rígida, sem considerar as nuances existentes no contexto. É uma ilusão comum, acreditarmos que o que sabemos hoje, é tudo o que poderemos saber sempre. Mais do que isso, só se pode verdadeiramente conhecer e explicar algo, quando se introduzem as intuições pessoais, a uma apreciação exata dos fatos e de suas conexões lógicas. Um investigador honesto terá de admitir que nem sempre é possível juntar as duas coisas, mas será desonesto de sua parte não ter isso sempre presente em mente.

O cientista também é um ser humano. Por isso, é natural que deteste coisas a que não consegue dar explicação lógica e racional o tempo todo. E ainda admitir que uma teoria científica pode não explicar fatos indeterminadamente e que nunca será uma verdade eterna.

O ser cientista, investigador e acima de tudo formador de conclusões e de opinião, deve esguiar-se de respostas generalistas, extremistas, pois assim de nada adiantariam as explicações de causa e efeito sem a flexibilidade de ponderar as modificações ao longo do tempo e espaço. Além disso, considerações subjetivas de crescimento pessoal e espiritual devem ser respeitadas, pois somente assim verdadeiramente será formado uma cientista, não somente pelo trabalho realizado e publicado, mas pelo conjunto de sua obra, incluindo ele próprio.

5.4 Psicologia na pós-graduação – Observação pertinente

As exigências do mercado de trabalho demandam por profissionais com alta qualificação. Isso têm levado a um aumento da procura pela pós-graduação. Além disso, o aluno tem na realização da pós-graduação, diferentes objetivos pessoais, como exemplo: busca elevar conhecimentos em determinada área, aumento da empregabilidade, reconhecimento profissional, redirecionamento de carreira, entre outros.

Ao longo do tempo de realização de mestrado e doutorado, foi possível encontrar vários colegas desmotivados, sobrecarregados, confusos e até mesmo em depressão. Diversos estudos com alunos de pós-graduação mostram altos níveis de estresse, em sua maioria mulheres (e.g Malagris et al., 2009; Levecque et al., 2017). Fica o alerta de que a preocupação deve estar além dos aspectos estritamente relacionados à formação acadêmica.

Sabe-se que o desenvolvimento da ciência no Brasil acontece à custa de um enorme desgaste emocional das pessoas envolvidas (Carmo & De Meis, 2003). No contexto acadêmico, no qual a Pós-Graduação em Produção Vegetal da Universidade Federal do Paraná encontra-se, existe fortes pressões e cobranças. São elas: competitividade, cumprimento de prazos, inserção no mercado de trabalho, incertezas quanto ao futuro profissional, preocupação com o tempo médio de titulação, situações de avaliação, relacionamento com o orientador e demais professores, uso da língua inglesa, desenvolvimento da dissertação ou tese (busca de material bibliográfico, coleta e análise dos dados, redação), cobrança de produtividade (principalmente publicações), autodisciplina, obtenção de bolsa ou financiamento, crescente número de orientandos por professor. Além disso, questões interpessoais, auto cobrança e preocupações financeiras, interface trabalho-família, demandas de trabalho e controle de trabalho, cultura de tomada de decisão da equipe e percepção de uma carreira fora da academia; são estressores comuns em alunos de pós-graduação e estão ligados a problemas de saúde mental (Malagris et al., 2009; Levecque et al., 2017).

Sabendo que processo de aprendizagem e rendimento de trabalho não se resume somente ao acadêmico e que os observadores das políticas de pesquisa estão cada vez mais preocupados com o potencial impacto das atuais condições acadêmicas de trabalho na saúde mental, particularmente nos estudantes de doutorado (Levecque et al., 2017), vale a pena verificar aspectos psicológicos, sociais, econômicos, culturais e de lazer como forma de atingir a excelência de ensino e pesquisa. É necessário um olhar neste sentido, muitas vezes negligenciado e tido como sem importância, pelos próprios alunos e professores.

Ações como apoio psicológico a pós-graduação, palestras motivacionais e filosóficas devem ser uma constante. Ação realizada pela Núcleo de Inovação Tecnológica em Agropecuária da Universidade Federal do Paraná (NITA-UFPR), em 2015 chamado “Cine debate”, onde os alunos e estagiários do grupo assistiam a um vídeo, e com ajuda de um facilitador discutiam assuntos de natureza pessoal e motivacional, é uma proposta que está à frente deste contexto, como ótimo exemplo de apoio aos estudantes (Anexo – Figura 6). Ações recentes utilizado pelo Grupo de Pesquisa em Ecologia do Pastejo da Universidade Federal do Rio Grande do Sul (GPEP- UFRS), com a utilização de profissional de “Coaching”, é outro exemplo importante que toma direção aos aspectos aqui levantados.

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ANEXOS

Anexos I – Figuras

(a)

(b)

Figura 1: (a) Área experimental de pasto de azevém e lavoura antecessora milho, tratamento 30 cm. No detalhe, resíduo de milho em 30 cm; (b) Área experimental de pasto de azevém e lavoura antecessora soja, tratamento 21 cm. No detalhe, resíduo de soja em 21 cm.

Figura 2: (a) Lavoura antecessora de milho; (b) Lavoura antecessora soja; (c) Colheita da lavoura antecessora milho nos alvos dos tratamentos demarcados e simultânea retirada das plantas.

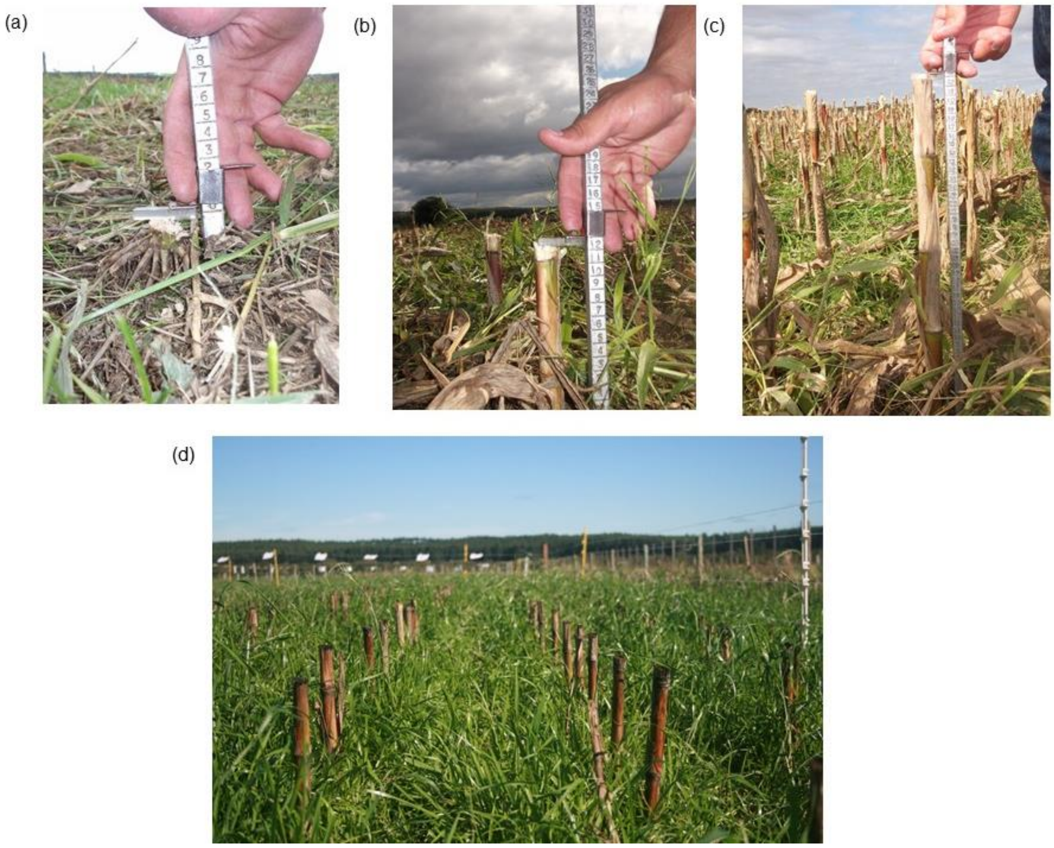

Figura 3: (a) Resíduo da lavoura antecessora milho, tratamento zero cm; (b) Resíduo da lavoura antecessora milho, tratamento 15 cm; (c) Resíduo da lavoura antecessora milho, tratamento 45 cm; (d) Resíduo da lavoura antecessora milho, tratamento 30 cm.

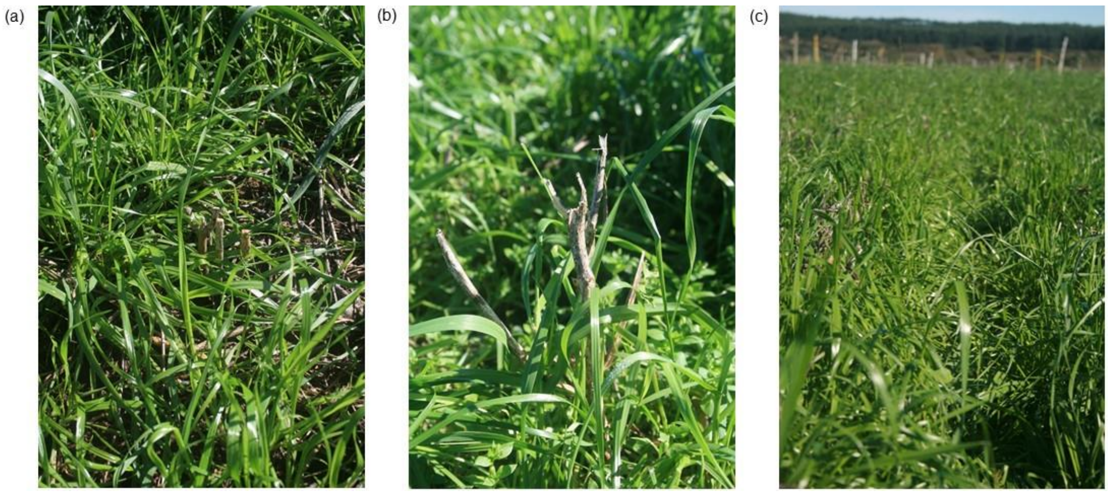

Figura 4: (a) Resíduo da lavoura antecessora soja, tratamento 7 cm; (b) Resíduo da lavoura antecessora soja, tratamento 14 cm; (c) Resíduo da lavoura antecessora soja, tratamento 21 cm.

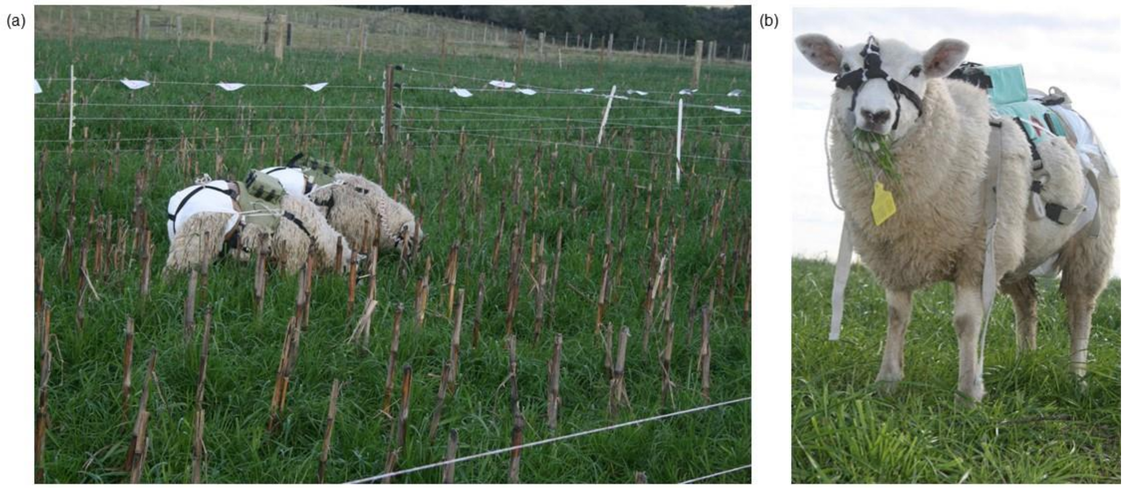

Figura 5: (a) Teste de pastejo, animais equipados com bolsas coletoras, e IGERS, tratamento lavoura antecessora milho 45 cm; (b) Animal após a colheita de bocado, tratamento lavoura antecessora soja zero cm.

Figura 6: Experimento com micropasto: (a) Tratamento zero resíduos; (b) Simulação de resíduos de milho com canos de PVC (18 mm), tratamento 15 cm e espaçamento entre plantas de 7 cm; (c) Animal em teste de pastejo em simulação de lavoura antecessora milho, tratamento de altura de 30 cm e espaçamento entre plantas de 7 cm; (d) Animal em teste de pastejo em simulação de lavoura antecessora milho, tratamento de altura 45 cm e espaçamento entre plantas de 7 cm; (e) Visto de cima, animal em teste de pastejo em simulação de lavoura antecessora milho, tratamento de altura 45 cm e espaçamento entre plantas de 30 cm.

Figura 7: Alunos de pós-graduação e estagiário do Núcleo de Inovação Tecnológica em Agropecuária da Universidade Federal do Paraná (NITA- UFPR), participam do Cine-debate.

Anexos II - Normas das revistas

A- Agricultural Systems – Preparation

B- Livestock Science - Preparation

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Regardless of the application used, when your electronic artwork is finalized, 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 (or JPG): Bitmapped line drawings: use a minimum of 1000 dpi.
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minimum of 500 dpi is required.
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• Supply files that are too low in resolution.
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Figure captions
Ensure that each illustration has a caption. A caption should comprise a brief title (**not** on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

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Please submit tables as editable text and not as images. Tables can be placed either next to the relevant text in the article, or on separate page(s) at the end. Number tables consecutively in accordance with their appearance in the text and place any table notes below the table body. Be sparing in the use of tables and ensure that the data presented in them do not duplicate results described elsewhere in the article. Please avoid using vertical rules and shading in table cells.

References

Citation in text
Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Unpublished results and personal communications are not recommended in the reference list, but may be used. If these references are included in the reference list they should follow the standard reference style of the journal and should include a substitution of the publication date with either "Unpublished results" or "Personal communication" Citation of a reference as "in press" implies that the item has been accepted for publication. Minimize references to non-English publications as these are not easily accessible for the majority of the readership.

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Increased discoverability of research and high quality peer review are ensured by online links to the sources cited. In order to allow us to create links to abstracting and indexing services, such as Scopus, CrossRef and PubMed, please ensure that data

provided in the references are correct. Please note that incorrect surnames, journal/book titles, publication year and pagination may prevent link creation. When copying references, please be careful as they may already contain errors. Use of the DOI is encouraged.

A DOI can be used to cite and link to electronic articles where an article is in-press and full citation details are not yet known, but the article is available online. A DOI is guaranteed never to change, so you can use it as a permanent link to any electronic article. An example of a citation using DOI for an article not yet in an issue is: VanDecar J.C., Russo R.M., James D.E., Ambeh W.B., Franke M. (2003). Aseismic continuation of the Lesser Antilles slab beneath northeastern Venezuela. Journal of Geophysical Research, https://doi.org/10.1029/2001JB000884. Please note the format of such citations should be in the same style as all other references in the paper.

Web references
As a minimum, the full URL should be given and the date when the reference was last accessed. Any further information, if known (DOI, author names, dates, reference to a source publication, etc.), should also be given. Web references can be listed separately (e.g., after the reference list) under a different heading if desired, or can be included in the reference list.

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This journal encourages you to cite underlying or relevant datasets in your manuscript by citing them in your text and including a data reference in your Reference List. Data references should include the following elements: author name(s), dataset title, data repository, version (where available), year, and global persistent identifier. Add [dataset] immediately before the reference so we can properly identify it as a data reference. The [dataset] identifier will not appear in your published article.

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2. *Two authors:* both authors' names and the year of publication;
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Citations may be made directly (or parenthetically). Groups of references should be listed first alphabetically, then chronologically.
Examples: 'as demonstrated (Allan, 2000a, 2000b, 1999; Allan and Jones, 1999). Kramer et al. (2010) have recently shown ....'
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Reference to a journal publication:
Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2010. The art of writing a scientific article. J. Sci. Commun. 163, 51–59.
Reference to a book:
Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.
Reference to a chapter in an edited book:
Mettam, G.R., Adams, L.B., 2009. How to prepare an electronic version of your article, in: Jones, B.S., Smith , R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281–304.
Reference to a website:
Cancer Research UK, 1975. Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/ (accessed 13.03.03).
Reference to a dataset:
[dataset] Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions. Mendeley Data, v1. https://doi.org/10.17632/xwj98nb39r.1.

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C- Plos one - Preparation

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File format	Manuscript files can be in the following formats: DOC, DOCX, RTF, or PDF. Microsoft Word documents should not be locked or protected.

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Nomenclature	Use correct and established nomenclature wherever possible.	
	Units of measurement	Use SI units. If you do not use these exclusively, provic in parentheses after each value. Read more about SI
	Drugs	Provide the Recommended International Non-Prop (rINN).
	Species names	Write in italics (e.g., *Homo sapiens*). Write out in full t species, both in the title of the manuscript and at the f an organism in a paper. After first mention, the firs genus name followed by the full species name may be *sapiens*).
	Genes, mutations, genotypes, and alleles	Write in italics. Use the recommended name by c appropriate genetic nomenclature database (e.g., HU genes). It is sometimes advisable to indicate the syn gene the first time it appears in the text. Gene prefixes used for oncogenes or cellular localization should roman typeface (e.g., v-fes, c-MYC).

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Manuscripts should be organized as follows. Instructions for each element appear below the list.

Beginning section	*The following elements are required, in order:* • Title page: List title, authors, and affiliations as first page of manuscript • Abstract • Introduction
Middle section	*The following elements can be renamed as needed and presented in any order:* • Materials and Methods • Results • Discussion • Conclusions (optional)
Ending section	*The following elements are required, in order:* • Acknowledgments • References • Supporting information captions (if applicable)
Other elements	• Figure captions are inserted immediately after the first paragraph in which the figure is cited. Figure files are uploaded separately. • Tables are inserted immediately after the first paragraph in which they are cited. • Supporting information files are uploaded separately.

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On the title page, write author names in the following order:

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Each author on the list must have an affiliation. The affiliation includes department, university, or organizational affiliation and its location, including city, state/province (if applicable), and country. Authors have the option to include a current address in addition to the address of their affiliation at the time of the study. The current address should be listed in the byline and clearly labeled “current address.” At a minimum, the address must include the author’s current institution, city, and country.

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- Not exceed 300 words

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- Abbreviations, if possible

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The introduction should:

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- Define the problem addressed and why it is important
- Include a brief review of the key literature
- Note any relevant controversies or disagreements in the field
- Conclude with a brief statement of the overall aim of the work and a comment about whether that aim was achieved

Materials and Methods

The Materials and Methods section should provide enough detail to allow suitably skilled investigators to fully replicate your study. Specific information and/or protocols for new methods should be included in detail. If materials, methods, and protocols are well established, authors may cite articles where those protocols are described in detail, but the submission should include sufficient information to be understood independent of these references.

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Methods sections describing research using human or animal subjects and/or tissue or field sampling must include required ethics statements. See the reporting guidelines for human research, clinical trials, animal research, and observational and field studies for more information.

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Methods sections of manuscripts adding new taxon names to the literature must follow the reporting guidelines below for a new zoological taxon, botanical taxon, or fungal taxon.

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These sections may all be separate, or may be combined to create a mixed Results/Discussion section (commonly labeled “Results and Discussion”) or a mixed Discussion/Conclusions section (commonly labeled “Discussion”). These sections may be further divided into subsections, each with a concise subheading, as appropriate. These sections have no word limit, but the language should be clear and concise.

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Acknowledgments

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References

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Source	Format
Published articles	Hou WR, Hou YL, Wu GF, Song Y, Su XL, Sun B, et al. cDNA, genomic sequence cloning and overexpression of ribosomal protein gene L9 (rpL9) of the giant panda (*Ailuropoda melanoleuca*). Genet Mol Res. 2011;10: 1576-1588. Devaraju P, Gulati R, Antony PT, Mithun CB, Negi VS. Susceptibility to SLE in South Indian Tamils may be influenced by genetic selection pressure on TLR2 and TLR9 genes. Mol Immunol. 2014 Nov 22. pii: S0161-5890(14)00313-7. doi: 10.1016/j.molimm.2014.11.005 *Note: A DOI number for the full-text article is acceptable as an alternative to or in addition to traditional volume and page numbers.*
Accepted, unpublished articles	Same as published articles, but substitute “Forthcoming” for page numbers or DOI.
Web sites or online articles	Huynen MMTE, Martens P, Hilderlink HBM. The health impacts of globalisation: a conceptual framework. Global Health. 2005;1: 14. Available from: http://www.globalizationandhealth.com/content/1/1/14.
Books	Bates B. Bargaining for life: A social history of tuberculosis. 1st ed. Philadelphia: University of Pennsylvania Press; 1992.
Book chapters	Hansen B. New York City epidemics and history for the public. In: Harden VA, Risse GB, editors. AIDS and the historian. Bethesda: National Institutes of Health; 1991. pp. 21-28.
Deposited articles (preprints, e-prints, or arXiv)	Krick T, Shub DA, Verstraete N, Ferreiro DU, Alonso LG, Shub M, et al. Amino acid metabolism conflicts with protein diversity; 1991. Preprint. Available from: arXiv:1403.3301v1. Cited 17 March 2014.
Published media (print or online newspapers and magazine articles)	Fountain H. For Already Vulnerable Penguins, Study Finds Climate Change Is Another Danger. The New York Times. 29 Jan 2014. Available from: http://www.nytimes.com/2014/01/30/science/earth/climate-change-taking-toll-on-penguins-study-finds.html. Cited 17 March 2014.
New media (blogs, web sites, or other written works)	Allen L. Announcing PLOS Blogs. 2010 Sep 1 [cited 17 March 2014]. In: PLOS Blogs [Internet]. San Francisco: PLOS 2006 - . [about 2 screens]. Available from: http://blogs.plos.org/plos/2010/09/announcing-plos-blogs/.

Source	Format
Masters' theses or doctoral dissertations	Wells A. Exploring the development of the independent, electronic, scholarly journal. M.Sc. Thesis, The University of Sheffield. 1999. Available from: http://cumincad.scix.net/cgi-bin/works/Show?2e09
Databases and repositories (Figshare, arXiv)	Roberts SB. QPX Genome Browser Feature Tracks; 2013 [cited 2013 Oct 5]. Database: figshare [Internet]. Available from: http://figshare.com/articles/QPX_Genome_Browser_Feature_Tracks/701214.
Multimedia (videos, movies, or TV shows)	Hitchcock A, producer and director. Rear Window [Film]; 1954. Los Angeles: MGM.

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Authors may use almost any description as the item name for a supporting information file as long as it contains an “S” and number. For example, “S1 Appendix” and “S2 Appendix,” “S1 Table” and “S2 Table,” and so forth.

Supporting information files are published exactly as provided, and are not copyedited.

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All potential competing interests must be declared in full. If the submission is related to any patents, patent applications, or products in development or for market, these details, including patent numbers and titles, must be disclosed in full.

Anexo III - Normas do Programa – Produção vegetal – Agronomia – UFPR

NORMA INTERNA Nº 07/2015
Regulamenta redação de dissertação e tese do Programa de Pós-Graduação em Agronomia – Área de Concentração Produção Vegetal da UFPR.
O COLEGIADO DO PROGRAMA DE PÓS-GRADUAÇÃO EM AGRONOMIA – ÁREA DE CONCENTRAÇÃO PRODUÇÃO VEGETAL, em sua 1ª Reunião Ordinária de 23 de Fevereiro de 2015, considerando a necessidade de adequação das Normas Internas para o Programa, de acordo com o artigo 86° da Resolução N° 65/09 CEPE.
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.
Art. 3º - Quanto à estrutura, a dissertação/tese deverá ser composta de: (i) capa, (ii) páginas pré-textuais, (iii) corpo da Dissertação/Tese propriamente dito e, opcionalmente, (iv) anexo (páginas pós-textuais).
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- TÍTULO
- NOTA EXPLICATIVA:

Dissertação/Tese apresentada ao Programa de Pós-Graduação em Agronomia, Área de Concentração em Produção Vegetal, Departamento de Fitotecnia e Fitossanitarismo, Setor de Ciências Agrárias, Universidade Federal do Paraná, como parte das exigências para obtenção do título de Mestre/Doutor em Ciências.

 ORIENTADOR
 CO-ORIENTADOR (opcional)
 LOCAL
 ANO DE APROVAÇÃO DE DISSERTAÇÃO/TESE
 Constará, no verso desta folha a ficha catalográfica.

b) Segunda folha interna, contendo o parecer da Banca Examinadora.

c) Opcionalmente, poderão ser incluídas páginas adicionais contendo:
 Dedicatória: na parte inferior direita da página, quando curta;
 Agradecimento(s): a palavra agradecimento deve estar centralizada, em letras maiúsculas negritadas, na primeira linha do texto; com uma linha em branco separando a palavra **AGRADECIMENTO** do texto, quando longo e na parte inferior direita, quando curto; iniciar parágrafo com 1,25 cm na primeira linha;
 Biografia do autor.

d) Folha(s) em que conste(m) o *Resumo* em português (com Palavras-chave) e o *Abstract* em inglês (com Key words). Deverão ser inseridas de três a seis palavras-chave, que não constem no título.

e) Folha(s) de conteúdo ("Sumário").

f) Lista de figuras, tabelas, abreviaturas e de símbolos: em letra maiúscula negritada e centralizada, com dois espaços de 1,5 cm separando o título da lista, numeradas de acordo com a sequência que aparecem no texto.

Art. 4º - O corpo da dissertação/tese conterá todo o trabalho impresso, avaliado e aprovado pela Banca Examinadora. O corpo da dissertação/tese deverá ser redigido nas seguintes seções:
1 INTRODUÇÃO
2 REVISÃO DE LITERATURA ,
3 MATERIAL E MÉTODOS
4.RESULTADOS E DISCUSSÃO
5 CONCLUSÕES
6. CONSIDERAÇÕES FINAIS
REFERÊNCIAS
ANEXOS
O corpo da tese poderá alternativamente (a critério do orientador) ser redigido com as seguintes seções:
1 INTRODUÇÃO GERAL
2 REVISÃO DE LITERATURA (opcional para doutorado)
3 Título do primeiro artigo (em negrito e letra maiúscula)

RESUMO
ABSTRACT
3.1 INTRODUÇÃO
3.2 MATERIAL E MÉTODOS
3.3 RESULTADOS E DISCUSSÃO (juntos ou separados)
3.4 CONCLUSÕES

REFERÊNCIAS
4 Títulos dos demais artigos (em negrito e letra maiúscula)
RESUMO
ABSTRACT
4.1 INTRODUÇÃO
4.2 MATERIAL E MÉTODOS
4.3 RESULTADOS E DISCUSSÃO
4.4 CONCLUSÕES
REFERÊNCIAS
5 CONCLUSÕES GERAIS
6. CONSIDERAÇÕES FINAIS
REFERÊNCIAS
ANEXOS
Art. 5° - O anexo (páginas pós-textuais) é opcional.
Art. 6º - Quanto à Editoração, as Dissertações/Teses deverão possuir a seguinte composição tipográfica:

- As dissertações/teses deverão ser impressas em forma permanente e legível, com caracteres de alta definição e de cor preta.
- Deve-se utilizar a fonte Arial no tamanho 12, com espaçamento entre linhas de 1,5 cm.
- Para citação longa, nota de rodapé legendas, notas indicando a natureza acadêmica e paginação, deverá ser usada letra no tamanho 10.
- Para resumo/*abstract*, referência, notas de rodapé, citação longa, legendas e notas indicando a natureza acadêmica, o espaçamento será de 1 cm (simples).
- Para separar referências entre si, deverão ser usados espaçamento duplo.
- Os títulos de seções e subseções deverão ser separados por dois espaços de 1,5 cm.
- Título deve ser em maiúsculo em Arial no tamanho 12.

§ 1º - Notação científica e medidas *:* A nomenclatura científica deverá ser diferenciada contextualmente, de acordo com as normas internacionais. As unidades métricas deverão seguir o padrão do Sistema Internacional de Unidades.
§ 2º - Papel: Utilizar papel branco A4 (210 x 297 mm) .

§ 3º - Margens: As margens devem ser de 30 mm para margens superior e esquerda e 20 mm para margens inferior e direita.
§ 4º - Paginação: Todas as páginas textuais e pós-textuais deverão ser numeradas em seqüência contínua, em algarismos arábicos, no canto superior direito da folha, devendo ser exibida a partir da Introdução. A seqüência deverá incluir as páginas pré-textuais (dedicatória, agradecimentos, sumário e listas), porém não serão numeradas. A capa e folha de rosto não são contadas e nem numeradas.
§ 5º - Tabelas, figuras, quadros e outras ilustrações: deverão ser montadas de forma definitiva e incluídas no corpo da tese, sendo admitido o uso de cores. As tabelas deverão ser numeradas sequencialmente ao longo do documento com algarismos arábicos, encabeçadas por título auto-explicativo, com letras maiúsculas, não devendo ser usadas linhas verticais para separar colunas. As figuras (quadros, gráficos, organogramas, plantas, mapas, desenhos, esquemas, lâminas, retratos, fluxogramas e/ou fotografias) deverão ser numeradas em algarismos arábicos; as legendas digitadas logo abaixo da figura e iniciadas com denominação de Figura, devem ser seguidas do respectivo número e texto, em letras maiúsculas.
§ 6º - Unidades de medida: Devem ser redigidas com espaço entre o valor numérico e a unidade. Exemplos: 10 ºC, 10 mL, µS cm-1 g-1 O símbolo de percentagem deve ficar junto do algarismo, sem espaço. Ex: 10%.
Art. 7º - As referências também deverão ser apresentadas
seguinte as orientações constantes no site **www.portal.ufpr.br/normalizacao.html**
Art. 8° - A presente Norma Interna entrará em vigor na data de sua aprovação, ficando revogada a Norma Interna Nº 07/2011.
Curitiba, 23 de Fevereiro de 2015.
Professor CICERO DESCHAMPS
Coordenador do Programa

BIOGRAFIA PROFISSIONAL DA AUTORA

Delma Fabíola Ferreira da Silva, filha de Eloy Martins da Silva e Elifas Ferreira da Silva, nasceu em Curitiba, Paraná, no dia 30 de agosto de 1985.

Em março de 2005 ingressou no curso de Zootecnia da Universidade Estadual de Ponta Grossa, campus Castro, Paraná. Em março de 2006 ingressou no curso de Zootecnia na Universidade Federal do Paraná, em primeiro lugar no Processo de Ocupação de Vagas Remanescentes (PROVAR).

Durante o período da graduação realizou diversos estágios: Em 2005 na Cooperativa Castrolanda, e na Universidade Estadual de Ponta Grossa ; 2006 na empresa de pesquisa em forragicultura AGROSUS; 2007 no Departamento de Solos na Universidade Federal do Paraná a qual teve participação no projeto de extensão Solo Planta; 2008 estagiou no Programa de Análise de Rebanhos Leiteiros do Paraná da Associação Paranaense de Criadores de Bovinos da raça Holandesa, e na Fundação ABC na área de Forragicultura. Em 2010 ingressou no estágio curricular obrigatório na Cooperativa Agropecuária Castrolanda no setor de assistência técnica a pequenos e médios produtores de leite. Em abril de 2011 recebeu o título de Bacharel em Zootecnia.

Participou de três programas de iniciação científica pela Universidade Federal do Paraná a qual sendo bolsista em dois deles nos anos de 2008/2009 e 2009/2010.

Em 2013 no Programa de Pós-Graduação em Agronomia recebeu o título de Mestre em Ciências, na área de concentração em Produção Vegetal, na Universidade Federal do Paraná. Em 2013 deu sequência ao curso de Doutorado na área de concentração em Produção Vegetal, na Universidade Federal do Paraná.

Em 2014 foi aprovada, em primeiro lugar, no concurso da Empresa de Assistência Técnica e Extensão Rural (EMATER-PR), iniciando o exercício do cargo em setembro de 2016. Atualmente reside em Quedas do Iguaçu, e atua na extensão rural e transferência de tecnologia na bacia leiteira do sudoeste do Paraná a produtores familiares.