UNIVERSIDADE ESTADUAL PAULISTA – UNESP
CÂMPUS DE JABOTICABAL

AVALIAÇÃO DOS COMPORTAMENTOS DE PASTEJO E SUAS RELAÇÕES COM CARACTERES INDIVIDUAIS DOS BOVINOS DE CORTE

Natalia Maria Alejandra Aguilar
Médica Veterinária

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Orientador: Prof. Dr. Francisco Xavier Manteca Vilanova
Coorientador: Dr. Mateus J. R. Paranhos da Costa

Tese apresentada à Faculdade de Ciências Agrárias e Veterinárias – Unesp, Câmpus de Jaboticabal, como parte das exigências para a obtenção do título de Doutora em Zootecnia.

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TÍTULO DA TESE: AVALIAÇÃO DOS COMPORTAMENTOS DE PASTEJO E SUAS RELAÇÕES COM CARACTERES INDIVIDUAIS DOS BOVINOS DE CORTE

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Jaboticabal, 22 de março de 2016

DADOS CURRICULARES DA AUTORA

NATALIA MARIA ALEJANDRA AGUILAR – Nascida na cidade de Resistencia, Chaco, Argentina, no dia 17 de novembro de 1977, filha de Raquel Norma Taborda e Antonio Hector Aguilar. Graduou-se em Medicina Veterinária no ano de 2003, pela Faculdade de Ciências Veterinárias (FCV), da Universidad Nacional del Nordeste (UNNE), Corrientes – Argentina e obteve título de Mestre em Zootecnia em 2007, pela FCAV/UNESP, Câmpus de Jaboticabal. Foi docente auxiliar das disciplinas de Bioquímica e Nutrição Animal entre os anos de 2007 e 2012 na FCV/UNNE. Atualmente é pesquisadora do Instituto Nacional de Tecnologia Agropecuária (INTA-Argentina), onde foi coordenadora nacional do projeto de 'Bem-Estar Animal' do INTA, de janeiro de 2010 até julho de 2012. Em agosto de 2012 tornou-se aluna de doutorado do Programa de Pós-graduação em Zootecnia da Faculdade de Ciências Agrárias e Veterinária da Unesp, Câmpus de Jaboticabal. Durante o doutorado realizou treinamento no exterior entre os meses de fevereiro a julho de 2015, junto a *'The University of Sydney'*, Sydney, Austrália.

Quando o homem aprender a respeitar até o menor ser da Criação, seja animal ou vegetal, ninguém precisará ensiná-lo a amar seu semelhante

Albert Schweitzer

Dedico....

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Certificamos que o Protocolo nº 09/14 do trabalho de pesquisa intitulado "**Avaliação das estratégias de forrageamento de ruminantes em sistemas de pastagens**", sob a responsabilidade do Prof. Dr. Mateus José Rodrigues Paranhos da Costa está de acordo com os Princípios Éticos na Experimentação Animal adotado pelo Conselho Nacional de Controle de Experimentação Animal (CONCEA) e foi aprovado pela COMISSÃO DE ÉTICA NO USO DE ANIMAIS (CEUA), em reunião ordinária de 03 de fevereiro de 2014.

Jaboticabal, 03 de fevereiro de 2014.

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AVALIAÇÃO DOS COMPORTAMENTOS DE PASTEJO E SUAS RELAÇÕES COM CARACTERES INDIVIDUAIS DOS BOVINOS DE CORTE

RESUMO – O objetivo principal foi identificar relações entre comportamento durante o pastejo e temperamento dos bovinos de corte, com objetivos específicos de: predizer o comportamento a partir de informação de dispositivos de precisão e, verificar a influência do temperamento sobre o comportamento durante o pastejo de bovinos mantidos em pastagens tropicais suplementadas (*Brachiaria brizantha - cv. Marandu*). Inicialmente comparou-se dados comportamentais de observação visual dos bovinos com dados dos colares GSP com sensores de inclinação (3300 LR, Loteck®), determinando por meio de árvores de decisão os limiares de predição e classificação dos comportamentos. Quarenta e oito tourinhos Nelore (PV = 231 ± 19,6 kg; de 10 - 12 meses), foram recriados em 14 piquetes recebendo um dos um dos seis planos nutricionais, resultantes de três alturas de pastagens (15, 25 ou 35 cm) com dos tipos de suplementos (minerais ou proteína), durante as águas. Doze animais por ciclo levaram aleatoriamente um colar GPS durante 24 horas por 7 dias. Foram encontradas associações entre dados do colar e observações visuais, com variação do 75,11% explicada pelos componentes principais (PC1 e PC2). A variável do colar cabeça baixa (%), mostrou alta correlação (P <0,0001) com pastejo (GRA, r = 0.76) e com rumia (RUM, r = - 0.78); entretanto variáveis do colar: X-act, Y-act, somatória de ambos e distância percorrida, tiveram baixa associação com comportamentos observados. O modelo de árvore de decisão de menor erro de classificação (13,98%), foi escolhido para prever o comportamento animal durante intervalos não observados; apresentando alta precisão para GRA (90%) e RUM (76%) e menor para não-pastejo (Not-gra, 59%). Determinando-se a previsão média total de tempo diário para GRA (38,8%), RUM (44,2%) e Não-gra (17%). Não foram encontradas diferenças (P> 0,05) dos comportamentos previstos entre os diferentes planos nutricionais. Sugerindo que, colares GPS com sensores de inclinação fornecem informações aceitáveis para prever e classificar os comportamentos de bovinos em pastagens. Seguidamente, avaliou-se a associação do temperamento com a produtividade (GMD e PV_{final}) e o comportamento dos bovinos (tempo de GRA, RUM, Not-gra e caminhada diária). Inicialmente 126 novilhos foram mantidos em 18 piquetes das mesmas características ao estudo anterior. Todos os animais foram pesados individualmente no início e final do estudo, sendo avaliado o temperamento por escore de reatividade visual (RS), enquanto o animal foi mantido na balança e velocidade de saída (FS, m/s) após de sair da balança. Para avaliar o efeito do temperamento sobre o comportamento utilizou-se os tempos previstos dos comportamentos descritos previamente. O temperamento mostrou baixa relação de PV_{final} com RS (r_s = 0,18; P = 0,05), entretanto não teve efeitos sobre GMD (P> 0,05). Encontrou-se efeito sobre os tempos previstos dos comportamentos (P <0,0001) Not-gra avaliado por ambos métodos (FS e RS); RUM avaliado por FS; GRA com apenas tendência negativa (P = 0.07) avaliado por FS. Com base nestes resultados, demostrou-se que o temperamento bovino, avaliado pelas respostas ao manejo, não representa diretamente o comportamento durante o pastejo de bovinos mantidos em pastagem suplementadas, sugerindo que estas características provavelmente sejam independentes.

Palavras-chave: árvores de decisão, etologia, GPS, raça Nelore, temperamento

ASSESSING THE GRAZING BEHAVIOUR AND ITS RELATIONSHIP TO THE INDIVIDUAL CHARACTERISTICS IN BEEF CATTLE

ABSTRACT – The main aim was to identify the possible relationship between behaviour during the grazing and beef cattle temperament, specific aims were: predict the behaviour from information given by precision devices, and verify the influence of temperament on the behaviour cattle during grazing in supplemented tropical pastures (*Brachiaria - Marandu cv.*). Initially, compared cattle behaviour visual observed and data from collars GSP with built-in tilt sensors (LR 3300, Loteck®), it was determined by decision trees the thresholds for the prediction and classification of behaviour cattle. Forty-eight young bulls Nellore (BW = 231 ± 19.6 kg; 10 to 12 mo-old) were breeding in 14 paddocks that received one of the six nutritional plans, resulting from three heights of pastures (15, 25 or 35 cm) and the types of supplements (minerals or protein), on season wet. Twelve animals randomly per cycle wear a GPS collar for 24 hours for 7 days. Found associations among the data behavioural visual observations and from GPS collars, where75.11% explained by the principal components (PC1 and PC2). The variable head down (%) showed high correlation ($P < 0.0001$) with grazing (GRA, $r = 0.76$) and ruminating (RUM, $r = - 0.78$); but the others variables by collar: X-act, Y-act, sum of both and distance traveled, had a low correlation with observed behaviour. The decision tree model of lower misclassification (13.98%), was chosen to predict animal behaviour during intervals unobserved. Shown high precision with GRA (90%) and RUM (76%) and lower with not-grazing (Not-gra, 59%). The determining average daily time predict to GRA (38.8%), RUM (44.2%) and Not-gra (17%). There were no differences ($P > 0.05$) of behaviour referred among different nutritional plans. Results suggested, that GPS collars with tilt sensors provide acceptable information to predict and classify the cattle behaviour in pastures. Followed, was assessment the association of temperament with productivity (ADG and BW_{final}) and behaviour (GRA, RUM, Not-gra and daily distance walked). Initially 126 steers were kept in 18 paddocks of the same characteristics the previous study. All animals were individually weighing at the beginning and end of the study, while assess temperament by two usual test: visual reactivity score (RS) while the animal was kept inside the squeeze chute; and flight speed (FS, $m.s^{-1}$) velocity to exit the squeeze chute. Furthermore, to evaluate the effect of temperament on the behaviour we used the of predicted behaviors time described previously. The temperament shows low correlation BW_{final} with RS (r_s = 0.18; $P = 0.05$), but had no effect on ADG ($P > 0.05$). Was found effect on the distance walked, the behavior predicted time ($P < 0.0001$) where Not-gra assessed by both methods (FS and RS); RUM assessed by FS and GRA with only negative tendency ($P = 0.07$) assessed by FS. Based on these results, it demonstrated that the cattle temperament, measured by responses to management, is not directly the behavior during the grazing of cattle kept on pasture supplemented, suggesting that these characteristics are likely to be independent.

Keywords: decision trees, ethology, GPS, Nellore breed, temperament

LISTA DE ABREVIATURAS

% BW/d – porcentagem do peso vivo por dia (percent of body weight per day)

ADG – ganho médio diário (average daily gain)

BI – intensidade de respiração (breathing intensity)

BP – postura corporal (body posture)

BW – peso vivo (body weight)

BW_{final} – peso vivo final (final body weight)

BW_{incial} – peso vivo inicial (initial body weight)

CAR ou RFI – consumo alimentar residual (residual feed intake)

CS – escore de tronco (chute score)

DW – bebendo água (drinking water)

ES – comendo suplemento ou sal (eating supplement or salt)

FS – teste de velocidade de fuga ou saída (flight speed test)

FSmean – velocidade de saída média (mean flight speed)

g MS.dia^{-1} – gramas de matéria seca por dia (grams of dry matter per day)

GPS – sistema de posicionamento geográfico (global position system)

GRA – pastejo (grazing)

h/d – hora por dia (hour per day)

ha – hectare (hectare)

HD – cabeça baixa (head down)

kg ha^{-1} – quilograma por hectare (kilogram per hectare)

kg.animal^{-1} – quilograma por animal (kilogram per animal)

km.d^{-1} – quilômetro por dia (kilometre per day)

m.s^{-1} – metros por segundo (meters per sec)

MH – pastagem de altura moderada (moderate pasture height, 25 cm)

MHLS – pastagem de altura moderada com baixa suplementação (moderate pasture height with low supplementation)

MHMS – pastagem de altura moderada com suplementação moderada (moderate pasture height with moderate supplementation)

MOV – escore de movimento (movement score)

Not-gra – não-pastejo (not-grazing)

OA – outras atividades (others activities)
PCA – análises de componentes principais (Principal Components Analysis)
PDOP – precisão diluída da posição (position dilution of precision)
RS – escore de reatividade (reactivity score)
RSmean – escore de reatividade médio (mean reactivity score)
RUM – ruminação (ruminating)
SH – pastagem de altura baixa (short pasture height, 15 cm)
SHHS – pastagem de altura baixa com alta suplementação (short pasture height with high supplementation)
SHMS – pastagem de altura baixa com moderada suplementação (short pasture height with moderate supplementation)
SI – interação social (social interactions)
SIG – sistema de informação geográfica (geographical information system)
Sum-XY-act – somatória da atividade dos eixos horizontal e vertical (sum activities horizontal and vertical axes)
TH – pastagem de altura alta (tall pasture height, 35 cm)
THLS – pastagem de altura alta com baixa suplementação (tall pasture height with low supplementation)
THMS – pastagem de altura alta com moderada suplementação (tall pasture height with moderate supplementation)
TS – tensão muscular (muscular tension)
UTM – sistema universal transverso de mercator (universal transverse mercator geographic coordinate system)
WAL – andando (walking)
X-act – atividade do eixo horizontal (horizontal axis activity)
Y-act – atividade do eixo vertical (vertical axis activity)

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CAPÍTULO 1 – Considerações gerais

1.1 Introdução

Os estudos do comportamento de ingestão dos bovinos em pastejo geralmente analisam a interação planta-animal com a finalidade de responder perguntas relacionadas à nutrição animal, à ecofisiologia das pastagens e ao impacto sobre o desempenho animal, assim, o comportamento de pastejo vem sendo amplamente estudado sob o ponto de vista nutricional (FORBES, 2007). Porém, sabe-se pouco sobre como os caracteres individuais e a psicologia dos animais podem afetar o comportamento de pastejo. Alguns autores definem que o processo de pastejo poderia ocorrer em duas escalas temporais: uma de curto prazo, definida pela escala de minutos a horas de pastejo, e outra de longo prazo, definida pela escala de dias a semanas de pastejo (LACA; DEMMENT, 1992; BAILEY et al., 1996). Em geral, para estudar o comportamento de pastejo é desejável que as observações sejam feitas durante as 24 horas do dia (CARVALHO et al., 2007), mas observações deste tipo não são fáceis de serem feitas quando dependem da presença de observadores humanos, uma vez que há uma série de dificuldades nas coletas de dados decorrentes de erros de registro, de imprecisão na identificação da área de estudo, além das limitações decorrentes do ambiente como fatores físicos e climáticos, associados à fadiga dos observadores (TURNER et al., 2000; LACA, 2009). Além disso, as observações visuais nem sempre permitem detectar variações individuais do comportamento, que poderiam ser importantes para a compreensão das questões que estamos avaliando.

Para reduzir os riscos de ocorrência desses problemas e o efeito da presença dos humanos durante as observações, podemos utilizar ferramentas tecnológicas, como os dispositivos de registro eletrônico, que tornam possível avaliar o comportamento dos bovinos ao longo do tempo, com alto nível de detalhamento e em diferentes condições de criação (ADAMCZYK et al., 2013). Estes dispositivos poderiam ser utilizados para estudar os fatores individuais que potencialmente afetam o comportamento de ingestão dos animais, por exemplo o temperamento do animal, definido como a reação dos animais frente à presença dos humanos, que geralmente é atribuída ao medo (FORDYCE; GODDARD; SEIFERT, 1982; BURROW, 1997). Sendo que durante os testes de avaliação de temperamento, os animais não expressam os comportamentos relacionados a categoria de alimentação.

Levando em conta estas considerações o objetivo geral desta tese foi identificar as possíveis relações entre o temperamento de bovinos de corte e seu comportamento durante a atividade de pastejo, tendo dois objetivos específicos: (1) avaliar a viabilidade de predição do comportamento de pastejo de bovinos de corte a partir de informações obtidas com dispositivos eletrônicos e, (2) verificar a influência de indicadores do temperamento sobre o comportamento durante o pastejo em bovinos de corte mantidos em pastagens tropicais suplementadas.

1.2 Revisão de Literatura

1.2.1 Generalidades sobre o comportamento de pastejo dos bovinos

Os herbívoros ungulados possuem habilidades que permitem a tomada de decisões durante o processo de forrageamento, sendo capazes de memorizar os sítios, dentro de sua área de vida, onde encontrarão a biodiversidade das plantas preferentemente ingeridas otimizando a utilização de nutrientes e evitando aquelas plantas que poderiam conter toxinas para o animal (PROVENZA; LAUNCHBAUGH, 1999; PROVENZA et al., 2003, LAUNCHBAUGH; HOWERY, 2005; MANTECA et al., 2008). De tal modo, ao longo de sua história evolutiva, os ruminantes domésticos desenvolveram estratégias bem-sucedidas para otimizar seu comportamento de forrageamento, resultando no que foi definido como processo de pastejo (CARVALHO et al., 1999).

Está descrito que várias dessas habilidades ou processos poderiam ser tanto herdadas quanto aprendidas através da convivência com outros indivíduos do grupo (LAUNCHBAUGH et al., 1999). Desta maneira, Ganskopp e Cruz (1999) mostraram que quando animais experientes e animais sem experiência são introduzidos em um novo ambiente com forragens de diferentes qualidades, estes últimos expressaram rapidamente suas preferências alimentares, que são semelhantes às dos animais experientes, embora, a composição da dieta dos animais sem experiência apresentassem menor proporção de forragens mais palatáveis, se comparada às dos animais experientes. Em contextos como este, é evidente que o comportamento exploratório, definido como qualquer atividade do indivíduo com potencial aquisição de novas informações sobre sua área de vida ou território, apresenta uma função vital para a sobrevivência dos animais (WOOD-GUSH; VESTERGAARD, 1993; BROOM; FRASER, 2010). Portanto, o processo de pastejo se dá, provavelmente, pela combinação de comportamentos por imitação e pelos processos de aprendizagem associativa resultando, por exemplo, em respostas de aversão ou preferência alimentar, que poderiam ajudar a explicar como ocorrem as interações entre plantas e herbívoros (LAUNCHBAUGH et al., 1999; LAUNCHBAUGH; HOWERY, 2005).

As teorias que tentam explicar a regulação do consumo de alimentos em ruminantes consideram mecanismos multifatoriais tanto físicos como fisiológicos do animal (FORBES, 2003 e 2007). Portanto, a regulação do consumo de alimento é resultado da interação entre informações de origem genética, estado fisiológico do animal e sinais das reservas intestinais e dos tecidos que são transmitidas através do sistema nervoso e endócrino (MERTENS, 1996; FORBES, 2001). Entre esses fatores bióticos e abióticos que regulam o consumo dos ruminantes, podemos considerar: (1) fatores bióticos – relacionados à qualidade nutricional da forragem (composição química e produtividade das plantas) (BAILEY et al., 1996), o comportamento social dos animais (SIBBALD et al., 2000), os efeitos das perturbações (possíveis ataques de predadores ou insetos), dentre outros (HOWERY et al., 1998; BROOM, 2010); e (2) fatores abióticos, tais como declividade do terreno, localização da fontes de água ou sal (SENFT et al., 1987; SMITH, 1988; GANSKOPP, 2001), distância percorrida para obter alimentos, temperatura ambiente, dentre outros (RIGGS; URNESS; GONZALEZ, 1990). A influência de alguns fatores abióticos, como o aumento do tempo e a escala espacial do pastejo determinam o aumento do consumo de matéria seca (BAILEY et al., 1996). Estes fatores em conjunto podem afetar o tempo de pastejo, influenciando principalmente na taxa de bocado e, consequentemente, no consumo de matéria seca (FRYXELL et al., 2001; SHIPLEY, 2007). Em situações com diferentes ofertas de forragem se incorpora o efeito das estruturas e da qualidade do ambiente na regulação do comportamento de pastejo (MEZZALIRA et al., 2011). Assim, em situações de baixa oferta de forragem, os animais aumentam a atividade de colheita, diminuindo a busca de alimento e a duração de cada refeição (MEZZALIRA et al., 2012). Em resumo, a seleção da dieta resultaria de sinais internos e externos percebidos pelo animal, determinando que a taxa do bocado seja realizada eficazmente para obter o alimento que satisfaça as necessidades do mesmo (GREGORINI et al., 2009; VILLALBA et al., 2009).

A maioria dos estudos sobre comportamento de bovinos de corte em pastagens indica que os mesmos gastam entre 90% e 95% do período do dia expressando três comportamentos básicos: pastejo, ruminação e descanso, e descreve que os bovinos têm uma rotina de alimentação muito bem definida, embora possa variar de acordo com a disponibilidade de forragem (KILGOUR, 2012a). Deve-se destacar que quando as observações são apenas realizadas durante o período diurno, o pastejo é o comportamento mais frequente (KILGOUR et al., 2012b) e o entendimento deste comportamento pode contribuir para melhorar o manejo das pastagens, sendo utilizado como um indicador de curto prazo, enquanto a estrutura do pasto poderia ser considerada um indicador de longo prazo (CARVALHO; BATELLO, 2009). Por conseguinte, Carvalho et al. (2007) alertaram sobre a importância de avaliar adequadamente as relações de causa-efeito envolvidas no processo de pastejo, entendendo a vinculação entre as variáveis do pastejo analisadas, não sendo tratadas como informações meramente adicionais nas pesquisas.

1.2.2 Tecnologia de precisão auxiliando nos estudos do comportamento animal

A utilização de tecnologias de precisão nos estudos do comportamento de alimentação, tanto em ungulados selvagens quanto domésticos, tem como objetivo facilitar a coleta de informações dos animais e do ambiente (FROST et al., 1997).

Alguns destes recursos foram desenvolvidos inicialmente com a finalidade de diminuir a interferência dos observadores sobre o comportamento dos animais. Para este fim, há várias ferramentas desenvolvidas, por exemplo: sistema pneumático que registra os movimentos da cabeça e as atividades de alimentação do animal, com propósito de estimar o tempo de ingestão (DUCKWORTH; SHIRLAW, 1955), ou equipamentos que já existiam no mercado e foram adaptados, como o interruptor de mercúrio (O'SHEA, 1969), ou ainda os *vibracordes* que permitem gravar as atividades e, em especial, o tempo de pastejo de bovinos (STOBBS, 1970; GWYNNE; KINGABY, 1976; RUCKEBUSCH; BUENO, 1978).

Inicialmente foram desenvolvidos sistemas que permitiam registrar os movimentos do maxilar, para determinar com exatidão o tempo despendido na mastigação (PENNING et al., 1984; MATSUI; OKUBO, 1991), que pode inclusive, ser registrado digitalmente (RUTTER; CHAMPION, PENNING, 1997; RUTTER, 2000; UNGAR; RUTTER, 2006). Há ainda os interruptores como os de mercúrio bascular que foram desenvolvidos como dispositivos que fornecem um registro de alta precisão (99%) para os comportamentos de descanso, postura em pé ou caminhada tanto para ovelhas como para bovinos (CHAMPION et al., 1997).

Todos os dispositivos descritos acima tiveram algumas limitações de uso em grandes áreas ou para registrar e armazenar informações do comportamento durante vários dias. Por essa razão, para estudar o comportamento em sistemas extensivos de pastejo, começou-se a utilizar dispositivos com maior capacidade de armazenamento e que poderiam determinar, por exemplo, as distâncias percorridas. Assim, os pedômetros foram utilizados pela primeira vez para determinar a distância percorrida por animal por dia (ROUDA et al., 1990) e os dispositivos de transmissão via radiofrequência para monitorar animais em confinamento durante vários dias (SOWELL et al., 1998).

Também, existem equipamentos que utilizam o sistema de posicionamento geográfico (*Global Position System*, GPS) que tornaram possível avaliar a distribuição espacial dos animais, permitindo uma análise da dispersão com maior precisão. Estes dispositivos funcionam em conjunto com o sistema de informação geográfica (SIG), caracterizado por ser um conjunto de ferramentas úteis para a coleta, armazenamento, edição, processamento e apresentação de dados sobre os mapas ou sobre uma área específica (georreferenciada) (BURROUGH, 2001; HULBERT; FRENCH, 2001). Este sistema permite que se avalie o comportamento de pastejo em ambientes heterogêneos, emergindo como uma importante ferramenta para compreensão do uso do espaço pelos bovinos em ecossistemas de pastagens (PARSONS; SCHWINNING; CARRERE, 2001).

1.2.3 Utilização de colares com GPS e sensores de movimento para avaliar o comportamento

Inicialmente, os colares de GPS foram utilizados para estudar o comportamento de animais em vida selvagem (MOEN; PASTOR; COHEN, 1996; DUSSAULT et al., 1999; BLAKE; HAMILTON; KARESH, 2001). Mais tarde, estes dispositivos foram implementados nos estudos de animais de produção com o propósito de registrar, além da localização, os comportamentos realizados, determinando o tipo e nível de atividade por meio dos movimentos da cabeça, registrados pelos sensores de movimentos do eixo horizontal e vertical (X-act e Y-act, respectivamente) (TURNER et al., 2000). Assim, estes recursos tecnológicos passaram a ser utilizados para estudar o comportamento de bovinos em pastagens fornecendo informações, por exemplo, da definição das áreas de preferência para pastejo, a seleção de forragem de acordo com as alturas das mesmas (BLACK; KENNEY, 1984; ARNOLD, 1987; BAZELY, 1990), as mudanças no conteúdo de nutrientes das pastagens (BAZELY, 1990; LANGVATN; HANLEY, 1993; WALLIS DE VRIES; SCHIPPERS, 1994), ou ainda para definir a seleção de áreas não contaminadas com placas de fezes (DOHI; YAMADA; ENTSU, 1991; HUTCHINGS et al., 1998; PÁSCOA, 2005). Do mesmo modo, estes dispositivos têm servido também para avaliar o uso de recursos como água, minerais e suplementos alimentares que afetam a distribuição dos animais na pastagem e, consequentemente, seu consumo (GANSKOPP, 2001; BAILEY et al., 2008, VALENTE et al., 2013).

Para analisar e interpretar as informações fornecidas por esses dispositivos (colar GPS com ou sem sensores de movimentos ou com acelerômetros, entre outros), há diferentes algoritmos e modelos matemáticos que poderiam predizer os comportamentos dos animais como, por exemplo, modelos que utilizam dados de GPS submétricos (SCHLECHT et al., 2004), modelos de regressão e análise discriminante (UNGAR et al., 2005; BARBARI et al., 2006), análise de *cluster* (*K-means*) (SCHWAGER et al., 2007) e árvores de decisão e classificação para identificar comportamentos desconhecidos provenientes dos sensores de movimentos, ou sensores de inclinação dos colares (NADIMI; SØGAARD; BAK, 2008; UMSTÄTTER;

WATERHOUSE; HOLLAND, 2008; ROBERT et al., 2009; UNGAR et al., 2011, AUGUSTINE; DERNER, 2013), ou dos colares com acelerômetros (SWAIN; WARK; BISHOP-HURLEY, 2008; GONZÁLEZ et al., 2015).

Embora existam informações sobre a aplicação dessa tecnologia para estudos de comportamento alimentar de bovinos em pastagens, como descrito por Swain et al. (2011) e Anderson et al. (2013), ainda é pouco explorada a utilização da tecnologia de precisão para entender algumas características individuais dos bovinos em outros contextos ou situações. O estudo de Wesley et al. (2012), com vacas, mostrou que existem diferenças individuais dos animais em relação a velocidade de consumo e a distância percorrida, quando as mesmas são mantidas em confinamento *vs* em pastagens, considerando que alguma característica do indivíduo (síndrome comportamental) poderia estar influenciando essas respostas. Por outro lado, MacKay et al. (2013) analisaram a associação existente entre o temperamento de bovinos de corte (novilhos) avaliado em curto prazo pelos testes de velocidade de saída (FS) e escore de tronco (CS), junto às características dos indivíduos a longo prazo avaliadas pelo comportamento social no cocho (escore de agressividade e escore de habilidade de deslocamento), encontrando possíveis associações entre as mesmas. Por outro lado, em um estudo realizado com búfalas, não foram encontradas correlações significativas entre a distância média percorrida diariamente e a reatividade das fêmeas durante a a ordenha, a produção e a qualidade do leite, demonstrando que provavelmente estas características sejam independentes (CARVALHAL, 2014).

1.2.4 Por que avaliamos o temperamento dos bovinos?

Ao estudar as bases fisiológicas das diferenças individuais é comum o uso do termo “estilos de ajuste” (*coping styles*), que é definido como o conjunto de estratégias fisiológicas e comportamentais que um indivíduo utiliza para lidar com uma situação estressante, sendo provável que estas estratégias tenham sido moldadas pela evolução (WECHSLER, 1995). Este conceito é útil para compreender a capacidade de adaptação e vulnerabilidade dos animais às doenças relacionadas com o estresse, considerando que as diferenças entre os estilos de ajuste (reativa e proativa) representam traços biológicos fundamentais (KOOLHAAS et al., 1999).

No contexto da ecologia comportamental, os estudos do comportamento têm um enfoque populacional, mas nos últimos anos começou-se a considerar o estudo do temperamento animal como uma característica de avaliação individual, que poderia ser usada para estudar as tendências dos animais em serem mais ou menos agressivos, medrosos, agitados e reativos. Para isso, utiliza-se o termo "síndrome comportamental" (*behavioral syndrome*) que se refere à consistência comportamental entre os indivíduos, em diferentes situações (SIH; BELL; JOHNSON, 2004). A partir desta condição é que Réale et al. (2007) sugeriram caracterizar o temperamento dos animais dentro de cinco dimensões, sendo elas: (1) ousadia *vs* cautela, considerando as respostas dos animais frente a situações de perigo; (2) exploração *vs* evitação, referindo-se a como os animais respondem a situações novas; (3) atividade, que avalia o nível geral de atividade dos animais; (4) agressividade, estudando reações agonísticas a coespecíficos; (5) sociabilidade, que considera a resposta geral dos animais à presença de coespecíficos. Entretanto, na produção pecuária de bovinos de corte, as pessoas que trabalham diretamente com os animais ou que estão envolvidas na sua gestão reconhecem que existem diferenças individuais nas reações dos animais perante uma situação particular.

A importância de considerar as diferenças individuais em bovinos de corte se tornou mais evidente a partir do momento em que os técnicos e produtores perceberam que havia um impacto positivo na economia do sistema de produção quando o manejo era realizado com animais mais calmos e mais dóceis, evitando trabalhar com animais muito agressivos ou medrosos, que dificultavam a realização dos trabalhos trazendo consequências negativas para a segurança dos trabalhadores (PARANHOS DA COSTA, 2002).

O uso do termo temperamento passou a ser usado para referir-se à individualidade dos bovinos em produção animal, sendo definido, de forma operacional, como a reação dos animais frente ao manejo realizado pelos humanos, geralmente atribuída ao medo (FORDYCE; GODDARD; SEIFERT, 1982; BURROW, 1997) ou a outros estímulos associados à presença humana (BOIVIN et al., 1992). Há diversos estudos mostrando que o temperamento, como definido acima, tem relações diretas com a produção, o bem-estar animal e o bem-estar humano (PARANHOS DA

COSTA, 2002; HASKELL; SIMM; TURNER, 2014) e, por conta disto, vem recebendo maior atenção de produtores e pesquisadores ao longo do tempo.

Outro ponto que deve ser levado em consideração é que as práticas de manejo podem moldar o temperamento dos animais em função da qualidade da interação humano-animal (BOIVIN et al., 1994). Existem evidências de que quando o manejo é realizado de forma descuidada ou até agressiva há um comprometimento do desempenho produtivo provavelmente decorrente do aumento da reatividade dos bovinos (BOISSY; BOUISSOU, 1988; SCHWARTZKOPF-GENSWEIN et al., 1997; HEMSWORTH et al., 2000; COOKE et al., 2009; TITTO et al., 2010). Por outro lado, é possível reduzir a expressão da reatividade realizando a adoção de boas práticas de manejo, além de estimular o contato positivo dos bovinos com os humanos (CEBALLOS BETANCOURT, 2014).

1.2.5 Principais metodologias utilizadas na avaliação do temperamento dos bovinos

Os métodos para avaliar o temperamento de bovinos podem ser classificados de acordo com diferentes critérios (MANTECA; DEAG, 1993; BURROW, 1997). Uma das possibilidades, apresentada por Manteca e Deag (1993) e adaptada por Sant'Anna (2013), define quatro categorias de classificação desses métodos, que são: (1) testes comportamentais; (2) escores visuais com escalas de pontuações pré-definidas; (3) escalas de classificação com base na impressão do observador (escalas de avaliação) e (4) medidas automatizadas de registro dos comportamentos. Dentre os testes mais usados para a avaliação do temperamento dos bovinos destacam-se o teste de velocidade de fuga e o escore de agitação no tronco de contenção, que são descritos a seguir:

O teste de velocidade de fuga ou de saída (*flight speed*, FS), proposto por Burrow, Seifert e Corbet (1988), mede a velocidade com que o animal deixa o tronco de contenção ou a balança em direção a um espaço aberto. O resultado do teste pode ser expressado pelo tempo que o animal leva em percorrer uma distância conhecida (em s), ou pela velocidade com que o faz ($m.s^{-1}$) (BURROW; SEIFERT; CORBET, 1988; BURROW; CORBET, 2000), considerando que os animais que demoram menos tempo (s) ou que apresentam maior velocidade de saída ($m.s^{-1}$) são de pior temperamento (PETHERICK et al., 2002; CAFE et al., 2011a). Este tornou-se um dos testes mais utilizados dada a facilidade de aplicação, eficácia e validade (BURROW, 1997; CURLEY JÚNIOR et al., 2006; MÜLLER; VON KEYSERLINGK, 2006; CAFE et al., 2011a).

Os escores visuais utilizam-se de escalas de pontuações (ou escalas pré-definidas) para atribuir notas que identificam diferentes reações dos bovinos durante algum manejo de rotina, geralmente usando escalas que variam entre 3 e 7 níveis, nas quais os valores extremos representam animais de melhor ou de pior temperamento. Dentre estes, os testes mais utilizados são aqueles que medem o grau de perturbação dos animais quando são contidos no tronco de contenção ou na balança, avaliando-se a frequência e a intensidade dos movimentos, da respiração, as tentativas de coices, entre outros (FORDYCE; GODDARD; SEIFERT, 1982). Estes testes também recebem outras denominações como, por exemplo, escore de tronco (*crush score* ou *chute score,* CS) (VOISINET et al., 1997a, b; BURROW; CORBET, 2000; OLMOS; TURNER, 2008; HOPPE et al., 2010, CAFE et al., 2011a, b), escore de movimentação (FORDYCE; DODT; WYTHES, 1988; GRANDIN, 1993; BENHAJALI et al., 2010) ou também escore de comportamento ou reatividade (PIOVEZAN CYRILLO; COSTA, 2013).

Em geral, estes testes são consistentes ao longo do tempo, como demonstrado em pesquisas que realizaram repetidas avaliações de temperamento ao longo do tempo nos mesmo animais (BURROW; DILLON, 1997; CURLEY JÚNIOR et al., 2006; KILGOUR; MELVILLE; GREENWOOD, 2006; BARBOSA SILVEIRA; FISCHER; WIEGAND, 2008; PETHERICK et al., 2009). No entanto, os diferentes testes apresentam correlações significativas moderadas entre si (FELL et al., 1999; OLMOS; TURNER, 2008; HOPPE et al., 2010; CAFE et al., 2011b, TURNER et al., 2011) e, por isso, Haskell, Simm e Turner (2014) sugeriram, em revisão bibliográfica, que cada um destes testes poderia avaliar dimensões diferentes do temperamento animal.

1.2.6 Relações entre as características indicadoras do temperamento e produção de bovinos de corte

O principal interesse em avaliar o temperamento dos bovinos de corte está na sua associação com as características de desempenho desses animais, sendo esperado, por exemplo, que o ganho médio diário de peso seja menor em animais mais reativos (de pior temperamento), provavelmente em função do maior gasto de energia de manutenção, necessário para manter estados mais intensos de vigilância, alerta e fuga, comparado aos animais menos reativos (MÜLLER; VON KEYSERLINGK, 2006). Há evidências, para os bovinos mantidos em regime de confinamento, que os animas de pior temperamento apresentam menor eficiência de conversão alimentar, com menores ganhos de peso diário e baixa condição corporal, comparados aos de melhor temperamento (PETHERICK et al., 2002). Este resultado foi corroborado pelos achados de Cafe et al. (2011b), que encontraram associações quadráticas e negativas das medidas fenotípicas de eficiência alimentar com o temperamento (avaliado pelo FS) em bovinos da raça Brahman, durante o confinamento, onde os autores estimaram uma redução média do peso vivo entre 20,0 e 20,9 kg.animal^{-1} a cada 1 m.s^{-1} de aumento no FS. Além disso, mostraram que este resultado estaria acompanhado da redução no consumo de matéria seca da ordem de 370 g MS.dia^{-1} a cada 1 m.s^{-1} de aumento de FS e uma redução no tempo despendido no cocho de 4,7 min.d^{-1} (CAFE et al., 2011b). Entretanto, outros autores, ao avaliarem as associações do consumo alimentar residual (CAR) com o temperamento (avaliado pelo FS) de bovinos em confinamento, encontraram correlações genéticas e fenotípicas baixas e negativas, onde os animais de elevado FS apresentaram baixos escores de CAR (NKRUMAH et al., 2007; ELZO et al., 2009; ROLFE et al., 2011). Esses resultados indicam que o temperamento poderia interferir de alguma forma no controle do consumo de alimento e no tempo de alimentação, sendo justificados em função do medo que esses animais experimentam frente à presença dos humanos, às possíveis interações com os coespecificos ou ao menor tempo de permanência no cocho, não sendo necessariamente em função de variações do seu metabolismo (PETHERICK et al., 2002, PETHERICK; HOLROYD; SWAIN, 2003; CAFE et al., 2011b).

Esses achados confirmaram que bovinos confinados classificados como mais reativos (de pior temperamento) geralmente crescem mais lentamente (FORDYCE et al., 1985; BURROW; DILLON, 1997; VOISINET et al., 1997a; FELL et al., 1999), com menor ganho de peso diário, redução da condição corporal, do peso vivo final e do rendimento em geral (BARBOSA SILVEIRA; FISCHER; SOARES, 2006; BARBOSA SILVEIRA; FISCHER; WIEGAND, 2008; HOPPE et al., 2010; SEBASTIAN et al., 2011; TURNER et al., 2011).

Independentemente da idade do animal foram observadas correlações entre temperamento calmo e maior ganho de peso diário tanto para *Bos indicus* quanto para *Bos taurus* (REINHARDT; BUSBY; CORAH, 2009; CAFE et al., 2011b). Isto também foi demonstrado por Sant'Anna et al. (2012) que estudaram um grande número de bovinos da raça Nelore (n = 7.402) e encontraram que animais com melhores temperamentos (avaliado pelo FS) tendem a ter um melhor desempenho, embora as correlações genéticas e fenotípicas entre FS e as características produtivas de peso à desmama e ganho de peso diário tenham sido baixas.

Existem evidências de que o temperamento poderia apresentar baixa correlação com o ganho de peso diário, quando os animais são avaliados em diferentes fases da recria (fase inicial no confinamento e fase final da recria a pasto) (PETHERICK et al., 2002, 2009), ou em novilhos de diferentes raças (Bosmara cruzados, Angus, Brahman e cruzados Angus × Hereford) recriados em pastagens e terminados em confinamento (BEHRENDS et al., 2009; CAFE et al., 2011a, b; FRANCISCO et al., 2012), ou ainda em novilhos de raças cruzadas (*Bos indicus* x *Bos taurus)* recriados em pastagens com suplemento energético-proteico (DEL CAMPO et al., 2010).

Entretanto, não há um consenso geral ao respeito de tal associação, porque em algumas pesquisas não foram observadas diferenças de ganho médio diário de peso quando compararam bovinos de diferentes temperamentos mantidos em grupos separados comparados aos grupos de calmos e de reativos mantidos juntos no mesmo grupo do confinamento (HOLROYD et al., 2000), ou para bovinos cruzados recriados em pastagem natural com baixa oferta de forragem (BARBOSA SILVEIRA; FISCHER; WIEGAND, 2008). Em correspondência com esses resultados, previamente Müller e Von Keyserlingk (2006) descreveram que a associação entre o temperamento e o desempenho nem sempre é linear, observando uma associação quadrática entre as características, explicando a complexidade que tem a expressão do temperamento dos indivíduos.

A tendência atual de selecionar animais menos reativos se deve principalmente ao aumento da pecuária de corte que está sendo realizada em regime de confinamento e, consequentemente, na proximidade com seres humanos (KOOLHAAS et al., 2007; RÉALE et al., 2007; GRAUNKE et al., 2013). Turner et al. (2011) sugeriram em revisão bibliográfica que a seleção de temperamento com base nos testes de velocidade de saída (FS) e escore do tronco (CS ou RS) podem ter pouco impacto quando os animais são colocados em outros contextos e situações desafiadoras, onde precisam expressar agressividade intraespecífica, sociabilidade ou comportamento materno defensivo frente a predadores. Por conta disso, Haskell, Simm e Turner (2014) sugeriram que seria conveniente avaliar outros traços de temperamento, além das respostas ao manejo, para ampliar as possibilidades de entendimento sobre as diferenças individuais dos bovinos, utilizando ferramentas e dispositivos de precisão para avaliar os bovinos mantidos em diferentes condições de criação e manejo, de forma de reduzir o risco das interpretações antropomórficas das observações (ADAMCZYK et al., 2013).

Frente a este cenário, assume-se que observação do comportamento utilizando dispositivos de precisão forneceriam informações úteis que nos auxiliariam a entender a expressão do temperamento dos animais em outras situações que estes podem enfrentar durante a vida.

1.3 Referências

ADAMCZYK, K.; POKORSKA, J.; MAKULSKA, J.; EARLEY, B.; MAZUREK, M. Genetic analysis and evaluation of behavioural traits in cattle. **Livestock Science**, Amsterdam, v. 154, n. 1–3, p. 1–12, 2013. Disponível em: <http://dx.doi.org/10.1016/j.livsci.2013.01.016>.

ANDERSON, D. M.; ESTELL, R. E.; CIBILS, A. F. Spatiotemporal cattle data – a plea for protocol standardization. **Positioning**, Irvine, v. 4, n. 1, p. 115–136, 2013. Disponível em: <http://dx.doi.org/10.4236/pos.2013.41012>.

ARNOLD, G. E. Influence of the biomass, botanical composition and sward height of annual pastures on foraging behaviour of sheep. **Journal of Applied Ecology**, West Sussex, v. 24, n. 3, p. 759–772, 1987. Disponível em: <http//dx.doi.org/10.2307/2403 979>.

AUGUSTINE, D. J.; DERNER, J. D. Assessing herbivore foraging behavior with GPS collars in a semiarid grassland. **Sensors**, Basel, v. 13, n. 3, p. 3711–3723, 2013. Disponível em: <http://dx.doi.org/10.3390/s130303711>.

BAILEY, D. W.; GROSS, J. E.; LACA, E. A.; RITTENHOUSE, L. R.; COUGHENOUR, M. B.; SWIFT, D. M.; SIMS, P. L. Invited Synthesis Paper: Mechanisms that result in large herbivore grazing distribution patterns. **Journal of Range Management**, Littleton, v. 49, n. 5, p. 386–400, 1996. Disponível em: <http://dx.doi.org/ 10.2307/4002919>.

BAILEY, D. W.; VANWAGONER, H. C.; WEINMEISTER, R.; JENSEN, D. Comparison of low-moisture blocks and salt for manipulating grazing patterns of beef cows. **Journal of Animal Science**, Champaign, v. 86, n. 5, p. 1271–1277, 2008. Disponível em: <http://dx.doi.org/10.4236/pos.2013.41012>.

BALZER, H. U.; KULTUS, K., KÖHLER, S. A new generation of fertility monitoring in cattle herds. In: CONFERENCE JOINT INTERNATIONAL AGRICULTURAL, 4., 2009, Wageningen. **Proceedings…** Wageningen: Precision Livestock Farming, 2009. p. 225–234.

BARBARI, M.; CONTI, L.; KOOSTRA, B. K.; MASI, G.; SORBETTI GUERRI, F.; WORKMAN. S. R. The use of global positioning and geographical information systems in the management of extensive cattle grazing. **Biosystems Engineering**, London, v. 95, n. 2, p. 271–280, 2006. Disponível em: <http://dx.doi.org/10.1016/j.biosystemseng. 2006.06.012>.

BARBOSA SILVEIRA, I. D.; FISCHER, V.; SOARES, G. J. D. Relação entre o genótipo e o temperamento de novilhos em pastejo e seu efeito na qualidade da carne. **Revista Brasileira de Zootecnia**, Viçosa, v. 35, n. 2, p. 519–526, 2006. Disponível em: <http://dx.doi.org/10.1590/S1516-35982006000200026>.

BARBOSA SILVEIRA, I. D.; FISCHER, V.; WIEGAND, M. M. Temperamento em bovinos de corte: métodos de medida em diferentes sistemas produtivos. **Archivos de Zootecnia**, Córdoba, v. 57, n. 219, p. 321–332, 2008.

BAZELY, D. R. Rules and cues used by sheep foraging in monocultures. In: HUGHES, R. N. (ed.), Behavioural Mechanisms of Food Selection. **Nato Asi Series**, London, v. 20, p. 343–367, 1990. Disponível em: <http://dx.doi.org/10.1007/978-3-642-75118-9>.

BEHRENDS, S. M.; MILLER, R. K.; ROUQUETTE JÚNIOR, F. M.; RANDEL, R. D.; WARRINGTON, B. G.; FORBES, T. D. A.; WELSH, T. H; LIPPKE, H.; BEHRENDS, J. M.; CARSTENS, G. E.; HOLLOWAY, J. W. Relationship of temperament, growth, carcass characteristics and tenderness in beef steers. **Meat Science**, Amsterdam, v. 81, n. 3, p. 433–438, 2009. Disponível em: <http://dx.doi.org/10.1016/j.meatsci.2008.09.003>.

BENHAJALI, H.; BOIVIN, X.; SAPA, J.; PELLEGRINI, P.; BOULESTEIX, P.; LAJUDIE, P.; PHOCAS, F. Assessment of different on-farm measures of beef cattle temperament for use in genetic evaluation. **Journal of Animal Science**, Champaign, v. 88, n. 11, p. 3529–3537, 2010. Disponível em: <http://dx.doi.org/10.2527/jas.2010-3132>.

BLACK, J. L.; KENNEY, P. A. Factors affecting diet selection by sheep. II. Height and density of Pasture. **Australian Journal of Agricultural Research**, Clayton, v. 35, n. 4, p. 565–578, 1984. Disponível em: <http://dx.doi.org/10.1071/AR9840565>.

BLAKE, S.; HAMILTON, I. D.; KARESH, W. B. GPS Telemetry of forest elephants in central Africa: results of a preliminary study. **African Journal of Ecology**, West Sussex, v. 39, n. 2, p. 178–186, 2001. Disponível em: <http://dx.doi.org/10.1046/j.1365-2028.2001.00296.x>.

BOISSY, A.; BOUISSOU, M. F. Effects of early handling on heifers' subsequent reactivity to humans and to unfamiliar situations. **Applied Animal Behaviour Science**, Amsterdam, v. 20, p. 259–273, 1988. Disponível em: <http://dx.doi.org/10.1 016/0168-1591(88)90051-2>.

BOIVIN, X.; LE NEINDRE, P.; CHUPIN, J. M.; GAREL, J. P.; TRILLAT, G. Influence of breed and early management on ease of handling and open-field behaviour of cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 32, n. 4 p. 313–23, 1992. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(05)80024-3>.

BOIVIN, X.; LE NEINDRE, P.; GAREL, J. P.; CHUPIN, J. M. Influence of breed and rearing management on cattle reactions during human handling. **Applied Animal Behaviour Science**, Amsterdam, v. 39, n. 2, p. 115–122. 1994. Disponível em: <http://dx.doi.org/10.1016/0168-1591(94)90131-7>.

BROOM, D. M. Cognitive ability and awareness in domestic animals and decisions about obligations to animals. **Applied Animal Behaviour Science**, Amsterdam, v. 126, n. 1, p. 1–11, 2010. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2010.05.001>.

BROOM, D. M.; FRASER, A. F. **Comportamento e bem-estar de animais domésticos**. 4. ed. Barueri: Editora Manole, 2010. 452 p.

BURROUGH, P. A GIS and geostatistics: Essential partners for spatial analysis. **Environmental and Ecological Statistics**, New York, v. 8, n. 4, p. 361–377, 2001. Disponível em: <http://dx.doi.org/10.1023/A:1012734519752>.

BURROW, H. M. Measurements of temperament and their relationships with performance traits of beef cattle. **Animal Breeding Abstracts**, Oxfordshire, v. 65, n. 7, p. 477–495, 1997.

BURROW, H. M.; CORBET, N. J. Genetic and environmental factors affecting temperament of zebu and zebu-derived beef cattle grazed at pasture in the tropics. **Australian Journal of Agricultural Research**, Clayton, v. 51, n. 1, p. 155–162, 2000. Disponível em: <http://dx.doi.org/10.1071/AR99053>.

BURROW, H. M.; DILLON, R. D. Relationships between temperament and growth in a feedlot and commercial carcass traits of Bos indicus crossbreds. **Australian Journal of Experimental Agriculture**, Clayton, v. 37, n. 4, p. 407–411, 1997. Disponível em: <http://dx.doi.org/10.1071/EA96148>.

BURROW, H. M.; SEIFERT, G. W.; CORBET, N. J. A new technique for measuring temperament in cattle. **Australian Society of Animal Production**, Toowong, v. 17, p. 154–157, 1988.

CAFE, L. M., ROBINSON, D. L.; FERGUSON, D. M.; GEESINK, G. H.; GREENWOOD, P. L. Temperament and hypothalamic-pituitary-adrenal axis function are related and combine to affect growth, efficiency, carcass, and meat quality traits in Brahman steers. **Domestic Animal Endocrinology**, Philadelphia, v. 40, n. 4, p. 230–240, 2011a. Disponível em: <http://dx.doi.org/10.1016/j.domaniend.2011.01.005>.

CAFE, L. M.; ROBINSON, D. L.; FERGUSON, D. M.; MCINTYRE, B. L.; GEESINK, G. H.; GREENWOOD, P. L. Cattle temperament: Persistence of assessments and associations with productivity, efficiency, carcass and meat quality traits. **Journal of Animal Science**, Champaign, v. 89, n. 5, p. 1452–1465, 2011b. Disponível em: <http://dx.doi.org/10.2527/jas.2010-3304>.

CARVALHAL, M. V. L. **Temperamento de búfalas em lactação e suas relações com o uso do espaço e a produção e qualidade do leite**. 2014. 66 f. Dissertação (Mestrado em Zootecnia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista “Júlio de Mesquita Filho”, Jaboticabal, 2014.

CARVALHO, P. C. F.; KOZLOSKI, G. V.; RIBEIRO FILHO, H. M. N.; REFFATTI, M. V.; GENRO, T. C. M.; EUCLIDES, V. P. B. Avanços metodológicos na determinação do consumo de ruminantes em pastejo. **Revista Brasileira de Zootecnia**, Viçosa, v. 36, sup. 0, 2007. Disponível em: <http://dx.doi.org/10.1590/S1516-35982007001000016>.

CARVALHO, P. C. F.; BATELLO, C. Access to land, livestock production and ecosystem conservation in the Brazilian Campos biome: the natural grasslands dilemma. **Livestock Science**, Amsterdam, v. 120, n. 1–2, p. 158–162, 2009. Disponível em: <http://dx.doi.org/10.1016/j.livsci.2008.04.012>.

CARVALHO, P. C. F.; PRACHE, S.; DAMASCENO, J. C. O processo de pastejo: desafios da procura e apreensão da forragem pelo herbívoro. In: PENZ JÚNIOR, A. M.; AFONSO, L. O. B.; WASSERMANN, G. J. (Eds.). REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 36., 1999, Porto Alegre. **Anais...** Porto Alegre: Sociedade Brasileira De Zootecnia, 1999. p. 253–268.

CEBALLOS BETANCOURT, M. C. **Efeito de diferentes frequências de manejos no temperamento de bovinos de corte**. 2014. 70 f. Dissertação (Mestrado em Zootecnia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista “Júlio de Mesquita Filho”, Jaboticabal, 2014.

CHAMPION, R. A.; RUTTER, S. M.; PENNING, P. D. An automatic system to monitor lying, standing and walking behaviour of grazing animals. **Applied Animal Behaviour Science**, Amsterdam, v. 54, n. 4, p. 291–305, 1997. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(96)01210-5>.

COOKE, R. F.; ARTHINGTON, J. D.; AUSTIN, B. R.; YELICH, J. V. Effects of acclimation to handling on performance, reproductive, and physiological responses of Brahman-crossbred heifers. **Journal of Animal Science**, Champaign, v. 87, n. 10, p. 3403–3412, 2009. Disponível em: <http://dx.doi.org/10.2527/jas.2009-1910>.

CURLEY JÚNIOR, K. O.; PASCHAL, J. C.; WELSH, T. H.; RANDEL, R. D. Technical note: Exit velocity as a measure of cattle temperament is repeatable and associated with serum concentration of cortisol in Brahman bulls. **Journal of Animal Science**, Champaign, v. 84, n. 11, p. 3100–3103, 2006. Disponível em: <http://10.2527/jas. 2006-055>.

DEL CAMPO, M.; BRITO, G.; SOARES DE LIMA, J.; HERNÁNDEZ, P.; MONTOSSI, F. Finishing diet, temperament and lairage time effects on carcass and meat quality traits in steers. **Meat Science**, Amsterdam, v. 86, n. 4, p. 908–914, 2010. Disponível em: <http://dx.doi.org/10.1016/j.meatsci.2010.07.014>.

DOHI, H.; YAMADA, A.; ENTSU, S. Cattle feeding deterrents emitted from cattle faeces. **Journal of Chemical Ecology**, New York, v. 17, n. 6, p. 1197–1203, 1991. Disponível em: <http://10.1007/BF01402943>.

DUCKWORTH, J. E.; SHIRLAW, D. W. The development of an apparatus to record the jaw movements of cattle. **The British Journal of Animal Behaviour**, London, v. 3, n. 2, p. 56–60, 1955. Disponível em: <http://dx.doi.org/10.1016/S0950-5601(55)80013-5>.

DUSSAULT, C.; COURTOIS, R.; OUELLET, J. P.; HUOT, J. Evaluation of GPS telemetry collar performance for habitat studies in the boreal forest. **Wildlife Society Bulletin**, Hoboken, v. 27, n. 4, p. 965–972, 1999.

ELZO, M. A.; RILEY, D. G.; HANSEN, G. R.; JOHNSON, D. D.; MYER, R. O.; COLEMAN, S. W.; CHASE, C. C.; WASDIN, J. G.; DRIVER, J. D. Effect of breed composition on phenotypic residual feed intake and growth in Angus, Brahman, and Angus × Brahman crossbred cattle. **Journal of Animal Science**, Champaign, v. 87, n. 12, p. 3877–3886, 2009. Disponível em: <http://10.2527/jas.2008-1553>.

FELL, L. R.; COLDITZ, I. G.; WALKER, K. H.; WATSON, D. L. Associations between temperament, performance and immune function in cattle entering a commercial feedlot. **Australian Journal of Experimental Agriculture**, Clayton, v. 39, n. 7, p. 795–802, 1999. Disponível em: <http://dx.doi.org/10.2527/jas.2008-1553>.

FORBES J. M. A personal view of how ruminant animals control their intake and choice of food: minimal total discomfort. **Nutrition Research Reviews**, Cambridge, v. 20, n. 2, p. 132–146, 2007. Disponível em: <http://dx.doi.org/10.1017/S095442240 7797834>.

FORBES J. M. The multifactorial nature of food intake control. **Journal Animal Science**, Champaign, v. 81, n. 14, sup. 2, p. 139–144, 2003. Disponível em: <http://dx.doi.org/doi:/2003.8114_suppl_2E139x>.

FORBES, J. M. Consequences of feeding for future feeding. **Comparative Biochemistry and Physiology – Part A: Molecular & Integrative Physiology**, Philadelphia, v. 128, n. 3, 461–468, 2001. Disponível em: <http://dx.doi.org/10.1016/S1095-6433(00)00328-7>.

FORDYCE, G.; DODT, R. M.; WYTHES, J. R. Cattle temperaments in extensive beef herds in northern Queensland 1. Factors affecting temperament. **Australian Journal of Experimental Agriculture**, Clayton, v. 28, n. 6, p. 683–687, 1988. Disponível em: <http:dx.doi.org/10.1071/EA9880683>.

FORDYCE, G.; GODDARD, M. E.; SEIFERT, G. W. The measurement of temperament in cattle and the effect of experience and genotype. **Animal Production in Australia**, Toowong, v. 14, p. 329–332, 1982.

FORDYCE, G.; GODDARD, M. E.; TYLER, R.; WILLIAMS, G.; TOLEMAN, M. A. Temperament and bruising of Bos indicus cross cattle. **Australian Journal of Experimental Agriculture**, Clayton, v. 25, n. 2, p. 283–288, 1985. Disponível em: <http://dx.doi.org/10.1071/EA9850283>.

FRANCISCO, C. L.; COOKE, R. F.; MARQUES, R. S.; MILLS, R. R.; BOHNERT, D. W. Effects of temperament and acclimation to handling on feedlot performance of Bus taurus feeder cattle originated from a rangeland-based cow-calf system. **Journal of Animal Science**, Champaign, v. 90, n. 13, p. 5067–5077, 2012. Disponível em: <http://dx.doi.org/10.2527/jas.2012-5447>.

FROST, A. R.; SCHOFIELD, C. P.; BEAULAH, S. A.; MOTTRAM, T. T.; LINES, J. A.; WATHES, C. M. A review of livestock monitoring and the need for integrated systems. **Computers and Electronics in Agriculture**, Amsterdam, v. 17, n. 2, p. 139–159, 1997. Disponível em: <http://dx.doi.org/10.1016/S0168-1699(96)01301-4>.

FRYXELL, J. M.; FORTIN, C. B. D.; WILMSHURST, J. On the scale dependence of foraging in terrestrial herbivores. In: INTERNATIONAL GRASSLAND CONGRESS, 19., 2001, São Pedro. **Proceedings…** São Pedro: ABZ, 2001. p. 271–275.

GANSKOPP, D. Manipulating cattle distribution with salt and water in large arid-land pastures: A GPS/GIS assessment. **Applied Animal Behaviour Science**, Amsterdam, v. 73, n. 4, p. 251–262, 2001. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(01)00148-4>.

GANSKOPP, D.; CRUZ, R. Selective differences between naive and experienced cattle foraging among eight grasses. **Applied Animal Behaviour Science**, Amsterdam, v. 62, n. 4, p. 293–303, 1999.

GONZÁLEZ, L. A.; BISHOP-HURLEY, G. J.; HANDCOCK, R. N.; CROSSMAN, C. Behavioral classification of data from collars containing motion sensors in grazing cattle. **Computers and Electronics in Agriculture**, Amsterdam, v. 10, p. 91–102, 2015. Disponível em: <http://dx.doi.org/10.1016/j.compag.2014.10.018>.

GRANDIN, T. Behavioral agitation during handling of cattle is persistent over time. **Applied Animal Behaviour Science**, Amsterdam, v. 36, n.1, p. 1–9, 1993. Disponível em: <http://dx.doi.org/10.1016/0168-1591(93)90094-6>.

GRAUNKE, K. L.; NÜRNBERG, G.; REPSILBER, D.; PUPPE, B.; LANGBEIN, J. Describing Temperament in an Ungulate: A Multidimensional Approach. **Plos One**, San Francisco, v. 8, n. 9, e74579, p. 1–12, 2013. Disponível em: <http://dx.doi.org/10.1371/journal.pone.0074579>.

GREGORINI, P.; GUNTER, S. A.; BECK, P. A.; CALDWELL, J.; BOWMAN, M. T.; COBLENTZ, W. K. Short–term foraging dynamics of cattle grazing swards with different canopy structures. **Journal of Animal Science**, Champaign, v. 87, n. 11, p. 3817–3824, 2009. Disponível em: <http://dx.doi.org/10.2527/jas.2009-2094>.

GWYNNE, M. D.; KINGABY, G. P. A grazing zebu type. **Journal of Range Management**, Littleton, v. 29, n. 3, p. 260–262, 1976.

HASKELL, M. J.; SIMM, G.; TURNER, S. P. Genetic selection for temperament traits in dairy and beef cattle. **Frontiers in Genetics**, Lausanne, v. 5, n. 368, p. 1–18, 2014. Disponível em: <http://dx.doi.org/10.3389/fgene.2014.00368>.

HEMSWORTH, P. H.; COLEMAN, G. J.; BARNETT, J. L.; BORG, S. Relationships between human-animal interactions and productivity of commercial dairy cows. **Journal of Animal Science**, Champaign, v. 78, n. 11, p. 2821–2831, 2000. Disponível em: <http:dx.doi.org/2000.78112821x>.

HOLROYD, R. G.; PETHERICK, J. C.; VENU, B. K.; DOOGAN, V. J. Effects of grouping feedlot steers with a range of flight speeds on live weight and temperament changes. **Asian Australasian Journal of Animal Sciences**, Seoul, v. 13, suppl. B, p. 188, 2000.

HOPPE, S.; BRANDT, H. R.; KÖNIG, S.; ERHARDT, G.; GAULY, M. Temperament traits of beef calves measured under field conditions and their relationships to performance. **Journal of Animal Science**, Champaign, v. 88, n. 6, p. 1982–1989, 2010. Disponível em: <http://dx.doi.org/10.2527/jas.2008-1557>.

HOWERY, L. D.; PROVENZA, F. D.; BANNER, R. E., SCOTT, C. B. Social and environmental factors influence cattle distribution on rangeland. **Applied Animal Behaviour Science**, Amsterdam, v. 55, n. 3–4, p. 231–244, 1998. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(97)00054-3>.

HULBERT, I. A. R.; FRENCH, J. The accuracy of GPS for wildlife telemetry and habitat mapping. **Journal of Applied Ecology**, West Sussex, v. 38, n. 4, p. 869–878, 2001. Disponível em: <http://dx.doi.org/10.1046/j.1365-2664.2001.00624.x>.

HUTCHINGS, M. R.; KYRIAZAKIS, I.; ANDERSON, D. H.; GORDON, I. J.; COOP, R. L. Behavioural strategies used by parasitised and non-parasitised sheep to avoid ingestion of gastrointestinal nematodes. **Animal Science**, Cambridge, v. 67, n. 1, p. 97–106, 1998. Disponível em: <http://dx.doi.org/10.1017/S1357729800009838>.

KILGOUR, R. J.; MELVILLE, G. J.; GREENWOOD, P. L. Individual differences in the reaction of beef cattle to situations involving social isolation, close proximity of humans, restraint and novelty. **Applied Animal Behaviour Science**, Amsterdam, v. 99, n. 1–2, p. 21–40, 2006. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2005.09.012>.

KILGOUR, R. J. In pursuit of “normal”: A review of the behaviour of cattle at pasture. **Applied Animal Behaviour Science**, Amsterdam, v. 138, n. 1, p. 1–11, 2012a. Disponível em <http://dx.doi.org/10.1016/j.applanim.2011.12.002>.

KILGOUR, R. J.; UETAKE, K.; ISHIWATA, T; MELVILLE, G. J. The behaviour of beef cattle at pasture. **Applied Animal Behaviour Science**, Amsterdam, v. 138, n. 1–2, p. 12–17, 2012b. Disponivel em: <http://dx.doi.org/10.1016/j.applanim.2011.12.001>.

KOOLHAAS, J. M.; DE BOER, S. F.; BUWALDA, B.; VAN REENEN, K. Individual variation in coping with stress: a multidimensional approach of ultimate and proximate mechanisms. **Brain, Behavior and Evolution**, Basel, v. 70, n. 4, p. 218–226, 2007. Disponível em: <http://dx.doi.org/10.1159/000105485>.

KOOLHAAS, J. M.; KORTE, S. M.; DE BOER, S. F.; VAN DER VEGT, B. J.; VAN REENEN, C. G.; HOPSTER, H.; DE JONG, I. C.; RUIS, M. A.; BLOKHUIS, H. J. Coping styles in animals: Current status in behavior and stress-physiology. **Neuroscience & Biobehavioral Reviews**, Oxford, v. 23, n. 7, p. 925–935, 1999. Disponível em: <http://dx.doi.org/10.1016/S0149-7634(99)00026-3>.

LACA, E. A. Precision livestock production: tools and concepts. **Revista Brasileira de Zootecnia**, Viçosa, v. 38, n. especial, p. 123–132, 2009. Disponível em: <http://dx.doi.org/10.1590/S1516-35982009001300014>.

LACA, E. A.; DEMMENT, M. W. Modelling intake of a grazing ruminant in a heterogeneous environment. In: INTERNATIONAL SYMPOSIUM ON VEGETATION: HERBIVORE RELATIONSHIPS, 24., New York. **Proceedings…** New York: Academic Press, 1992. p. 57–76.

LANGVATN, R.; HANLEY, T. A. Feeding patch choice by red deer in relation to forging efficiency. **Oecologia**, Heidelberg, v. 95, n. 2, p. 164–170, 1993. Disponível em: <http://dx.doi.org/10.1007/BF00323486>.

LAUNCHBAUGH, K. L.; HOWERY, L. D. Understanding landscape use patterns of livestock as a consequence of foraging behavior. **Rangeland Ecology & Management**, Littleton, v. 58, n. 2, p. 99–108, 2005. Disponível em: <http://dx.doi.org/10.2111/03-146.1>.

LAUNCHBAUGH, K. L.; WALKER, J. W; TAYLOR, C. A. Foraging behavior: experience or inheritance? In: LAUNCHBAUGH, K. L.; MOSLEY, J. C.; SANDERS, K. D. (Eds.). **Grazing Behavior of Livestock and Wildlife:** Pacific Northwest Range Short Course. Moscow: University of Idaho, 1999. p. 28–35.

MACKAY, J. R. D.; TURNER, S. P.; HYSLOP, J.; DEAG, J. M.; HASKELL, M. J. Short-term temperament tests in beef cattle relate to long-term measures of behavior recorded in the home pen. **Journal of Animal Science**, Champaign, v. 91, n. 10, p. 4917–4924. 2013. Disponível em: <http://dx.doi.org/10.2527/jas.2012-5473>.

MANTECA, X.; DEAG, J. M. Individual differences in temperament of domestic animals: A review of methodology. **Animal Welfare**, London, v. 2. n. 3, p. 247–268, 1993.

MANTECA, X.; VILLALBA, J. J.; ATWOOD, S. B.; DZIBA, L. E; PROVENZA, F. D. Is dietary choice important to animal welfare? **Journal of Veterinary Behavior: Clinical Applications and Research**, Philadelphia, v. 3, n. 5, p. 229–239, 2008. Disponível em: <http://dx.doi.org/ 10.1016/j.jveb.2008.05.005>.

MATSUI, K.; OKUBO, T. A method for quantification of jaw movements suitable for use on free-ranging cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 32, n. 1–2, p. 107–116, 1991. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(05)8003 5-8>.

MERTENS, D. R. Methods in modelling feeding behaviour and intake in herbivores. **Annales de Zootechnie**, Paris, v. 45, sup. 1, p. 153–164, 1996.

MEZZALIRA, J. C.; CARVALHO, P. C. F.; FONSECA, L.; BREMM, C.; REFFATTI, M. V.; POLI, C. H. E. C.; TRINDADE, J. K. Aspectos metodológicos do comportamento ingestivo de bovinos em pastejo. **Revista Brasileira de Zootecnia**, Viçosa, v. 40, n. 5, p. 1114–1120, 2011. Disponível em: <http://dx.doi.org/10.1590/S1516-359820110005 00024>.

MEZZALIRA, J. C., BREMM, C., DA TRINDADE, J. K., NABINGER, C.; CARVALHO, P. C. F. The ingestive behaviour of cattle in large-scale and its application to pasture management in heterogeneous pastoral environments. **Journal of Agricultural Science and Technology**, Tehran, v. A 2, n. 7, p. 909–916, 2012.

MOEN, R.; PASTOR, J.; COHEN, Y.; SCHWARTZ, C. C. Effects of moose movement and habitat use on GPS collar performance. **The Journal of Wildlife Management**, Hoboken, v. 60, n. 3, p. 659–668, 1996. Disponível em: <http://dx.doi.org/10.2307/ 3802085>.

MÜLLER, R.; VON KEYSERLINGK, M. A. G. Consistency of flight speed and its correlation to productivity and to personality in Bos Taurus beef cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 99, n. 3–4, p. 193–204, 2006. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2005.05.012>.

NADIMI, E. S.; SØGAARD, H. T.; BAK, T. ZigBee-based wireless sensor networks for classifying the behaviour of a herd of animals using classification trees. **Biosystems Engineering**, London, v. 100, n. 2, p. 167–176, 2008. Disponível em: <http://dx.doi.org/10.1016/j.biosystemseng.2008.03.003>.

NKRUMAH, D.; CREWS, H.; BASARAB JR., J. A.; PRICE, M. A.; OKINE, E. K.; WANG, Z.; LI, C.; MOORE, S. S. Genetic and phenotypic relationships of feeding behavior and temperament with performance, feed efficiency, ultrasound, and carcass merit of beef cattle. **Journal of Animal Science**, Champaign, v. 85, n. 10, p. 2382–2390, 2007. Disponível em: <http://dx.doi.org/10.2527/jas.2006-657>.

OLMOS, G.; TURNER, S. P. The relationships between temperament during routine handling tasks, weight gain and facial hair whorl position in frequently handled beef cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 115, n. 1–2, p. 25–36, 2008. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2008.05.001>.

O'SHEA, J. Evaluation of a simple device for measuring the time animals spend grazing. **Irish Journal of Agricultural Research**, Carlow, v. 8, n. 3, p. 329–335. 1969.

PARANHOS DA COSTA, M. J. R. Comportamento de bovinos durante o manejo: Interpretando os conceitos de temperamento e reatividade. In: SEMINÁRIO NACIONAL DE CRIADORES E PESQUISADORES, 11., 2002, Ribeirão Preto. **Anais...** Ribeirão Preto: ANCP, 2002. p. 1–5.

PARSONS, A. J.; SCHWINNING, S.; CARRERE, P. Plant growth functions and possible spatial and temporal scaling errors in models of herbivory. **Grass and Forage Science**, West Sussex, v. 56, n. 1, 21-34. 2001. Disponível em: <http://dx.doi.org/10.1046/j.1365-2494.2001.00243.x>.

PÁSCOA, A.G. **Comportamento de bovinos da raça Nelore mantidos em pastagem de Cynodon spp cv Tifton 85:** defecação e rejeição da forragem contaminada por fezes. 2005. 50 f. Dissertação (Mestrado em Zootecnia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista "Júlio de Mesquita Filho", Jaboticabal, 2005.

PENNING, P. D.; STEEL, G. L.; JOHNSON, R. H. Further development and use of an automatic recording system in sheep grazing studies. **Grass and Forage Science**, West Sussex, v. 39, n. 4, p. 345–351, 1984. Disponível em: <http://dx.doi.org/10.1111/j.1365-2494.1984.tb01706.x>.

PETHERICK, J. C.; HOLROYD, R. G.; DOOGAN, V. J.; VENUS, B. K. Productivity, carcass and meat quality of lot-fed Bos indicus cross steers grouped according to temperament. **Australian Journal of Experimental Agriculture**, Clayton, v. 42, n. 4, p. 389–398, 2002. Disponível em: <http://dx.doi.org/10.1071/EA01084>.

PETHERICK, J. C.; HOLROYD, R. G.; SWAIN, A. J. Performance of lot-fed Bos indicus steers exposed to aspects of a feedlot environment before lot-feeding. **Animal Production Science**, Clayton, v. 43, n. 10, p. 1181–1191, 2003. Disponível em: <http://dx.doi.org/10.1071/EA02118>.

PETHERICK, J. C.; DOOGAN, V. J.; HOLROYD, R. G., OLSSON, P; VENUS, B. K. Quality of handling and holding yard environment, and beef cattle temperament: 1. Relationships with flight speed and fear of humans. **Applied Animal Behaviour Science**, Amsterdam, v. 120, n. 1–2, p. 18–27, 2009. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2009.05.008>.

PIOVEZAN, U.; CYRILLO, J. N. D. S. G.; PARANHOS DA COSTA, M. J. R. Breed and selection line differences in the temperament of beef cattle. **Acta Scientiarum, Animal Sciences**, Maringá, v. 35, n. 2, p. 207–212, 2013. Disponível em: <http://dx.doi.org/10.4025/actascianimsci.v35i2.16426>.

PROVENZA, F. D.; LAUNCHBAUGH, K. L. **Foraging on the edge of chaos**. Grazing behavior of livestock and wildlife. Moscow: University of Idaho, 1999. 12 p.

PROVENZA, F. D.; VILLALBA, J. J; DZIBA, L. E.; ATWOOD, S. B.; BANNER, R. E. Linking herbivore experience, varied diets, and plant biochemical diversity. **Small Ruminant Research**, Amsterdam, v. 49, n. 3, p. 257–274, 2003. Disponível em: <http://dx.doi.org/10.1016/S0921-4488(03)00143-3>.

RÉALE, D.; READER, S. M.; SOL, D.; MCDOUGALL, P. T.; DINGEMANSE, N. J. Integrating animal temperament within ecology and evolution. **Biological Reviews of the Cambridge Philosophical Society**, West Sussex, v. 82, n. 2, p. 291–318, 2007. Disponível em: <http://dx.doi.org/10.1111/j.1469-185X.2007.00010.x>.

REINHARDT, C. D.; BUSBY, W. D.; CORAH, L. R. Relationship of various incoming cattle traits with feedlot performance and carcass traits. **Journal of Animal Science**, Champaign, v. 87, n 9, p. 3030–3042, 2009. Disponível em: <http://dx.doi.org/10.2527/jas.2008-1293>.

RIGGS, R.; URNESS, P. J.; GONZALEZ, K. A. Effects of domestic goats on deer wintering in Utah oakbrush. **Journal of Range Management**, Littleton v. 43, n. 3, p. 229–234, 1990. Disponível em: <http://dx.doi.org/10.2307/3898679>.

ROBERT, B.; WHITE, B. J.; RENTER, D. G.; LARSON, R. L. Evaluation of three-dimensional accelerometers to monitor and classify behavior patterns in cattle. **Computers and Electronics in Agriculture**, Amsterdam, v. 67, n. 1–2, p. 80–84, 2009. Disponível em: <http://dx.doi.org/10.1016/j.compag.2009.03.002>.

ROUDA, R. R.; ANDERSON, D. M.; MURRAY, L. W.; SMITH, J. N. Distance traveled by free-ranging supplemented and non-supplemented lactating and non-lactating cows. **Applied Animal Behaviour Science**, Amsterdam, v. 28, n. 3, p. 221–232, 1990. Disponível em: <http://dx.doi.org/10.1016/0168-1591(90)90101-I>.

RUCKEBUSCH, Y.; BUENO, L. An analysis of ingestive behaviour and activity of cattle under field conditions. **Applied Animal Ethology**, Amsterdam, v. 4, n. 4, p. 301–313, 1978. Disponível em: <http://dx.doi.org/10.1016/0304-3762(78)90002-0>.

RUTTER, S. M. Graze: a program to analyze recordings of the jaw movements of ruminants. **Behavior Research Methods, Instruments & Computers**, New York, v. 32, n. 1, 86–92, 2000. Disponível em: <http://dx.doi.org/10.3758/BF03200791>.

RUTTER, S. M.; CHAMPION, R. A.; PENNING, P. D. An automatic system to record foraging behaviour in free-ranging ruminants. **Applied Animal Behaviour Science**, Amsterdam, v. 54, n. 2–3, p. 185–195, 1997. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(96)01191-4>.

SANT'ANNA, A. C. **Métodos para avaliação do temperamento de bovinos:** Estimação de parâmetros genéticos e relações com o desempenho. 2013. 117 f. Tese (Doutorado em Zootecnia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista "Júlio de Mesquita Filho" Jaboticabal, 2013.

SANT’ANNA, A. C.; PARANHOS DA COSTA, M. J. R.; BALDI, F.; RUEDA, P. M.; ALBUQUERQUE, L. G. Genetic associations between flight speed and growth traits in Nellore cattle. **Journal of Animal Science**, Champaign, v. 90, n. 10, p. 3427–3432, 2012. Disponível em: <http://dx.doi.org/10.2527/jas.2011-5044>.

SCHLECHT, E.; HÜLSEBUSCH, C.; MAHLER, F.; BECKER, K. The use of differentially corrected global positioning system to monitor activities of cattle at pasture. **Applied Animal Behaviour Science**, Amsterdam, v. 85, n. 3–4, p. 185–202, 2004. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2003.11.003>.

SCHWAGER, M.; ANDERSON, D. M.; BUTLER, Z; RUS, D. Robust classification of animal tracking data. **Computers and Electronics in Agriculture**, Amsterdam, v. 56, n. 1, p. 46–59, 2007. Disponível em: <http://dx.doi.org/10.1016/j.compag.2007.01 .002>.

SCHWARTZKOPF-GENSWEIN, K. S.; STOOKEY, J. M.; JANZEN, E. D.; MCKINNON, J. Effects of branding on weight gain, antibiotic treatment rates and subsequent handling ease in feedlot cattle. **Canadian Journal of Animal Science**, Ottawa, v. 77, n. 3, p. 361–367, 1997. Disponível em: <http://dx.doi.org/10.4141/A96-104>.

SEBASTIAN, T.; WATTS, J.; STOOKEY, J.; BUCHANAN, F.; WALDNER, C. Temperament in beef cattle: Methods of measurement and their relationship to production. **Canadian Journal of Animal Science**, Ottawa, v. 91, n. 4, p. 557–565, 2011. Disponível em: <http://dx.doi.org/10.4141/CJAS2010-041>.

SENFT, R. L.; COUGHENOUR, M. B.; BAILEY, D. W.; RITTENHOUSE, L. R.; SALA, O. E.; SWIFT, D. M. Large herbivore foraging and ecological hierarchies. **Bioscience**, Paris, v. 37, n. 11, p. 789–799. 1987. Disponível em: <http://dx.doi.org/10.2307/1310545>.

SHIPLEY, L. A. The influence of bite size on foraging at larger spatial and temporal scales by mammalian herbivores. **Oikos**, Medellin, v. 116, n. 12, p. 1964–1974, 2007. Disponível em: <http://dx.doi.org/10.1111/j.2007.0030-1299.15974.x>.

SIBBALD, A. M.; SMITH, D. J. F.; HOOPER, R. J. Individual differences in sociability and their consequences for foraging in sheep. **Proceedings of the Britsh Society of Animal Science**, Scotland Midlothian, v. 129, p. 129, 2000.

SIH, A.; BELL, A.; JOHNSON, J. C. Behavioral syndromes: An ecological and evolutionary overview. **Trends in Ecology and Evolution**, Oxford, v. 19, n. 7, p. 272–278, 2004. Disponível em: <http://dx.doi.org/10.1016/j.tree.2004.04.009>.

SMITH, M. S. **Modelling:** three approaches to predicting how herbivore impact is distributed in rangelands. New Mexico: State University Agricultural Experiment Station Research Report, 1988. 628 p.

SOWELL, B. F.; BOWMAN, J. G. P.; BRANINE, M. E.; HUBBERT, M. E. Radio frequency technology to measure feeding behavior and health of feedlot steers. **Applied Animal Behaviour Science**, Amsterdam, v. 59, n ° 4, p. 277-284, 1998. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(98)00110-5>.

STOBBS, T. H. Automatic measurement of grazing time by dairy cows on tropical grass and legume pastures. **Tropical Grasslands**, St Lucia, v. 4, n. 3, p. 237-244, 1970.

SWAIN, D. L.; FRIEND, M. A.; BISHOP-HURLEY, G. J.; HANDCOCK, R. N.; WARK, T. Tracking livestock using global positioning systems–are we still lost? **Animal Production Science**, Clayton, v. 51, n. 3, p. 167-175, 2011. Disponível em: <http://dx.doi.org/10.1071/AN10255>.

SWAIN, D. L.; WARK, T.; BISHOP-HURLEY, G. J. Using high fix rate GPS data to determine the relationships between fix rate, prediction errors and patch selection. **Ecological Modelling**, Amsterdam, v. 212, n. 3–4, p. 273–279, 2008. Disponível em: <http://dx.doi.org/10.1016/j.ecolmodel.2007.10.027>.

TITTO, E. A. L.; TITTO, C. G.; GATTO, E. G.; NORONHA, C. M. S.; MOURÃO, G. B.; NOGUEIRA FILHO, J. C. M.; PEREIRA, A. M. F. Reactivity of Nellore steers in two feedlot housing systems and its relationship with plasmatic cortisol. **Livestock Science**, Amsterdam, v. 129, n. 1-3, p. 146–150, 2010. Disponível em: <http://dx.doi:10.1016/j.livsci.2010.01.017>.

TURNER, L. W; UDAL, M. C.; LARSON, B. T.; SHEARER, S. A. Monitoring cattle behavior and pasture use with GPS and GIS. **Canadian Journal of Animal Science**, Ottawa, v. 80, n. 3, p. 405–413, 2000. Disponível em: <http://dx.doi.org/10.4141/A99-093>.

TURNER, S. P.; NAVAJAS, E. A.; HYSLOP, J. J.; ROSS, D. W.; RICHARDSON, R. I.; PRIETO, N.; BELL, M.; JACK, M. C.; ROEHE, R. Associations between response to handling and growth and meat quality in frequently handled beef cattle. **Journal of Animal Science**, Champaign, v. 89, n. 12, p. 4239–4248, 2011. Disponível em: <http://dx.doi.org/10.2527/jas.2010-3790>.

UMSTÄTTER, C.; WATERHOUSE, A.; HOLLAND, J. P. An automated sensor-based method of simple behavioural classification of sheep in extensive systems. **Computers and Electronics in Agriculture**, Amsterdam, v. 64, n. 1, p. 19–26, 2008. Disponível em: <http://dx.doi.org/10.1016/j.compag.2008.05.004>.

UNGAR, E. D.; HENKIN, Z.; GUTMAN, M.; DOLEV, A.; GENIZI, A.; GANSKOPP, D. Inference of animal activity from GPS collar data on free–ranging cattle. **Rangeland Ecology & Management**, Wheat Ridge, v. 58, n. 3, p. 256–266, 2005. Disponível em: <http://dx.doi.org/10.2111/1551-5028(2005)58[256:IOAAFG]2.0.CO;2>.

UNGAR, E. D.; RUTTER, S. M. Classifying cattle jaw movements: comparing IGER behaviour recorder and acoustic techniques. **Applied animal behaviour science**, Amsterdam, v. 98, n. 1, p. 11-27, 2006. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2005.08.011>.

UNGAR, E. D., SCHOENBAUM, I., HENKIN, Z., DOLEV, A., YEHUDA, Y.; BROSH, A. Inference of the activity timeline of cattle foraging on a Mediterranean woodland using GPS and pedometry. **Sensors**, Basel, v. 11, n. 1, p. 362–383. 2011. Disponível em: <http://dx.doi.org/10.3390/s110100362>.

VALENTE, E. E. L.; PAULINO, M. F.; DETMANN, E.; VALADARES FILHO, S. C.; CHIZZOTTI, M. L.; SILVA, A. G.; MACIEL, I. F. S., Grazing Behavior and Locomotion of Young Bulls Receiving Different Nutritional Plans in a Tropical Pasture. **Asian Australasian Journal of Animal Sciences**, Seoul, v. 26, n. 12, p. 1717–1725, 2013. Disponível em: <http://dx.doi.org/10.5713%2Fajas.2013.13165>.

VILLALBA, J. J.; SODER, K. J.; LACA, E. A. Understanding diet selection in temperate biodiverse pasture systems. **Rangeland Ecology and Management**, Littleton, v. 62, p. 387–388, 2009. <http://dx.doi.org/10.2111/09-003.1>.

VOISINET, B. D.; GRANDIN, T.; TATUM, J. D.; O'CONNOR, S. F.; STRUTHERS, J. J. Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. **Journal of Animal Science**, Champaign, v. 75, n. 4, p. 892–896, 1997a. Disponível em: <http://dx.doi.org/1997.754892x>.

VOISINET, B. D.; GRANDIN, T.; TATUM, J. D.; O'CONNOR, S. F.; DEESING, M. J. Bos indicus-cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. **Meat Science**, Amsterdam, v. 46, n. 4, p. 367–377, 1997b. Disponível em: <http://dx.doi.org/10.1016/S0309-1740(97)00031-4>.

WALLIS DE VRIES, M. F.; SCHIPPERS, P. Foraging in a landscape mosaic: selection for energy and minerals in free-ranging cattle. **Oecologia**, Heidelberg, v. 100, n. 1-2, p.107-117, 1994. Disponível em: <http://dx.doi.org/10.1007/BF00317137>.

WECHSLER B. Coping and coping strategies: A behavioural view. **Applied Animal Behaviour Science**, Amsterdam, v. 43, n. 2, p. 123–34. 1995. Disponível em: <http://dx.doi:10.1016/0168-1591(95)00557-9>.

WESLEY, R. L.; CIBILS, A. F.; MULLINIKS, J. T.; POLLAK, E. R.; PETERSEN, M. K.; FREDRICKSOND, E. D. L. An assessment of behavioural syndromes in rangeland-raised beef cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 139, n. 3–4, p. 183–194, 2012. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2012.04.005>.

WOOD-GUSH, D. G. M.; VESTERGAARD, K. Inquisitive exploration in pigs. **Animal Behaviour**, London, v. 45, n. 1, p. 185-187, 1993. Disponível em: <http://dx.doi.org/10.1006/anbe.1993.1017>.

CHAPTER 2 – Assessing the behaviour of pasture-based beef cattle by using GPS collars with built-in tilt sensors

Abstract – To improve the objectivity and sensitivity of observational data collection, new advances in the field of livestock precision farming are increasingly applied to animal behaviour domestic studies. The aim of this study was to determine the thresholds for the prediction and classification of behaviour in pasture-based beef cattle using data obtained from GPS collars with built-in tilt sensors, and comparing this data with behavioural visual observations. A sample of 48 young bulls Nellore was distributed among 14 paddocks, receiving one of six the nutrition plan treatments, consisting of a combination of three tropical pastures heights (15, 25 and 35 cm) and two types of supplements (mineral or protein). Twelve animals per cycle were randomly selected to wear the GPS collar devices (Lotek®, 3300 LR), available for a period of 7 days. To structure the training dataset (dataset A), visual behavioural observations of the 39 animals were performed and then synchronized with the electronic dataset from the GPS collars (dataset C). Associations were found among the behavioural visual observations and the GPS collars, where two principal components (PC1 and PC2) explained 75.11% of the dataset variation. High positive loadings were shown principally for sum-XY-act (count), head down (%) (data from GPS collar), and grazing (GRA, from behavioural visually observed); while high negative loadings were found for ruminating (RUM, from behavioural visually observed). Thus, the category head down (%), had a high correlation coefficient ($P < 0.0001$) to GRA ($r = 0.76$) and to RUM ($r = -0.78$); while the other sensor's categories: horizontal axes (X-act), vertical axes (Y-act), sum vertical and horizontal (sum-XY-act) and the distance walked (m) had a low association among the behaviours visually observed. The results from the classification decision trees confirmed that head down (%) was the main variable used for predicting the behaviours; while that X-act, Y-act, sum-XY-act and distance (m) were bad predictors. The algorithm model from the classification decision trees that presented a lower misclassification rate of 13.98%, was chosen to predict and to classify the behaviours during the non-observed interval. This model showed a concordance of 78% for the predicted behaviour and high precision to predict GRA (90%) and RUM (76%), but low precision to Not-gra (59%). Afterwards, we applied the algorithm thresholds to the whole dataset (B) with unknown behaviours, and we obtained an average prediction of 38.8% for GRA, 44.2% for RUM and 17% for Not-gra. No significant differences were observed ($P > 0.05$) among the average frequencies of the three predicted behaviours (GRA, RUM and Not-gra), the different forage mass and the nutrition plans. The results of this study showed that GPS collars with tilt sensors can provide acceptable and useful information to predict and classify behaviours throughout the day and night on pasture-based beef cattle kept in small areas and can be a useful tool to assess individual grazing behaviour.

Keywords: behavioural classification, decision trees, grazing, livestock, tilt sensor

2.1 Introduction

Aiming to improve the objectivity and sensitivity of observational data collection, new advances in the field of livestock farming are increasingly applied to animal behaviour studies (TURNER et al., 2000). Foraging and grazing behaviour of domestic ungulates are the main focus of research carried out by many ethologists, animal nutritionists and grassland scientists to characterise the relationship between these animals and their environment, providing potential information to modify the pasture management, improving efficiency, and maximizing profits (GORDON, 1995; TURNER et al., 2000).

Developments in the field of Global Navigation Satellite Systems devices (such as Global Positioning System or GPS) increased the interest in using this technology to help researchers to evaluate the spatial distribution of animals, allowing a more accurate analysis of their dispersion in the environment (GANSKOPP, 2001; HULBERT; FRENCH, 2001). Furthermore, the prediction of different behaviours by these devices is achieved through linear discriminant analysis (SCHLECHT et al., 2004), using the distance variable from the sub-meter precision GPS data or from the GPS collars (BAILEY et al., 2008).

The GPS collars with built-in tilt sensors have emerged making possible to register the movements of the animals' head from 1 to 3 axes (vertical, horizontal and forward–backward). This information can be used to predict animals' activities on a 24-hour period for several days (e.g. time spent grazing, resting, travelling) by using regression models, discriminant analysis and cluster analysis (*K-means*) (BARBARI et al., 2006; SCHWAGER et al., 2007). Moreover, statistical tools such as the classification and decision tree algorithms have been used by several authors to turn electronic data into categorical behaviours (DE'ATH; FABRICIUS, 2000; NADIMI et al., 2008). The classification and decision tree algorithms showed high precision and specificity to estimate grazing and activity level from GPS data (NADIMI et al., 2008; ROBERT et al., 2009), tilt sensor devices (UNGAR et al., 2005; UMSTÄTTER et al., 2008; AUGUSTINE; DERNER, 2013) and accelerometers (GONZÁLEZ et al., 2015).

Most studies on predicting cattle behaviour using such technologies have been carried out in large pastures (ANDERSON et al., 2013). However, little is known about the use of GPS collars in small paddocks of tropical pastures to prediction of behaviour

(VALENTE et al., 2013) and the influence of sward structures (e. eg. height, density and above ground biomass) can affect the sensors' thresholds used to prediction of behaviour to the classification trees algorithm in these areas.

Thus, the aim of this study was to determine the thresholds for the prediction and classification of pasture-based beef cattle behaviour with data obtained from GPS collars with tilt sensors compared with behavioural visual observations. Were tested the following hypothesis, 1) tilt sensors can provide useful data to calculate threshold values required for the behavioural classification to cattle kept in small areas; 2) available forage mass can affect the threshold values used to classify different behaviours.

2.2 Material and Methods

This study was approved by the Committee of Ethical Use of Animals of Faculty of Agricultural and Veterinary Sciences, São Paulo State University, Câmpus of Jaboticabal, São Paulo, Brazil (Certified number 09/2014).

2.2.1 Study site and design

The study was conducted in the research facilities of the Department of Forage Sciences, at the Faculty of Agricultural and Veterinary Sciences, São Paulo State University (FCAV/UNESP), located in the city of Jaboticabal, Brazil (21º15'22''S latitude; 48º18'58'' W longitude; 595-m elevation), from February to April, 2014 (70 days during wet season). The region climate is classified as Aw (tropical wet and dry) according to Köppen and Geiger system (KOTTEK et al., 2006), with rainy summers and dry winters. During the study, air temperature (°C), air relative humidity (%), radiation solar (W/m2) and rainfall (mm), were all recorded daily at the Agrometeorological Station, located in the same University, situated 800-m from the study area. Throughout the measurement period monthly, minimum, average and maximum temperatures were registered: 19.6 °C, 25.5 °C and 32.1 °C in February, 19.2 °C, 24.1 °C and 30.5 °C in March, 17.8 °C, 22.9 °C and 29.5 °C in April respectively. There were average of rainfall 95.2 mm in February, 97.3 mm in March and 63.3 mm in April. The average daily distribution of air temperature (°C), relative humidity (%) and radiation solar (W/m^2) monthly are presented in Figure 1.

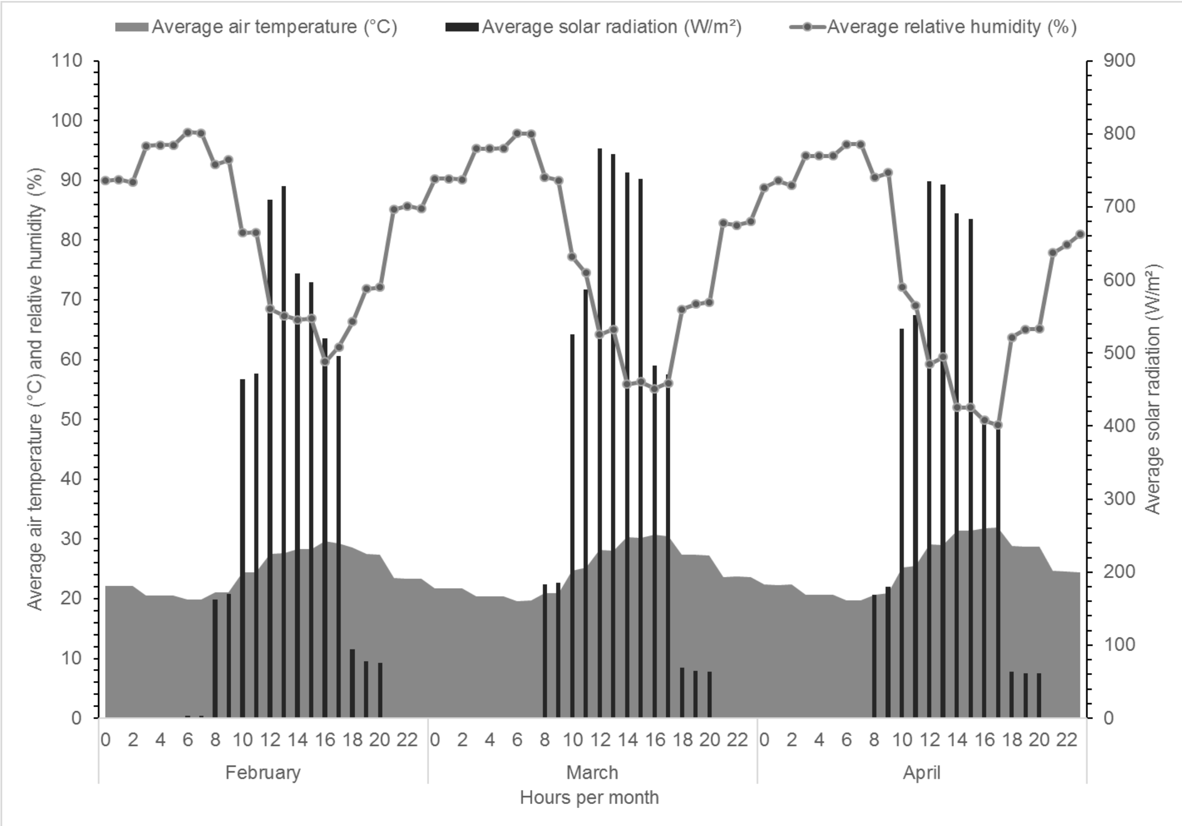


Figure 1. Average daily temperature (°C), relative humidity (%) and radiation solar (W/m^2) during observation. Data from the Agrometeorological Station.

The study area consisted of fourteen experimental paddocks with areas of 1.3 ha (six paddocks), 1.0 ha (four paddocks) or 0.7 ha (four paddocks), all composed of a pasture of *Brachiaria brizantha* (*Hochst ex A. Rich, Stapf cv. Marandu*). The herbage characteristics were: a) the 1.3 ha paddocks were maintained at a 35 cm pasture height (characterized as tall pasture height and available forage mass high, TH), with an estimated herbage mass of 10,826.9 kg ha^{-1} (3,354.6 kg ha^{-1} of green leaves mass and a proportion of 0:88 leaves/stem); b) the 1.0 ha paddocks were maintained at a 25 cm pasture height (characterized as moderate pasture height and available forage mass medium, MH), with an estimated herbage mass of 8,699.7 kg ha^{-1} (2,698.2 kg.ha^{-1} of green leaves mass and a proportion of 1:08 leaves/stem); c) the 0.7 ha paddocks were maintained at a 15 cm pasture height (characterized as short pasture height available forage mass low, SH), with an estimated herbage mass of 5,513.5 $kg.ha^{-1}$ (1,992.9 $kg.ha^{-1}$ of green leaves mass and a proportion of 1:29 leaves/stem).

The nutritional plans were defined by the arrangement the three available forage mass (high, medium and low) and the supplementation levels (mineral mixture only and protein supplements). Six nutritional plans were assigned to the animals, as follows: 1) THMS: 3 paddocks of available high forage mass with tall pasture height (35 cm) with a mineral mixture only; 2) THLS: 3 paddocks of available high forage mass with tall pasture height (35 cm) with a low supplementation (lower protein intake supplement, 0.1% BW/d); 3) MHLS: 2 paddocks of available medium forage mass with moderate pasture height (25 cm) with low supplementation (0.1% BW/d); 4) MHMS: 2 paddocks of available medium forage mass with moderate pasture height (25 cm) with moderate supplementation (0.3% BW/d); 5) SHMS: 2 paddocks of available low forage mass with short pasture height (15 cm) with moderate supplementation (0.3% BW/d); 6) SHHS: 2 paddocks of available low forage mass with short pasture height (15 cm) with high supplementation (0.6% BW/d). The mineral salt and the supplementation were delivered daily between 10:30 to 11:30 h and the water was available *ad libitum*.

Once a week, 100 random pasture height points were measured in each paddock and the stocking rate adjusted by the ‘‘put-and-take’’ methodology (MOTT; LUCAS, 1952) with the aim to maintain the pasture height and forage mass available corresponding.

2.2.2 Animals and measurements

A sample of 48 young bulls Nellore, ranging from 10 to 12 mo-old and average weighing 231 ± 19.60 kg, were used in the study. The animals were weighed in the beginning and in the end of the study. Twelve animals per cycle were randomly selected to wear GPS collar devices Lotek® 3300 LR that were available (Lotek Engineering, Newmarket, Ontario, Canada).

The study was carried out during four observational cycles, as follow: 1st and 2nd cycles: four animals in each of three paddocks (THMS and THLS) for both cycles; 3rd and 4th periods: three animals in each of four paddocks, being 6 animals kept in paddocks of MHLS and MHMS; and 6 in paddocks of SHMS and SHHS. Each animal wore the collar for 7 to 10 days.

Nine from the 48 animals assessed were removed from the dataset due to failures in the GPS collars or lost data. Two collars (two animals per cycle) the failure was due to: 1) manufacturing problems, probably due to a connection malfunction between the information's storage device and the battery; 2) battery failure. Others animal's removal was because detected inaccuracies in the dataset.

The collars were composed of a GPS, a tilt sensor, a temperature sensor and a radio frequency transmitter, all programmed by the GPS Lotek® 3000 Host Software, with a schedule for collecting the data position every 5 minutes (fix rate) for 24-hours periods (usually 288 data points/d). The tilt sensor worked like a captive bolt with switch that opens or closes by movements and it was sensitive to movements in a dual axis: vertical, which recorded Y activity count (Y-act); and horizontal, which recorded X activity count (X-act). The data obtained from the tilt sensors counted in 5-min periods from a minimum value 0 (no movement) to a maximum value 255 (high activity).

Based on these data from tilt sensor, the collars' software calculated the proportion of time that the animal kept its head in a downward position (head down, %). The contact closes when the collar is at an angle > 7.5° clockwise to perpendicular to the horizontal plane, registers a downward position. The contact is open when the collar angle is > 7.5° anticlockwise to perpendicular to the horizontal plane, registers an upward position. In the intermediate angle range of ± 7.5° to perpendicular to the horizontal plane, the animal's head position was considered undetermined because the contact could be open or closed, adapted from Ungar et al. (2011) (Figure 2). The GPS and the tilt sensor data from the past 5 minutes were then stored in the device's memory. All data was downloaded to a computer using the GPS Lotek® 3000 Host Software.

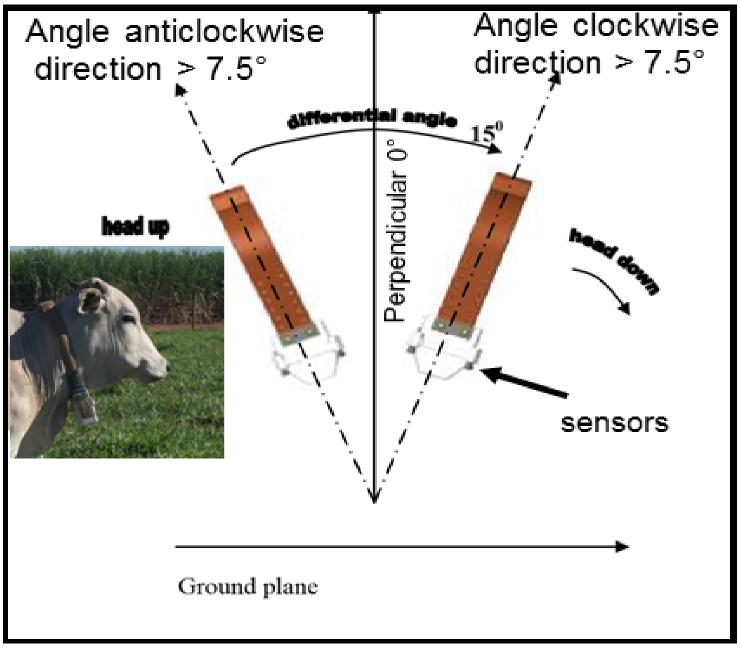


Figure 2. GPS collar diagram indicating the location of the sensors and their operation; and after being placed on the animal's neck. Adapted from Lotek® user's manual (2011).

2.2.3 Description of the data collected by the GPS collars

The data from the GPS was collected with the default configuration including: collar number, record number, date, time (hh:mm:ss), latitude and longitude in spherical coordinates (WGS 84) and altitude. It also measured the quality achieved (either two- or three-dimension), delay signal, number of satellites used to calculate the position, position dilution of precision (PDOP) and air temperature (°C). The data from the tilt sensors consisted of a fixed record number, date, time (hh:mm:ss), horizontal axis count (X-act, from 0 to 255), vertical axis count (Y-act, from 0 to 255) and the proportion of head down (%) in the 5-min intervals. This dataset was transformed directly from the GPS Lotek® 3000 Host software to TXT format and saved in Microsoft Excel worksheets.

2.2.4 Paddocks' boundaries

Coordinates of fence boundaries for the paddocks were collected using sub-meter precision GPS receivers (Trimble® Juno, Trimble Navigation Limited, Sunnyvale, CA, USA), operated with TerraSyncTM® software (TerraSync Inc., Burlington, MA, USA) and downloaded to a computer with the Pathfinder® software.

2.2.5 Behavioural visual observations of the animals

Direct visual observations of the GPS-collared young bulls were performed. Animals were identified individually by numbers painted on their ribs and rumps using hair dye products (Wella® Soft color, for human use, ammonia free). Behavioural recordings were made between 08:00 h to 12:00 h and between 13:00 h to 18:00 h, on the 3^{rd}, 4^{th}, 5^{th}, 6^{th} and 7^{th} day after fitting the GPS collars on the animals. The first two days were assumed as an adaptation period for the animals and, therefore, no behavioural observations were made.

Observations were performed from outside of the paddocks using binoculars and chronometers synchronized with GPS collars to record time. A scan sampling method, with 1-min intervals, was used (MARTIN; BATESON, 1986) by two trained observers (with Kappa test concordance coefficient of 0.80) to record the behaviour of two animals from each group simultaneously. The following information was recorded: animal identification, time (hh:mm to the nearest minute), and behaviours performed by the animals, the behavioural categories recorded are described in Table 1. The behavioural observations totalled 109 hours and 40 minutes.

Table 1. Descriptions of the cattle behavioural categories observed in this study (adapted from UMSTÄTTER et al., 2008)

Behaviour	Descriptions
Grazing (GRA)	when the animal had its head down, making movements of forage prehension or searching for feed while moving to new alimentary patches
Eating supplement or salt (ES)	when the animal kept its head inside the feed bunk or above the feed bunk while chewing
Ruminating (RUM)	when the animal was chewing or regurgitating the feed bolus
Drinking (DW)	when the animal had its head down inside the water trough
Social interactions (SI)	when the animal was either grooming a group mate; being pushed or pushing a group mate with physical contact; or chasing or being chased by a group mate
Walking (WAL)	when the animal walked or ran to relocate or search for other path.
Others activities (OA)	when the animal performed an activity, either standing or lying, with the exception of the categories described above.

2.2.6 Data processing

The visual behavioural observations of the 39 animals were summarized into 5-minute intervals and then synchronized with the intervals from the GPS collars. Each interval was based on the predominant behaviour (greatest frequency of determined behaviour within an interval). Frequencies were then converted to the proportion of time (%) spent on that behaviour for each 5-min interval, dataset which contained n = 2,591 5-minute intervals (dataset **A**).

The GPS and tilt sensors datasets were put together in a single file after rounding time to the nearest minute in each dataset. Missing from the latitude and longitude information (0.99% of all data points) were removed from the data file. The GPS coordinates were converted to the Universal Transverse Mercator (UTM) format, in order to facilitate algebraic derivation areas and distance (GANSKOPP, 2001). Ellipsoid paddocks' boundaries were also converted to UTM format using the same procedures described above. Datasets from collar and paddocks' boundaries were merged and plotted into scatter plots. All data points outside the paddocks' fences were removed manually, as outliers (13.70% of remaining data points), according to the criteria recommended by Schwager et al. (2007). The altitude outlier values for each paddock were identified as values outside of the 99.73% (mean ± 3 SD) level of confidence, accounting for 0.61% of all data points, and also removed from data files.

All data from the first and the last day of the data collection were removed for being incomplete records, with less than 24 hours (6.86% of remaining data points). Data cleaning was also performed, eliminating data points from less than or equal to 6 satellites, when PDOP was greater than 6, and the delay to obtain the fix exceeded 45 seconds. Thus, a total of 1.81% of all data points was removed according to the criteria by Ganskopp and Johnson (2007).

The final step in processing the data from the collars consisted in calculating the distance walked (m) between 2 successive GPS points and the distance travelled per day ($km.d^{-1}$) was calculated. In this step, we removed 6.77% of total data points due to errors in distance calculations. The integral dataset (dataset **B**) had a total of 118,735 5-min intervals.

The training dataset (dataset **C**) was established with paired GPS, tilt sensor and behavioural visual observations, all data points with missing or mixed behaviours per interval were eliminated in order to get the dataset which contained only n = 2,051 5-minute intervals, to process the classification algorithm,

All data analysis and organization were performed using SAS® 9.4 (SAS Inst. Inc., Cary, NC, 2012) and R© 2.15.3 (R DEVELOPMENT CORE TEAM, 2008). All steps and procedures of data processing are summarized in table 2 to provide a better understanding.

Table 2. Data processing procedures used in the dataset from the GPS collars, tilt sensors and visual observations

Step	Procedures	Total points recorded (n)	Points removed (%)
	Behaviour dataset from visual observation (dataset A)		
1	Raw behavioural dataset (1-min intervals)	13,135	
2	Behavioural dataset after summarising the 5-min intervals	2,591	
	GPS and tilt sensor dataset from collar (dataset B)		
3	Raw GPS and tilt sensor dataset	170,028	
4	GPS dataset after removal of non-experimental days and data lines with no GPS coordinates or tilt sensor data	151,359	0.24
5	GPS dataset after removing missing coordinates	149,860	0.99
6	GPS dataset after removing outside paddock data points	130,616	12.84
7	GPS dataset after removing first and last day of experiment (incomplete days)	121,661	6.86
8	GPS dataset after removing outliers for large DOP, satellite, delay signal	119,462	1.81
9	GPS dataset after removing outliers for slope and paddock distance	118,735	0.61
	Training dataset (with paired GPS, tilt sensor and behavioural observations, dataset C)		
10	Dataset A + Dataset B	2,591	
11	Dataset A + Dataset B after removing intervals longer than 5 min	2,051	7.58

2.2.7 Statistical analysis and algorithm development

The dataset **C** was used initially to the exploratory analysis to understand the average distribution of electronic data for each behaviour observed, box plots were made and the procedure PROC UNIVARIATE of SAS was used. To analysed the association among the electronic data (recorded by the collars) and the proportion of each behaviour in the 5-min intervals (from the visual observations) a principal component analysis (PCA) was applied (MANLY, 2008) between the variables from the GPS collars: X-act, Y-act, sum-XY-act (sum of X-act plus Y-act), head down (%), distance walked (m) and the frequency of behavioural visually observed (%). Afterwards, to confirmation this relation by estimating the Pearson´s correlation coefficients.

Decision trees and classification were developed with dataset **C**, initially for all nutrition plans together and then considering the data separately according to forage availability, by using the Tree Package implemented in R© 2.15.3 (R DEVELOPMENT CORE TEAM, 2008). The predictive variables for the decision trees were X-act, Y-act, sum-XY-act, head down (%) and distance (m). In order to calculate the Kappa coefficient between the visual observations and the data from the GPS collars, the behaviours that were not discriminated in the decision tree model, such as SI and DW, were merged with OA, called not-grazing (Not-gra), while ES and WAL were merged with GRA as being the most alike activities.

The accuracy and specificity of the decision trees were estimated through 4 categories resulting from the classification trees: 1) true positive (TP; e.g. a data point classified as grazing by the algorithm while the animal was trully grazing according to the visual observations); 2) true negative (TN; e.g. a data point classified as not grazing while the animal was not grazing); 3) false positive (FP; e.g. a data point classified as grazing while the animal was not grazing); and 4) false negative (FN; e.g. a data point classified as not grazing when the animal was actually grazing). With these values was calculated the sensitivity (TP/ [TP + FN]) and specificity (TN/ [TN + FP]) were found for each behaviour (GONZÁLEZ et al., 2015).

Was calculated the average values of tilt sensor for the recording intervals, considering 24 hours as intervals classes of 2 or 3 hours' daytime, as follows: interval 1 (00:00 to 02:59 h), interval 2 (03:00 to 05:59 h), interval 3 (06:00 to 07:59 h), interval 4 (08:00 to 09:59 h), interval 5 (10:00 to 11:59 h), interval 6 (12:00 to 13:59 h), interval 7 (14:00 to 15:59 h), interval 8 (16:00 to 17:59 h), interval 9 (18:00 to 20:59 h) and interval 10 (21:00 to 23:59 h). Thus, was considered intervals from 08:00 to 17:59 h as day, and from 18:00 to 07:59 h as night.

To evaluate the effect of the behaviour frequency on the tilt sensor values average, was applied a mixed-model (PROC MIXED of SAS), where nutrition plans, frequency of behaviour, classes daytime hours and their interaction were considered as fixed effects and day of assessment as a covariate, whereas the animal group was considered as random effect. Differences between average were adjusted using Bonferroni's test for multiple comparisons.

Further, on the dataset **B** (which did not contain the behavioural observations) firstly was calculated the Pearson´s correlation coefficients among the electronic data performed. The effect of nutrition plans on the values of the electronic data (head down, X-act, Y-act, sum-XY-act and distance) was determined using the PROC MIXED of SAS considering the nutrition plans, the classes daytime hours and interactions as fixed effect and the animal group as a random effect. Differences between average were adjusted using Bonferroni's test for multiple comparisons to classes daytime and contrasts to nutrition plans.

Afterwards, to predict the unknown behaviours in the dataset **B**, was applied thresholds from the decision trees obtained in dataset **C**, initially classifying the behaviours to the daytime hours that coincided with the observed hours visual, and then was classifying the night hour intervals.

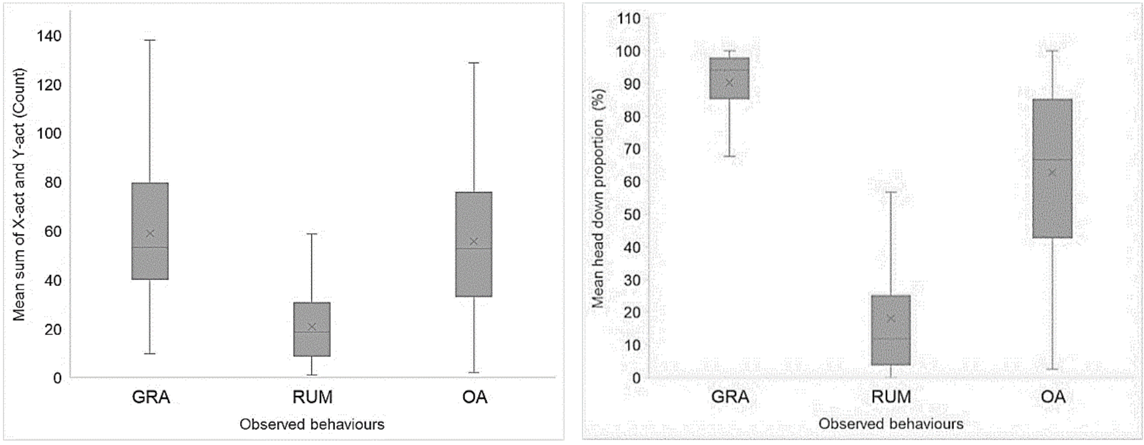
Finally, to predict the proportion of daily time spent during 24 hours in each behaviour and calculate an accurate value of it, days with more than 10% of data loss were removed. Pearson´s correlation coefficients were calculated between the electronic data and the predicted proportion grazing time, not-grazing time and ruminating time, then was performed the distribution plot relating the predicted grazing time, not-grazing time and ruminating time and the average values sensor.

2.3 Results

2.3.1 Relationship between the visual behavioural observations and the tilt sensor records

The most frequent behaviour observed was grazing (GRA, 61.2%), followed by ruminating (RUM, 19.4%) and other activity (OA, 15.9%). The sum of eating supplement (ES), drinking water (DW), social interaction (SI) and walking (WAL) did not exceed 3.5% of the visual observations.

The distribution of sum-XY-act (count) and head down (%) for the most frequently observed behaviours (GRA, RUM and OA) are shown in Figures 3A and 3B, respectively. It is possible to observe that the variable head down differs in its distribution according to the behaviour occurrence visually recorded.



A B

Figure 3. Distribution of the tilt sensor variables sum-XY-act (A; count) and head down (B; %) for the most frequently observed behaviours (grazing = GRA, ruminating = RUM and other activities = OA).

The principal component analysis (PCA) identified two components, where the first and second principal components (PC1 and PC2) explained 75.11% of the dataset variation. PC1 explained 47.37% of the variation, with high positive loadings for X-act, Y-act, sum-XY-act, head down (data from GPS collar), and GRA (from behavioural observed); while having high negative loadings for RUM (behavioural observed). PC2 explained 27.74% of the variation, with high positive loadings for X-act, Y-act and sum-XY-act and negative loadings for GRA and head down (Figure 4).

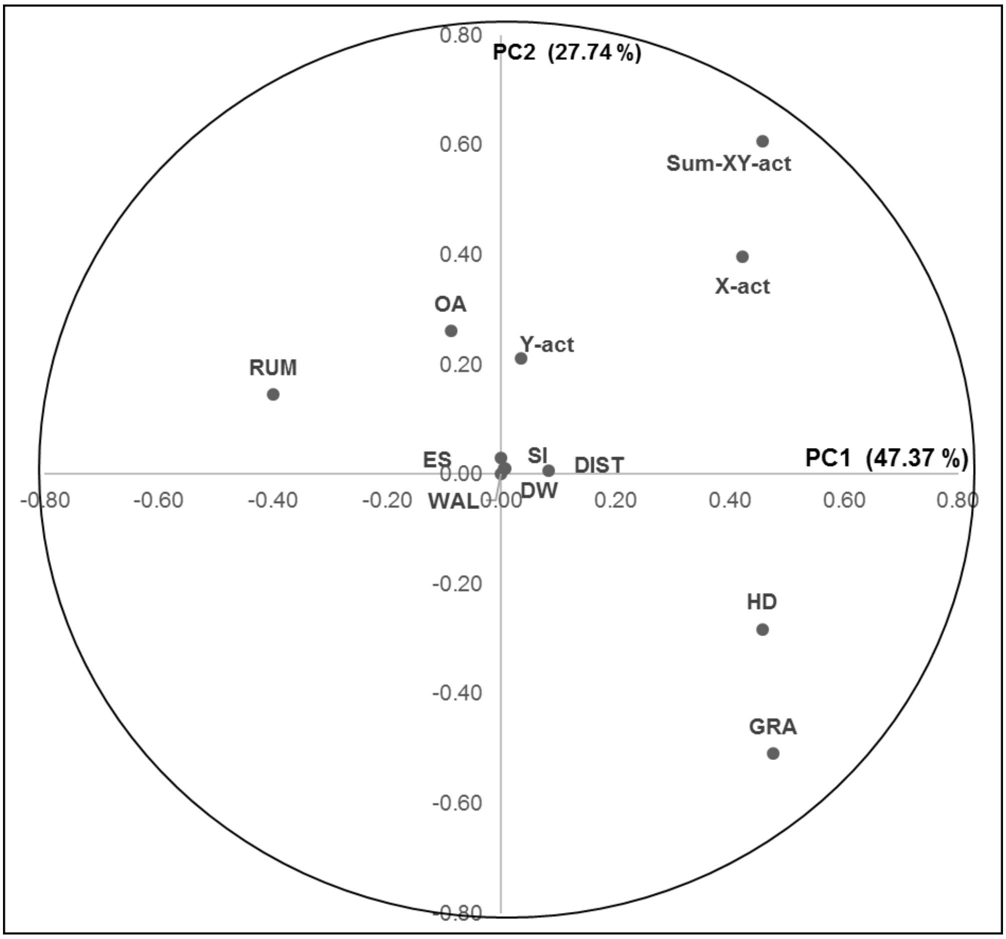


Figure 4. Loading plot for tilt sensors and behavioural observations on the first and second principal components (PC1 and PC2). Where RUM= rumination; ES = eating supplement; GRA = grazing; WAL= walking; OA = other activities; DW = drinking water; SI = social interaction; HD = Head down (%); X-act = horizontal axe (count); Y-act = vertical axe (count); Sum-XY-act = sum horizontal plus vertical axes (count); DIST = distance walked (m).

The relationship between the tilt sensor records showed that head down (%) was associated (with low correlation coefficients) to X-act and sum-XY-act ($P < 0.0001$); and was not associated to Y-act ($P > 0.05$). The distance walked (m) showed low to moderate correlation (from $r = 0.18$ to $r = 0.45$, $P < 0.0001$) to X-act, sum-XY-act, head down (%) and Y-act (Table 3). The correlation coefficient among the average values of the tilt sensor variables and the measures for each behaviour were quite variable, but GRA and RUM showed high correlation with head down (%), as shown in table 3.

Table 3. Pearson correlation coefficients between the tilt sensor variables and the observed visually behaviour frequencies in 5 min intervals (n = 2,051)

	Tilt sensor variables					Observed visual behaviour frequencies						
	HD[a]	**X-act[b]**	**Y-act[c]**	**Sum-XY-act[d]**	**DIST[e]**	**RUM[f]**	**ES[g]**	**GRA[h]**	**WA[i]**	**OA[j]**	**DW[k]**	**SI[l]**
HD[a]	1.00	0.37***	-0.05	0.29***	0.37***	-0.76***	0.08	0.78***	0.00	-0.27***	0.05	0.05
X-act[b]		1.00	0.07	0.89***	0.18***	-0.32***	0.02	0.26***	-0.01	-0.04	0.01	0.11***
Y-act[c]			1.00	0.53***	0.45***	-0.10***	0.08*	-0.25***	0.04	0.26***	0.30***	0.13***
Sum-XY-act[d]				1.00	0.36***	-0.32***	0.05	0.11***	0.01	0.08*	0.15***	0.16***
DIST[e]					1.00	-0.36***	-0.07	0.29***	0.02	-0.08*	0.25***	0.06
RUM[f]						1.00	-0.09***	-0.61***	-0.01	-0.21***	-0.08*	-0.07
ES[g]							1.00	-0.22***	0.13***	-0.03	0.01	-0.03
GRA[h]								1.00	-0.08*	-0.51***	-0.07	-0.05
WAL[i]									1.00	-0.03	0.07	0.10***
OA[j]										1.00	0.02	-0.05
DW[k]											1.00	0.01
SI[l]												1.00

Significance level of *t* test ***P < 0.0001, *P < 0.05
[a] HD: Head down (%)
[b] X-act: horizontal axe (count)
[c] Y-act: vertical axe (count)
[d] Sum-XY-act: sum horizontal plus vertical axes (count)
[e] DIST: distance travelling calculates (m)
[f] RUM: ruminating (%)
[g] ES: eating supplement or salt (%)
[h] GRA: grazing (%)
[i] WAL: walking (%)
[j] OA: other activities (%)
[k] DW: drinking water (%)
[l] SI: social interactions (%)

2.3.2 Behaviour classification based on the decision tree algorithms from training dataset (C)

Figure 5 shows the classification by the decision tree algorithms models obtained from the visual behavioural observations and the GPS collar threshold values for all nutrition plans together. The models had the variable head down (%) as a priority and it was the main root of the splits. Y-act and distance walked (m) helped to this result; while sum-XY-act and X-act did not contribute to the construction of the decision tree algorithms. The first model, where we considered all categories of the observed behaviours had a misclassification of 16.34% and a residual deviance mean of 0.90. The second model had a misclassification of 13.98% and a residual deviance mean of 0.70, and we considered the three highest frequency behaviours GRA, RUM and the combination of remaining categories as Not-gra. We also tested similar models for forage availability difference separately, but it did not show any classification differences.

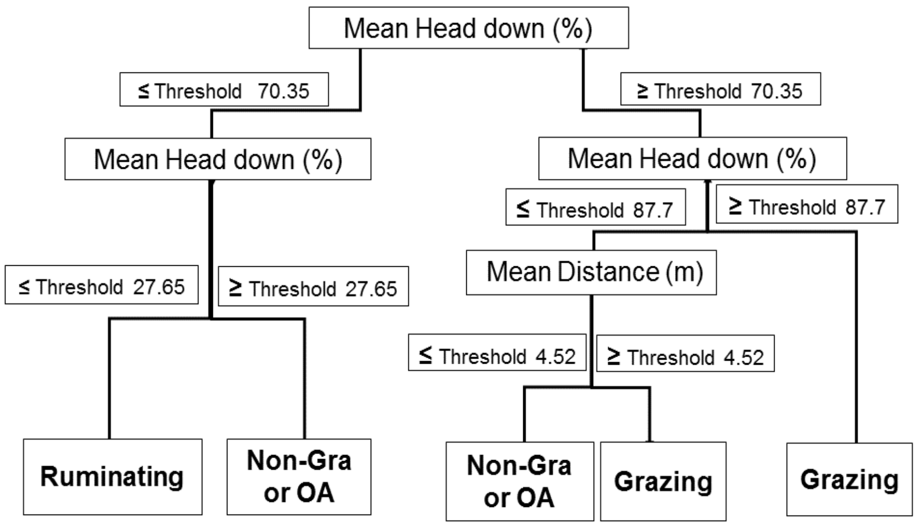


Figure 5. Decision tree algorithm models used to classify data from the GPS collars according to the threshold values obtained from the behavioural observations. The behaviours classified were ruminating (RUM), grazing (GRA), other activities (OA) or not-gra (Not-gra).

Table 4 shows the confusion matrix for all the observed and predicted behaviours by the decision tree algorithms, where GRA and RUM had high accuracy and specificity, OA had low accuracy and moderate specificity, and DW, ES and SI were not predicted.

Table 4. Confusion matrix obtained from the decision tree algorithms applied to dataset (C). The frequency of the correctly classified behaviour pattern can be read on the diagonal observed (**DW**: drinking water; **ES**: eating supplement; **GRA**: grazing; **RUM**: ruminating; **OA**: other activities and **SI**: social interactions) *vs* predicted behaviours (**GRA**; **OA**; **RUM**)

All observed behaviour categories	Predicted activity (first model - All behavioural categories)				
	GRA	**OA**	**RUM**	Total predicted	Misclassification rate (%)
DW	2	1	0	3	---
ES	45	13	0	58	---
GRA	**1216**	32	0	1248	3
OA	96	**124**	105	325	62
RUM	19	51	**335**	405	17
SI	4	8	0	12	---
Total observed	1382	229	440	2051	---
Precision (%)	88%	54%	76%	---	---
Specificity (%)	93%	89%	95%	---	---

The final selected binary model included three behavioural categories: GRA, RUM and Not-gra. When merged into a new category, called not-grazing (Not-gra), the misclassification rate was minimised and presented a concordance of 78% with the predicted behaviour. Exactly 1,306 visual observations were recorded as GRA while 1,271 were predicted as GRA; 405 observations were recorded as RUM, while 335 were predicted as RUM; and 340 observations were recorded as Not-gra, while 117 were predicted as Not-gra. The model showed high precision to predict GRA and RUM, but low precision to Not-gra (Table 5).

Table 5. Confusion matrix obtained from the second model of the decision tree algorithms applied to dataset (C). The frequency of the correctly classified behaviour pattern can be read on the diagonal observed (**GRA:** grazing; **RUM**: ruminating; **OA**: other activities) *vs* predicted behaviours (**GRA:** grazing; **RUM**: ruminating; **Not-gra:** not-grazing)

Observed behaviour	Predicted activity (second model-three behaviour categories)				
	GRA	**Not-gra**	**RUM**	Total predicted	Misclassification rate (%)
GRA	**1271**	35	0	1306	3
OA	118	**117**	105	340	66
RUM	22	48	**335**	405	17
Total observed	1411	200	440	2051	---
Precision (%)	90%	59%	76%	81%	---
Specificity (%)	93%	88%	95%	---	---
Statistical concordance (%)	---	---	---	78%	---

Table 6 shows the sensors' mean values per day, in the frequency of 0 to 100% for every visually behaviour observed. The mean values of X-act (count) and sum-XY-act (count) were affected by the behaviour proportions (P < 0.0001) with significant differences for GRA, compared to RUM and Not-gra at proportions of 100% (P < 0.0001). Differences within the behaviour proportions of 0% and 100% were observed only at RUM and Not-gra (P < 0.0001). The average of head down (%) was also affected by the behaviour proportions (P < 0.0001) and was the only variable that presented significant differences on the behaviour proportion from 0 to 100% and among different behaviours (P < 0.0001). Finally, the average distance walked (m) was also affected by the behaviour proportions (P < 0.0001), but only RUM and Not-gra differed between the proportions 0 and 100%. The average Y-act was not affected by the behaviour proportions (P > 0.05).

Table 6. Effect of the behaviour proportions visually observed on average (SD) tilt sensors variables from the GPS collars (head down, X-act, Y-act, sum-XY-act and distance walked)

Tilts sensors	Behaviour proportion (%)	Behaviours observed		
		Grazing	Not-grazing	Ruminating
X-act [a] (count)	0	40.02 (8.21) A a	48.04 (7.96) A a	53.74 (8.64) A a
	100	54.70 (8.42) A a	31.01 (8.92) B a	20.34 (8.74) B b
Y-act [b] (count)	0	14.10 (2.62) A a	10.92 (2.30) A a	13.36 (3.14) A a
	100	6.42 (2.84) A a	17.23 (3.45) A a	7.23 (3.25) A a
Sum-XY-act [c] (count)	0	56.97 (9.18) A a	61.81 (8.84) A a	69.94 (9.78) A a
	100	64.08 (9.47) A a	51.68 (10.27) AB a	30.43 (9.91) B b
HD [d] (%)	0	53.41 (2.59) C b	75.07 (2.24) B a	88.57 (3.13) A a
	100	97.37 (2.82) A a	39.25 (3.44) B b	9.06 (3.25) C b
DIST [e] (m)	0	10.34 (1.87) A a	13.50 (1.68) A a	16.23 (2.19) A a
	100	11.83 (2.01) A a	6.53 (2.36) AB a	2.73 (2.26) B b

Means followed by the same lowercase letters (rows) or uppercase letters (columns) did not differ at a 5% of probability, according to Bonferroni's test

[a] HD: Head down (%)

[b] X-act: horizontal axe (count)

[c] Y-act: vertical axe (count)

[d] Sum-XY-act: sum horizontal plus vertical axes (count)

[e] DIST: distance walked (m)

2.3.3 The relationship of tilt sensors on dataset (B) with unknown behaviours

On the whole dataset **B** with unknown behaviours (110,738 intervals), the relationship among the sensor values showed that head down (%) had a low to moderate correlation to sum-XY-act, X-act and distance walked (m) (from $r = 0.38$ to $r = 0.41$; $P < 0.0001$). Y-act showed a low to moderate correlation (from $r = 0.15$ to $r = 0.54$, $P < 0.0001$) to X-act, distance (m) and sum-XY-act, respectively. Distance (m) had a low to moderate correlation to X-act ($r = 0.25$), Y-act ($r = 0.34$) and head down ($r = 0.44$) ($P < 0.0001$).

Table 7 presents the effects found for the interaction ($p < 0,05$) of the nutritional plans and the daily hours' classes intervals on the tilt sensors average values. The differences among average were little and we found that the contrast between THMS groups *vs* others ($p < 0,05$) showed that animals in this group had lower HD (%) average during the intervals 4 and 5 (from 08:00 to 09:59 h and from 10:00 to 11:59 h), but showed higher average on the interval 6 (from 12:00 to 13:59 h). Still considering groups THMS *vs* others for the distance travelled ($p < 0,05$), lower average were also found for the intervals 4 and 8 (from 08:00 to 09:59 h and from 16:00 to 17:59 h), but presented higher average only in the interval 9 (from 18:00 to 20:59 h). Regarding Sum-XY-act, no differences were found ($p > 0,05$) for THMS *vs* others within each time interval.

When were analyzed the average of the groups THLS *vs* MHLS ($p < 0,05$), the animals in group THLS had lower HD (%) average during intervals 5, 7 and 10 (from 10:00 to 11:59 h, from 14:00 to 15:59 and from 21:00 to 23:59 h); while presented higher average only during the time interval 9 (from 18:00 to 20:59 h). The distance travelled presented ($p < 0,05$) lower average in the time intervals 4 to 8 (from 08:00 to 17:59 h), and higher average during the intervals 9 and 10 (from 18:00 to 20:59 h). Now, Sum-XY-act presented ($p < 0,05$) lower average during the intervals 7, 8 and 9 (from 14:00 to 20:59 h).

When comparing the contrasts between the groups MHMS *vs* SHMS we have found ($p < 0,05$) that animals in the group MHMS presented lower HD (%) average in the intervals 4 and 7 (from 08:00 to 09:59 h and from 14:00 to 15:59 h). For the distance travelled, lower average ($p < 0,05$) were presented in the intervals 4, 7 and 8 (from

08:00 to 09:59 h and from 14:00 to 17:59 h). Regarding, Sum-XY-act, no differences (p > 0,05) were found between treatments for this contrast.

Finally, the contrast average for the group SHHS *vs* others (p < 0,05) presented animals from the group SHHS had lower HD (%) average during intervals 3 and 10 (from 06:00 to 07:59 h and from 21:00 to 23:59 h). Regarding the distance travelled (p < 0,05), lower average were found in the intervals 5, 6 and 10 (from 10:00 to 13:59 h and from 21:00 to 23:59 h). For Sum-XY-act no differences (p > 0,05) were found between treatments in this contrast.

We have also analyzed the classes' intervals, where the intervals 7 and 8 (from 14:00 to 15:59 h and from 16:00 to 17:59 h) presented the highest average (p < 0,05) in the different sensors from each treatment. In general, these intervals were considered the ones with highest activity levels for all treatments (Table 7).

2.3.4 Predicting behaviours based on the decision tree algorithm models

To predict the unidentified behaviours in dataset **B** we applied the thresholds of the two models only to the day period, corresponding to the same hour intervals when the visual observations occurred. Thus, the second model, which showed lower misclassification (13.98%) was chosen as the best model to be applied to the whole dataset to predict the time spent on each behaviour (GRA, RUM and Not-gra). Thereafter, the thresholds applied to the day period could also predict behaviours throughout the night, when no visual observations were performed. The best algorithm had HD thresholds < 26.65% to classify RUM and Not-gra. To classify Not-gra and GRA, it had the HD thresholds > 70.35%. Then, the most significant predicted behaviours (GRA, Not-Gr and RUM) showed a 97% of correct classified behaviours during the day and 96% at night. It also showed great sensitivity to GRA, followed by RUM; and low sensitivity to Not-gra, both on day and night (Table 8). Analysing the average frequencies of the three predicted behaviours (GRA, RUM and Not-gra) for the different forage mass available and nutrition plans, no significant differences were observed (P > 0.05).

Table 7. Effect of the interaction of the nutritional plan with classes' interval (least square means ± SEM) on average tilt sensor activities

Tilt sensors	Daily hour intervals	Nutrition plan treatments (mean ± SEM)						Contrast and P-values			
		THMS[f]	THLS[g]	MHLS[h]	MHMS[i]	SHMS[j]	SHHS[k]	THMS *vs* others	THLS *vs* MHLS	MHMS *vs* SHMS	SHHS *vs* others
HD (%)[a]	3	30.57 (2.18) d	28.33 (1.93) d	31.06 (2.04) c	27.29 (1.91) c	29.13 (2.23) b	24.45 (2.00) c	0.3057	0.4199	0.5463	0.0457
	4	38.61 (2.61) cd	46.11 (2.54) ab	57 (3.01) ab	46.75 (2.75) ab	57.46 (2.89) a	53.15 (2.91) a	<0.0001	0.0088	0.0094	0.2536
	5	48.35 (2.93) bc	53.18 (2.63) a	55.1 (3.05) ab	58.63 (3.11) a	61.53 (3.08) a	55.75 (3.19) a	0.0081	0.7083	0.4435	0.9503
	6	60.96 (2.4) ab	52.62 (2.16) a	54.66 (2.34) b	56.89 (2.65) a	54.32 (2.70) a	52.22 (2.63) a	0.0146	0.7084	0.4925	0.2144
	7	62.45 (1.88) a	52.32 (1.79) a	69.15 (1.97) a	59.58 (2.18) a	66.83 (2.12) a	62.57 (2.09) a	0.9671	<0.0001	0.0476	0.9780
	9	30.65 (1.92) d	33.29 (1.81) cd	28.09 (1.92) c	31.3 (1.72) c	32.0 (2.11) b	31.97 (1.92) bc	0.6730	0.0424	0.7602	0.7037
	10	43.32(1.43) c	37.82 (1.26) bc	49.40 (1.77) b	43.07 (1.53) b	39.92 (1.77) b	34.85 (1.52) b	0.2648	<0.0001	0.2555	0.0001
Sum-XY-act (count) [b]	7	41.16 (2.62) ab	30.52 (2.51) b	59.85 (2.75) a	41.6 (3.04) b	41.99 (2.96) ab	54.63 (2.92) a	0.4404	0.0048	0.9806	0.0868
	8	49.73 (2.51) a	46.42 (2.37) a	70.36 (2.74) a	60.78(2.86) a	55.95 (2.73) a	66.38 (2.61) a	0.0978	0.0132	0.6861	0.0774
	10	32.31 (2.00) b	21.51 (1.76) b	41.14 (2.48) b	34.16 (2.14) b	30.11 (2.48) b	32.04 (2.13) b	0.8383	0.0222	0.7162	0.9312
DIST (m) [c]	4	6.29(0.63) c	7.92 (0.61) bcd	9.98 (0.72) bc	7.31 (0.66) bcd	10.46 (0.69) bcd	8.85 (0.70) bc	<0.0001	0.0117	0.0005	0.6387
	5	9.95 (0.70) bc	9.83 (0.63) b	11.71 (0.73) bc	11.13 (0.74) b	12.22 (0.74) bc	7.92 (0.76) bc	0.3401	0.0244	0.2374	<0.0001
	6	9.27 (0.58) bc	8.74 (0.52) bc	11.25 (0.56) bc	9.77 (0.63) bc	9.42 (0.65) cde	8.36 (0.63) bc	0.5528	0.0003	0.6551	0.0381
	7	10.46 (0.45) b	8.54 (0.43) b	13.18 (0.47) b	10.16 (0.52) bc	12.74 (0.51) b	11.3 (0.50) b	0.0962	<0.0001	0.0004	0.7956
	8	15.37 (0.43) a	16.46 (0.41) a	18.36 (0.47) a	15.67 (0.49) a	17.32 (0.47) a	16.81 (0.45) a	0.0006	0.0012	0.0210	0.9076
	9	8.24 (0.46) bc	6.06 (0.43) cd	5.57 (0.46) d	6.27 (0.41) d	7 (0.50) e	6.87 (0.46) c	0.0001	0.5119	0.3042	0.7127
	10	8.2 (0.34) bc	6.18 (0.30) d	8.96 (0.42) c	7.76 (0.37) cd	7.77 (0.42) de	6.67 (0.37) c	0.0687	<0.0001	0.9774	0.0066

Lsmeans values followed by the same lowercase letter in row do not differ by Bonferroni test ($p<0.05$).
[a] HD: Head down (%);
[b] Sum-XY-act: sum horizontal plus vertical axes (count);
[c] DIST: distance travelled calculated (m);
[d] THMS: paddocks of tall pasture height (35 cm) with a mineral mixture only;
[e] THLS: paddocks of tall pasture height (35 cm) with a low supplementation (lower protein intake supplement, 0.1% BW/d);
[f] MHLS: paddocks of moderate pasture height (25 cm) with low supplementation (0.1% BW/d);
[g] MHMS: paddocks of moderate pasture height (25 cm) with moderate supplementation (0.3% BW/d);
[h] SHMS: paddocks of short pasture height (15 cm) with moderate supplementation (0.3% BW/d);
[i] SHHS: paddocks of short pasture height (15 cm) with high supplementation (0.6% BW/d).

Table 8. Classification frequency versus predicted behaviour by thresholds from the decision trees obtained from the tilt sensors during 24 hours with the percentage and hours predicted for each behaviour (GRA: grazing; RUM: ruminating and Not-gra: not-grazing)

Evaluation trial (first model) daylight hours	Predicted activity (second model) GRA	Not-gra	RUM	Total predicted	Misclassification rate (%)
Grazing	**29,626**	0	0	29,626	0
Other activity	1,005	**5,088**	0	6,093	16
Ruminating	0	0	**11,485**	11,485	0
Total	30,631	5,088	11,485	47,204	
Sensitivity or precision (%)	97%	100%	100%		
Specificity (%)	100%	98%	100%		
Statistical concordance (%)				97%	
Predicted (% daily)	53%	15%	32%		
Predicted Hours	5:30	1:50	3:20		
Evaluation trial (first model) night hours	**Predicted activity (second model) GRA**	**Not-gra**	**RUM**	**Total predicted**	**Misclassification rate (%)**
Grazing	**16,500**	0	0	16,500	0
Other activity	2,072	**10,099**	0	12,171	17
Ruminating	0	0	**34,863**	34,863	0
Total	18,572	10,099	34,863	63,534	
Sensitivity or precision (%)	89%	100%	100%		
Specificity (%)	100%	96%	100%		
Statistical concordance (%)				96%	
Predicted (% daily)	31 %	18 %	51%		
Predicted Hours	4.34	2.52	7.14		

We found that the algorithm predicted to GRA presented a 38.8% of average time, to Not-gra a 17% of average time, and RUM a 44.2% of average time, considering total predicted hours around 9 h/d to GRA, 4 h/d to Not-gra and 11 h/d to RUM.

Figure 6 shows the average distribution of the predicted behaviour times (GRA, RUM and Not-gra) and its relationship to the distribution of the sensor mean values, which showed high correlation ($P < 0.0001$) among grazing time to head down ($r = 0.92$), X-act ($r = 0.83$) and sum-XY-act ($r = 0.76$), and low correlation to Y- act ($r = 0.33$, $P < 0.0001$) throughout the 24-hour daily.

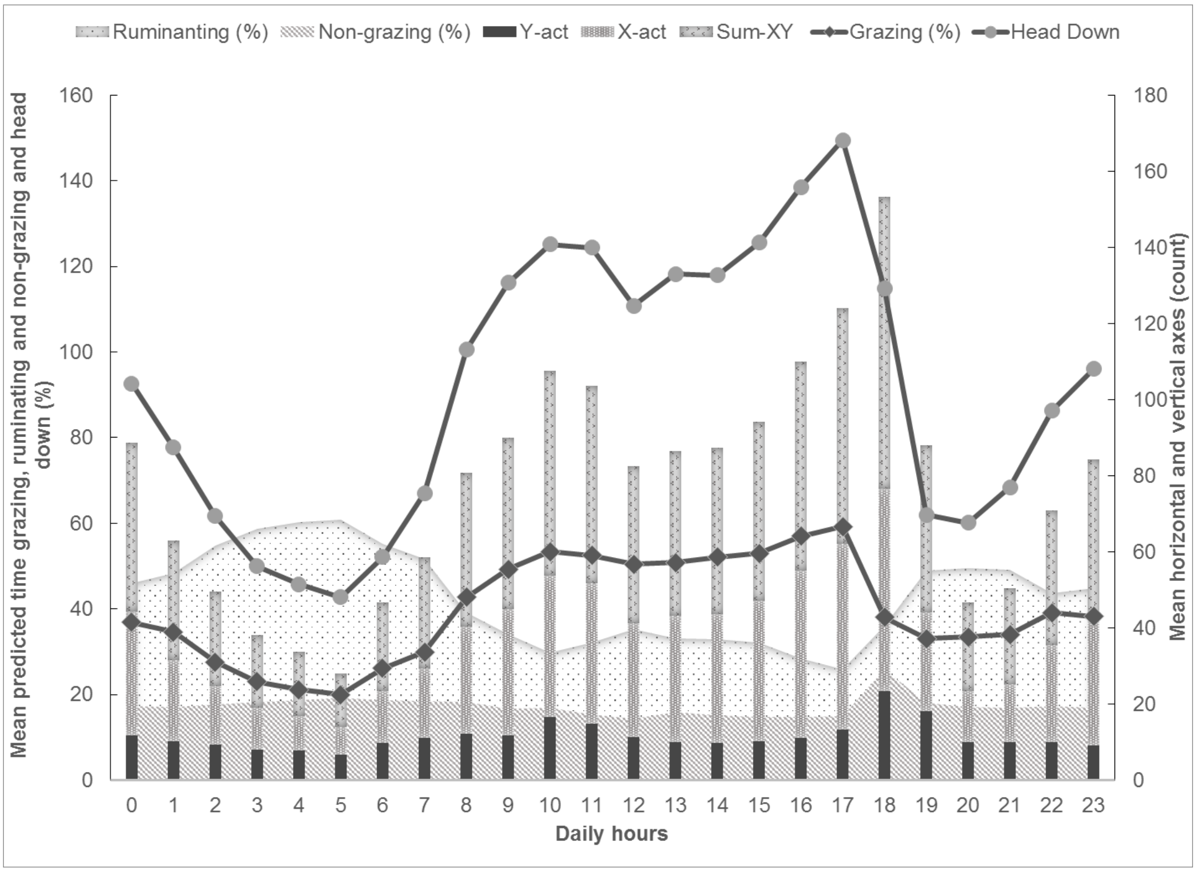


Figure 6. Distribution of average values of tilt sensors in relation to the average proportion of predicted time for behaviours (grazing, not-grazing, ruminating) by the decision tree algorithms model throughout the day.

2.4 Discussion

The GPS collars have functioned properly, as expected and generated a good quality dataset for a 24-hour daily behavioural prediction. Nevertheless, the mean data points collected per collar, per day, was of 260 points, but the expected number informed by the company was of 288 points. This difference may be due to the small size of the paddocks, and the fact that all paddocks were divided by electric fences, which probably interfered on the interpolation points, resulting in a low accuracy to determine the distances travelled by the animals. Some authors have already described that in smaller distances, that data calculated from GPS was imprecise (ROTHWELL et al., 2011); and that elements like tree covers and electric fence lines may produce some additional error and could interfere on the precision of the georeferenced points (AGOURIDIS et al., 2004, GANSKOPP; JOHNSON 2007).

Moreover, the difficulty of determining the distances in small areas could be also associated to the recording intervals of the collar, which have been set for every 5 minutes. This was considered a limitation of the equipment, as it was the minimum time interval allowed by the manufactures. During our direct observations we noticed that an animal could leave and return to the same point in the interval of 5 minutes, being the GPS collars unable to register it. Thus, as demonstrated by Swain et al. (2008), a recording interval of 10 seconds in areas of 100 m^2 would reduce to 1% the prediction error of the calculated speed. Nevertheless, as the GPS data was collected separately from the tilt sensors data, it probably did not interfere in the behavioural prediction.

Looking at the relationship of the mean values of the sensors variables with the observed behaviours, grazing and ruminating showed high correlation to head down (%) and sum-XY-act (count), probably because these behaviours categories were more frequently seen during visual observations. This was also demonstrated by the PCA, where grazing is visibly separated from ruminating, while the other categories are barely separated from each other (Figure 4). This could be explained as when there is a low frequency of one behaviour, the GPS collar has difficulty in identifying differences in the positioning of the head and therefore, it is difficult to classify the behaviour category that is occurring. Our results showed that it is possible to classify separately rumination, grazing and other activities, differently from results of other authors who included rumination within the ‘rest activities’, as indicated by Ungar et al. (2011); or in ‘other activities’ by Augustine and Derner (2013). Thus, unlike the results found by Ungar et al. (2011), that suggests the combination of grazing, resting and travel in the same category, in this study we suggested to combine eating supplement with grazing by the similarity of the head movements presented on these behaviours and maintained the category rumination isolated. Regarding our results, we considered that the manufacturer’s programming of 5-min intervals was reasonable to detect the behaviour when the animal remained more time performing it, i.e., the states of grazing and ruminating; however, quicker behaviours were more difficult to identify and to relate to the sensor values. Similar results were demonstrated by Turner et al. (2000)

and Ungar et al. (2005) who used the same 5-min intervals and reported high accuracy for classifying grazing and resting activities, but differ from our study for considering the sum of X-act and Y-act with a threshold of 200.

From the decision trees algorithm models, it was possible to identify the variable head down (%) as the best attribute to classify behaviours, which was also found by others authors (UNGAR et al., 2011; AUGUSTINE; DERNER, 2013). However, the thresholds for head down obtained in this study differ from other studies as presented by Ungar et al. (2011), which combined head down ≤ 77%, X-act ≥ 39 and distance < 100 m to identify grazing; or by Augustine and Derner (2013), who found threshold values for head down ≥ 94.7% to identify grazing, without considering other variables.

In our study, X-act, Y-act and sum-XY-act, due to their low association with the observed behaviours, could not be considered good predictors, but helped in the classification. The distance walked, calculated alone, was also considered a bad predictor. This result might have been influenced by the GPS decreased accuracy mentioned earlier, due to the records made in small areas. These results agree with the results from Ungar et al. (2005) and Augustine and Derner (2013).

The classification by the decision tree algorithms showed that the misclassification rate was higher for the first prediction model (16.34%) with all categories from the behaviours observed, when compared to the second prediction model (13.98%), where only three behaviour categories were considered. This could be due to the difficulty in classifying undetermined behaviours (social interaction, drinking water, others activities and walking), where the activities included in this category presented a low movement rate in the tilt sensors or various head positions. The animal probably had an undetermined head position, or even their inactivity, making it difficult to be predicted by the algorithm. A similar result was found by Moen, Pastor and Cohen (1996) using similar GPS collars in elks, wherein when the animal was inactive and active in the same time interval it could underestimate the behavioural category. During our direct observations, we recorded that an animal took < 2 or 3 min to drink water, which would be a difficult behaviour to be identified by the sensors. Ganskopp (2001) and Ungar et al. (2005) also demonstrated that the water and salt consumption were short lasting and infrequent events, being more difficult to be separately identified from the other behavioural categories. It was also similar to the result found by Augustine and Derner (2013), when separating categories such as rest, travel and mixed activities, grazing increased the misclassification rate to 16.4%. Maybe these activities are more likely to be behavioural events or happen in a very short period of time, making them difficult to be detected by the collar due to the sampling intervals of 5 minutes. Our overall misclassification rate (13.98%) from the algorithm chosen was similar to the ones described on previews research, ranging from 8.3 to 14% (UNGAR et al., 2005; AUGUSTINE; McNAUGHTON, 1998; AUGUSTINE; DERNER, 2013; VALENTE et al., 2013).

The predicted classification in the dataset with unknown behaviours had high precision and concordance on both daily periods (day and night), and different frequencies for each behaviour (grazing, ruminating e not-grazing). Thus, it is considered that the GPS collar can be used in small paddocks. A predicted daily behaviour pattern was obtained with means 9 ± 1 h/d for grazing, 4 ± 0.5 h/d for not-grazing and 11 ± 0.5 h/d to rumination. According to Kilgour (2012), in a revision of literature, beef cattle kept in pastures spend a greater time (among 90-95%) on three basic behaviours: grazing, ruminating and resting. Thus, our prediction model would be a good predictor for these behaviours for animals kept in small paddocks.

The HD (%), DIST (m) and Sum-XY-act (count) of dataset B showed a peak of tilt sensor activities at daily hours intervals 7 and 8 (14:00 to 15:59 h and 16:00 to 17:59 h) for all nutrition plan. In a similar study Kjellqvist (2008) and Einemo (2008) evaluating behaviour of 6-8 Nellore heifers (*Bos indicus*), discovered that the animals travelled greater DIST in late afternoon, 14:00 till 18:00 h. These differences were not observed to predict the behaviours' averages at different nutritional plan treatments. This result was the opposite of what we were expecting, could have happened due to an animal having a greater forage offer; we expected it would increase the interval between meals and decrease grazing time, or the other way around, an animal having a lower forage offer was expected to decrease the interval between meals and increase grazing time. However, a decrease in grazing time was substituted by the supplement consumption. Since meal duration is reciprocal, the satiety sensation would be achieved faster and longer intervals would be seen among meals, with a similar pattern of grazing time for the animals with a greater forage supply. This result was the opposite showed by Casagrande et al. (2011) when analyzing the grazing time of heifers by visual observations on the same experimental area, where greater grazing times were found in the 15 cm pasture height when compared to the 35 cm pasture height. This could be probably explained by the lower amount of rainfall observed during the wet season in 2014. Unlike previous years, that could affect the available green mass from the forage. Similar results were found by Valente et al. (2013), who also compared different nutritional plan treatments with forage, different proportions of protein (high and low) and carbohydrates, but did not find differences in the grazing time either.

In another study, Gontijo Neto et al. (2006) studied the effects of forage allowance on canopy changes by assessing the grazing time and forage intake by steers grazing *Tanzania grass* (*Panicum maximum Jacq.*) pasture. The authors found that daily grazing time showed a quadratic effect by the variation in herbage allowance (HA) under four levels (kg of leaf blade /100 kg animal live weight/day, %): 6.1 ± 0.59; 11.1 ± 0.77; 18.0 ± 1.24 and 23.9 ± 1.15%, being the values between 6.2 and 10.1 hours, showing higher values observed for smaller herbage allowance. Mezzalira et al. (2012) reported that in a low-quality forage, animals spent 510 minutes harvesting forage (83% of total grazing time), while the same activity for a high-quality forage allowance was decreased to 271 minutes (57% of total grazing time). In contrast, the time spent searching for forage was restricted to 107 minutes when the herbage allowance was low (17% of the daily grazing time), and to more than 180 minutes (43% of the daily grazing time) when the herbage allowance was higher.

In the conditions of our study, a longer grazing time was observed in the intervals between 16:00 h till 18:00 h and from 05:00 h till 09:59 h in animals from all nutrition plans, probably this due to a decrease in the overall air temperature. On the other side, the intervals from 11:00 h till 13:59 h, presented a shorter grazing time in all nutrition plans, probably due to being the warmer hours of the day. Moreover, the predicted time spent on rumination and not-grazing, showed the opposite manner of the time spent grazing, where young bulls changed their behaviour to reduce the heat production and to keep body temperatures at an appropriate physiologic level, during the hottest hours. According to Carvalho (1997), the animals could intensify their nutrient ingestion from the dry matter by the end of the day, which combined with the thermal comfort, would explain the grazing peak during the cooler hours of the day. At high temperature, it is difficult to animals to dissipate metabolic heat and consequently, a reduction in DM intake occurs (Tucker et al., 2008, Valente et al. 2013). Similar results were also found by Titto et al. (2011) with bulls and Valente et al. (2013) with young bulls, which in similar climatic conditions they have demonstrated a decrease in the grazing time during the warmer periods of the day.

Our results support and agree with previous results found by Valente et al. (2013), that there are many factors that could be responsible for the food intake control. Even when grazing time is not modified, food consumption may change, and this could be due to individual characteristics of the animals.

2.5 Conclusion

Our results demonstrated that GPS collars with tilt sensors can provide acceptable and useful information for the prediction and classification of behaviors throughout the day and night on pasture-based beef cattle kept in small areas. However, no significant differences were found among the thresholds of the different nutrition plans, not showing differences especially in the grazing time. Anyway, it can be considered that these devices are an useful tool to determine the behaviour of cattle when it cannot be visually observed for long time.

2.6 References

AGOURIDIS, C. T.; STOMBAUGH, T. S.; WORKMAN, S. R.; KOOSTRA B. K.; EDWARDS D. R; VANZANT E. S. Suitability of a GPS collar for grazing studies. **American Society of Agricultural Engineers**, Saint Joseph, v. 47, n. 4, p.1321–1329, 2004. Disponível em: <http://dx.doi.org/10.13031/2013.16566>.

ANDERSON, D. M.; ESTELL, R. E.; CIBILS, A. F. Spatiotemporal cattle data – a plea for protocol standardization. **Positioning**, Irvine, v. 4, n. 1, p. 115–136, 2013. Disponível em: <http://dx.doi.org/10.4236/pos.2013.41012>.

AUGUSTINE, D. J.; DERNER, J. D. Assessing herbivore foraging behavior with GPS collars in a semiarid grassland. **Sensors**, Basel, v. 13, n. 3, p. 3711–3723, 2013. Disponível em: <http://dx.doi.org/10.3390/s130303711>.

AUGUSTINE, D. J.; MCNAUGHTON, S. J., Ungulate effects on the functional species composition of plant communities: herbivore selectivity and plant tolerance. **The Journal of Wildlife Management**, Hoboken, v. 62, n. 4, p.1165–1183, 1998. Disponível em: <http://dx.doi.org/10.2307/3801981>.

BAILEY, D. W.; VANWAGONER, H. C.; WEINMEISTER, R.; JENSEN, D. Comparison of low-moisture blocks and salt for manipulating grazing patterns of beef cows. **Journal of Animal Science**, Champaign, v. 86, n. 5, p. 1271–1277, 2008. Disponível em: <http://dx.doi.org/10.4236/pos.2013.41012>.

BARBARI, M.; CONTI, L.; KOOSTRA, B. K.; MASI, G.; SORBETTI GUERRI, F.; WORKMAN. S. R. The use of global positioning and geographical information systems in the management of extensive cattle grazing. **Biosystems Engineering**, London, v. 95, n. 2, p. 271–280, 2006. Disponível em: <http://dx.doi.org/10.1016/j. biosystemseng.2006.06.012>.

CARVALHO, P. C. F. A estrutura da pastagem e o comportamento ingestivo de ruminantes em pastejo. In: SIMPÓSIO SOBRE AVALIAÇÃO DE PASTAGENS COM ANIMAIS, 2., 1997, Maringá. **Anais...** Maringá: Universidade Estadual de Maringá, 1997. p. 25–52.

CASAGRANDE, D. R.; AZENHA, M. V.; VALENTE, A. L. D. S.; VIEIRA, B. R., MORETTI, M. H.; RUGGIERI, A. C.; BERCHIELLI, T. T.; REIS, R. A. Canopy characteristics and behavior of Nellore heifers in Brachiaria brizantha pastures under different grazing heights at a continuous stocking rate. **Revista Brasileira de Zootecnia**, Viçosa, v. 40, n. 11, p. 2294–2301, 2011. Disponível em: <http://dx.doi.org/10.1590/S1516-35982011001100003>.

DE'ATH, G.; FABRICIUS, K. E. Classification and regression trees: a powerful yet simple technique for ecological data analysis. **Ecology**, Hoboken, v. 81, n. 11, p. 3178–3192, 2000. Disponível em: <http://dx.doi.org/10.1890/0012-9658(2000)081%5B3178:CARTAP%5D2.0.CO;2>.

EINEMO, A. **Interpretation of data from GPS-collars with movement sensors on cattle**. Skara: Department of Animal Environment and Health Ethology and Animal Welfare programme - Swedish University of Agricultural Sciences, 2008. 19 p. (Student report, 209).

GANSKOPP, D. Manipulating cattle distribution with salt and water in large arid-land pastures: A GPS/GIS assessment. **Applied Animal Behaviour Science**, Amsterdam, v. 73, n. 4, p. 251–262, 2001. Disponível em: <http://dx.doi.org/10.1016/S0168-1591(01)00148-4>.

GANSKOPP, D. C.; JOHNSON, D. D. GPS error in studies addressing animal movements and activities. **Rangeland Ecology & Management**, Littleton, v. 60, n. 4, p. 350–358, 2007. Disponível em: <http://dx.doi.org/doi:10.2111/1551-5028(2007)60[350:GEISAA]2.0.CO;2>.

GONTIJO NETO, M. M.; EUCLIDES, V. P. B.; NASCIMENTO JÚNIOR, D.; MIRANDA, L. F.; FONSECA, D. M.; OLIVEIRA, M. P. Consumo e tempo diário de pastejo por novilhos Nelore em pastagem de capim-tanzânia sob diferentes ofertas de forragem. **Revista Brasileira de Zootecnia**, Viçosa, v. 35, n. 1, p. 60–66, 2006. Disponível em: <http://dx.doi.org/10.1590/S1516-35982006000100007>.

GONZÁLEZ, L. A.; BISHOP-HURLEY, G. J.; HANDCOCK, R. N.; CROSSMAN, C. Behavioral classification of data from collars containing motion sensors in grazing cattle. **Computers and Electronics in Agriculture**, Amsterdam, v. 110, p. 91–102, 2015. Disponível em: <http://dx.doi.org/10.1016/j.compag.2014.10.018>.

GORDON, I. J. Animal-based techniques for grazing ecology research. **Small Ruminant Research**, Amsterdam, v. 16, n. 3, p. 203–214, 1995. Disponível em: <http://dx.doi.org/10.1016/0921-4488(95)00635-X>.

HULBERT, I. A. R.; FRENCH, J. The accuracy of GPS for wildlife telemetry and habitat mapping. **Journal of Applied Ecology**, West Sussex, v. 38, n. 4, p. 869–878, 2001. Disponível em: <http://dx.doi.org/10.1046/j.1365-2664.2001.00624.x>

KILGOUR, R. J. In pursuit of “normal”: A review of the behaviour of cattle at pasture. **Applied Animal Behaviour Science**, Amsterdam, v. 138, n. 1, p. 1–11, 2012. Disponível em <http://dx.doi.org/10.1016/j.applanim.2011.12.002>.

KJELLQVIST, S. **Determining cattle pasture utilization using GPS-collars**. Skara: Department of Animal Environment and Health Ethology and Animal Welfare programme - Swedish University of Agricultural Sciences, 2008. 14 p. (Student report, 208).

KOTTEK, M.; GRIESER, J.; BECK, C.; RUDOLF, B.; RUBEL, F. World map of the Koppen-Geiger climate classification updated. **Meteorologische Zeitschrift**, Stuttgart, v. 15, n. 3, p. 259–263, 2006. Disponível em: <http://dx.doi.org/10.1127/0941-2948/2006/0130>.

LOTEK GPS_3300. **Small and Midsize Animals: GPS Location System User's Manual**. Newmarket, Ont.: Lotek Engineering, Inc, 2011.

MANLY, B. J. F. **Métodos estatísticos multivariados:** uma introdução. 3. ed. Porto Alegre: Bookman, 2008. 230 p.

MARTIN, P.; BATESON, P. **Measuring behaviour:** an introductory guide. Cambridge: Cambridge University Press, 1986, 200 p.

MEZZALIRA, J. C., BREMM, C., DA TRINDADE, J. K., NABINGER, C.; CARVALHO, P. C. F. The ingestive behaviour of cattle in large-scale and its application to pasture management in heterogeneous pastoral environments. **Journal of Agricultural Science and Technology**, Tehran, v. A 2, n. 7, p. 909–916, 2012.

MOEN, R.; PASTOR, J; COHEN, Y. Interpreting behavior from activity counters in GPS collars on moose. **Alces**, Thunder Bay, v. 32, p. 101–108, 1996.

MOTT, G. O.; LUCAS, H. L. The design, conduct and interpretation of grazing trials on cultivated and improved pastures. In: INTERNATIONAL GRASSLAND CONGRESS, 6., 1952, Pennsylvania. **Anais…** Pennsylvania: State College, 1952. p. 1380–1385.

NADIMI, E. S.; SØGAARD, H. T.; BAK, T. ZigBee-based wireless sensor networks for classifying the behaviour of a herd of animals using classification trees. **Biosystems Engineering**, London, v. 100, n. 2, p. 167–176, 2008. Disponível em: <http://dx.doi.org/10.1016/j.biosystemseng.2008.03.003>.

R DEVELOPMENT CORE TEAM. **R: A language and environment for statistical computing**. 2008. Vienna: R Foundation for Statistical Computing. ISBN 3-900051-07-0. Disponível em: <http://www.R-project.org>.

ROBERT, B.; WHITE, B. J.; RENTER, D. G.; LARSON, R. L. Evaluation of three-dimensional accelerometers to monitor and classify behavior patterns in cattle. **Computers and Electronics in Agriculture**, Amsterdam, v. 67, n. 1–2, p. 80–84, 2009. Disponível em: <http://dx.doi.org/10.1016/j.compag.2009.03.002>.

ROTHWELL, E. S.; BERCOVITCH, F. B.; ANDREWS, J. R. M.; ANDERSON, M. J. Estimating daily walking distance of captive African elephants using an accelerometer. **Zoo Biology**, Hoboken, v. 30, n. 5, p. 579–591, 2011. Disponível em: <http://dx.doi.org/10.1002/zoo.20364>.

SAS INSTITUTE, 2012. **SAS/STAT 9.4 User’s Guide**. SAS Institute, Cary, NC.

SCHLECHT, E.; HÜLSEBUSCH, C.; MAHLER, F.; BECKER, K. The use of differentially corrected global positioning system to monitor activities of cattle at pasture. **Applied Animal Behaviour Science**, Amsterdam, v. 85, n. 3–4, p. 185–202, 2004. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2003.11.003>.

SCHWAGER, M.; ANDERSON, D. M.; BUTLER, Z; RUS, D. Robust classification of animal tracking data. **Computers and Electronics in Agriculture**, v. Amsterdam, 56, n. 1, p. 46–59, 2007. Disponível em: <http://dx.doi.org/10.1016/j.compag.2007.01 .002>.

SWAIN, D. L.; WARK, T.; BISHOP-HURLEY, G. J. Using high fix rate GPS data to determine the relationships between fix rate, prediction errors and patch selection. **Ecological Modelling**, Amsterdam, v. 212, n. 3–4, p. 273–279, 2008. Disponível em: <http://dx.doi.org/10.1016/j.ecolmodel.2007.10.027>.

TITTO, C. G.; TITTO, E. A. L.; TITTO, R. M.; MOURAO, G. B., Heat tolerance and the effects of shade on the behavior of Simmental bulls on pasture. **Animal Science Journal**, Richmond, v. 82, n. 4, p. 591–600, 2011. Disponível em: <http://dx.doi.org/10.1111/j.1740-0929.2011.00872.x>.

TURNER, L. W; UDAL, M. C.; LARSON, B. T.; Shearer, S. A. Monitoring cattle behavior and pasture use with GPS and GIS. **Canadian Journal of Animal Science**, Ottawa, v. 80, n. 3, p. 405–413, 2000. Disponível em: <http://dx.doi.org/10.4141/A99-093>.

TUCKER, C. B.; ROGERS, A. R.; SCHÜTZ, K. E. 2008. Effect of solar radiation on dairy cattle behaviour, use of shade and body temperature in a pasture-based system. **Applied Animal Behaviour Science**, Amsterdam, v. 109, n. 2-4, p. 141-154, 2008. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2007.03.015>.

UMSTÄTTER, C.; WATERHOUSE, A.; HOLLAND, J. P. An automated sensor-based method of simple behavioural classification of sheep in extensive systems. **Computers and Electronics in Agriculture**, Amsterdam, v. 64, n. 1, p. 19–26, 2008. Disponível em: <http://dx.doi.org/10.1016/j.compag.2008.05.004>.

UNGAR, E. D.; HENKIN, Z.; GUTMAN, M.; DOLEV, A.; GENIZI, A.; GANSKOPP, D. Inference of animal activity from GPS collar data on free–ranging cattle. **Rangeland Ecology & Management**, Wheat Ridge, v. 58, n. 3, p. 256–266, 2005. Disponível em: <http://dx.doi.org/10.2111/1551-5028(2005)58[256:IOAAFG]2.0.CO;2>.

UNGAR, E. D., SCHOENBAUM, I., HENKIN, Z., DOLEV, A., YEHUDA, Y.; BROSH, A. Inference of the activity timeline of cattle foraging on a Mediterranean woodland using GPS and pedometry. **Sensors**, Basel, v. 11, n. 1, p. 362–383. 2011. Disponível em: <http://dx.doi.org/10.3390/s110100362>.

VALENTE, E. E. L.; PAULINO, M. F.; DETMANN, E.; VALADARES FILHO, S. C.; CHIZZOTTI, M. L.; SILVA, A. G.; MACIEL, I. F. S., Grazing Behavior and Locomotion of Young Bulls Receiving Different Nutritional Plans in a Tropical Pasture. **Asian Australasian Journal of Animal Sciences**, Seoul, v. 26, n. 12, p. 1717–1725, 2013. Disponível em: <http://dx.doi.org/10.5713%2Fajas.2013.13165>.

CHAPTER 3 – The relationship between temperament and grazing behaviour in pasture-based beef cattle

Abstract – The beef cattle temperament is usually assessed by measuring the reactions of the animals towards humans (or to situations related to them). Nevertheless, many other traits (e.g. exploratory behaviour) could also be used as temperament indicators. The aim of this study was to assess the association between the productivity traits (ADG and BW_{final}), cattle behaviour in the pasture (grazing time, not-grazing, ruminating and walking) and two usual traits used to assess cattle temperament: visual reactivity score (RS) while the animal was kept inside the squeeze chute during weighing; and flight speed (FS, $m.s^{-1}$) velocity to exit the squeeze chute. To assess the effects of temperament on the performance (ADG and BW_{final}), 126 young Nellore bulls (BW = 231 ± 19.6 kg; 10 to 12 mo-old) were randomly assigned to 18 groups that received one of three nutrition plan treatments, consisting in a combination of three tropical pasture heights (15, 25 and 35 cm) and two types of supplementation (mineral or protein). To assessed effects of temperament on the behaviour a subsample of forty-eight animals were fitted with GPS collars (3300 LR, Loteck®) for 7 days to measure behaviour time (% daily time; 90% prediction precision) and distance travelled per day ($Km.d^{-1}$) described previously. Mixed-effects models were used to test the fixed effects of RS (low, intermediate and high) or FS (slow, intermediate and fast), nutrition plan treatments and their interaction, whereas group was the random effect. Temperament only showed a weak relationship to productivity with low correlation between BW_{final} and RS (r_s = 0.18; P = 0.05). No significant effects of temperament were found on ADG (P > 0.05). Effect was found in temperament measured by both methods (FS and RS) on the tilt sensor variables from GPS collar sum-XY-act and the distance travelled ($Km.d^{-1}$)(P < 0.0001), but no effect was found on Head Down (%) (P > 0.05). Regarding the behaviour time, effects were found (P < 0.0001) on the proportion of not-grazing time assessed by FS and RS; ruminating time assessed by FS; and grazing time showed only a negative tendency when assessed by FS. The results showed that the temperament evaluated in the short-term when handling the animals, does not represent directly the long-term behavior of beef cattle when kept at grassland conditions with supplementation. It suggests that these traits are probably independent and the behaviour of beef cattle throughout the day in this conditions would be regulated by other traits individual not captured by usual methods of temperament assessment.

Keywords: behaviour monitoring, GPS, livestock, reactivity, Zebu breeds

3.1 Introduction

Grazing systems in Brazil and in other tropical countries have the predominant use of Nellore breeds (*Bos indicus*), pure or crossbreed (with European breeds), searching for a better adaptation to the tropical environment (BARBOSA SILVEIRA et al., 2012). However, Zebu cattle does not have a good reputation when it comes to temperament and ease of handling, especially when raised under extensive conditions (FORDYCE; GODDARD; SEIFERTG, 1982; HEARNSHAW; MORRIS, 1984; MORRIS et al., 1994; BURROW, 1997).

In livestock production, in particular for beef cattle, it is common to use the term temperament defined as the reaction of animals to the human handling, which is generally attributed to fear (FORDYCE; GODDARD; SEIFERTG, 1982; BURROW, 1997) or the associated stimuli caused by the human presence (BOIVIN; LE NEINDRE; CHUPIN, 1992; PETHERICK et al., 2009a). It is also used in different ways to indicate how easy it is to approach, to handle, to weigh, to treat for injury, among other activities, always regarding the human-animal contact. The connection between the temperament and the individual performance as weight gain (VOISINET et al., 1997a; PETHERICK et al., 2009b; HOPPE et al., 2010; SEBASTIAN et al., 2011; TURNER et al., 2011), carcass and meat quality (VOISINET et al., 1997b; NKRUMAH et al., 2007; CAFE et al., 2011a, b; HALL et al., 2011), physiological indicators of stress (CURLEY JÚNIOR et al., 2006, 2008; PETHERICK et al., 2009b) faecal pathogen loads (SCHUEHLE PFEIFFER et al., 2009) and immune system functioning (FELL et al., 1999; BURDICK et al., 2009; HULBERT et al., 2011) have all been studied.

In the context of behavioral ecology, behavior studies began to consider the study of animal temperament as an individual assessment feature, therefore, uses the term "behavioral syndrome" as regards the behavioral consistency among individuals in different situations (SIH; BELL; JOHNSON, 2004). Thus, some authors recommend assess the temperament in different contexts to capture the different dimensions of it (RÉALE et al., 2007; SMITH; BLUMSTEIN, 2008; KOOLHAAS et al., 2010), plus some qualitative temperament characteristics (GRAUNKE et al., 2013; SANT'ANNA; PARANHOS DA COSTA, 2013). One of these dimensions is represented by the "boldness" characteristic, and it is considered especially important for animals kept under grassland conditions or in constant changing environments (e.g. during grazing, mating and anti-predator behaviour) (KOOLHAAS et al., 2010). Nowadays, there is still no consensus among researchers in how to assess this characteristic in farmed species, as it presents a positive correlation to the activity level in different species (BIRO et al., 2006; BIRO; STAMPS, 2008). For this reason, Adamczyk et al. (2013) suggests the implementation of other technologies (such as GPS, accelerometers, etc.) for an assessment in other contexts, to select animals better adapted to different situations. The continuous selection of animals based only on performance will have a minimum impact on the progress of temperament, and this selection will affect not only the animal welfare, but also the human well-being (HASKELL; SIMM; TURNER, 2014).

With the development of devices such as pedometers and GPS collars with built-in activity sensors (e.g. accelerometers and motion sensors), it is possible to assess the animal behaviour remotely, without interfering in their activity when doing behavioural observations (TURNER et al., 2000). As a result of this technology, cattle grazing behaviour could be better studied, determining different patterns of behaviours and activities (UNGAR et al., 2005; GANSKOPP; JOHNSON, 2007; SWAIN; WARK; BISHOP-HURLEY et al., 2008; UNGAR et al., 2011; AUGUSTINE; DERNER, 2013; GONZÁLEZ et al., 2015). The first results focusing on differences in individual behaviour and using this technology, were presented by Wesley et al. (2012) that studied individual differences of foraging behaviour in different environments (confinement *vs.* pasture) with GPS collars. The authors found that the same cows who consumed their feed rapidly in confinement did make a better use of the grassland. In another study, MacKay et al. (2013) showed that temperament tests such as crush score and flight speed used to assess the behaviour of confined steers in a short-term, could also be related to a long-term activity level and a long-term social behaviour throughout the day. In addition, a research studying water buffaloes showed no significant correlations between the average distances travelled daily and the animals' reactivity during milking, the milk yield and the milk quality, demonstrating that these characteristics are probably independent from each other (CARVALHAL, 2014).

In this context, it is assumed that short-term temperament tests could be associated with the animal's behaviour in a long-term. Thus, the aim of this study was to analyse the influence of temperament on the performance and the daily behaviour, represented by time spent grazing, not-grazing and ruminating with the following hypothesis: 1) the animal's productivity can be affected by the temperament assessed through their reactivity to human handling; and 2) the temperament can affect the daily behaviour assessed by GPS collars.

3.2 Material and Methods

The methods used in this study were approved by the Committee of Ethical Use of Animals from the Faculty of Agricultural and Veterinary Sciences, São Paulo State University, Campus of Jaboticabal, São Paulo, Brazil. Protocol number 09/2014.

3.2.1 Study site and experimental design

The study was conducted in the research facilities of the Animal Science Department at the Faculty of Agricultural and Veterinary Sciences, São Paulo State University (FCAV/UNESP), located in the city of Jaboticabal, São Paulo, Brazil (21º15'22''S latitude, 48º18'58''W longitude and 595-m elevation).

The climate in the region is classified as Aw (tropical wet and dry) according to Köppen and Geiger system (KOTTEK et al., 2006), with rainy summers and dry winters. The data collection was carried out from January to April, 2014. The air temperature (°C), the relative humidity (%) and the precipitation (mm) were recorded by the Agrometeorological Station, located 800 m away from the experimental area shown in Table 1.

Table 1. Weather conditions are showed during the period the data collection

	Temperature (°C)			**Relative humidity (%)**			**Precipitation (mm)**
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Total monthly
January	19.5	25.2	32.2	37.8	68.8	90.8	98.8
February	19.6	25.5	32.1	37.6	63.3	96.9	95.2
March	19.2	24.1	30.5	44.7	73.2	92.4	97.3
April	17.8	22.9	29.5	43.9	71.5	91.0	63.3

Data from the Agrometeorological Station at FCAV/UNESP.

The experimental area was sown with *Brachiaria brizantha* (Hochst ex A. Rich, Stapf cv. *Marandu*) and divided in 6 paddocks of 0.7 ha, 6 of 1.0 ha and 6 of 1.3 ha, totalling 18 paddocks of the same characteristics described in chapter II of this thesis (AGUILAR, 2016). The nutritional plans were defined by the arrangement the three available forage mass (available high, medium and low) and the supplementation levels (mineral mixture only and protein supplements). Six nutritional plans were assigned to the animals, as follows: 1) THMS: paddocks of available high forage mass with tall pasture height (35 cm) and a mineral mixture only; 2) THLS: paddocks of available high forage mass with tall pasture height (35 cm) and a low supplementation (lower protein intake supplement, 0.1% BW/d); 3) MHLS: paddocks of available medium forage mass with moderate pasture height (25 cm) and low supplementation (0.1% BW/d); 4) MHMS: paddocks of available medium forage mass with moderate pasture height (25 cm) and moderate supplementation (0.3% BW/d); 5) SHMS: paddocks of available low forage mass with short pasture height (15 cm) and moderate supplementation (0.3% BW/d); 6) SHHS: paddocks of available low forage mass with short pasture height (15 cm) and high supplementation (0.6% BW/d). The mineral salt and the supplementation were delivered daily between 10:30 and 11:30 h and the water was available *ad libitum*. An additional area of 5 ha, divided in 3 paddocks, was used as a reservation area.

3.2.2 Animals and measurements

A sample of 126 Nellore young bulls with an average of 10 to 12 mo-old, and weighing around 231 ± 19.60 kg of body weight (BW) was used. The animals were randomly divided in 18 groups of 7 animals and placed into paddocks previously described (127 days during wet season). The animals were weighed at the beginning ($BW_{initial}$; kg.animal^{-1}) and at the end (BW_{final}; kg.animal^{-1}) after fasting (12 h), to calculate the individual average daily gain (ADG, kg.animal^{-1}.d^{-1}), being this characteristics considered as the animal productivity. One additional group of 14 animals (apart from the total 126) were kept in an additional area and was used to maintain the pasture height in the experimental paddocks (MOTT; LUCAS, 1952).

All animals in the study were conducted to a handling pen every 28 days for individual weighing and for adjusting the feed ration. Moreover, the animals who wore the GPS collars were handled every 14 days for exchanging the collars and were also frequently handled for other routine managements.

3.2.3 Temperament assessment

The temperament assessment was conducted by one trained observer using two methodologies: 1) reactivity score test (RS) adapted from Piovezan, Cyrillo and Paranhos da Costa (2013), defined as the combination of scores of movement (MOV), body posture (BP), tension (TS) and breathing intensity (BI) while the animal was kept inside the squeeze chute during weighing; and 2) flight speed test (FS) adapted from Burrow, Seifert and Corbet (1988), defined as the speed in which an animal leaves the squeeze chute after being weighed.

For the reactivity test, the scores of movement (MOV), tension (TS), body posture (BP) and breathing intensity (BI) were assessed throughout observations during the first 4 seconds after the animal entered the squeeze chute, and without being physically restrained by the head bail. The description of these scores is shown in Table 2. We also recorded when an animal vocalized and kicked (score 1), or not (score 0), and since these behaviours occurred in a low frequency, they were not considered in the definition of RS. The reactivity score (RS) was defined by the sum of MOV, TS, BI and BS (adapted from FORDYCE et al., 1985).

Table 2. Definitions of the reactivity test with the scores of movement (MS), tension (TS), body posture (BP) reactivity (RS) and breathing intensity (BI); plus the absolute and relative frequencies of the animals assessed

Behavioural categories	Score definitions	Absolute frequency (n)	Relative frequency (%)
Movement score (MS)	1 = no movement	18	14.51
	2 = little movement (during less than half of the observation time)	38	30.64
	3= frequent movements (during half or more of the observation time), but not vigorous	43	34.67
	4 = constant and vigorous movements, with attempts to turn the body, and bending the neck back	24	19.35
	5 = constant and vigorous movements, animal jumps and raises its forelimbs not less than 2.5 cm off of the ground	1	0.81
Body posture score (BPS)	1= standing, animal supporting on all four hooves	114	91.94
	2= kneeling, when in intervals the animal supports on the knees and / or on the two back hooves	10	8.06
	3 (*) = lying, when at some point the animal has the ventral part of the body in contact with the floor without supporting on the hooves	-	-
Tension score (TS)	1 = relaxed, when the animal presents regular muscle tone, do not exhibit sudden movements of the tail and / or the head and neck	5	4.03
	2 = alert, when animal moves the tail, head and neck in a fast pace and forces the output for less than half the observation time	58	46.77
	3 = tense, when the animal exhibits continuous and vigorous movements of the tail, head and neck, but no visible muscle tremors, force out	61	49.19
	4 (*) = very tense, when the animal is paralysed "freezing"; muscle tremors are visible	-	-
Breathing intensity (BI)	1 = normal and rhythmic breathing, not audible	94	75.81
	2 = audible with rhythmic breathing or not;	30	24.19
	3 (*) = snorting with no rhythmic breathing.	-	-
Reactivity score test (RS)	1 = from score 4 to 6	39	31.45
	2 = score 7	23	18.54
	3 = score 8	24	19.35
	4 = score 9	27	21.77
	5 = score 10	10	8.06
	6 = score 11	1	0.81
	7 (*) = from score 12 to 13	-	-

[a]n = 124 animals in the reactivity test assessment (2 animals were excluded from the dataset due to missing data). [*]Scores were not displayed in this group of animals.

The flight speed test (FS) was made by using an electronic device consisting of a pair of photoelectric cells, a stopwatch, and a processor programmed to register the time taken by each animal to cover the distance of 1.7 m after leaving the squeeze chute. The time was then converted into speed (distance/time, in $m.s^{-1}$), where faster animals were considered to have a worse temperament (BURROW, 1997).

The temperament of the animals was assessed in two occasions with an interval of 120 days. The first assessment will now be named FS (1) ($m.s^{-1}$) or RS (1) and the second assessment will be named FS (2) ($m.s^{-1}$) or RS (2).

3.2.4 Monitoring animal behaviour with GPS collars' tilt sensors

In addition to evaluating the temperament, it was calculated the proportion of predicted daily time spent (%) grazing (GRA), not-grazing (Not-gra), ruminating (RUM) and the total distance travelled per day ($Km.d^{-1}$), all from a small sample of 48 young bulls (randomly selected) that were maintained and distributed as described in chapter II of this thesis (AGUILAR, 2016). The animals were monitored by the Lotek® 3300 LR GPS collars (Lotek Engineering, Newmarket, Ontario, Canada) during 24-hour considering 10 intervals, encompassing the daytime hours' classes, as follows: interval 1 (00:00 to 02:59 h), interval 2 (03:00 to 05:59 h), interval 3 (06:00 to 07:59 h), interval 4 (08:00 to 09:59 h), interval 5 (10:00 to 11:59 h), interval 6 (12:00 to 13:59 h), interval 7 (14:00 to 15:59 h), interval 8 (16:00 to 17:59 h), interval 9 (18:00 to 20:59 h) and interval 10 (21:00 to 23:59 h). Nine young bulls were excluded from the dataset due to missing data, resulting in an analysis based on 39 animals. The data from the GPS collars and tilt sensors (head down and sum-XY-act) were analysed and described in chapter II of this thesis (AGUILAR, 2016).

3.2.5 Statistical analysis

Firstly, an exploratory statistical analysis was conducted, where the Shapiro-Wilk normality test was held for all dependent variables ($P > 0.05$). Outliers (studentised residuals) with values greater than 3.0 or lower than - 3.0, were removed.

For the statistical analyses, the arithmetic mean for each animal was calculated based on the two measurements of FS record (FSmean) and the two measurements of RS record (RSmean). FSmean was defined as a three classes discrete variable, as follows: 1) slow animal (n = 36, values lower than the mean – 0.5 SD, FSmean ≤ 2.68

m.s-[1]); 2) intermediate animal (n = 58, the mean ± 0.5 SD, FSmean > 2.68 and ≤ 3.35 m.s-[1]); and 3) fast animal (n = 30, values greater than the mean + 0.5 SD, FSmean > 3.35 m.s-[1]) (BEHRENDS et al., 2009). To RSmean it was defined three classes: 1) low animal (n = 43, RSmean scores 1 and 2), 2) intermediate animal (n = 52, RSmean scores 3 and 4); and 3) high animal (n = 30, RSmean scores greater than 4).

An analysis to investigate the relationship between variables was initially done, and involved calculating Pearson´s correlation coefficients to FS test, or Spearman´s test to RS, both with the performance (BW_{final} and ADG), the predicted daily behaviour time and the tilt sensor variables (head down and Sum-XY-act) from the GPS collar.

To test the hypothesis that the animal performance could be affected by the temperament, the dataset containing all animals (n = 124) was used. A mixed model (PROC MIXED by SAS) was held, where ADG ($kg.animal^{-1}.d^{-1}$) or BW_{final}($kg.animal^{-1}$) were considered as dependent variables. The model is represented by:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Zu} + \mathbf{e}$$

where **y** is a vector of records for all recorded animals; **b** is a vector of the fixed effects of FSmean ($m.s^{-1}$) in classes, nutrition plan, FSmean*nutrition plan and $BW_{initial}$ as covariate or RSmean in class, nutrition plan, RSmean* nutrition plan and $BW_{initial}$ as covariate; **u** is a vector of paddock effect (random) ~ N (0, $\mathbf{I}\sigma_u^2$) where **I** is an identity matrix; **X** and **Z** are the incidence matrices related to fixed and random effect; respectively, **e** is a vector of random environmental effects with mean 0 and variance-covariance matrix $\mathbf{R}\sigma^2$.

To test the hypothesis that the temperament can affect the daily behaviour time spent and the distance travelled ($Km.d^{-1}$), the subsample animals with GPS collars were used (n = 39). A mixed model (PROC MIXED by SAS) was used where the dependent variables were considered as: the GPS collar data (head down and sum-XY-act), the distance travelled ($Km.d^{-1}$), proportion of the predicted daily time spent grazing (%), proportion of the predicted daily time spent not-grazing (%), proportion of the predicted daily time spent ruminating (%), represented by:

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Zu} + \mathbf{e}$$

where **y** is a vector of records for all recorded animals; **b** is a vector of the fixed effects of FSmean ($m.s^{-1}$) in classes, nutrition plan treatment, daily hours classes, FSmean*daily hours classes or RSmean, nutrition plan treatment, daily hours classes, RSmean*daily hours classes; **u** is a vector of paddock effect (random) ~ N (0, $\mathbf{I}\sigma_u^2$) where **I** is an identity matrix; **X** and **Z** are the incidence matrices related to fixed and random effect, respectively, and **e** is a vector of random environmental effects with mean 0 and variance-covariance matrix $\mathbf{R}\sigma^2$.

Model selections were done by the Akaike information criterion (AIC). In a model selection application, the optimal fitted model is identified by the minimum value of AIC (AKAIKE, 1974).

The Kenward-Roger method was used to perform a general Satterthwaite approximation for the denominator degrees of freedom of F- distribution to fixed effects. For multilevel models with factorial type designs, the recommended correction is generally Kenward and Roger (1997).

Afterwards, means differences were obtained with the Bonferroni's adjustment test for multiple comparisons. Differences among means were considered significant at $P < 0.05$. Main effects and interactions were considered significant at $P < 0.05$, and considered as tendency at $P < 0.10$. The data management and analyses were performed using SAS® 9.4 (SAS Inst. Inc., Cary, NC, 2012).

3.3 Results

3.3.1 The relationship between cattle temperament and performance

Table 3 shows the descriptive statistics for the temperament variables (flight speed and reactivity score) and performance (ADG and BW_{final}) used in the data analysis to relate temperament and performance.

Table 3. Descriptive analysis of all animals for the temperament and performance variables

Indicator	Variables	Flight speed ranking: slow	intermediate	fast
Temperament	FSmean[a] (m.s-1)	2.25 (0.38)	3.06 (0.20)	3.91 (0.36)
	$BW_{initial}$[c] (kg.animal-1)	231.8 (19.9)	229.9 (19.5)	234.3 (21.3)
Performance	BW_{final}[d] (kg.animal^{-1})	348.1 (28.1)	344.8 (29.7)	345.2 (30.3)
	ADG[e] (kg.animal^{-1}.d^{-1})	0.927 (0.104)	0.921 (0.157)	0.883 (0.148)
		Reactivity score: low	**intermediate**	**high**
Temperament	RSmean[b]	1	2	3
	$BW_{initial}$[c] (kg.animal-1)	229.6 (19.1)	232.1 (20.6)	233.4 (20.0)
Performance	BW_{final}[d] (kg.animal^{-1})	341.6 (27.8)	347.5 (30.8)	348.5 (28.5)
	ADG[e] (kg.animal^{-1}.d^{-1})	0.893 (0.138)	0.922 (0.150)	0.920 (0.137)

[a] FSmean: the arithmetic mean for each animal was calculated based on the two measurements of FS record, and by defining a three-class discrete variable, as follows: slow animal (n = 36, values lower than the mean – 0.5 SD, FSmean ≤ 2.68 m.s-1); intermediate animal (n = 58, the mean ± 0.5 SD, FSmean > 2.68 and ≤ 3.35 m.s-1), fast animal (n = 30, values greater than the mean + 0.5 SD, FSmean > 3.35 m.s-1);
[b] RSmean: the arithmetic mean for each animal was calculated based on the two measurements of RS record, and by defining three classes: 1) low animal score (n = 43, RSmean scores 1 and 2), 2) intermediate animal score (n = 52, RSmean scores 3 and 4); and 3) high animal score (n = 30, RSmean scores greater than 4);
[c] $BW_{initial}$: initial body weight;
[d] BW_{final}: final body weight;
[e] ADG: average daily gain.

The temperament tests showed a weak relationship to performance, with only a low correlation between BW_{final} (kg.animal^{-1}) and RS (1) (r_s = 0.18; P = 0.05). No association was found (P > 0.05) among BW_{final} (kg.animal^{-1}) and RS (2), FS (1 or 2), FSmean or RSmean; or among ADG (kg.animal-1.d-1) and both temperament test.

No effect of temperament (RS or FS) was either found (P > 0.05) on ADG (kg.animal^{-1}.d^{-1}) or BW_{final} (kg.animal^{-1}).

3.3.2 Effect of temperament on the daily time spent on different behaviours

It was found an effect of temperament measured by both methods (FS and RS) on the tilt sensor variables sum-XY-act and the distance travelled per day (Km.d^{-1}) (P <0.0001), but no effect was found for head down (%) (P> 0.05).

Table 4 shows the compared mean values according to FSmean ranking, where differences were found between FSmean classes (P <0.0001). The animals classified with intermediate speed had the highest mean values for both sum-XY-act (count) and distance travelled (Km.d^{-1}) followed by the fast speed animals and the slow speed animals (Table 4).

Moreover, effects were found on the proportion of time spent not-grazing and ruminating (P <0.0001). When we compared the mean values of the proportion predicted time not-grazing, the greatest proportion was shown by the animals classified as intermediate and fast speed; while the lower mean values were shown by animals classified as slow (P <0.0001) (Table 4). Then, we also found that the highest proportion of the predicted time ruminating was shown by the animals classified as slow, followed by fast animals which did not differ from the animals classified as intermediate (P <0.0001). On the other hand, no effects of temperament were found on the proportion of the predicted time spent grazing, but showed a tendency (P <0.07), where animals classified as slow speed had the highest mean values for the proportion of grazing time (Table 4).

Table 4. Effects of temperament measured by flight speed on mean values (SE) of the tilt sensors and on the proportion of behaviours' predicted time (24 hours)

Variables	Flight speed ranking		
	slow [a]	**intermediate** [b]	**fast** [c]
HD (%)[d]	45.76 (0.66)	47.36 (0.57)	45.71 (0.63)
Sum -XY- act (count) [e]	32.38 (2.89) c	38.88 (2.86) a	36.02 (2.88) b
DIST (Km.d-^{1}) [f]	2.33 (0.04) c	2.48 (0.04) a	2.46 (0.04) b
Grazing time (%) [g]	41.98 (0.59)	41.71 (0.52)	40.39 (0.56)
Not-grazing time (%)[h]	15.33 (0.39) b	17.41 (0.38) a	17.48 (0.36) a
Ruminating time (%) [i]	42.67 (0.61) a	40.78 (0.55) b	42.19 (0.60) ab

Means followed by the same lower-case letter (for rows) were not significantly different of 5 % according to Bonferroni's test.
[a] slow animal: (n = 36, values lower than the mean – 0.5 SD, FSmean ≤ 2.68 m.s-^{1});
[b] intermediate animal: (n = 58, the mean ± 0.5 SD, FSmean > 2.68 and ≤ 3.35 m.s-^{1}),
[c] fast animal: (n = 30, values greater than the mean + 0.5 SD, FSmean > 3.35 m.s-^{1});
[d] HD: the proportion of head down (%);
[e] Sum -XY- act: sum horizontal plus vertical movements axes (count);
[f] DIST: distance travelled per day (Km.d-^{1});
[g] Grazing time (%): proportion of predicted grazing time to 24 hours from data sensor GPS collar;
[h] Not-grazing time (%): proportion of predicted not-grazing time to 24 hours from data sensor GPS collar;
[i] Ruminating time (%): proportion of predicted ruminating time to 24 hours from data sensor GPS collar.

Accordingly, as mentioned in the beginning of the results section, it was also observed an effect of temperament measured by RS (P <0.0001) on sum-XY-act (tilt sensor GPS collar) and the distance travelled ($km.d^{-1}$), but no effects were found for head down (%) ($P > 0.05$).

Table 5 shows mean values comparing the RS classes. Differences were found among RS classes ($P < 0.0001$), but in this case, the animals classified with a high reactivity score had the highest mean values for sum-XY-act and distance travelled ($km.d^{-1}$), followed by animals with intermediate and low reactivity.

Furthermore, also was found an effect when measured by RS, but only on the proportion of the predicted not-grazing time ($P < 0.0001$). When we compared the mean values, animals classified as high reactivity presented the highest proportions of not-grazing time, followed by animals classified as low and intermediate reactivity, but without differences between them ($P < 0.0001$) (Table 5).

Nevertheless, no temperament effects were found on the proportion of the predicted grazing time and rumination time; only a tendency ($P < 0.07$) that animals classified as intermediate and low reactivity had higher mean values for the proportion of predicted grazing and rumination times, respectively (Table 5).

Table 5. Effects of temperament measured by reactivity score (RS) on the mean values (SE) of the tilt sensors and the proportion of behaviours' predicted time (24 hours)

Variables	**Reactivity score ranking**		
	low [a]	**intermediate** [b]	**high** [c]
HD (%)[d]	46.26 (0.60)	45.70 (0.71)	47.27 (0.63)
Sum -XY- act (count) [e]	37.75 (3.07) b	30.94 (3.11) c	39.87 (3.07) a
DIST ($Km.d^{-1}$) [f]	2.44 (0.037) b	2.36 (0.04) c	2.52 (0.04) a
Grazing time (%) [g]	41.50 (0.52)	41.58 (0.61)	40.84 (0.54)
Not-grazing time (%)[h]	16.58 (80.34) b	16.43 (0.39) b	17.94 (0.35) a
Ruminating time (%) [i]	41.89 (0.56)	42.00 (0.65)	41.21 (0.58)

Means followed by the same lower-case letter (for rows) were not significantly different according to Bonferroni's test.
[a] low animal score: (n = 43, RSmean scores 1 and 2),
[b] intermediate animal score: (n = 52, RSmean scores 3 and 4);
[c] high animal score: (n = 30, RSmean scores greater than 4);
[d] HD: the proportion of head down (%);
[e] Sum -XY- act: sum of horizontal plus vertical movements axes (count);
[f] DIST: distance travelled per day ($Km.d^{-1}$);
[g] Grazing time (%): proportion of predicted grazing time to 24 hours from data sensor GPS collar;
[h] Not-grazing time (%): proportion of predicted not-grazing time to 24 hours from data sensor GPS collar;
[i] Ruminating time (%): proportion of predicted ruminating time to 24 hours from data sensor GPS collar.

The daily hours had effect on the proportion of the behaviours' predicted time, as expected ($P < 0.0001$), but no significant differences were found for temperament on both FS and RS. Thus, we will not show their mean comparisons, for not being the main effect evaluated in this chapter.

Finally, no effects were found of interaction the temperament by the nutrition plans, on the proportion of the predicted behaviours, or on the sensor variables from GPS collars ($P > 0.05$).

3.4 Discussion

The results in this study showed a low relationship between the temperament with ADG and BW_{final}, the opposite of what was expected, and presented in previous studies where cattle temperament was evaluated in confinement. Some authors (PETHERICK et al., 2002; MÜLLER; VON KEYSERLINGK, 2006) suggested that the reason that high temperament animals had a greater weight lost is because they spend more metabolic energy on alert and surveillance for longer periods when compared to the low temperament animals, which spend less of maintenance metabolic energy. This could all affect the feed conversion efficiency and the final weight in confined animals. Cafe et al. (2011a) assessed BW, ADG and phenotypical measures of feed efficiency (dry matter intake, time spent eating at feedlot) in young Brahman breed bulls, found a quadratic negative relationship with FS, estimating an average decrease in BW_{final} of 20.0 to 20.9 kg.animal^{-1}, per each 1 m.s^{-1} increased in FS. Presumably, this difference in the feed intake could be due to behavioural mechanisms instead of metabolic mechanisms as shown in confined animals, where the worst temperament animals lower their intake due to their fear of humans (PETHERICK et al., 2002; CAFE et al., 2011a).

Some authors in previous studies have found a tendency ($P = 0.07$) for differences in ADG when compared groups with low and high temperament animals; but this tendency disappeared when the group was mixed between animals (HOLROYD et al., 2000; PETHERICK et al., 2002). Nevertheless, in previous studies with beef cattle reared in different conditions (pasture and feedlot), different breeding phases also showed weak to moderate negative correlation (from r = - 0.18 to - 0.32) among FS and ADG (PETHERICK et al., 2002, 2009b). Moreover, Bosmara crossbred steers in different production stages kept at pasture showed a slight negative tendency among ADG and FS (r = - 0.13, P = 0.11) (BEHRENDS et al., 2009). On the other hand, feeder cattle (Angus × Hereford) reared in extensive rangeland systems until weaning presented no differences (P ≥ 0.21) for ADG during preconditioning, growing and finishing phases in high temperament calves compared with low temperament ones (FRANCISCO et al., 2012). In a study considering a large number of animals from the Nellore breed (n = 7,402), although the genetic and phenotypic correlations among FS, performance and ADG were low; the animals with better temperament (FS slow) had a tendency to a better performance (SANT'ANNA et al., 2012). Conversely, beef cattle crossbred steers (*Bos indicus* and *Bos taurus*) kept on pastures with energy-protein supplementation (corn grain) did not show association between FS or CS with ADG (DEL CAMPO et al., 2010). A similar result was shown for crossed (*Bos indicus* and *Bos taurus*) animals kept on pasture with a low forage offer (BARBOSA SILVEIRA; FISCHER; SOARES, 2008). Based on that, we suggest that the temperament is not a factor affecting the performance of cattle kept on pasture with supplementation. Considering the environment and the quality of the food, our study may have greater influence on ADG and BW_{final} than the individual animal's temperament.

It was found that the temperament assessed by FS affected the movements of the animal's head which were detected by the sensors in the GPS collar, affecting the ratio of predicted behaviour. While these average differences were little observed in intermediate animals, fast speed spent more time performing not-grazing, and presented a tendency to reduced grazing time and rumination. Now the slow animals that had average lower values in the activity sensors, spent less time on not-grazing, and a tendency to spend longer periods in rumination and grazing. However, when temperament was evaluated by RS, animals classified as high and low reactivity were more active on grassland. If we consider the high reactivity animals, they were even more active spending more time on not-grazing, with no significant differences between the other behaviours (grazing and rumination). These results partially corroborate with a study from MacKay et al. (2013) where the authors investigated the association between beef cattle temperament (crossbred, *Bos taurus* beef steers at home pen) assessed by 2 handling tests (flight speed and chute score) as the behaviour in a short-term with the characteristics of long-term assessed by 2 feeding behaviour scores (aggression at feeders and ability to displace at feeders). These authors found that steers with fast FS were associated with greater activity in the home pen by the aggression index score (MotionIndex $r_s = 0.35$, $P = 0.004$), than steers with slow FS; also, regarding feeding behaviour scores, steers that were more capable of displacing other steers at feeders had longer average standing bout durations ($r_s = 0.26$, $P = 0.036$), but aggression index or displacement index bore any relationship with flight speed or chute score ($P > 0.05$) (MACKAY et al., 2013). This would suggest that flight speed and chute score are not directly related to feeding behaviour. Those results could be explained as both methods could have evaluated different animal temperament traits when being restricted during handling.

For the distance travelled per day, our results showed that although differences between averages were small, the animals with high and intermediate reactivity, as well as the ones with intermediate and fast velocity, walked more kilometers throughout the day. We can assume that those animals that walked more exhibit similar behaviours to those animals considered as proactive according to the categories of individual adaptation, when referred to the “behavioural syndrome” concept (KOOLHAAS et al., 1999). This concept was previously used to characterize individual differences in animal production by Wesley et al. (2012), who assessed the individual differences (behavioural syndrome) of cows under different contexts (feedlot vs pasture) where they found that cows with a faster feed intake (proactive) in confinement, also travelled longer distances when compared to cows that consumed their food slowly (reactive).

Overall, there is a tendency in animal production to select better temperament animals, assuming that they will have a better performance, especially in beef cattle where they are usually raised in intensive systems (confinement) and in close proximity to humans (KOOLHAAS et al., 2007; RÉALE et al., 2007; GRAUNKE et al., 2013). However, a direct linear relationship among temperament with less productivity and different behaviours have not been found, as expected.

Turner et al. (2011) had previously described that the temperament selection based only on the reactivity score (RS) and the flight speed (FS) can have a low impact on animals in other contexts, as demonstrated by our results. As noted there are still only few studies considering the relationship of temperament and some measures of the level of activity such as: the locomotion of dairy cows (SCHRADER, 2002; MÜLLER; SCHRADER, 2005); the activity of buffaloes, which showed no significant correlation between the distance travelled and the reactivity during milking (RS) (CARVALHAL, 2014); or the level of activity every day (MACKAY et al., 2013). This leads us to think that we still need more research to understand the link between temperament and animal production.

3.5 Conclusion

We conclude that the temperament evaluated in the short-term when handling the animal, does not represent directly the long-term behaviour of beef cattle kept on grassland conditions with supplementation. It is suggested that these characteristics are probably independent; being the behaviour of beef cattle throughout the day in these conditions regulated by other characteristics not captured by conventional temperament assessment methods during the human handling of animals.

3.6 References

AGUILAR, N. M. A. **Avaliação dos comportamentos de pastejo e suas relações com caracteres individuais dos bovinos de corte**. 2016. 102 f. Tese (Doutorado em Zootecnia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista “Júlio de Mesquita Filho”, Jaboticabal, 2016.

AKAIKE, H. A new look at the statistical model identification. **IEEE Transactions on Automatic Control**, Piscataway, v. AC-19, n. 6, p. 716–723, 1974.

AUGUSTINE, D. J.; DERNER, J. D. Assessing herbivore foraging behavior with GPS collars in a semiarid grassland. **Sensors**, Basel, v. 13, n. 3, p. 3711–3723, 2013. Disponível em: <http://dx.doi.org/10.3390/s130303711>.

BARBOSA SILVEIRA, I. D.; FISCHER, V; FARINATTI, L. H.; RESTLE, J.; ALVES FILHO, D. C.; MENEZES, L. F. G. Relationship between temperament with performance and meat quality of feedlot steers with predominantly Charolais or Nelore breed. **Revista Brasileira de Zootecnia**, Viçosa, v. 41, n. 6, p. 1468–1476, 2012. Disponível em: <http://dx.doi.org/10.1590/S1516-35982012000600022>.

BARBOSA SILVEIRA, I. D.; FISCHER, V; RESTLE, J. Relação entre genótipos e temperamento de novilhos Charolês × Nellore em confinamento. **Revista Brasileira de Zootecnia**, Viçosa, v. 37, n. 10, p. 1808–1814, 2008. Disponível em: <http://dx.doi.org/10.1590/S1516-35982008001000014>.

BARBOSA SILVEIRA, I. D.; FISCHER, V.; SOARES, G. J. D. Efeito do grupo etnológico no temperamento de novilhos mantidos em condições extensivas. **Archivos de Zootecnia**, Córdoba, v. 57, n.18, p. 123–129, 2008.

BEHRENDS, S. M.; MILLER, R. K.; ROUQUETTE JÚNIOR, F. M.; RANDEL, R. D.; WARRINGTON, B. G.; FORBES, T. D. A.; WELSH, T. H; LIPPKE, H.; BEHRENDS, J. M.; CARSTENS, G. E.; HOLLOWAY, J. W. Relationship of temperament, growth, carcass characteristics and tenderness in beef steers. **Meat Science**, Amsterdam, v. 81, n. 3, p. 433–438, 2009. Disponível em: <http://dx.doi.org/10.1016/j.meatsci.2008.09.003>.

BIRO, P. A.; ABRAHAMS, M. V.; POST, J. R.; PARKINSON, E. A. Behavioural trade-offs between growth and mortality explain evolution of submaximal growth rates. **Journal of Animal Ecology**, West Sussex, v. 75, n. 5, p. 1165–1171, 2006. Disponível em: <http://dx.doi.org/10.1111/j.1365-2656.2006.01137.x>.

BIRO, P. A.; STAMPS, J. A. Are animal personality traits linked to life-history productivity? **Trends in Ecology & Evolution**, Oxford, v. 23, n. 7, p. 361–368, 2008. Disponível em: <http://dx.doi.org/10.1016/j.tree.2008.04.003>.

BOIVIN, X.; LE NEINDRE, P.; CHUPIN, J. M. Establishment of cattle–human relationships. **Applied Animal Behaviour Science**, Amsterdam, v. 32, n. 4, p. 325–335, 1992.

BURDICK, N. C.; BANTA, J. P.; NEUENDORFF, D. A.; WHITE, J. C.; VANN, R. C.; LAURENZ, J. C. WELSH JÚNIOR, T. H.; RANDEL R. D. Interrelationships among growth, endocrine, immune, and temperament variables in neonatal Brahman calves. **Journal of Animal Science**, Champaign, v. 87, n. 10, p. 3202–3210. Disponível em: <http://dx.doi.org/10.2527/jas.2009-1931>.

BURROW, H. M.; SEIFERT, G. W.; CORBET, N. J. A new technique for measuring temperament in cattle. **Australian Society of Animal Production**, Toowong, v. 17, p. 154–157, 1988.

BURROW, H. M. Measurements of temperament and their relationships with performance traits of beef cattle. **Animal Breeding Abstracts**, Oxfordshire, v. 65, n. 7, p. 477–495, 1997. Disponível em: <http://dx.doi.org/10.1071/EA96148>.

CAFE, L. M.; ROBINSON, D. L.; FERGUSON, D. M.; MCINTYRE, B. L.; GEESINK, G. H.; GREENWOOD, P. L. Cattle temperament: Persistence of assessments and associations with productivity, efficiency, carcass and meat quality traits. **Journal of Animal Science**, Champaign, v. 89, n. 5, p. 1452–1465, 2011a. Disponível em: <http://dx.doi.org/10.2527/jas.2010-3304>.

CAFE, L. M., ROBINSON, D. L.; FERGUSON, D. M.; GEESINK, G. H.; GREENWOOD, P. L. Temperament and hypothalamic-pituitary-adrenal axis function are related and combine to affect growth, efficiency, carcass, and meat quality traits in Brahman steers. **Domestic Animal Endocrinology**, Philadelphia, v. 40, n. 4, p. 230–240, 2011b. Disponível em: <http://dx.doi.org/10.1016/j.domaniend.2011.01.005>.

CARVALHAL, M. V. L. **Temperamento de búfalas em lactação e suas relações com o uso do espaço e a produção e qualidade do leite**. 2014. 66 f. Dissertação (Mestrado em Zootecnia) – Faculdade de Ciências Agrárias e Veterinárias, Universidade Estadual Paulista “Júlio de Mesquita Filho”, Jaboticabal, 2014.

CURLEY JÚNIOR, K. O.; NEUENDORFF, D. A.; LEWIS, A. W.; CLEERE, J. J.; WELSH JÚNIOR, T. H.; RANDEL, R. D. Functional characteristics of the bovine hypothalamic–pituitary–adrenal axis vary with temperament. **Hormones and Behavior**, Maryland Heights, v. 53, n. 1, p. 20–27, 2008. Disponível em: <http://dx.doi.org/10.1016/j.yhbeh.2007.08.005>.

DEL CAMPO, M.; BRITO, G.; SOARES DE LIMA, J.; HERNÁNDEZ, P.; MONTOSSI, F. Finishing diet, temperament and lairage time effects on carcass and meat quality traits in steers. **Meat Science**, Amsterdam, v. 86, n. 4, p. 908–914, 2010. Disponível em: <http://dx.doi.org/10.1016/j.meatsci.2010.07.014>.

ELZO, M. A., RILEY, D. G., HANSEN, G. R., JOHNSON, D. D., MYER, R. O., COLEMAN, S. W., CHASE, C. C., WASDIN, J. G., DRIVER, J. D. Effect of breed composition on phenotypic residual feed intake and growth in Angus, Brahman, and Angus × Brahman crossbred cattle. **Journal of Animal Science**, Champaign, v. 87, n. 12, p. 3877–3886, 2009. Disponível em: <http:// dx.doi.org/10.2527/jas.2008-1553>.

FELL, L. R.; COLDITZ, I. G.; WALKER, K. H.; WATSON, D. L. Associations between temperament, performance and immune function in cattle entering a commercial feedlot. **Australian Journal of Experimental Agriculture**, Clayton, v. 39, n. 7, p. 795–802, 1999. Disponível em: <http://dx.doi.org/10.2527/jas.2008-1553>.

FORDYCE, G.; GODDARD, M. E.; SEIFERT, G. W. The measurement of temperament in cattle and the effect of experience and genotype. **Animal Production in Australia**, Toowong, v. 14, p. 329–332, 1982.

FORDYCE, G.; GODDARD, M. E.; TYLER, R.; WILLIAMS, G.; TOLEMAN, M. A. Temperament and bruising of *Bos indicus* cross cattle. **Australian Journal of Experimental Agriculture**, Clayton, v. 25, n. 2, p. 283–288, 1985. Disponível em: <http://dx.doi.org/10.1071/EA9850283>.

FRANCISCO, C. L.; COOKE, R. F.; MARQUES, R. S.; MILLS, R. R.; BOHNERT, D. W. Effects of temperament and acclimation to handling on feedlot performance of Bus taurus feeder cattle originated from a rangeland-based cow-calf system. **Journal of Animal Science**, Champaign, v. 90, n. 13, p. 5067–5077, 2012. Disponível em: <http://dx.doi.org/10.2527/jas.2012-5447>.

GANSKOPP, D. C.; JOHNSON, D. D. GPS error in studies addressing animal movements and activities. **Rangeland Ecology & Management**, Wheat Ridge, v. 60, n. 4, p. 350–358. 2007. Disponível em: <http://dx.doi.org/10.2111/1551-5028(2007)60 [350:GEISAA]2.0.CO;2>.

GONZÁLEZ, L. A.; BISHOP-HURLEY, G. J.; HANDCOCK, R. N.; CROSSMAN, C. Behavioral classification of data from collars containing motion sensors in grazing cattle. **Computers and Electronics in Agriculture**, Amsterdam, v. 110, p. 91–102. 2015. Disponível em: <http://dx.doi.org/10.1016/j.compag.2014.10.018>.

GRAUNKE, K. L.; NÜRNBERG, G.; REPSILBER, D.; PUPPE, B.; LANGBEIN, J. Describing Temperament in an Ungulate: A Multidimensional Approach. **Plos One**, San Francisco, v. 8, n. 9, e74579, p. 1–12, 2013. Disponível em: <http://dx.doi.org/10.1371/journal.pone.0074579>.

HALL, N. L.; BUCHANAN, D. S.; ANDERSON, V. L.; ILSE, B. R.; CARLIN, K. R.; BERG, E. P. Working chute behavior of feedlot cattle can be an indication of cattle temperament and beef carcass composition and quality. **Meat Science**, Amsterdam, v. 89, n. 1, 52–57, 2011. Disponível em: <http://dx.doi.org/10.1016/j.meatsci.2011.03.020>.

HASKELL, M. J.; SIMM, G.; TURNER, S. P. Genetic selection for temperament traits in dairy and beef cattle. **Frontiers in Genetics**, Lausanne, v. 5, n. 368, p. 1–18, 2014. Disponível em: <http://dx.doi.org/10.3389/fgene.2014.00368>.

HEARNSHAW, H.; MORRIS, C. A. Genetic and environmental effects on a temperament score in beef cattle. **Australian Journal of Agricultural Research**, Clayton, v. 35, n. 5, p. 723–733, 1984. Disponível em: <http://dx.doi.org/10.1071/AR9840723>.

HOLROYD, R. G.; PETHERICK, J. C.; VENU, B. K.; DOOGAN, V. J. Effects of grouping feedlot steers with a range of flight speeds on live weight and temperament changes. **Asian Australasian Journal of Animal Sciences**, Seoul, v. 13, suppl. B, p. 188, 2000.

HOPPE, S.; BRANDT, H. R.; KÖNIG, S.; ERHARDT, G.; GAULY, M. Temperament traits of beef calves measured under field conditions and their relationships to performance. **Journal of Animal Science**, Champaign, v. 88, n. 6, p. 1982–1989, 2010. Disponível em: <http://dx.doi.org/10.2527/jas.2008-1557>.

HULBERT, L. E.; CARROLL, J. A.; BURDICK, N. C.; RANDEL, R. D.; BROWN, M. S.; BALLOU, M. A. Innate immune responses of temperamental or calm cattle after transportation. **Veterinary Immunology and Immunopathology**, Amsterdam, v. 143, n. 1–2, p. 66–74, 2011. Disponível em: <http://dx.doi.org/10.1016/j.vetimm.2011.06.025>.

KENWARD, M. G.; ROGER, J. H. Small sample Inference for fixed effects from restricted maximum likelihood. **Biometrics**, Chichester, v. 53, n. 3, p. 983-997, 1997.

KOOLHAAS, J. M.; KORTE, S. M.; DE BOER, S. F.; VAN DER VEGT, B. J.; VAN REENEN, C. G.; HOPSTER, H.; DE JONG, I. C.; RUIS, M. A.; BLOKHUIS, H. J. Coping styles in animals: Current status in behavior and stress-physiology. **Neuroscience & Biobehavioral Reviews**, Oxford, v. 23, n. 7, p. 925–935, 1999. Disponível em: <http://dx.doi.org/10.1016/S0149-7634(99)00026-3>.

KOOLHAAS, J. M.; DE BOER, S. F.; BUWALDA, B.; VAN REENEN, K. Individual variation in coping with stress: a multidimensional approach of ultimate and proximate mechanisms. **Brain, Behavior and Evolution**, Basel, v. 70, n. 4, p. 218–226, 2007. Disponível em: <http://dx.doi.org/10.1159/000105485>.

KOOLHAAS, J. M.; DE BOER, S. F.; COPPENS, C. M.; BUWALDA, B. Review Neuroendocrinology of coping styles: Towards understanding the biology of individual variation. **Frontiers in Neuroendocrinology**, Maryland Heights, v. 31, n. 3, p. 307–321, 2010. Disponível em: <http://dx.doi.org/10.1016/j.yfrne.2010.04.001>.

KOTTEK, M.; GRIESER, J.; BECK, C.; RUDOLF, B.; RUBEL, F. World map of the Koppen-Geiger climate classification updated. **Meteorologische Zeitschrift**, Stuttgart, v. 15, n. 3, 259–263, 2006. Disponível em: <http://dx.doi.org/10.1127/0941-2948/2006/0130>.

MACKAY, J. R. D.; TURNER, S. P.; HYSLOP, J.; DEAG, J. M.; HASKELL, M. J. Short-term temperament tests in beef cattle relate to long-term measures of behavior recorded in the home pen. **Journal of Animal Science**, Champaign, v. 91, n. 10, p. 4917–4924. 2013. Disponível em: <http://dx.doi.org/10.2527/jas.2012-5473>.

MORRIS, C. A.; CULLEN, N. G.; KILGOUR, R.; BREMNER, K. J. Some genetic factors affecting temperament in Bos Taurus cattle. **New Zealand Journal of Agricultural Research**, Singapore, v. 37, n. 2, p. 167–175, 1994. Disponível em: <http://dx.doi.org/10.1080/00288233.1994.9513054>.

MOTT, G. O.; LUCAS, H. L. The design, conduct and interpretation of grazing trials on cultivated and improved pastures. In: INTERNATIONAL GRASSLAND CONGRESS, 6., 1952. Pennsylvania, **Annals…** Pennsylvania: State College, 1952. p. 1380–1385.

MÜLLER, R.; L. SCHRADER. Individual consistency of dairy cows' activity in their home pen. **Journal of Dairy Science**, New York, v. 88, n. 1, p. 171–175, 2005.

MÜLLER, R.; VON KEYSERLINGK, M. A. G. Consistency of flight speed and its correlation to productivity and to personality in Bos taurus beef cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 99, n. 3–4, p. 193–204, 2006. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2005.05.012>.

NKRUMAH, D.; CREWS, H.; BASARAB JR., J. A.; PRICE, M. A.; OKINE, E. K.; WANG, Z.; LI, C.; MOORE, S. S. Genetic and phenotypic relationships of feeding behavior and temperament with performance, feed efficiency, ultrasound, and carcass merit of beef cattle. **Journal of Animal Science**, Champaign, v. 85, n. 10, p. 2382–2390, 2007. Disponível em: <http://dx.doi.org/10.2527/jas.2006-657>.

PETHERICK, J. C.; HOLROYD, R. G.; DOOGAN, V. J.; VENUS, B. K. Productivity, carcass and meat quality of lot-fed Bos indicus cross steers grouped according to temperament. **Australian Journal of Experimental Agriculture**, Clayton, v. 42, n. 4, p. 389–398, 2002. Disponível em: <http://dx.doi.org/10.1071/EA01084>.

PETHERICK, J. C.; DOOGAN, V. J.; HOLROYD, R. G., OLSSON, P; VENUS, B. K. Quality of handling and holding yard environment, and beef cattle temperament: 1. Relationships with flight speed and fear of humans. **Applied Animal Behaviour Science**, Amsterdam, v. 120, n. 1–2, p. 18–27, 2009a. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2009.05.008>.

PETHERICK, J. C.; DOOGAN, V. J.; HOLROYD, R. G., OLSSON, P; VENUS, B. K. Quality of handling and holding yard environment, and beef cattle temperament: 2. Consequences for stress and productivity. **Applied Animal Behaviour Science**, Amsterdam, v. 120, n. 1–2, p. 28–38, 2009b. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2009.05.009>.

PIOVEZAN, U.; CYRILLO, J. N. D. S. G.; PARANHOS DA COSTA, M. J. R. Breed and selection line differences in the temperament of beef cattle. **Acta Scientiarum, Animal Sciences**, Maringá, v. 35, n. 2, p. 207–212, 2013. Disponível em: <http://dx.doi.org/10.4025/actascianimsci.v35i2.16426>.

RÉALE, D.; READER, S. M.; SOL, D.; MCDOUGALL, P. T.; DINGEMANSE, N. J. Integrating animal temperament within ecology and evolution. **Biological Reviews of the Cambridge Philosophical Society**, West Sussex, v. 82, n. 2, p. 291–318, 2007. Disponível em: <http://dx.doi.org/10.1111/j.1469-185X.2007.00010.x>.

ROLFE, K. M.; SNELLING, W. M.; NIELSEN, M. K.; FREETLY, H. C.; FERRELL, C. L.; JENKINS, T. G. Genetic and phenotypic parameter estimates for feed intake and other traits in growing beef cattle, and opportunities for selection. **Journal of Animal Science**, Champaign, v. 89, n. 11, p. 3452–3459, 2011. Disponível em: <http://dx.doi.org/10.2527/jas.2011-3961>.

SANT'ANNA, A. C.; PARANHOS DA COSTA, M. J. R.; BALDI, F.; RUEDA, P. M.; ALBUQUERQUE, L. G. Genetic associations between flight speed and growth traits in Nellore cattle. **Journal of Animal Science**, Champaign, v. 90, n. 10, p. 3427–3432, 2012. Disponível em: <http:dx.doi.org/10.2527/jas.2011-5044>.

SANT'ANNA, A. C.; PARANHOS DA COSTA, M. J. R. Validity and feasibility of qualitative behavior assessment for the evaluation of Nellore cattle temperament. **Livestock Science**, Amsterdam, v. 157, n. 1, p. 254–262, 2013. Disponível em: <http://dx.doi.org/10.1016/j.livsci.2013.08.004>.

SAS INSTITUTE, 2012. **SAS/STAT 9.4 User's Guide**. SAS Institute, Cary, NC.

SCHRADER, L. Consistency of individual behavioural characteristics of dairy cows in their home pen. **Applied Animal Behaviour Science**, Amsterdam, v. 77, n. 4, p. 255–266, 2002. Disponível em: <http://dx.doi.org/ 10.1016/S0168-1591(02)00075-8.

SCHUEHLE PFEIFFER, C. E.; KING, D. A.; LUCIA, L. M.; CABRERA-DIAZ, E.; ACUFF, G. R.; RANDEL, R. D.; SAVELL, J. W. Influence of transportation stress and animal temperament on fecal shedding of Escherichia coli O157: H7 in feedlot cattle. **Meat Science**, Amsterdam, v. 81, n. 2, p. 300–306, 2009. Disponível em: <http://dx.doi.org/10.1016/j.meatsci.2008.08.005>.

SEBASTIAN, T.; WATTS, J.; STOOKEY, J.; BUCHANAN, F.; WALDNER, C. Temperament in beef cattle: Methods of measurement and their relationship to production. **Canadian Journal of Animal Science**, Ottawa, v. 91, n. 4, p. 557–565, 2011. Disponível em: <http://dx.doi.org/10.4141/CJAS2010-041>.

SMITH, B. R.; BLUMSTEIN, D. T. Fitness consequences of personality: a meta-analysis. **Behavioral Ecology**, Cary, v. 19, n. 2, p. 448–455, 2008. Disponível em: <http://dx.doi.org/10.1093/beheco/arm144>.

SWAIN, D. L.; WARK, T.; BISHOP-HURLEY, G. J. Using high fix rate GPS data to determine the relationships between fix rate, prediction errors and patch selection. **Ecological Modelling**, Amsterdam, v. 212, n. 3–4, p. 273–279, 2008. Disponível em: <http://dx.doi.org/10.1016/j.ecolmodel.2007.10.027>.

TURNER, L. W; UDAL, M. C.; LARSON, B. T.; Shearer, S. A. Monitoring cattle behavior and pasture use with GPS and GIS. **Canadian Journal of Animal Science**, Ottawa, v. 80, n. 3, p. 405–413, 2000. Disponível em: <http://dx.doi.org/10.4141/A99-093>.

TURNER, S. P.; NAVAJAS, E. A.; HYSLOP, J. J.; ROSS, D. W.; RICHARDSON, R. I.; PRIETO, N.; BELL, M.; JACK, M. C.; ROEHE, R. Associations between response to handling and growth and meat quality in frequently handled beef cattle. **Journal of Animal Science**, Champaign, v. 89, n. 12, p. 4239–4248, 2011. Disponível em: <http://dx.doi.org/10.2527/jas.2010-3790>.

UNGAR, E. D.; HENKIN, Z.; GUTMAN, M.; DOLEV, A.; GENIZI, A.; GANSKOPP, D. Inference of animal activity from GPS collar data on free- ranging cattle. **Rangeland Ecology & Management**, Wheat Ridge, v. 58, n. 3, p. 256–266, 2005. Disponível em: <http://dx.doi.org/10.2111/1551-5028(2005)58[256:IOAAFG]2.0.CO;2>.

UNGAR, E. D., SCHOENBAUM, I., HENKIN, Z., DOLEV, A., YEHUDA, Y.; BROSH, A. Inference of the activity timeline of cattle foraging on a Mediterranean woodland using GPS and pedometry. **Sensors**, Basel, v. 11, n. 1, p. 362–383. 2011. Disponível em: <http://dx.doi.org/10.3390/s110100362>.

VOISINET, B. D.; GRANDIN, T.; TATUM, J. D.; O'CONNOR, S. F.; STRUTHERS, J. J. Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. **Journal of Animal Science**, Champaign, v. 75, n. 4, p. 892–896, 1997a. Disponível em: <http://dx.doi.org/1997.754892x>.

VOISINET, B. D.; GRANDIN, T.; TATUM, J. D.; O'CONNOR, S. F.; DEESING, M. J. Bos indicus-cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. **Meat Science**, Amsterdam, v. 46, n. 4, p. 367–377, 1997b. Disponível em: <http://dx.doi.org/10.1016/S0309-1740(97)00031-4>.

WESLEY, R. L.; CIBILS, A. F.; MULLINIKS, J. T.; POLLAK, E. R.; PETERSEN, M. K.; FREDRICKSOND, E. D. L. An assessment of behavioural syndromes in rangeland-raised beef cattle. **Applied Animal Behaviour Science**, Amsterdam, v. 139, n. 3–4, p. 183–194, 2012. Disponível em: <http://dx.doi.org/10.1016/j.applanim.2012.04.005>.

CAPÍTULO 4 – Considerações finais

O entendimento do comportamento de alimentação dos bovinos pode ser uma ferramenta importante no manejo das pastagens. Existe ampla informação agronômica acerca da ecofisiologia das pastagens, além de numerosos estudos tentando entender porque os animais escolhem determinadas plantas ou momentos para pastejar. No entanto, entendemos que alguns problemas de manejo das pastagens só podem ser bem compreendidos e resolvidos pela combinação de informações relacionadas aos animais e ao ambiente dada à complexidade dos processos envolvidos.

Atualmente, existem vários dispositivos de precisão e de sensoriamento remoto no mercado (colares com GPS, colares com GPS e sensor de inclinação, colar com GPS e acelerômetro, acelerômetros, pedômetros, brincos com identificação eletrônica com monitoramento à distância) que são usados para registrar o comportamento dos bovinos nas pastagens, sem que seja necessária a presença de observadores. Algumas empresas fornecem colares prontos para serem utilizados, mas com programações fechadas e, por isso, não é possível, por exemplo, modificar os intervalos de coleta, outros já permitem fazer uma programação adequada aos objetivos da pesquisa. Portanto, para o estudo do comportamento animal é importante considerar que, dependendo do intervalo de tempo entre registro, os colares são eficientes para registrar apenas comportamentos de longa duração (em casos de intervalo de registro longo) ou registrar comportamentos de longa e curta duração (em casos de intervalo de registro curto). Também, em muitas ocasiões, as empresas não fornecem as fórmulas com que realizam os cálculos internos das variáveis fornecidas pelo colar e, por esta razão, é recomendado realizar uma validação do colar nas condições de campo onde serão realizadas as coletas dos dados.

Embora estes dispositivos ainda não sejam suficientemente econômicos para serem utilizados em grande escala, poderiam fornecer informações interessantes e precisas das atividades dos animais nas pastagens. No entanto, a complexidade do processamento e entendimento das informações fornecidas por estes dispositivos pode ser considerada um limitante, pois existem diversas formas de analisar e apresentar os resultados de acordo com os objetivos da pesquisa. Esta foi uma das dificuldades em realizar este estudo, pois para obter as informações do colar que precisávamos para responder à pergunta inicial do nosso trabalho foi importante aprofundar os estudos sobre outros campos da ciência como a bioengenharia eletrônica, a ecologia e a etologia animal. O colar GPS com sensores de inclinação é um desses dispositivos que pode auxiliar na avaliação do comportamento de pastejo dos bovinos. Mas, para que isto seja feito de forma correta é indispensável que os usuários procurem assistência técnica ou pesquisadores que possam instruí-los sobre o seu uso para que a ferramenta esteja de acordo com as necessidades e os objetivos da utilização no campo.

Em nosso estudo, no qual utilizamos colares com GPS e sensores de inclinação, os dados obtidos diretamente do colar não forneciam a identificação direta das diferentes atividades dos animais. Portanto, o método de árvores de decisões foi adequado para conseguir obter os limiares para identificar três comportamentos básicos: pastejo, ruminação e não-pastejo, obtendo maior precisão e especificidade para a categoria pastejo. Além disso, avaliamos o efeito do temperamento sobre o comportamento predito observando que a categoria pastejo estaria afetada pelo mesmo.

Embora a obtenção dos resultados tenha sido demorada, entendemos que o uso de outros dispositivos com intervalos menores de registro ou acelerômetros integrados auxiliariam no entendimento das respostas dos animais, especialmente quando nos interessa avaliar o comportamento individual dos bovinos sem a interferência da presença humana.

Apesar das limitações descritas acima, para a utilização de colares GPS com sensores de inclinação, as informações que obtivemos com esta ferramenta são valiosas para o estudo do comportamento de bovinos de corte em pastagens e nossos resultados indicaram um caminho de como utilizar essas informações do comportamento que, combinadas a outras, serviriam para entender a complexidade dos processos envolvidos na interação planta-animal-ambiente.