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CÂMPUS DE JABOTICABAL

MÉTODOS PARA AVALIAÇÃO DO TEMPERAMENTO DE BOVINOS: ESTIMAÇÃO DE PARÂMETROS GENÉTICOS E RELAÇÕES COM O DESEMPENHO

Aline Cristina Sant'Anna

Bióloga

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Tese apresentada à Faculdade de Ciências Agrárias e Veterinárias – Unesp, Câmpus de Jaboticabal, como parte das exigências para a obtenção do título de Doutor em Genética e Melhoramento Animal

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TÍTULO: MÉTODOS PARA AVALIAÇÃO DO TEMPERAMENTO DE BOVINOS: ESTIMAÇÃC PARÂMETROS GENÉTICOS E RELAÇÕES COM O DESEMPENHO

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ALINE CRISTINA SANT'ANNA – Nascida em 11 de dezembro de 1983, na cidade de Álvares Florence – SP. Formada em Licenciatura e Bacharelado em Ciências Biológicas pela Unesp Campus de S. J. do Rio Preto – SP no ano de 2006. Durante a graduação foi bolsista do Programa de Educação Tutorial (PET) Sesu – MEC e, da FAPESP. Iniciou seus estudos em etologia em 2004, durante a iniciação científica, pesquisando o comportamento de anfíbios anuros. A partir de 2006 passou a fazer parte do Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal (ETCO) da FCAV – Unesp, Campus de Jaboticabal. Em 2009 concluiu o mestrado pelo Programa de Pós-Graduação em Zootecnia desta mesma Universidade. Neste mesmo ano iniciou o curso de Doutorado no Programa de Pós-graduação em Genética e Melhoramento Animal, da FCAV – Unesp. Atualmente atua principalmente nas áreas de etologia aplicada, bem-estar dos animais domésticos e genética do comportamento

“Fatos suficientes já foram apresentados a respeito das expressões de diversos animais. É impossível concordar com Sir C. Bell quando ele diz que ‘os rostos dos animais parecem capazes de exprimir principalmente raiva e medo’ (...). Aquele que observar um cão preparando-se para atacar outro cão ou um homem, e o mesmo animal acariciando seu dono, ou a expressão de um macaco quando provocado e quando afagado pelo seu tratador, será forçado a admitir que os movimentos de seus traços e gestos são quase tão expressivos quanto aos dos humanos.” Trecho do livro *“A expressão das emoções no homem e nos animais.”*

Charles Darwin (1809-1882)

Dedico essa tese à minha mãe Dalvina de Queiroz Sant'Anna, minha maior incentivadora...

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SUMÁRIO

MÉTODOS PARA AVALIAÇÃO DO TEMPERAMENTO DE BOVINOS: ESTIMAÇÃO DE PARÂMETROS GENÉTICOS E RELAÇÕES COM O DESEMPENHO

RESUMO – O objetivo deste estudo foi identificar, dentre diferentes medidas de temperamento, a mais adequada para avaliação do temperamento de bovinos de corte, tendo em conta a praticidade de sua aplicação e possibilidade de utilização em programas de melhoramento genético. Como objetivos específicos buscamos: 1) avaliar a associação entre as escalas qualitativas de classificação do temperamento com quatro métodos tradicionalmente utilizados e, avaliar a possibilidade de uso deste método como indicador do temperamento de bovinos; 2) estimar parâmetros genéticos para diferentes indicadores do temperamento e avaliar a possibilidade de aplicação destes como critérios de seleção; 3) estimar a associação genética entre temperamento e características de crescimento na raça Nelore. O temperamento foi avaliado para 23.420 animais machos e fêmeas ao sobreano, em idade próxima aos 550 dias, nascidos entre 2002 e 2009 com uso de um escore de temperamento (TS), baseado em uma escala de 1 a 5 que considera a reação do animal, após sair do tronco de contenção. Além disso, 9.150 indivíduos nascidos em 2008 e 2009 foram avaliados para as seguintes características: escore de movimentação (MOV), em escala de 1 a 5 de acordo com a sua movimentação no tronco de contenção; escore de tronco (CS), em que são atribuídas notas de 1 a 4 para a reatividade geral do animal dentro do tronco de contenção; e velocidade de fuga (VF), que é um registro da velocidade (em m/s) com que os animais saem do tronco de contenção após a pesagem. As características de crescimento avaliadas foram peso à desmama (PD) e ganho de peso médio diário pós-desmama (GMD). Foi utilizada Inferência Bayesiana com Amostragem de Gibbs para estimar os componentes de (co) variância e valores genéticos dos animais. As estimativas de herdabilidade para VF, TS, CS e MOV foram de 0,35, 0,15, 0,19 e 0,18, respectivamente. As estimativas de correlação genética de VF com TS (0,85), CS (0,85) e MOV (0,76) foram altas, já as correlações fenotípicas foram todas baixas (entre 0,18 e 0,25). Para CS e MOV, tanto as correlações genéticas, quanto as fenotípicas foram altas (0,99 e 0,71, respectivamente). As estimativas de correlação genética entre GMD e os indicadores de temperamento foram favoráveis, com os seguintes valores: VF (-0,12), TS (-0,22), CS (-0,32) e MOV (-0,20), bem como entre estes e o PD, variando entre -0,04 (MOV) e -0,30 (CS). Concluímos que todos os indicadores de temperamento utilizados neste estudo podem ser úteis para fins de melhoramento genético, em especial a medida de VF que apresenta mais alto valor de herdabilidade. Estes apresentaram correlação favorável com GMD e PD. No entanto, a seleção indireta para temperamento por meio das características de crescimento promoveria ganho genético baixo e apenas em longo prazo. Portanto, para promover um rápido ganho genético no temperamento dos rebanhos é necessário incluir esta característica nos índices de seleção, sendo VF o indicador mais vantajoso, já que este pode produzir dados em escala contínua, e ser obtido eletronicamente, ou seja, está menos sujeita a erros de mensuração.

Palavras-chave: comportamento, correlação genética, herdabilidade, Inferência Bayesiana, raça Nelore, reatividade

METHODS FOR ASSESSING CATTLE TEMPERAMENT: GENETIC PARAMETERS ESTIMATE AND RELATIONSHIPS WITH GROWTH TRAITS

SUMMARY – The aim of this study was to identify, among several indicators, the most adequate method to assess beef cattle temperament on farms, considering its feasibility and possibility of use in breeding programs. The specific objectives were: 1) to access the relationship of observer temperament ratings, the qualitative behavior assessment methos (QBA) with four others traditional methods, and to evaluate the possibility of using QBA as an indicator of cattle temperament; 2) to estimate genetic parameters of four temperament indicator traits for Nellore cattle, and to evaluate the possibility of using such traits as selection criteria in breeding programs; and 3) to estimate the genetic association between four temperament indicators and growth traits in Nellore cattle. Temperament was assessed for 23,420 male and female animals at yearling age, approximately 550 days, which were born between 2002 and 2009. A temperament score (TS) was used, which is based on a scale from 1 to 5 and considers the animal's reaction after exiting the crush. Moreover, 9,150 individuals born between 2008 and 2009 were measured for the following traits: Movement Score (MOV), where animals were scored from 1 to 5 according to their movement inside the crush; Crush Score (CS), which assigns scores from 1 to 4 for an animal's general reactivity inside the crush; and Flight Speed (FS), which is a recording of the speed (in m/s) at which the animals exit the crush after being weighed. The growth traits evaluated were weaning weight (WW) and post weaning average daily gain (ADG), for male and female animals born between 1990 and 2009. Bayesian Inference using Gibbs Sampling was applied to estimate (co)variance components and breeding values of the animals. Heritability estimates for FS, TS, CS, and MOV were 0.35, 0.15, 0.19, and 0.18, respectively. The genetic correlation estimates of FS with TS (0.85), CS (0.85), and MOV (0.76) were high, although the phenotypic correlations were low (between 0.18 and 0.25). For CS and MOV, the genetic and phenotypic correlation estimates were high (0.99 and 0.71, respectively). The genetic correlation estimates between ADG and temperament traits were favorable, with the following estimates: FS (-0.12), TS (-0.22), CS (-0.32), and MOV (-0.20), as well as between them and WW, ranging from -0.04 (MOV) to -0.30 (CS). We concluded that all the temperament indicators addressed in this study would be useful for selective breeding purposes, and particularly FS, because it is easily measured in large scale programs and will promote a rapid genetic gain. All the temperament traits evaluated presented favorable correlation with ADG and WW. However, the indirect selection for temperament using growth traits would promote low genetic gain regardless of the temperament indicator used. The inclusion of FS as a selection criterion in Nellore breeding programs is appealing, because, in contrast to other indicators, this measurement can be obtained electronically and produces data on a continuous scale.

Key words: behavior, genetic correlation, heritability, Bayesian Inference, Nellore breed, reactivity

CAPÍTULO 1 - Considerações Gerais

1. INTRODUÇÃO

No Brasil, os diversos programas de melhoramento genético para a raça Nelore foram criados no final da década de 1980, incluindo inicialmente características de tipo racial e de crescimento, como critérios de seleção (ALENCAR, 2004). Uma década mais tarde a eficiência reprodutiva também passou a fazer parte dos objetivos de seleção, com a inclusão de características indicadoras de precocidade sexual. Apenas recentemente o temperamento passou a chamar a atenção de produtores e pesquisadores, com a expectativa de que esta característica esteja associada com um melhor desempenho, além de promover maior facilidade de manejo e redução de custos operacionais.

Internacionalmente, o bem-estar animal e a sustentabilidade ambiental vêm sendo considerados juntamente com parâmetros de qualidade dos produtos de origem animal (DE PASSILLÉ e RUSHEN, 2005; THIERMANN e BABCOCK, 2005). Assim, tem crescido a busca por alternativas que reduzam o estresse dos animais durante o manejo, além de aumentar a quantidade e qualidade da carne produzida, sem aumento da área utilizada. Estas questões produziram reflexo também em nosso país, com o desenvolvimento de regulamentações oficiais sobre o bem-estar dos animais de produção (BRASIL MAPA IN, nº 56, de 06/11/2008), e códigos de boas práticas de manejo (EUCLIDES FILHO et al., 2002; PARANHOS DA COSTA et al., 2006). Tais preocupações também impulsionaram o tema "temperamento" no cenário da pecuária de corte nacional.

Embora parte dos programas de melhoramento genético da raça Nelore ainda não inclua o temperamento nos critérios de seleção (SUMÁRIO TOUROS E MATRIZES INSTITUTO DE ZOOTECNIA, 2011; SUMÁRIO DE TOUROS NELORE CFM, 2011; LÔBO et al., 2013; SUMÁRIO NACIONAL DE AVALIAÇÃO GENÉTICA ABCZ, 2013), em outros esta característica vem sendo incluída, com estimativas de DEPS para seus touros (NELORE LEMGRUBER®, 2012; NELORE QUALITAS, 2012; SUMÁRIO DE TOUROS ALIANÇA NELORE, 2012; SUMÁRIO DE TOUROS CONEXÃO DELTA G, 2012; SUMÁRIO PAINT® CONSOLIDADO, 2012). Apesar de utilizarem um mesmo nome, “DEP temperamento”, os programas adotam diferentes maneiras de avaliar o temperamento. Um dos desafios nessa área é identificar uma medida que seja objetiva, fácil e segura para ser utilizada na avaliação fenotípica dos bovinos nas fazendas (ALENCAR, 2004).

Sabe-se que as várias medidas de temperamento existentes podem abordar diferentes aspectos do comportamento dos animais, como medo, agressividade, reatividade, agitação, dentre outros (KILGOUR et al., 2006). Deste modo, a escolha do método de avaliação é fator essencial na inclusão do temperamento como critério de seleção nos programas de avaliação genética, já que dependendo do método adotado, poderiam ser obtidas distintas respostas à seleção (por exemplo, animais menos agressivos ou menos reativos).

Um bom indicador de temperamento deve apresentar variabilidade genética suficiente para responder à seleção, requerer um baixo custo de obtenção, ser facilmente aplicado às grandes populações e apresentar boa repetibilidade entre os avaliadores. Além disso, deve apresentar associação genética favorável com outras características de interesse econômico no sistema de produção de bovinos de corte. Assim, o objetivo com esta tese foi identificar, dentre diferentes medidas de temperamento, a mais adequada para avaliação do temperamento de bovinos de corte, tendo em conta a praticidade de sua aplicação e possibilidade de utilização em programas de melhoramento genético.

Como objetivos específicos buscamos:

1) Avaliar a associação entre as escalas qualitativas de classificação do temperamento com quatro métodos tradicionalmente utilizados e, avaliar a possibilidade de uso deste método como indicador do temperamento de bovinos; 2) estimar parâmetros genéticos para diferentes indicadores do temperamento e avaliar a possibilidade de aplicação destes como critérios de seleção; 3) estimar a associação genética entre temperamento e características de crescimento na raça Nelore.

2. REVISÃO DE LITERATURA

2.1. Os conceitos de personalidade e temperamento

O reconhecimento das diferenças individuais teve origem na psicologia humana, com um enfoque clínico, buscando associá-las a quadros psiquiátricos e desordens comportamentais (RUTTER et al., 1964). Para os animais, este tema ganhou força a partir da década de 1970, após pesquisas revelarem a existência de importantes diferenças individuais em primatas (HEBB, 1946; BUIRSKI et al., 1978; STEVENSON-HINDE e ZUNZ, 1978) e em algumas espécies domésticas, como cães (CATTELL e KORT, 1973), gatos (TURNER et al., 1986), equinos (MILLS, 1998) e bovinos (FORDYCE et al., 1982; BURROW et al., 1988).

Na psicologia humana é comum os termos temperamento e personalidade serem utilizados com diferentes significados. Personalidade trata-se de um conceito mais amplo, que considera o estilo desenvolvido pelo indivíduo na forma de lidar com o ambiente, com o contexto social e as suas experiências, envolvendo também elementos como o humor e as projeções para o futuro, por exemplo, otimismo e pessimismo (RUTTER, 1987). Por outro lado, o temperamento inclui apenas as características herdáveis da personalidade, ou seja, as diferenças comportamentais entre os indivíduos, com uma forte base genética, que surgem logo na primeira infância e são consistentes ao longo da vida (BATES, 1989).

Diferentemente dos trabalhos de psicologia humana, a maioria das pesquisas com animais não diferencia temperamento de personalidade, tratando ambos como sinônimos (GOSLING, 2001). Especificamente para os animais de produção o termo temperamento é mais adotado por ser considerado menos antropomórfico, sendo definido como a reação dos animais ao serem manejados pelo homem, geralmente atribuída ao medo (FORDYCE et al., 1982). Apesar de tal definição ser muito específica, restringindo a expressão desta característica a situações em que os bovinos reagem à presença de humanos, admite-se que o temperamento destes animais se expressa também em situações em que os humanos não estão presentes, como por exemplo, na exploração de um novo piquete, na convivência com outros indivíduos do grupo e na defesa contra predadores.

Há um consenso de que a expressão da individualidade não se trata de uma característica simples, mas sim uma complexa combinação de diferentes dimensões ou aspectos (GOSLING e JOHN, 1999). Na psicologia humana um modelo para descrever este caráter multifatorial ficou amplamente conhecido como os cinco grandes (“*The Big Five*”), que descreve cinco fatores dentro dos quais estariam incluídos os diversos traços da personalidade: (1) extroversão, (2) neuroticismo (ou instabilidade emocional), (3) socialização, (4) realização e (5) abertura à experiência (STRELAU, 2002). Alguns autores também propuseram a divisão da personalidade dos animais em dimensões principais (STEVENSON-HINDE e ZUNZ, 1978; DUTTON et al., 1997; GOSLING, 1998). Segundo a proposta de Réale et al. (2007), as cinco dimensões principais do temperamento dos animais seriam: (1) precaução / ousadia - reação dos animais a situações de risco; (2) exploração / evitação - reação a novas situações; (3) atividade - nível geral de atividade; (4) agressividade - reação agonística a co-específicos; (5) sociabilidade - reação à presença de co-específicos, exceto agonismo.

A lista de termos utilizados para espressar as diferenças individuais no comportamento dos animais vai além da “personalidade” ou “temperamento”. Na literatura sobre as bases fisiológicas das diferenças individuais é comum o uso do termo estilos de ajuste (*coping stiles*), citado em estudos que visam desvendar os mecanismos neurológicos e hormonais subjacentes às diferenças individuais frente a situações de desafio (KOOLHAAS et al., 2010). Apesar de apresentar um diferente enfoque, este termo tem uma definição que converge para a de temperamento, sendo o conjunto de respostas comportamentais e fisiológicas a situações de desafio, que são consistentes ao longo do tempo e característicos de um grupo de indivíduos (KOOLHAAS et al., 1999). Foram descritos dois estilos frente a situações estressantes: os animais “proativos”, que são mais ofensivos / agressivos na resposta a tais situações; e os “reativos”, que são mais adaptáveis / flexíveis, e apenas exibem reações quando deparados com circunstâncias extremas (KOOLHAAS et al., 2010).

Nas áreas da evolução e ecologia comportamental os estudos apresentam abordagens essencialmente populacionais e apenas recentemente foi reconhecida a relevância do temperamento, com enfoque no indivíduo (RÉALE et al., 2007). Tal reconhecimento surgiu a partir de evidências sobre as bases genéticas do temperamento e, sobre seu papel nos processos evolutivos (efeitos no valor adaptativo) e ecológicos (como expansão de nichos, dispersão e organização social) (RÉALE et al., 2007). Nesta literatura é comum o uso do termo síndrome comportamental (*behavioral syndrome*), definido como um conjunto de características comportamentais correlacionadas, que refletem consistência entre os indivíduos, em múltiplas situações (SIH et al., 2004). Deste modo, as características comportamentais são estudadas em conjunto e não como unidades isoladas.

Apesar das diferentes terminologias, há um consenso a respeito da consistência e do caráter multifatorial das diferenças individuais no comportamento, bem como sobre a ampla gama de implicações na vida dos animais.

2.2. Métodos de avaliação do temperamento

Como o temperamento é uma característica de expressão complexa, sua avaliação geralmente é realizada com o uso de indicadores que acessam um ou poucos aspectos de cada vez, medindo-se a tendência do animal ser mais ou menos agressivo, ativo, atento, curioso, dócil, medroso, reativo, dentre outros (PARANHOS DA COSTA, 2002). Um grande desafio é encontrar um indicador de temperamento que integre vários dos seus aspectos em uma única medida (ou escala).

Alguns autores propuseram o uso de parâmetros fisiológicos como indicadores do temperamento, por exemplo, o grau de variabilidade na frequência cardíaca (VON BORELL et al., 2007), níveis de cortisol sanguíneos e temperatura retal (SANCHEZ-RODRÍGUEZ et al., 2013). Outros avaliaram a possibilidade de serem utilizados indicadores morfológicos, como a coloração da pelagem (TÕZSÉR et al., 2003) e a localização de redemoinhos nos pelos da cabeça (LANIER et al., 2001). No entanto, na maioria das pesquisas são utilizados indicadores comportamentais, que se baseiam em medidas de movimentos, posturas, velocidades, posicionamentos em uma área de teste, dentre outros.

Os indicadores comportamentais de temperamento podem ser classificados de acordo com o tipo de medida utilizada ou com a circunstância em que esta é aplicada (MANTECA e DEAG, 1993; BURROW et al., 1997). Neste capítulo será apresentada uma adaptação da classificação proposta por Manteca e Deag (1993), segundo a qual os indicadores de temperamento podem ser divididos em: (1) testes comportamentais; (2) escores visuais ou escalas com escores pré-definidos; (3) as escalas de classificação com base na impressão do observador (*rating scales*). Além destas, incluímos também (4) medidas automatizadas de registro comportamental.

2.2.1. Testes comportamentais

Para aplicação deste tipo de indicador, os animais são expostos a uma situação padronizada, comparando-se a reação de cada indivíduo frente a tal situação. Um dos testes mais conhecidos para avaliação do temperamento dos bovinos é a distância de fuga. Esta pode ser definida como a mínima distância que um observador consegue se aproximar do animal, antes que este expresse qualquer intenção de se afastar ou de atacar o observador (FORDYCE et al., 1982). Reconhecida por abordar um aspecto da reação do animal em relação à presença humana, a distância de fuga acessa não somente as diferenças de personalidade nos animais, como também a qualidade da interação humano-animal (WAIBLINGER et al., 2006). Por isso, esse teste tem sido empregado em muitas pesquisas para avaliar a resposta de bovinos a dois diferentes tipos de manejo (gentil *vs.* aversivo) (BOISSY e BOUISSOU, 1988). Uma limitação desta metodologia é a implicação de risco para o avaliador, no caso de bovinos com tendência à agressividade.

O teste de velocidade de fuga (VF), também conhecido como velocidade de saída, mede a velocidade com que o animal sai do tronco de contenção ou da balança em direção a um espaço aberto, geralmente uma das divisórias do curral (BURROW et al., 1988). Esta medida foi criada na década de 1980 por pesquisadores do CSIRO, Austrália (*Commonwealth Scientific and Industrial Research Organisation*) (BURROW et al., 1988). Atualmente o teste de VF é uma das medidas de temperamento mais conhecidas e utilizadas para avaliação do temperamento de bovinos de corte, validada nas mais diversas situações de manejo e raças bovinas (BURROW, 1997; CURLEY JR. et al., 2006; MÜLLER e VON KEYSERLINGK, 2006; CAFE et al., 2011a). Suas principais vantagens são a objetividade e a facilidade de obtenção da informação, que pode ser realizada de forma automática, utilizando um dispositivo eletrônico.

Segundo alguns autores a VF é uma medida de agitação e medo (PETHERICK et al., 2002; KILGOUR et al., 2006). Além disso, Müller e von Keyserlingk (2006) sugeriram que o resultado deste teste pode ser influenciado pela reação do animal ao isolamento social, assim ele refletiria também diferenças individuais nas motivações sociais dos bovinos. Duas variações da VF podem ser encontradas na literatura científica, alguns trabalhos apresentam os resultados em medida de tempo (segundos) e, nestes casos, os animais com maiores valores são os de melhor temperamento (BURROW et al., 1988; BURROW e CORBET, 2000). Outros apresentam a informação de velocidade (em m/s), assim, quanto melhor o temperamento, menores os valores desta medida (PETHERICK et al., 2002; CAFE et al., 2011a). Embora seja necessário considerar tais diferenças ao interpretar resultados das pesquisas, trata-se do mesmo método.

Outros testes são também utilizados na avaliação das diferenças individuais dos bovinos, porém, em virtude de algumas limitações práticas, apresentam uso mais restrito. Um deles é o teste de docilidade, que avalia a reação do animal ao ser manejado isoladamente por um observador, dentro das divisórias do curral (LE NEINDRE et al., 1995).

O teste é realizado em duas etapas, na primeira o animal é mantido por 30 s na presença de um avaliador imóvel. Na segunda etapa, o avaliador tenta conduzir o animal para um dos cantos da manga e, contê-lo nesta posição por 30 s. Após o período de contenção, o observador tenta tocar o animal com uma das mãos e, só então o teste é encerrado. Durante o teste são registradas variáveis relacionadas à atividade do animal (tempo correndo, tempo que permanece contido, ocorrência de saltos) e sua reação frente ao observador (agressividade, tentativas de escapar, ocorrência do toque). Alternativamente, toda a informação pode ser reunida em uma escala única, conferindo uma nota para cada indivíduo (escore de docilidade) (LE NEINDRE et al., 1995; GAULY et al., 2001; PHOCAS et al., 2006). Esse teste avalia um caráter de obediência do animal aos comandos dados pelo observador, e também o medo em relação a humanos.

Para avaliar o medo do animal frente a novas situações podem ser adotados testes de novo objeto e teste de campo aberto. O teste de campo aberto avalia a reação dos animais quando mantidos em uma arena de teste não familiar a eles, isolados e sem contato visual com outros indivíduos (DE PASSILLÉ et al., 1995). Geralmente são registradas variáveis relacionadas à atividade locomotora, comportamento exploratório, ocorrência de vocalização, defecação e micção, com o objetivo de abordar os seguintes aspectos do temperamento: atividade / agitação, motivação exploratória, medo em relação à novidade e ao isolamento social (DE PASSILLÉ et al., 1995; FORKMAN et al., 2007).

O teste de novo objeto pode ser utilizado independentemente ou em conjunto com o teste de campo aberto, acrescentando-se um objeto não familiar ao animal na arena de teste (FORKMAN et al., 2007). É realizado o registro da reação do animal frente ao objeto, como por exemplo, latência para o primeiro contato, distância do objeto, duração do contato com o objeto (KILGOUR et al., 2006; FORKMAN et al., 2007).

2.2.2. Escores visuais de temperamento

Este tipo de método consiste na aplicação de notas para a reação dos bovinos durante uma determinada situação de manejo (TULLOH, 1961). Na literatura é possível encontrar escalas variando de 3 a 7 níveis, com os valores extremos representando os animais de melhor e de pior temperamento (FORDYCE et al., 1982; GRANDIN, 1993).

Dentre os escores visuais, o mais comumente utilizado nas pesquisas consiste na avaliação do grau de perturbação do animal quando contido no tronco ou balança. São aplicadas notas para a intensidade e frequência de movimentação, respiração, coices e tentativas de abaixar-se e deitar-se (FORDYCE et al., 1982). A nomenclatura e / ou as reações avaliadas podem apresentar algumas variações de um estudo para o outro, sendo os mais comuns, escore de tronco (*crush score* ou *chute score*) (VOISINET et al., 1997a,b; BURROW e CORBET, 2000; OLMOS e TURNER, 2008; HOPPE et al., 2010, CAFE et al., 2011 a,b), escore de movimentação (FORDYCE et al., 1988a; GRANDIN, 1993; BENHAJALI et al., 2011), escore de agitação no tronco de contenção (PARANHOS DA COSTA et al., 2002), escore de facilidade para contenção na pescoceira (HALL et al., 2011).

Outro tipo de escore visual, conhecido como escore de temperamento ou escore de curral (tradução de *pen scores*), avalia a reação dos animais após serem liberados para uma das divisórias do curral (BEHRENDS et al., 2009). Este tipo de escore visual tem sido adotado como indicador do temperamento por alguns dos programas de melhoramento genético brasileiros, embora a escala de notas e a reação registrada possam variar de um programa para o outro (SUMÁRIO PAINT® CONSOLIDADO, 2012; SUMÁRIO DE TOUROS CONEXÃO DELTA G, 2012).

Outros tipos de escores visuais foram propostos para a avaliação do temperamento durante o manejo, como escores de facilidade para apartação dos animais (GAULY et al., 2001), escore de facilidade para condução pelo curral (*race score*) e escores de isolamento (TURNER et al., 2011).

2.2.3. Escalas de classificação

As escalas de classificação do temperamento dos animais tiveram origem na psicologia comparativa com o uso de adjetivos pré-definidos (e.g. agressivo, corajoso, confiante, medroso, irritado, calmo, ativo, nervoso), utilizados como descritores do comportamento (GOSLING, 2001; HIGHFILL et al., 2010). Visando evitar o uso do termo “subjetivo”, que por vezes é considerado não científico, as expressões “qualitativo” (WEMELSFELDER et al., 2000) ou “classificatório” (GOSLING, 2001) têm sido mais utilizadas para designar este tipo de método, baseado na impressão de observadores (MEAGHER, 2009).

A medida numérica é obtida com o uso de uma escala analógica visual, como exemplificada na Figura 1, onde o observador registra a sua impressão a respeito da expressão comportamental de cada indivíduo. Com a aplicação de métodos estatísticos multivariados os dados gerados pelos vários adjetivos são combinados em uma ou poucas medidas, os componentes principais (MANLY et al., 2008).

Figura 1. Exemplo de escala analógica visual utilizada para a classificação do temperamento dos animais.

Calmo
Min. Max.

Agitado
Min. Max.

Esta metodologia foi amplamente aplicada para animais selvagens mantidos em zoológicos ou outras formas de cativeiro, onde pessoas familiarizadas com os animais (os cuidadores) classificaram a personalidade de diversas espécies, como chimpanzés (BUIRSKI et al., 1978; DUTTON et al., 1997; WEISS et al., 2012), macacos Rhesus (STEVENSON-HINDE e ZUNZ, 1978), hienas (GOSLING, 1998), leopardos das neves (GARTNER e POWELL, 2011) e elefantes (GRAND et al., 2012). Por meio de comparações com métodos objetivos de avaliação do comportamento, diversos autores concluíram que as escalas de classificação podem ser válidas e confiáveis (LLOYD et al., 2007; KONEČNÁ et al., 2008; UHER e ASENDORPF, 2008; GARTNER e POWELL, 2011). Por isso, as escalas de classificação da personalidade foram consideradas uma ferramenta útil para revelar as diferenças individuais nos animais cativos, e assim propor formas de melhorar o manejo e o bem-estar dos animais de zoológico (TETLEY e O'HARA, 2012).

Segundo Meagher (2009), as principais vantagens deste tipo de método são seu caráter integrativo, que permite reunir vários aspectos da informação em uma única escala, com o uso dos descritores; além disso, as escalas de classificação geralmente são métodos "amigáveis ao bem-estar animal", ao contrário de alguns testes comportamentais que envolvem a exposição a situações aversivas, potencialmente causadoras de medo ou ansiedade. Por fim, estes consideram vantajosa a possibilidade de utilizar o conhecimento e a intimidade de cuidadores que estão em contato diário com os animais. Como principais limitações, este autor comenta sobre o risco do resultado ser enviesado, não expressando atributos reais do comportamento dos animais, mas sim um julgamento equivocado do observador. Uma segunda limitação seria o fato do método não ser útil para todos os comportamentos em todas as espécies, sendo útil apenas para aqueles animais em que as pessoas teriam uma boa habilidade de leitura da sua linguagem corporal.

Para os animais de fazenda as escalas de classificação foram propostas como indicadores comportamentais de bem-estar animal, recebendo o nome de avaliação qualitativa do comportamento (do inglês QBA - *qualitative behaviour assessment*) (WEMELSFELDER et al., 2000). Várias pesquisas avaliaram a validade e confiabilidade da QBA como indicador de bem-estar em suínos (WEMELSFELDER et al., 2000), ovelhas (WEMELSFELDER e FARISH, 2004), bovinos leiteiros (ROUSING e WEMELSFELDER, 2006), cavalos (NAPOLITANO et al., 2008), cães (WALKER et al., 2010), bovinos de corte (STOCKMAN et al., 2011, 2012) e búfalos (NAPOLITANO et al., 2012). Por isso, este método foi incluído em protocolos de auditoria do bem-estar de animais de fazenda (WELFARE QUALITY®, 2009). Embora pesquisas recentes tenham demonstrado limitações ao uso da QBA, devido à baixa consistência ao longo de sucessivas avaliações (TEMPLE et al., 2013).

2.2.4. Métodos automatizados de registro do temperamento

Foram reportadas algumas iniciativas para desenvolver métodos automatizados de registro da reatividade dos bovinos em ambiente de contenção móvel, visando obter informações de forma prática, para aplicação em programas de seleção (MAFFEI, 2009; SEBASTIAN et al., 2011; SCHWARTZKOPF-GENSWEIN et al., 2012). Em uma dessas pesquisas foi testado o uso de acelerômetros para avaliar a intensidade e a frequência de movimentos dos bovinos, quando contidos na balança, em uma escala numérica que varia de 1 a 9.999 (MAFFEI et al., 2006). Segundo os criadores deste método, suas principais vantagens são a objetividade, praticidade de obtenção da medida, e a grande variabilidade fenotípica obtida para a reatividade, com aplicação do equipamento (MAFFEI, 2009). Embora o dispositivo eletrônico já esteja patenteado com o nome de Reatest® (Patente n. DEINPI/MG 001088, Instituto Nacional de Propriedade Industrial), ainda há poucos trabalhos publicados apresentando a validação desta medida com base em indicadores comportamentais e fisiológicos (MAFFEI et al., 2006; MAFFEI, 2009; RIBEIRO et al., 2012).

Pesquisas realizadas no Canadá testaram o uso de sensores de movimentos e de pressão no tronco de contenção como indicadores da reatividade dos animais (SEBASTIAN et al., 2011; SCHWARTZKOPF-GENSWEIN et al., 2012). Dois sensores de tensão, ou extensômetros (do inglês *strain gauges*), instalados na pescoceira, registraram a força exercida pelo pescoço dos animais no momento da contenção na pescoçeira; enquanto dois acelerômetros, um acoplado à base do tronco e outro à lateral do mesmo registraram a movimentação do tronco no sentido horizontal e vertical (SCHWARTZKOPF-GENSWEIN et al., 2012). A partir dos quatro sensores puderam ser obtidas 24 variáveis de movimentação, sendo que 12 delas foram analisadas (número de picos nos gráficos de movimentação, magnitude média dos picos, área abaixo e acima dos picos, etc.). Os resultados foram validados com o uso de indicadores de temperamento tradicionalmente utilizados (velocidade de fuga, distância de fuga e escores visuais de movimentação no tronco de contenção), sendo considerados adequados para avaliação do temperamento. No entanto, Schwartzkopf-Genswein et al. (2012) concluem que o ideal seria combinar os resultados das medidas eletrônicas, com métodos já padronizados, como a velocidade de fuga, para a identificação mais acurada dos animais altamente reativos.

2.3. Parâmetros genéticos para características de temperamento

É amplamente reconhecido que as características de temperamento estão sob influência de fatores genéticos e ambientais, os quais interagem na sua formação e modificação ao longo da vida dos animais (BURROW, 1997). Práticas de manejo, qualidade da interação humano-animal e tipo de sistema de criação são fatores capazes de alterar o temperamento dos animais, tornando-os mais ou menos reativos (BOISSY e BOUISSOU, 1988; BECKER e LOBATO, 1997; SCHWARTZKOPF-GENSWEIN et al., 1997, COOKE et al., 2009; TITTO et al., 2010). Apesar de reconhecermos a relevância do manejo e da experiência prévia como fatores capazes de moldar o temperamento dos bovinos, para esta revisão vamos focar na influência genética sobre esta característica.

De modo geral, animais de raças zebuínas apresentam pior temperamento que indivíduos de raças taurinas (HEARNSHAW e MORRIS, 1984; FORDYCE et al., 1988a; VOISINET et al., 1997a). Dentre as diversas raças de origem europeia, as britânicas (p. ex. Angus e Hereford) são popularmente reconhecidas pelo melhor temperamento se comparadas às continentais (p. ex. Charolês, Limousin e Simental), conforme confirmado por Gauly et al. (2001) e Hoppe et al. (2010).

Com relação aos cruzamentos de *Bos taurus taurus* com *Bos taurus indicus*, Voisinet e colaboradores (1997a) não encontraram diferença significativa no temperamento de novilhos cruzados com diferentes porcentagens de sangue Zebu (1/4, 3/8, ou 1/2 da raça Brahman). Por outro lado, avaliando o temperamento de novilhos cruzados Nelore x Charolês, Barbosa Silveira et al. (2008) relataram aumento linear no tempo de saída e redução na distância de fuga, em função do aumento da participação do Charolês na composição genética dos cruzados (0, 25, 31, 38, 63, 69, 75, e 100% de Charolês em relação ao Nelore). Os mesmos autores relataram menor tempo de saída em novilhos Aberdeen Angus (2,10 ± 0,16 s) se comparados às suas cruzas com a raça Nelore (1,34 ± 0,16 s) (BARBOSA SILVEIRA et al., 2006).

É vasta a literatura que apresenta o grau de contribuição genética aditiva para características de temperamento, em populações das mais diversas raças europeias e zebuínas (Tabela 1). Na maioria das pesquisas que apresentam estimativas de herdabilidade para temperamento de bovinos, são utilizados como características indicadoras a velocidade de fuga (BURROW e COBERT, 2000; KADEL et al., 2006); o escore de tronco (FORDYCE et al., 1982; HEARNSHAW e MORRIS, 1984; HOPPE et al., 2010); os escores da reação dos animais após serem liberados para uma das divisórias do curral (BARROZO et al., 2012), e a distância de fuga (FORDYCE et al., 1996) sendo obtidas estimativas de herdabilidade que variam de baixas a moderadas (de 0,11 a 0,40). Assim, é adequado concluir que é possível promover mudança genética nas populações pela aplicação da seleção para temperamento. Embora ainda sejam limitados os resultados de pesquisas comparando a aplicabilidade dos diversos indicadores de temperamento para fins de avaliação genética (KADEL et al., 2006; BENHAJALI et al., 2010).

Tabela 1. Estimativas de herdabilidades (h^2) para características indicadoras do temperamento de bovinos de corte.

Indicadores	Referências	Grupos genéticos	h^2
Velocidade (ou tempo) de fuga	Piovezan et al. (2013)	Nelore, Gir, Guzerá e Caracu	0,35
	Rolfe et al. (2011)	*Bos taurus* (cruzados)	0,34
	Hoppe et al. (2010)	German Angus	0,20
	Hoppe et al. (2010)	Charolais	0,25
	Hoppe et al. (2010)	Hereford	0,36
	Hoppe et al. (2010)	Limousin	0,11
	Hoppe et al. (2010)	Simmental	0,28
	Prayaga et al. (2009)	Brahman	0,17
	Prayaga et al. (2009)	Raça sintética adaptada	0,31
	Nkrumah et al. (2007)	*Bos taurus* (cruzados)	0,49
	Kadel et al. (2006)	Brahman, Belmont Red e Santa Gertrudis	0,30-0,34
	Prayaga e Henshall (2005)	Diversas raças puras e cruzas (*B. taurus* x *B. indicus)*	0,19-0,63
	Burrow (2001)	Belmont Red (Africander, Brahman, Hereford e Shorthorn)	0,40
	Burrow e Corbet (2000)	Brahman e cruzados	0,35
	Burrow et al. (1988)	Belmont Red	0,26-0,54
Escores visuais de reatividade no tronco	Piovezan et al. (2013)	Nelore, Gir, Guzerá e Caracu	0,34
	Hoppe et al. (2010)	German Angus	0,15
	Hoppe et al. (2010)	Charolais	0,17
	Hoppe et al. (2010)	Hereford	0,33
	Hoppe et al. (2010)	Limousin	0,11
	Hoppe et al. (2010)	Simmental	0,18
	Kadel et al. (2006)	Brahman, Belmont Red e Santa Gertrudis	0,15-0,19
	Burrow e Corbet (2000)	Brahman e cruzados	0,30
	Fordyce et al. (1996)	Cruzados (*B. taurus* x *B. indicus*)	0,08-0,14
	Morris et al. (1994)	*Bos taurus* (puros e cruzados)	0,12-0,24
	Hearnshaw e Morris (1984)	*Bos taurus*	0,03
	Hearnshaw e Morris (1984)	Cruzados (*B. taurus* x *B. indicus*)	0,44
	Fordyce et al. (1982)	Cruzados (*B. taurus* x *B. indicus*)	0,25
Movimentos do tronco[1]	Benhajali et al. (2010)	Limousin	0,11-0,22
Acelerômetro[2]	Maffei (2009)	Nelore	0,08-0,39
Escore de docilidade	Phocas et al. (2006)	Limousin	0,18
	Gauly et al. (2001)	German Angus	0,11-0,61
	Gauly et al. (2001)	Simental	0,17-0,55
	Le Neindre et al. (1995)	Limousin	0,18-0,22
Escore de temperamento	Barrozo et al. (2012)	Nelore	0,18
	Morris et al. (1994)	*Bos taurus* (puros e cruzados)	0,13-0,29
Distância fuga	Figueiredo et al. (2005)	Nelore	0,16-0,17
	Fordyce et al. (1996)	Cruzados (*B. taurus* x *B. indicus*)	0,40-0,70

[1] Contagens do número de movimentos normais e bruscos do animal contido no tronco.
[2] Equipamento Reatest®.

Especificamente para a raça Nelore, foram estimados parâmetros genéticos para os indicadores de distância de fuga em escores (FIGUEIREDO et al., 2005), de reatividade na balança obtida com uso de acelerômetros (MAFFEI, 2009), e para um escore de temperamento realizado após a liberação dos animais para uma das divisórias do curral (BARROZO et al., 2012). Apesar dos indicadores de velocidade de fuga e de escore de tronco serem os mais utilizados internacionalmente nas pesquisas científicas, a variabilidade genética para esses indicadores ainda é pouco estudada para a raça Nelore, nas condições brasileiras de criação.

2.4. Correlações genéticas e fenotípicas com características de desempenho

2.4.1. Características de crescimento

Uma das expectativas mais óbvias sobre as implicações do temperamento de bovinos de corte é a de que os animais “calmos” ganham mais peso que aqueles de pior temperamento. Por isso, desde meados da década de 1990 a associação entre o temperamento de bovinos de corte e características de crescimento vem sendo o foco de diversos estudos (FORDYCE et al., 1985; BURROW e DILLON, 1997; VOISINET et al., 1997a). Em algumas destas pesquisas foi comparado o ganho de peso médio para grupos formados com base no temperamento (geralmente “calmos”, “intermediários” e “nervosos”), sendo relatados menores ganhos para os animais de pior temperamento (FELL et al., 1999; PETHERICK et al., 2002; BEHRENDS et al., 2009; DEL CAMPO et al., 2010; SEBASTIAN et al., 2011).

No entanto, não há um consenso acerca da associação entre temperamento e crescimento, já que em alguns trabalhos não foi encontrada correlação significativa entre temperamento e ganho médio diário (OLMOS e TURNER, 2008; BURDICK et al., 2009; HALL et al., 2011), ou foi estimada baixa correlação fenotípica entre ambas as características (BURROW, 2001). Segundo Turner et al. (2011), deve-se ter cuidado ao extrapolar os resultados existentes na literatura para distintos tipos de sistemas de produção, já que a associação entre temperamento e desempenho pode ser influenciada pelo nível de reatividade dos animais. Estes autores sugeriram que, para animais *Bos taurus* e frequentemente manejados, como os de seu estudo, o temperamento não chegaria a comprometer a performance dos mesmos.

No que diz respeito à associação genética entre características de temperamento com as de crescimento, a maioria das estimativas encontradas na literatura reportam correlação genética no sentido favorável (FIGUEIREDO et al., 2005; NKRUMAH et al., 2007; HOPPE et al., 2010). Deste modo, a seleção para animais mais pesados poderia reduzir a reatividade nos rebanhos. No entanto, o que se observa é uma ampla variação nos valores das estimativas de um estudo para outro, enquanto alguns estimaram valores de correlação genética próximos de zero (BURROW, 2001; PRAYAGA e HENSHALL, 2005), outros reportaram valores moderados a altos (FIGUEIREDO et al., 2005; HOPPE et al., 2010) (Tabela 2).

Para a raça Nelore, foi estimada correlação genética moderada entre um escore de distância de fuga (variando de 1 - pior temperamento a 5 - melhor temperamento) com os pesos ao nascimento (-0,04), desmama (0,44), ano (0,36) e sobreano (0,38) e de 0,20 com ganho de peso médio diário pós desmame (FIGUEIREDO et al., 2005).

Há algumas propostas para explicar os mecanismos subjacentes à associação do temperamento com crescimento; por exemplo, foi sugerido por Petherick e colaboradores (2002) que bovinos com pior temperamento, gastam mais tempo e energia permanecendo em estados de alerta (em função do medo), o que pode afetar a eficiência de conversão alimentar e o peso final dos animais em confinamento.

Pesquisas mais recentes sobre o efeito do temperamento no comportamento ingestivo e na eficiência alimentar acrescentaram importantes informações sobre como esta característica pode afetar o desempenho (NKRUMAH, et al., 2007; ROLFE et al., 2011; CAFE et al., 2011a). Segundo Cafe et al. (2011a), para animais da raça Brahman, a cada 1 m/s de aumento na velocidade de fuga dos animais, espera-se redução, em média, de 20 kg no peso final dos animais em confinamento, redução no consumo de matéria seca na ordem de 370 g.dia^{-1} e redução de 4,7 min.dia^{-1} no tempo despendido no cocho. No entanto, não foram encontradas evidências de associação fenotípica da velocidade de fuga com a taxa de conversão alimentar (kg de matéria seca / kg de ganho) nem com o consumo alimentar residual (kg de matéria seca.dia^{-1}) (NKRUMAH, et al., 2007; CAFE et al., 2011a). Assim, Cafe et al. (2011a) concluíram que os mecanismos de regulação comportamentais são mais importantes que os metabólicos para explicar como o temperamento ruim pode limitar o desempenho em confinamento.

Tabela 2. Estimativas de correlação genética entre características de temperamento e de crescimento. Onde: GMD = Ganho de peso médio diário; P = peso.

Referência	Grupo genético	Temperamento	Crescimento	r_g
Rolfe et al. (2011)	Cruzas (*B.taurus*)	Velocidade de fuga	GMD	0,07
Hoppe et al. (2010)	Angus	Velocidade de fuga	GMD	-0,04
		Escore de tronco	GMD	-0,13
	Charolais	Velocidade de fuga	GMD	-0,29
		Escore de tronco	GMD	-0,16
	Hereford	Velocidade de fuga	GMD	-0,37
		Escore de tronco	GMD	-0,58
	Limousin	Velocidade de fuga	GMD	-0,41
		Escore de tronco	GMD	-0,27
	Simental	Velocidade de fuga	GMD	-0,27
		Escore de tronco	GMD	-0,34
Nkrumah et al. (2007)	Cruzas (*B.taurus*)	Velocidade de fuga	GMD	-0,25
Phocas et al. (2006)	Limousin	Teste de docilidade	P Sobreano	0,08
Figueiredo et al. (2005)	Nelore	Distância de fuga	P Nascimento	-0,04
			P Desmama	0,36
			P Ano	0,44
			P Sobreano	0,38
			GMD	0,20
Prayaga e Henshall (2005)	Raças puras e cruzas (*B. taurus* x *B. indicus)*	Tempo de fuga	P Nascimento	-0,08
			P Desmama	0,01
			P Sobreano	0,0
			GMD	-0,12
Burrow (2001)	Belmont Red (Africander, Brahman, Hereford e Shorthorn)	Tempo de fuga	P Nascimento	-0,03
			P Desmama	0,00
			P Sobreano	0,01
			GMD	0,01
Gauly et al. (2001)	German Angus e Simental	Teste de docilidade	GMD	-0,22 a -0,07

Correlações genéticas de baixa a moderada magnitude foram estimadas para a velocidade de fuga com o consumo de matéria seca em confinamento (-0,11: NKRUMAH, et al., 2007 e -0,14: ROLFE et al., 2011), consumo alimentar residual genético (-0,44: NKRUMAH, et al., 2007 e -0,07: ROLFE et al., 2011) e com taxa de conversão alimentar (0,40: NKRUMAH, et al., 2007).

2.4.2. Qualidade da carcaça e carne

Bovinos altamente reativos durante o manejo pré-abate podem apresentar maior risco de ocorrência de hematomas nas carcaças (FORDYCE et al., 1988b). Além disso, como os animais com pior temperamento são mais susceptíveis a fatores estressantes durante transporte e manejo pré-abate, pode ocorrer elevação mais acentuada nos níveis de cortisol plasmático e adrenalina nestes animais (KING et al., 2006; BURDICK et al., 2010). Por isso, é esperada maior depleção nos níveis de glicogênio muscular, aumentando o risco de defeitos na qualidade na carne nos animais mais reativos (VOISINET et al., 1997b; PETHERICK et al., 2002; KING et al., 2006).

Há evidências de que animais de pior temperamento apresentam valores mais baixos de pH 0,5 h *post-mortem* (KING et al., 2006). Valores mais altos de velocidade de fuga e de escore de tronco foram associados com coloração mais escura do músculo *longissimus lumborum*, pH final (7 dias) mais elevado, maior compressão e maior perda por cocção (em %) (CAFE et al., 2011a). Garrotes com níveis mais altos de reatividade no momento da contenção na pescoceira apresentaram valores mais altos de pH 36 h *post-mortem*, coloração mais escura no M. *longissimus lumborum* e, escores mais baixos de marmoreio na carne (HALL et al., 2011).

Além dos indicadores acima descritos, são diversos os estudos relatando redução na maciez da carne (medida pela *Warner–Bratzler shear force*) em função do pior temperamento (VOISINET et al., 1997b; KING et al., 2006; BEHRENDS et al., 2009; DEL CAMPO et al., 2010; CAFE et al., 2011a; HALL et al., 2011). A alteração metabólica associada à maior responsividade ao estresse nos animais de pior temperamento parece criar uma condição menos favorável para a proteólise mediada pelas calpainas, o que pode comprometer a maciez na carne destes animais (KING et al., 2006). Além disso, Hall et al. (2011) propõe que, o maior grau de reatividade e agitação presente nos bovinos de pior temperamento pode promover maior intensidade de contração das fibras musculares nestes animais, provocando hipertrofia muscular, dada pelo aumento no diâmetro das fibras musculares e encurtamento no comprimento dos sarcômeros (KING et al., 2006). Como consequência ocorreria redução na maciez da carne.

Por fim, vale ressaltar que, em algumas pesquisas não foi encontrada associação fenotípica entre o temperamento e qualidade da carne, como em Turner et al. (2011) e Fordyce et al. (1985). Esta falta de associação foi atribuída ao baixo grau de reatividade dos animais, bem como à baixa ocorrência de defeitos de carne / carcaça nas condições avaliadas.

No que diz respeito à associação genética entre o temperamento e indicadores de qualidade da carne, ainda são escassas as estimativas presentes na literatura científica. Tal fato provavelmente se deve à dificuldade de obtenção de um banco de dados com informações fenotípicas suficientes para avaliações genéticas de ambos os tipos características em conjunto.

Em um estudo realizado na Austrália com animais de raças adaptadas aos trópicos (Brahman, Belmont Red, e Santa Gertrudis) foi estimada a associação genética de indicadores de temperamento (velocidade de fuga - VF e escore de tronco - CS) com características indicadoras de qualidade da carne (força de cisalhamento, compressão, % de perda por cocção, coloração L* e a* e avaliação sensorial de maciez) (KADEL et al., 2006). Ambos indicadores de temperamento apresentaram correlação genética moderada, no sentido favorável, apenas com os indicadores de maciez (força de cisalhamento com VF = -0,42 e com CS = -0,47; escore sensorial de maciez com VF = 0,33 e com CS = 0,39). Para os demais indicadores de qualidade da carne as estimativas de correlação com temperamento foram próximas de zero. Os autores concluíram que é possível melhorar o temperamento e a maciez da carne por meio da seleção para menor VF ou menor CS, nos grupos genéticos avaliados.

2.4.3. Características reprodutivas

O temperamento dos animais está associado à intensidade na resposta ao estresse, ou seja, em indivíduos mais reativos ocorre maior ativação do eixo hipotálamo-hipófise-adrenal (HPA) frente a situações estressantes, como consequência há uma redução na liberação de gonadotrofinas, o que afeta diretamente sua função reprodutiva (MOBERG, 2000). O pior temperamento também pode afetar a reprodução dos animais, pela redução na ingestão de matéria seca (NKRUMAH et al., 2007; CAFE et al., 2011a), o que pode comprometer a condição corporal e como consequência reduzir a fertilidade das fêmeas (COOKE et al., 2009). Além disso, segundo Burrow et al. (1988), em sistemas que adotam a inseminação artificial, fêmeas menos reativas apresentam sinais de cio na presença de um observador humano, mais frequentemente que as mais reativas, o que também pode afetar na taxa de sucesso reprodutivo destes animais.

Tais evidências foram confirmadas pelas pesquisas de Cooke e colaboradores (2009; 2011) que avaliaram os efeitos negativos do temperamento “excitável” dos animais na eficiência reprodutiva de fêmeas. A habituação de novilhas cruzadas (Brahman x Hereford e Brahman x Angus) ao manejo foi capaz de melhorar seu temperamento, reduzir as concentrações de cortisol plasmático em resposta ao manejo e, como consequência, adiantar a puberdade e também a prenhez das novilhas, em sistema de monta natural (COOKE et al., 2009). Em novilhas da raça Nelore, submetidas a protocolo de inseminação artificial em tempo fixo (IATF), o temperamento das fêmeas afetou negativamente sua prenhez, sendo que a taxa de prenhez dos animais de temperamento “excitável” foi reduzida em 17% se comparada aos animais de temperamento classificado como “adequado” (COOKE et al., 2011). Se comparados os animais com temperamentos extremos, os mais excitáveis chegaram a ter a taxa de prenhez 43% menor que a dos extremos mais calmos. A mesma tendência foi observada por Rueda (2012) para vacas da raça Nelore submetidas à IATF, onde aquelas classificadas como calmas (pelo teste de VF) apresentaram taxa de prenhez de 60%, enquanto nas mais reativas, essa taxa caiu para 47%.

No que diz respeito à associação genética entre temperamento e características reprodutivas, alguns estudos estimaram valores de correlação variando de baixos a moderados (Tabela 3).

Tabela 3. Estimativas de correlação genética entre características indicadoras de eficiência reprodutiva e indicadores de temperamento.

Referências	Grupos genéticos	Temperamento	Reprodução	r_g
Burrow (2001)	Belmont Red (Africander, Brahman, Hereford e Shorthorn)	Tempo de fuga	Perímetro escrotal à desmama	0,13
			Perímetro escrotal ao sobreano	0,22
			Prenhez	0,00
			Dias para o parto	0,15
Phocas et al. (2006)	Limousin	Escore de docilidade	Idade à puberdade	-0,18
			Fertilidade	0,03
			Facilidade de parto	-0,01
			Comportamento materno	0,00
			Produção de leite	0,10
Barrozo et al. (2012)	Nelore	Escore de temperamento	Perímetro escrotal ao sobreano	-0,02
			Idade ao primeiro parto	0,05
Valente (2012)	Nelore	Velocidade de fuga	Ocorrência de prenhez precoce	-0,19
			Idade ao primeiro parto	0,14
		Escore de movimentação	Ocorrência de prenhez precoce	-0,03
			Idade ao primeiro parto	0,13
		Escore de temperamento	Ocorrência de prenhez precoce	-0,03
			Idade ao primeiro parto	0,09

Dentre as características reprodutivas de fêmeas, a ocorrência de prenhez precoce e idade ao primeiro parto vêm sendo utilizadas como critérios de seleção nos programas de melhoramento genético da raça Nelore, com objetivo de aumentar a precocidade sexual das fêmeas (ALENCAR, 2004). Além destas, o perímetro escrotal também vem sendo incluído com este mesmo objetivo, uma vez que está favoravelmente associado com a precocidade sexual das fêmeas (FORNI e

ALBUQUERQUE, 2005), a produção e qualidade do sêmen (SARREIRO et al., 2002), e com as características de crescimento (SILVA et al., 2006). Tendo como base as estimativas de correlação genética entre tais características e o temperamento (BARROZO et al., 2012; VALENTE, 2012), a seleção atualmente aplicada para a precocidade sexual na raça Nelore não será capaz de reduzir a reatividade nos rebanhos.

2.5. Implicações do temperamento em outras características de interesse

2.5.1. Temperamento e comportamento materno

Ainda são pouco esclarecidos os efeitos da seleção para redução na reatividade dos bovinos sobre outros comportamentos de interesse, como por exemplo, a facilidade de condução dos animais no curral e o comportamento materno (TURNER e LAWRENCE, 2007). Há indícios de que fêmeas bovinas da raça Angus que são mais reativas ao manejo, são também mais eficientes em defender suas crias contra possíveis ameaças ou predadores (FLÖRCKE et al., 2012). Assim, em sistemas de cria em condições extensivas, a seleção para redução do medo e da reatividade das fêmeas deveria ser tratada com cautela.

Estimativas de herdabilidade para um escore de reação da vaca frente ao manejo de apartação e identificação de seu bezerro com colocação de brinco (de 1 – indiferente a 5 – reação agressiva, de ataque ao manejador) apresentaram valores de 0,14 para a raça Angus, 0,42 para Simental (HOPPE et al., 2008) e de 0,09 para *Bos taurus* puros e cruzados (MORRIS et al., 1994). Segundo os autores, este método é capaz de avaliar a habilidade da vaca em defender a cria de possíveis predadores, sendo que esta característica poderia ser modificada por meio da seleção.

Embora ambas as características apresentem uma base genética, é necessário saber também qual a magnitude da correlação genética entre os indicadores de defesa da cria, com os indicadores de temperamento tradicionalmente utilizados. Foram reportadas estimativas de baixa magnitude para a associação genética entre um escore de comportamento materno e a velocidade fuga (0,00: PHOCAS et al., 2006) e, também para o escore de reação da vaca à identificação do seu bezerro com um escore de reatividade no tronco (0,23: MORRIS et al., 1994).

Segundo Turner e Lawrence (2007), é necessário ampliar as pesquisas nesse tema, já que por meio das estimativas de correlação genética será possível prever com segurança os possíveis efeitos antagônicos da seleção para temperamento na redução da habilidade materna em vacas de corte. De acordo com esses autores, as estimativas de parâmetros genéticos existentes para defesa da cria são provenientes de animais de origem europeia, frequentemente manejados, com baixa variabilidade fenotípica para essa característica o que pode ter influenciado nos valores das estimativas.

Entendemos que os resultados obtidos para raças europeias, podem não ser extrapoláveis para as condições brasileiras de criação. De modo geral, a indiferença ao bezerro (baixa habilidade materna) não se caracteriza como um problema frequente em vacas da raça Nelore, já que estas são consideradas boas mães, permanecendo maior período de tempo em atividades de cuidado da cria, até mesmo quando comparadas a outras raças zebuínas (PARANHOS DA COSTA e CROMBERG, 1998). A situação contrária é a que geralmente traz implicações negativas, com vacas apresentando comportamentos agressivos ao defenderem suas crias, colocando em risco a segurança dos trabalhadores.

2.5.2. Temperamento do gado e o bem-estar na fazenda

Há diversas evidências de que o temperamento dos animais está intimamente associado à susceptibilidade ao estresse durante o manejo (CURLEY JR. et al., 2006; KING et al., 2006; TITTO et al., 2010). As características funcionais do eixo HPA variam em função do temperamento, o que foi comprovado por meio de testes de desafios com CRH e ACTH em novilhas da raça Brahman (CURLEY JR. et al., 2008). Em novilhas com pior temperamento (maior velocidade de fuga) houve maior ativação tanto da glândula pituitária quanto da adrenal em resposta aos desafios. Além disso, foi evidenciado que nestes animais os níveis basais de cortisol também são, em média, mais elevados que nas novilhas calmas.

Os resultados de Cafe et al. (2011b) corroboraram com tais afirmações, demonstrando que novilhos (também da raça Brahman) mais reativos apresentaram níveis mais altos de cortisol, glicose e lactato prévio ao desafio com ACTH e, no pós-desafio, os de pior temperamento mantiveram os altos níveis de glicose no sangue por mais tempo. Esses autores acrescentaram uma informação importante, de que tanto a resposta ao estresse relacionada à ativação do eixo HPA, como também a resposta ao estresse mediada pela ativação do sistema simpático - adrenomedular (SAM) são mais intensas em animais de pior temperamento.

As implicações dessa maior ativação das respostas ao estresse são várias e algumas delas já foram discutidas nos tópicos sobre respostas produtivas (pior qualidade da carne e queda na função reprodutiva). Neste tópico a respeito da deterioração no bem-estar animal, vale ressaltar ainda que nos animais de pior temperamento pode haver imunossupressão em resposta ao estresse do manejo (FELL et al., 1999).

O efeito do estresse na resposta imune após o manejo e transporte de touros foi avaliado por Hulbert e colaboradores (2011), sendo demonstrado que, 48h após o transporte, os animais classificados como “calmos” apresentavam maior capacidade de defesa contra agentes microbianos do que os “temperamentais”, em função da ativação mais efetiva dos seus neutrófilos. Embora promissor, esse tema ainda conta com poucos estudos publicados e, em alguns deles, os resultados não foram conclusivos sobre a associação entre o temperamento e a resposta imune, assim seus autores finalizam sugerindo mais pesquisas nesta área (SCHUEHLE PFEIFFER et al., 2009; BURDICK et al., 2011).

Quando pensamos nas implicações do temperamento dos bovinos não podemos nos esquecer do fator humano (GRANDIN, 1999). Sabe-se que o manejo de animais muito reativos é mais difícil e pode trazer uma série de inconvenientes que vão além do estresse dos animais, causando risco de acidentes de trabalho e de danos às instalações (PARANHOS DA COSTA et al., 2000).

Em uma revisão sobre os acidentes de trabalho com bovinos, Sheldon (2009) recomenda a conscientização dos trabalhadores sobre o risco oferecido pelos animais agressivos, já que em vários dos registros de acidentes levantados por sua pesquisa, a vítima era um trabalhador experiente na lida com animais. Pelo intenso contato com bovinos reativos, as pessoas se tornam muito confiantes e acabam negligenciando o risco que tais animais podem oferecer a elas. Além disso, uma das ferramentas que o autor sugere para prevenção dos incidentes é seleção para redução da agressividade dos animais, com descarte dos indivíduos agressivos. Este ressalta que tais animais não deveriam ser vendidos para outras fazendas, mas sim serem invariavelmente destinados ao abate.

Sabemos que um desafio neste caso é a identificação dos animais com tendência à agressividade. Um animal que apresente muito medo, se mal manejado e / ou acuado, também pode apresentar comportamentos agressivos. Assim, faz-se necessário a melhoria do manejo nas fazendas e o desenvolvimento de metodologias que permitam a identificação e descarte dos indivíduos essencialmente agressivos.

3. CONSIDERAÇÕES FINAIS

O temperamento, ou as diferenças individuais nos animais, tem sido alvo de interesse científico crescente, seja pela necessidade de desenvolver sistemas que respeitem essas diferenças, ou para aprendermos mais sobre a nossa própria personalidade humana. Apesar da vasta literatura já existente a respeito do temperamento dos bovinos de corte, este tema ainda apresenta muitas questões em aberto, principalmente no que se refere aos mecanismos subjacentes à expressão desta característica.

Com esta tese esperamos responder algumas perguntas sobre o temperamento dos animais da raça Nelore, agregando informações que possam ser úteis para as condições brasileiras de criação de bovinos de corte. Além disso, esperamos levantar outros questionamentos que darão abertura a pesquisas futuras, dando continuidade à construção do conhecimento nesta área. Estamos seguros de que a utilização de ferramentas do melhoramento genético, associadas à adoção das boas práticas de manejo e de bem-estar animal, poderão impulsionar a pecuária nacional a um nível de excelência internacional, sendo reconhecida não apenas pelo grande volume produzido, mas também pela busca por qualidade.

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CAPÍTULO 2 - Validity and feasibility of qualitative behavior assessment for the evaluation of Nellore cattle temperament[1]

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ABSTRACT: We aimed to assess to assess the validity and the feasibility of a method based on observer ratings, such as QBA, as an indicator of Nellore cattle temperament under field conditions, by evaluating its associations with four other traditional methods and weight gain. The temperament and live weight of 2,229 Nellore cattle was assessed at approximately 550 days of age. Five measurements of cattle temperament were recorded: flight speed test (FS, in m/s), visual scores of movement in the crush (MOV), crush score (CS), temperament score (TS), and the qualitative behavior assessment method (QBA), by using a list of 12 behavioral based adjectives as descriptors of temperament. Average daily weight gain (ADG) was calculated for each animal. For statistical analysis of QBA data, the Principal Component Analysis was used. A temperament index (TI) was defined for each animal using the scores for the first principal component. Pearson's correlation coefficients were estimated between TI with FS and ADG. A mixed model ANOVA was used to analyze the TI variation as a function of TS, CS, and MOV. The score plot for the first and second principal components was used to classify the cattle in four groups (from very bad to very good temperament). The first principal component explained 49.50% of the variation in the data set, with higher positive loadings for the adjectives agitated and active, and higher negative loadings for calm and relaxed. TI was significantly correlated with FS ($r = 0.49$; $P < 0.01$) and ADG ($r = -0.10$; $P < 0.01$). The means of ADG, FS, and the temperament scores (CS, TS, MOV) differed significantly ($P < 0.01$) among the four groups, from very bad to very good temperament. The QBA method could identify different behavioral profiles of Nellore cattle and were in agreement with other traditional methods used as indicators of cattle temperament. Additional studies are needed to assess the inter- and intra-observers reliability and to study its association with physiological parameters.

Keywords: crush score, flight speed, Nellore breed, observer ratings, principal components analysis

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1. INTRODUCTION

Cattle temperament was defined as the animals' responses to be handled by humans (Fordyce et al., 1982; Burrow, 1997), and has being considered an important subject for theoretical and practical reasons, particularly when there is a predominance of Zebu breeds and their crosses in herds. As a consequence, many recent studies have been published addressing this theme with the aim of understanding its physiological basis (Coppens et al., 2010; Koolhaas et al., 2010) and the effects of cattle temperament on animal's health (Burdick et al., 2010), stress during handling (Curley et al., 2006; Burdick et al., 2011), productivity, and meat quality (del Campo et al., 2010; Cafe et al., 2011).

The majority of studies recognize that temperament is a complex trait formed by several dimensions, such as fear, reactivity, and activity. However, most of them usually adopt assessment methods that focus only on one or a few aspects of cattle temperament, including docility (Le Neindre et al., 1995), reactivity (Van Reenen et al., 2004), fear (Forkman et al., 2007), reaction to humans (Windschnurer et al., 2009), and agitation (Kilgour et al., 2006).

Ratings by human observers have been widely used in scientific studies (Tetley and O'Hara, 2012). The principal advantage of these methods is their integrative nature that permits the observer to combine multiple factors into a single characteristic or scale, which is different from standardized objective methods that commonly divide the information in categories (Meagher et al., 2009). Another benefit of observer ratings is the possibility of taking advantage of caretakers' knowledge and familiarity with the animals (Gosling, 1998). In contrast, the qualitative methods have been criticized and sometimes considered as a non-scientific approach because of the risk of not reflecting reality. These approaches are viewed as providing a subjective impression of the observer that could occur in a biased manner.

Nevertheless, observer ratings based on the use of adjectives as behavioral descriptors have been widely applied in studies of animal personality, mainly in zoo animals (chimpanzees – Buirski et al., 1978; Rhesus monkeys – Stevenson-Hinde and Zunz, 1978; Spotted hyenas – Gosling, 1998; Snow Leopards – Gartner and

Powell, 2011; African Elephants – Grand et al., 2012). In animal science, a qualitative assessment of behavioral traits was developed by Wemelsfelder et al. (2000); the method, termed "qualitative behavioral assessment" (QBA), was validated as an indicator of animal welfare in farm species (Welfare Quality®, 2009). According to the authors, the QBA considers the "whole animal" and offers an integrated view of its behaviors and style of interaction with the environment (Wemelsfelder et al., 2001). Several studies have reported tests of validity and reliability for this method, and most of them have found the QBA to be useful and valid (Knierim and Winckler, 2009; Stockman et al., 2011).

Since temperament is a complex trait, this integrated view of behavior offered by the QBA method may be an appropriate approach for assessing beef cattle temperament using the intrinsic ability of cattle stockpeople to interpret the animals' body language. To date, there is only one published paper comparing the QBA with other cattle temperament indicators (crush score, tension score, and flight speed), in a specific context (pre-slaughter handling) (Stockman et al., 2012). The authors of that study found no relationship between the QBA assessed at slaughter time and the temperament measures; however, the temperament scores were recorded at weaning, 16 to 17 months before the QBA assessment.

In addition, the traditional methods used to assess cattle temperament, including flight speed (Burrow et al., 1988), visual scores of movement with the animal kept inside the crush (crush scores) (Grandin, 1993), flight distance (Fordyce et al., 1996), and docility tests (Le Neindre et al., 1995), present some inconvenience since they can generate danger to the evaluators or erroneous interpretations. For example, in Zebu cattle, the emotional state of fear may elicit different behavioral reactions: the intense avoidance (flight and agitation), the active defense (aggressiveness), or the inhibition of movement ("freezing"). Thus, the use of traditional methods of flight speed and crush score alone may lead to erroneous interpretations, such as when an animal "freezes", which may be misinterpreted as the animal having good temperament because it exhibited no movement inside the crush and exited slowly. In this case, an observer that knows the cattle would make a more realistic judgment about the real state of this animal, gathering information on its general temperament.

To date, there is no consensus regarding the ideal method for assessing beef cattle temperament, and few studies have evaluated temperament using an integrative approach. Therefore, the aims of this study were to assess the validity and the feasibility of a method based on observer ratings, such as QBA, as an indicator of Nellore cattle temperament under field conditions, by evaluating its associations with four other traditional methods and weight gain.

2. MATERIAL, METHODS, AND ANIMALS

2.1. Animals and husbandry conditions

This study was conducted at a commercial beef company (Agropecuária Jacarezinho®) that carries out a genetic breeding program with Nellore breed. Data were recorded using animals from two farms located in the towns of Valparaiso, SP, Brazil, and Cotegipe, BA, Brazil. Both farms follow the same procedures for cattle feeding and handling, all animals are raised on tropical pastures receiving only a mineral supplement. The calves are sorted in handling groups with around 150 individuals. Two performance evaluations are performed, at weaning (approximately 210 days of age) and again at yearling (approximately 550 days of age). The average daily gain (ADG, in kg/day) was calculated using these weights for the period from weaning to yearling age.

2.2. Temperament assessment

The temperament assessment was conducted once on 2,229 animals, born in 2008 and 2009, as part of the yearling performance evaluation and followed the routine handling procedures of the farms. The following tests were used:

2.2.1. Movement score (MOV)

The assessment of MOV was performed at the time of weighing with the animals inside the squeeze chute, but without physical restraint in the head bail. The following scores were applied: 1 = no movement; 2 = little movement, during less than half of the observation time (for 4 s); 3 = frequent movements (during half of the observation time or more), but not vigorous; 4 = constant and vigorous movements; and 5 = constant and vigorous movements, animal jumps and raises the limbs off of the ground (adapted from Grandin, 1993).

2.2.2. Crush Score (CS)

CS was also assessed with the animals inside the squeeze chute without physical restraint in the head bail, during 4 s. The following scores were used: 1 = animal does not offer resistance, remains with head, ears, and tail relaxed; 2 = some movement, with head up and ears erect; 3 = frequent movement but not vigorous, head, ear and tail movements, sclerotic membrane may be visible; 4 = offers great resistance, abrupt and vigorous movements of the whole animal as well as the head, ear, and tail, sclerotic membrane visible, audible breathing, and may jump or fall (adapted from Hearnshaw and Morris, 1984).

MOV and crush score were recorded by the same observer, a member of the research team, who was responsible only for these two measurements.

2.2.3. Temperament score (TS)

This method is currently used by the breeding program of the Agropecuaria Jacarezinho® (Conexão Delta G, 2011) as an independent criterion of selection. A score is given to the reaction of the animal after leaving the squeeze chute and entering one pen of the corral using the following scoring system: 1 = the animal walks slowly, allowing close proximity to the observer; 2 = trots or runs for a few seconds, allowing a moderate proximity to the observer; 4 = runs during the entire observation time, looking for an escape with constant movement of the tail, and does not allow approximation; and 5 = runs during the entire time of the assessment, jumps against fences and obstacles, and tries to attack the observer. Individuals that receive a score of 5 are subsequently eliminated from the breeding program. In order to avoid the tendency of assessors giving an intermediate score (TS = 3), the Agropecuária Jacarezinho eliminated it from the scale and only scored animals as 1, 2, 4, or 5.

The TS was recorded by three farm technicians who were trained to obtain this measurement for the purpose of genetic evaluations. The technicians observed each animal simultaneously and scored them individually. The scores were then compared and the mode of the three scores was used to determine the final score for each animal.

2.2.4. Flight speed (FS)

The FS was defined as the speed at which each animal left the squeeze chute (Burrow et al., 1988). The measurement was performed using an electronic device composed of a pair of photoelectric cells, a stopwatch, and a processor programmed to register the time taken by each animal to cover a known distance, which ranged from 1.6 to 2.0 m (depending on the facilities). The time data were converted into speed (m/s). Faster animals were considered to have a worse temperament. The FS was measured at the moment of release of the animal after weighing.

2.2.5. Qualitative behavior assessment (QBA)

The observer ratings were adapted from the cattle QBA method, described in the Welfare Quality Protocol® assessment system (for more details about the original methodology see Welfare Quality®, 2009). We adapted the original QBA method, which includes 20 descriptors (active, relaxed, fearful, agitated, calm, content, indifferent, frustrated, friendly, bored, positively occupied, lively, inquisitive, irritable, uneasy, sociable, apathetic, happy, distressed), by reducing it to 12 terms (active, relaxed, fearful, agitated, calm, attentive, positively occupied, curious, irritable, apathetic, happy, and distressed) in order to increase its feasibility in a fast manner (for approximately 30 s of observation and 30 s for scoring each animal) during the farm handling routine for weighing (around 60 heads per hour). Descriptors with social connotation (friendly, sociable) were all removed since the evaluation was conducted individually. At the end, adjectives expressing positive and negative dimensions of temperament were maintained evenly.

For the present study the observers interpreted the cattle body language using the above behavioral based adjectives as descriptors of cattle temperament and then quantified these terms along a 126 mm visual analogue scale. The minimum value represented the absence of the expression and the maximum value, the most intense manifestation of the expression. The scores were obtained by measuring the distance in millimeters from the left edge to the observer's mark.

The QBA was conducted by only one observer from our research team, who assessed all the animals, after exiting the crush, into a pen of the corral.

2.3. Statistical analysis

All data were analyzed using SAS statistical package (SAS Inst. Inc., Cary, NC) and results were considered statistically significant when $P < 0.05$.

Basic descriptive statistics, such as means, standard deviations, coefficient of variation, and minimum and maximum values were run for each adjective used in the QBA. A Principal Components Analysis was performed for the QBA data, which is a method that combines all of the variables in a data matrix to identify associations among them and, based on the results, generates indexes that are the principal components describing the variation present in the data (Manly, 2008). The first principal component (PC1) represents the greatest proportion of the data variation (higher eigenvalue), and therefore the scores received for each animal in this axis was defined as a temperament index (TI).

Pearson correlation coefficients were estimated to assess the associations between TI, FS, and ADG. The variation of TI as a function of the levels of visual scores of temperament was determined by mixed model analysis of variance (ANOVA), and the three analyses included one of the visual scores (TS, CS, or MOV) as a fixed effect and day of evaluation as a random effect in the following equation: $Y_{ij} = \mu + VS_i + day_j + e_{ij}$, where: Y_{ij} = dependent variable (TI); μ = average; VS_i = effect of i-th visual score (for TS and CS, i = 1 to 4, for MOV, i = 1 to 5); day_j = random effect of j-th management group; and e_{ij} = residual random effect. The Tukey test was applied to compare the adjusted means of TI for each one of the levels of TS, CS, and MOV. The random effect of management group (N = 15 groups, with an average size of 150 individuals) included the day effect, since only one of them was evaluated per day.

The score plot for the first and second principal components (PC1 and PC2) of the principal component analysis was used to define four groups of individuals based on the QBA. Each group corresponded to the quadrants of the score plot (from I to

IV). To characterize the groups, their means for each one of the adjective descriptor of temperament and for FS, CS, MOV, TS, and ADG were compared using one-factor ANOVA with the post-hoc Tukey test.

3. RESULTS

3.1. Characterization of Nellore cattle temperament based on the QBA

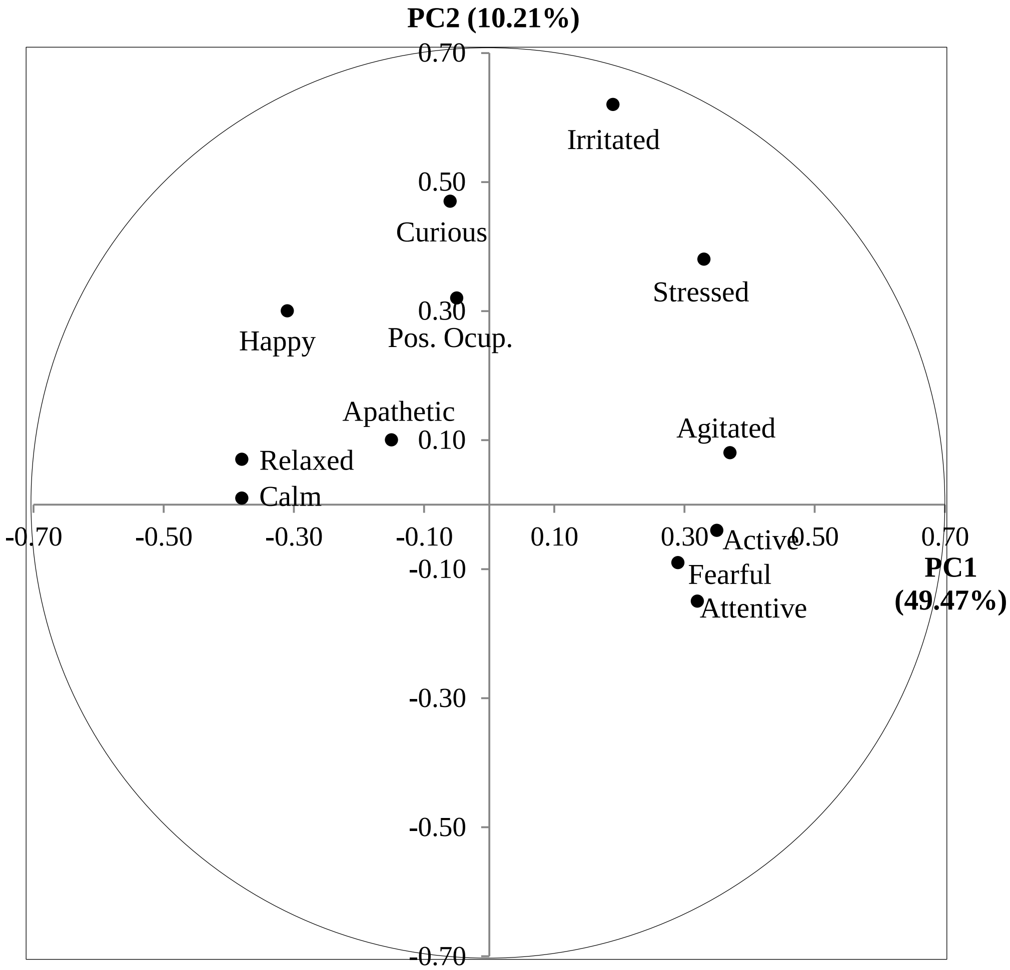
The QBA ratings generated scores of each individual for the 12 behavioral based adjectives. The descriptive statistics of them (Table 1) showed higher means for attentive, active, and calm adjectives and lower for curious, positively occupied, and apathetic.

Table 1. Descriptive statistics for the behavioral-based adjectives used for the QBA.

Term	N	Mean ± SD (mm)	Min.	Max.	CV (%)
Curious	2,222	1.25 ± 4.20	0.00	92.00	335.62
Positively occupied	2,220	1.53 ± 4.30	0.00	83.00	281.87
Apathetic	2,221	2.00 ± 3.87	0.00	56.00	193.33
Irritated	2,223	3.76 ± 10.76	0.00	98.00	286.23
Happy	2,225	13.60 ± 16.54	0.00	96.50	121.55
Stressed	2,224	13.79 ± 16.70	0.00	110.50	121.06
Fearful	2,230	19.59 ± 18.03	0.00	113.50	92.03
Agitated	2,228	48.11 ± 33.71	0.00	125.50	70.09
Relaxed	2,230	53.62 ± 34.26	0.00	126.00	63.90
Calm	2,225	58.02 ± 34.93	0.00	126.00	60.20
Active	2,230	61.56 ± 30.47	0.00	126.00	49.49
Attentive	2,222	70.33 ± 30.00	0.00	124.50	42.66

To evaluate the correlation between the 12 adjectives and summarize these data into a few principal components, a principal component analysis was performed. The PC1 explained 49.47% of the variation in the dataset and presented higher positive loadings for the adjectives agitated (0.37) and active (0.35) as well as higher negative loadings for the adjectives calm and relaxed (-0.38, for both). The PC2 explained 10.21% of the variation and presented higher positive loadings for irritated (0.62), curious (0.47), and stressed (0.38) as well as higher negative loadings for attentive (-0.11) and fearful (-0.09). The loading plots on PC1 and PC2 are presented in Figure 1.

Figure 1. Loading plot for the behavioral based adjectives on the first and second principal components (PC1 and PC2).

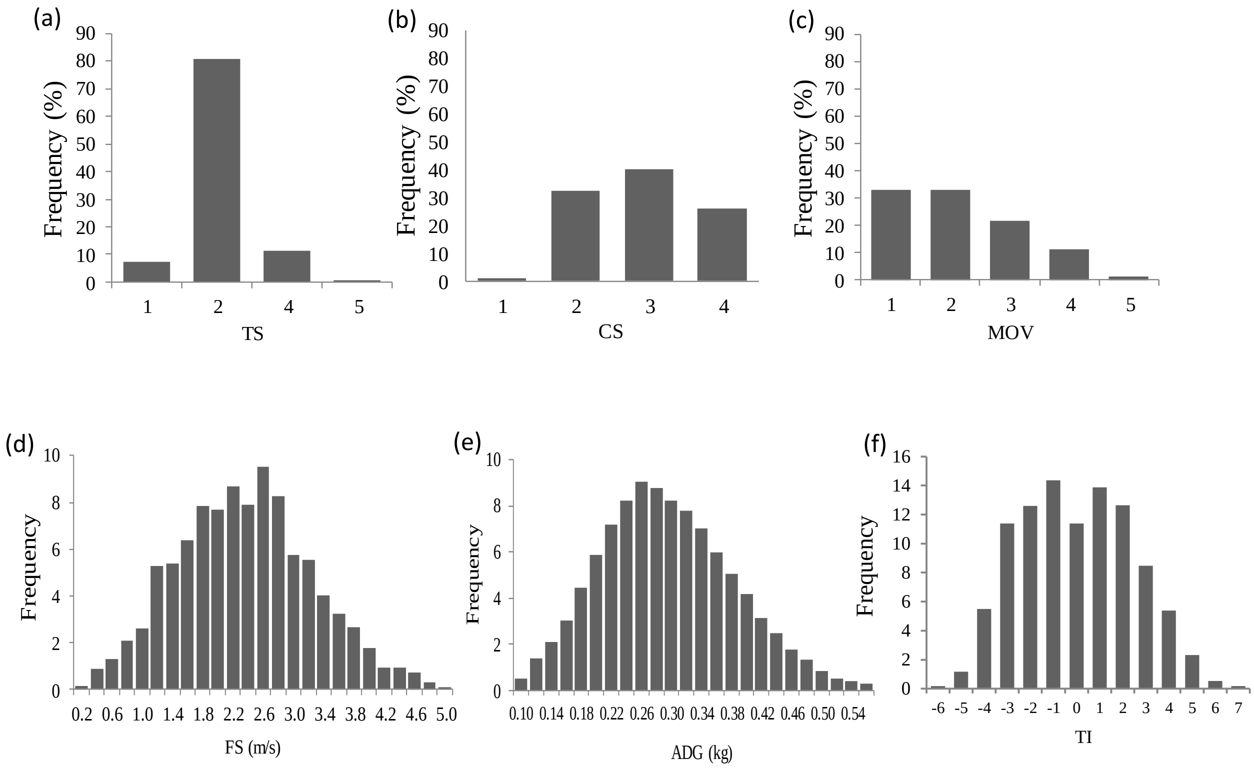


The scores of individuals on PC1 was used as a temperament index (TI) in order to produce a single temperament variable, which summarized the QBA data. This new variable ranged from -5.91 (best temperament) to 7.06 (worse temperament), and the mean was 0.00 (± 2.43, N = 2,206).

3.2. Relationship of TI with the other temperament indicators and ADG

The distributions of TI, FS, and ADG as well as the visual scores of TS, CS, and MOV for the herd evaluated are presented in Figure 2. Only FS and ADG had a normal distribution according to the Kolmogorov-Smirnov test ($P > 0.05$); nevertheless, based on the graphical analysis, we assumed that the TI distribution was approximated to normal (Figure 2f).

Figure 2. Distribution of (a) temperament score, (b) crush score, (c) movement score; and (d) flight speed as well as (e) average daily gain and (f) temperament index of Nellore cattle, N = 2,110.



TI was positively correlated to the FS (r = 0.49, P < 0.01). Although the coefficient value was not high (i.e. < 0.7) this association suggests that cattle with higher values of TI (perceived as more agitated /active) also had higher FS values. The ADG had significant correlation with TI (r = -0.10; P < 0.01), but the very low coefficient value indicated an extremely weak association between variables.

The TI means differed significantly according to the scores of TS (F = 160.24, P < 0.01), CS (F = 80.74, P < 0.01), and MOV (F = 32.21, P < 0.01). The group of individuals with TS = 1 (best temperament) represented the lower TI mean, followed by TS = 2, and then TS = 4 and 5 (with no statistical difference between them) (Table 3). The groups of animals with CS = 1 had lower TI means than CS = 2, 3, and 4, which differed from one another, increasing TI in the same direction as CS. The group of animals with MOV = 1 had the lower mean of TI, followed by animals with MOV = 1 and 2, and MOV = 4 and 5, which were not different from each other.

Table 3. Means and respective standard deviations of temperament indices (TI) according to the temperament score (TS), crush score (CS), and movement score (MOV) levels. Numbers of individuals are within parentheses.

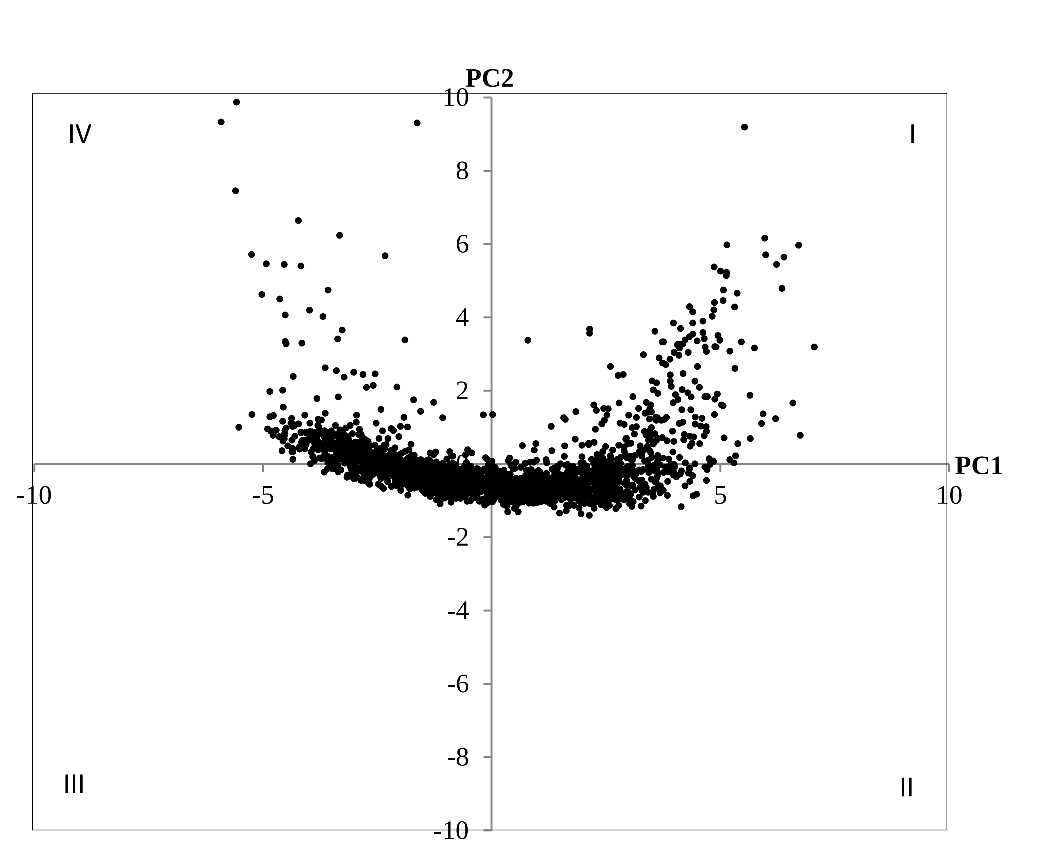
	TI means according to the scores of the independent variables		
Scores	TS	CS	MOV
1	-2.06 ± 1.78[a] (158)	-2.23 ± 1.54[a] (24)	-0.52 ± 2.28[a] (691)
2	-0.17 ± 2.28[b] (1717)	-0.87 ± 2.20[b] (677)	-0.17 ± 2.42[b] (687)
3	-	-0.17 ± 2.36[c] (843)	0.15 ± 2.41[b] (453)
4	2.55 ± 1.84[c] (239)	1.08 ± 2.36[d] (542)	1.37 ± 2.32[c] (231)
5	3.49 ± 3.34[c] (5)	-	1.70 ± 2.28[c] (24)

[a - c] = Different letters on the column represent differences between adjusted means according to the Tukey test ($P < 0.05$).

3.3. Characterization of temperament groups based on the QBA

The score plot for PC1 and PC2 was used to classify the cattle in four temperament groups corresponding to the graphic quadrants: group I (first quadrant) encompasses the individuals having positive scores for PC1 and PC2, group II (second quadrant) individuals having positive score for PC1 and negative for PC2, group III (third quadrant) individuals having negative scores for both PC1 and PC2, and group IV (fourth quadrant) individuals having negative scores for PC1 and positive for PC2 (Figure 3).

Figure 3. Score plot for individuals on the first and second principal components (PC1 and PC2). The numbers I to IV represent the quadrants.



The temperament groups differed significantly for the means of all 12 adjectives (ANOVA, P < 0.01), as shown in Table 4. The scores for adjectives fearful, agitated, and active decreased gradually from group I to IV, while relaxed and calm increased gradually from groups I to IV. The terms stressed and irritated were higher for group I than for the others, while the terms happy, positively occupied, and curious were higher for group IV than for the others. In general, from the first (group I) to the fourth (group IV) groups the temperament improved, and therefore we named these groups as very bad temperament, bad temperament, good temperament, and very good temperament, respectively.

Table 4. Means and respective standard deviation (in mm) for the adjectives according to the temperament groups (I to IV) (F-values from one-way ANOVA test).

Temperament Groups	I	II	III	IV	F-Value
N	254	827	656	469	-
Curious	1.41±1.75[b]	0.59±0.63[c]	0.59±0.70[c]	3.25±8.66[a]	50.80**
Positively o.	1.29±1.17[b]	1.25±1.14[b]	1.05±1.04[b]	2.77±8.91[a]	17.91**
Apathetic	1.02±1.75[c]	0.95±1.23[c]	1.79±2.36[b]	4.67±7.00[a]	116.38**
Irritated	24.64±21.78[a]	1.11±1.69[b]	0.77±0.72[b]	1.04±0.86[b]	750.97**
Happy	2.52±3.72[c]	3.78±2.99[c]	12.40±7.47[b]	38.87±17.74[a]	1,549.17**
Stressed	47.80±19.74[a]	16.37±10.10[b]	4.55±3.57[c]	3.42±4.60[c]	1,480.24**
Fearful	33.24±22.69[a]	29.82±17.52[b]	10.63±7.99[c]	6.77±8.15[d]	423.66**
Agitated	95.86±21.08[a]	68.84±22.42[b]	25.45±15.93[c]	16.53±11.98[d]	1,677.15**
Relaxed	13.28±14.57[d]	27.75±14.57[c]	72.29±17.27[b]	95.33±16.91[a]	2,662.80**
Calm	12.28±10.98[d]	31.94±18.32[c]	81.78±14.34[b]	96.05±15.14[a]	2,859.21**
Active	95.38±20.89[a]	78.34±19.79[b]	52.13±21.81[c]	26.02±16.72[d]	983.20**
Attentive	92.52±21.16[a]	91.93±16.28[a]	56.70±24.16[b]	39.10±19.87[c]	889.84**

[a - d] = Different letters on the row represent differences between means on the Tukey test (P < 0.05).
** = P < 0.01.

The four groups differed significantly for FS (F = 168.56; P < 0.01), CS (F = 69.90; P < 0.01), TS (F = 165.23; P < 0.01), MOV (F = 34.66; P < 0.01), and ADG (F = 6.23; P < 0.01). FS, CS, TS, and MOV had higher means in the group I (very bad temperament) than in the others, with a gradual decrease from groups II to IV, as shown in Table 5. Groups I and II (very bad and bad temperament) had lower ADG means than groups III and IV (which represent animals with better temperament).

Table 5. Means and respective standard deviations of the flight speed (FS), temperament score (TS), crush score (CS), and movement score (MOV) according to the temperament groups.

Temperament Groups	N	FS (m/s)	CS	TS	MOV	ADG (kg/day)
I	254	3.05±0.88[a]	3.36±0.70[a]	2.90±1.03[a]	2.56±1.11[a]	0.26±0.10[b]
II	827	2.49±0.79[b]	3.05±0.79[b]	2.25±0.74[b]	2.29±1.09[b]	0.27±0.09[b]
III	656	2.17±0.68[c]	2.79±0.72[c]	1.97±0.42[c]	1.99±0.93[c]	0.29±0.10[a]
IV	469	1.84±0.62[d]	2.59±0.76[d]	1.84±0.46[d]	1.87±0.91[c]	0.29±0.10[a]

[a - d] = Different letters on the column represent differences between adjusted means on the Tukey test (P < 0.05).

4. DISCUSSION

According to our results, the QBA method was efficient for detecting the variation in cattle behavior during handling in the corral. Some of the behavioral adjectives (curious, positively occupied, and happy) received low scores. This was expected, as the test was conducted during a stressful situation for the animals. Regardless of the low values, these positive terms were important because they enabled to identify some individuals that were apparently not affected by the handling procedures, and behaved in a positive manner even under a potentially stressful handling routine.

TI was heavily influenced by the adjectives agitated, active, calm, and relaxed, which reflects a continuum between extreme situations of being calm and agitated. Therefore, when used independently, TI would represent a measurement of activity and agitation. This was confirmed by its significant correlation to FS, which was reported by other authors as an indicator of general agitation (Kilgour et al., 2006) and innate fear in cattle (Petherick et al., 2002). FS is considered the most objective among the methods often used for assessing beef cattle temperament (Curley et al., 2006). Thus, based on this information and our finding of a significant and expressive association between FS and TI, we assume that the QBA would be a useful tool to assess cattle temperament in a broader manner.

The significant differences in TI for the different categories of TS, CS, and MOV also confirmed that the QBA were able to detect variations in cattle behavior, which were indicative of their temperament. This result is important for comparing the qualitative method to the current methods used on farms, since visual scales with predefined scores for assessing cattle temperament (including TS) are the most commonly used to assess beef cattle temperament for selective breeding purposes in Brazil (Barrozo et al., 2012). Among the visual scores used in this study, TS showed the greatest association with the TI, which, we hypothesize, was due to performing both methods without any physical restraint.

Our results differed from that described by Stockman et al. (2012), which reported no relationship between the QBA method with FS and crush agitation score. They found only a tendency towards significance, which suggested that animals with a higher tension score at weaning were scored as more ‘curious’/‘interested’ when observed during handling procedures at slaughter. The main difference between the two studies was that Stockman et al. (2012) assessed the QBA at slaughterhouses and the temperament indicators were recorded on a farm during three separate visits around the time of weaning, which is a significant length of time before slaughter.

According to the authors, the different periods of evaluation were an issue that could have affected the lack of association. In our study, due to the difficulties in carrying out behavioral assessments on a large number of animals under commercial conditions, we were only able to evaluate temperament once concomitantly with the QBA. We believe that this situation does not invalidate our data, because several authors have reported high short-term repeatability (Müller and von Keyserlingk et al., 2006) and long-term repeatability ranging from moderate (Curley et al., 2006; Kilgour et al., 2006; Cafe et al., 2011) to high (Petherick et al., 2002; Turner et al., 2011) when assessing cattle temperament, in addition to being moderately heritable (Burrow and Corbet, 2000; Sant'Anna et al., 2012). However, in order to extend the results of both studies commercially (present and Stockman et al., 2012), additional research is needed to confirm the association between quantitative and qualitative methods in a wider range of ages and circumstances of cattle temperament assessment.

In this study, it was possible to identify four groups of individuals based on the QBA that reflect differences in cattle temperament. The individuals from group I (very bad temperament) were distinguished from the others by higher scores for stressed and irritated, which indicates nervous reactions, threat, or attack; these individuals also had higher FS and visual scores of temperament (TS, CS, and MOV). For group II (bad temperament), in spite of high scores for fear and agitation similar to the first group, they were not scored as highly irritated, indicating lower negative reactions to the handling compared to the animals from group I. Individuals from group III (good temperament) had lower levels of fear and agitation as well as higher ratings for calm and relaxed than group II, and the differences were even greater when compared with group I. For group IV, besides having lower levels of fear and agitation as well as lower means of FS, TS, and CS than the other groups, they also differed from group III by having higher ratings for positive adjectives, including curious, happy, and positively occupied.

The identification and characterization of these four different behavioral profiles was only possible because of the integrative nature of the QBA, which permitted the observer to integrate different aspects of cattle temperament (irritation, curiosity, fear, activity) into a single evaluation. This result confirmed one of the advantages of the qualitative methods, derived from its integrative nature, which consider the animals “as a whole” (Wemelsfelder et al., 2001) and allow to discriminate individuals exhibiting positive expressions (e.g., being calm, curious, and positively occupied). From the perspective of selective breeding, the possibility of identifying animals with good temperament (such as those that integrated group IV) would be more relevant than only identifying those that were not exhibiting undesirable temperament (such as the animals in group III).

The low correlation between ADG and TI indicates a weak tendency of individuals scored as more agitated/active and less calm/relaxed had also the lower weight gains. There is no consensus in the scientific literature regarding the association between cattle performance and temperament, since some authors have reported significant phenotypic correlations (Voisinet et al., 1997; Petherick et al., 2002; del Campo et al., 2010), while others failed to find any relationship (Burrow and Corbet, 2000).

Our results showed that individuals with very bad and bad temperament (groups I and II, respectively) presented lower ADG means than those from the groups with better temperament (groups III and IV), which corroborate the findings of Cafe et al. (2011) that found a quadratic (stronger than linear) relationship between FS and ADG, with most declines in ADG occurring when FS > 2.5 m/s. This is consistent with our findings, since we found that individuals from groups I and II had FS means equal to 3.05 and 2.49 m/s, respectively. Some evidence in the literature (Nkrumah et al., 2007; Cafe et al., 2011) suggests that the variation in ADG in relation to the cattle temperament could be a result of the reduction of feed intake, which negatively affected ADG in individuals with bad temperament.

The agreement between the QBA and the traditional temperament indicators suggests that this method can identify real attributes of cattle temperament and was not just an artifact of observer interpretation. In addition, this method provides some practical benefits, such as being safe to the observer and widely feasible, because it does not require the observer to have physical contact with cattle, does not restrain animals in a crush, and does not require farms to purchase electronic devices for assessing temperament. As a result, this method has the potential to be used for assessing beef cattle temperament in conditions where traditional methods are limited, such as when dealing with aggressive animals, in farms without a restraining crush, or when electronic devices are not available.

5. CONCLUSION

In conclusion, we found that QBA can discriminate different behavioral profiles of Nellore cattle, which is in agreement with other traditional methods used as indicators of cattle temperament. In addition, the method was able to identify individuals exhibiting bad (similar to the other methods) and desirable temperaments. This wider range of temperament assessment could be attributed to the integrative characteristic of the method, which can combine the expression of agitation, fear, relaxing, curiosity, and other qualitative characteristics in the same analysis. In this study, individuals with good temperament were those that remained calm and exhibited positive behavioral expressions of happiness, curiosity, and being positively occupied, even in a situation characterized as potentially stressful (handling in the corral). This information is useful for distinguishing animals that are more likely to cope with handling procedures from those that are not, which provides an opportunity to identify animals with good temperament for selective breeding.

The development of a new behavioral indicator to assess cattle temperament is a complex process that will require additional research. In this first study, we have demonstrated the possibility of using the QBA for assessing cattle temperament. As the results are promising, the next steps for the development of this measurement will be an assessment of the inter- and intra-observers reliability as well as its association with physiological parameters, such as heart rate and plasma cortisol levels.

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CAPÍTULO 3 - Genetic associations between flight speed and growth traits in Nellore cattle[1]

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ABSTRACT: The aim of the present study was to estimate genetic parameters for flight speed and its association with growth traits in Nellore beef cattle. The flight speed (**FS**) of 7,402 yearling animals was measured using a device composed of a pair of photoelectric cells. Time interval data (s) were converted to speed (m/s), and faster animals were regarded as more reactive. The growth traits analyzed were weaning weight (**WW**), average daily weight gain from weaning to yearling age (ADG) and yearling scrotal circumference (**SC**). The (co)variance components were estimated using REML in a multitrait analysis applying an animal model. The model included the random direct additive genetic and residual effects, the fixed effects of contemporary groups, age of the dam (classes) and age of the animal as covariables. For WW, the model also included the maternal genetic and permanent environmental random effects. The direct heritability estimate for FS was 0.26 ± 0.05 and for WW, SC and ADG, were 0.30 ± 0.01, 0.48 ± 0.02 and 0.19 ± 0.01, respectively. Estimates of the genetic correlation between FS and the growth traits were -0.12 ± 0.07 (WW), -0.13 ± 0.08 (ADG) and -0.11 ± 0.07 (SC). Although the values were low, these correlations showed that animals with better temperaments (slower FS) tended to have better performance. It is possible to infer that long term selection for weight and scrotal circumference can promote a positive genetic response in the temperament of animals. Nevertheless, to obtain faster genetic progress in temperament, it would be necessary to perform direct selection for such traits. Flight speed is an easily measured indicator of temperament and can be included as a selection criterion in breeding programs for Nellore cattle.

Key words: average daily gain, genetic correlation, heritability, scrotal circumference, temperament

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1. INTRODUCTION

Brazilian beef cattle production is characterized by the use of extensive systems and a predominance of Zebu breeds, mostly Nellore and its crosses. The ability of Zebu breeds to adapt to the climatic conditions that prevail in the tropical zone, as well as their moderate growth capacity and resistance to ectoparasite infestations, favors their use in extensive production systems under tropical conditions (Cundiff, 2005).

Several studies comparing Zebu and European breeds have shown that Zebu breeds and their crosses demonstrate greater reactivity, defined by a behavioral predisposition to respond to handling by humans (Fordyce et al., 1988; Burrow, 1997). The management of highly reactive animals is more difficult and brings a series of inconveniences, such as an increased stress response in animals (Curley et al., 2006) and risk of accidents (Grandin, 1999), resulting in poor reputations for these breeds due to their temperament (Fordyce et al., 1988). In this context, it is possible to reduce cattle reactivity, either through the learning process resulting from improved handling skills, which tends to decrease reactivity in future managements (Becker and Lobato, 1997), or through the selection of less reactive animals for reproduction (Jensen et al., 2008; D’Eath, et al., 2010).

Several measures have been used to assess temperament in cattle. One of these measures is flight speed (**FS**), which determines the speed at which an animal exits the squeeze chute and proceeds towards an open space of the corral (Burrow et al., 1988). The advantages of this measure include its objectivity and ease of use; it is performed automatically using a relatively simple and inexpensive electronic device (Curley et al., 2006; Müller and von Keyserlingk, 2006). Moreover, there is some evidence that FS has enough genetic variability to respond to individual selection (Burrow, 2001; Nkrumah et al., 2007). For instance, Burrow and Cobert (2000) estimated a value of 0.35 for the heritability of FS in a sample of 591 purebred and crossbred Brahman animals.

Although the importance of improving temperament in cattle is generally recognized, and there is evidence that temperament responds to selection, most Zebu breeding programs focus on growth traits and temperament is not used as a criterion for selection (Yokoo et al., 2007). Body weight at different ages and BW gain are included as selection criteria in almost all beef cattle breeding programs, because these traits have enough genetic variability to respond to selection and are associated with other traits of economic interest (Eler et al., 1995; Albuquerque and Meyer, 2001). Scrotal circumference is also used as a selection criterion in breeding programs, because it is associated with growth traits and indicators of female sexual precocity, with moderate to high heritability estimates (Yokoo et al., 2007, Boligon et al., 2010). In some cases, temperament is assessed in beef cattle breeding programs; however, generally, this trait is not included in the selection indices. Rather, it is used as an independent selection criteria, resulting in the culling of animals that have the worst temperament scores. To date, few studies (Burrow, 2001; Barrozo et al., 2012) have been conducted to estimate the genetic basis of FS and the correlation between FS and traits normally used as selection criteria in Zebu breeds.

Therefore, the aim of the present study was to estimate genetic parameters for FS (as an indicator of temperament) in Nellore cattle and to study the genetic associations between FS and weaning weight (**WW**), post-weaning ADG, and scrotal circumference (**SC**). The intended goal was to explore the possibility of using FS as a selection criterion in breeding programs for Nellore cattle.

2. MATERIAL AND METHODS

This study was approved by the Comittee of Ethical Use of Animals from the Faculty of Agricultural and Veterinarian Sciences, São Paulo State University, Jaboticabal-SP, Brazil, Certified n.007808/11. The study was conducted on herds of Nellore cattle from the Agropecuária Jacarezinho Ltda. on farms located in the counties of Valparaíso, in southeast Brazil, and Cotegipe, in northeast Brazil. The growth traits analyzed were WW, ADG and SC of animals born between 1990 and 2010.

Both farms followed the same procedures for the formation of management groups. Calves were weighed immediately after birth and assigned to management groups, which were kept in pastures and received only a mixture of minerals as dietary supplementation. Weaning occurred at approximately 210 d of age, when they were weighed and subjected to the first evaluation. Animals were assigned visual scores for conformation, precocity, muscling and navel (considers the size and positioning of navel and sheath). When the animals reached 550 d of age, they were subjected to a second evaluation, recording their BW, visual scores and testicular measurements (in males).

A certain number of animals were selected to be discarded at weaning and at 550 d (50% of males and 10% of females in each age). The decision was based on a selection index that included these criteria: i) number of days required to gain 160 kg of BW from birth to weaning; ii) the number of days required to gain 240 kg of BW post-weaning; iii) visual scores of conformation, precocity, and muscling in both age groups; and iv) SC at 550 d, adjusted for age and BW.

The traits used in the present study were: i) WW, to minimize the influence of selection and culling on genetic parameter estimates; ii) ADG, calculated based on WW and yearling weight; iii) SC, measured at 550 d of age; and iv) temperament, assessed using the FS test. The average age of the animals (± SD) in assessments for WW, ADG, SC and FS were: 188.04 ± 25.17, 506.75 ± 35.57, 510.52 ± 39.97 and 494.59 ± 39.48 d, respectively.

Flight speed was assessed during handling for the determination of weight at yearling age, in males and females born in 2008 and 2009, as described by Burrow et al. (1988). Measurements were performed with an electronic device composed of two pairs of photoelectric cells, a chronometer, and a small processor programmed to record the time taken by each animal to cover a known distance, which ranged from 1.6 to 2.0 m (depending on facilities). Time data (s) were converted to speed (m/s); faster animals were considered to have less desirable temperaments.

Contemporary groups were formed for each trait, using these criteria: i) for WW, farm and year of birth; management groups at birth and weaning; and calf sex; ii) for ADG, farm, year and season of birth; management groups at birth and weaning; farm, year and management group at yearling age; and calf sex; iii) for SC, farm and year of birth; management groups at birth, weaning and yearling age; iv) for FS, farm of birth; management group at weaning and yearling age; paddock; date of yearling assessment; and calf sex.

Contemporary groups (**CG**) with < 5 animals and CG having coefficients of variation >67% were excluded from the analysis. For each trait, records out of range (within CG) given by the mean of the CG ± 3 SD were also excluded.

The (co)variance components were estimated by REML using WOMBAT software (Meyer, 2006). Multitrait analyses were performed applying an animal model. The direct additive genetic and residual effects were included in the model as random effects. Fixed effects were: CG, age of the dam at calving (in classes ranging from 2 to 14 yr) and age of the animal at the time of measurement (linear effect for FS and quadratic effect for WW, ADG and SC). The model for WW also included the maternal genetic and permanent environmental random effects. The general model used was as follows: $\mathbf{y} = \mathbf{Xb} + \mathbf{Z_1a} + \mathbf{Z_2m} + \mathbf{Z_3c} + \mathbf{e}$; where **y** = vector of observed traits; **b** = vector of fixed effects; **a** = vector of direct additive genetic effects; **m** = vector of maternal additive genetic effects; **c** = vector of maternal permanent environmental effects; and **e** = vector of residual effects. The **X**, $\mathbf{Z_1}$, $\mathbf{Z_2}$, and $\mathbf{Z_3}$ are incidence matrices associating **b**, **a**, **m** and **c** to **y**. In this study, it was assumed that E[y] = **Xb**; Var(a) = **A** $\otimes$ ($\otimes$ = Kronecker product) $\mathbf{S_a}$; Var(m) = $\mathbf{A} \otimes \mathbf{S_m}$; Var(c) = $\mathbf{I} \otimes \mathbf{S_c}$ and Var(e) = $\mathbf{I} \otimes \mathbf{S_e}$, where $\mathbf{S_a}$ is the additive genetic covariance matrix; $\mathbf{S_m}$, the maternal genetic covariance matrix; $\mathbf{S_c}$, the maternal permanent environmental covariance matrix; $\mathbf{S_e}$, the residual covariance matrix; **A**, the additive genetic numerator relationship matrix; **I**, the identity matrix; and $\otimes$, the direct product of the matrices. The vectors **a**, **m**, **c** and **e** were assumed to be uncorrelated.

The pedigree file included 706 sires; 38,285 dams; 492 maternal grandsires and 19,236 maternal grandmothers; the relationship matrix included 124,730 animals.

3. RESULTS AND DISCUSSION

The average FS obtained in the present study (Table 1) was within the ranges reported in the literature for Zebu breeds and their crosses. In Nellore cattle, the mean FS ranges from 0.68 to 1.68 m/s (Paranhos da Costa et al., 2002; Maffei et al., 2006; Barbosa Silveira et al., 2008a). In crossbred animals, FS ranged from 0.99 to 2.08 m/s for Charolais x Nellore crosses (Barbosa Silveira et al., 2008b) and from 0.46 to 0.96 m/s for Angus x Nellore crosses (Barbosa Silveira et al., 2006). Similar results were obtained for Brahman animals and their crosses, whose flight speeds ranged from 0.59 to 2.83 m/s (Burrow, 2001; Kadel et al., 2006; Petherick et al., 2009).

Table 1. Descriptive statistics for WW[1], ADG, SC[1] and FS[1] in Nellore cattle.

Trait	n	Mean	SD	CV, %
WW, kg	108,386	172.29	26.47	15.35
ADG, kg/d	76,432	0.30	0.09	30.00
SC, cm	30,515	26.54	3.12	11.70
FS, m/s	7,402	2.26	1.00	44.17

[1]WW = weaning weight; SC = scrotal circumference, FS = flight speed.

The heritability estimate for FS was moderate (Table 2). The only heritability estimate found in the literature for this trait in Nellore cattle was greater (0.35) than that obtained in the present study; however these results are not widely comparable because the authors used a database that included 4 breeds of cattle (*Bos indicus*: Nellore, Gir and Guzerat, and *Bos taurus*: Caracu, a breed adapted to the tropics) and applied a sire model with breed as a fixed effect (Paranhos da Costa et al., 2002). Conversely, the heritability estimated in the present study was greater than that found by Prayaga et al. (2009) for Brahman cattle (0.17 ± 0.07), though less than that obtained by the same authors for a synthetic breed adapted to the tropics ("Tropical Composite", which is composed of ~50% *Bos indicus* or African Sanga and 50% *Bos taurus*, of British and European breeds not adapted to the tropics; 0.31 ± 0.09).

Table 2. Estimates of variance components and heritability (± SE) for FS[1], WW[1], and SC[1].

Trait	σ^2_a[1]	σ^2_c[1]	σ^2_d[1]	σ^2_e[1]	h[1]	c[1]	d[1]
FS	0.22	-	-	0.62	0.26 ± 0.05	-	-
WW	85.53	28.74	44.65	126.84	0.30 ± 0.01	0.10	0.16
ADG	0.0005	-	-	0.0022	0.19 ± 0.01	-	-
SC	3.09	-	-	3.30	0.48 ± 0.02	-	-

[1]FS = flight speed; WW = weaning weight; SC = scrotal circumference; σ^2_a = additive genetic variance; σ^2_c = maternal genetic variance; σ^2_d = maternal environmental variance; σ^2_e = residual variance; h = heritability; c = fraction of phenotypic variance due to maternal genetics; d = fraction of phenotypic variance due to maternal environment.

The FS heritability estimate was less than that obtained in the studies conducted in Australia, both with *Bos indicus* (Brahman) cattle and their crosses with *Bos taurus* (Belmont Red, Angus, Hereford, Shorthorn, Charolais and Limousin), which ranged from 0.35 (Burrow and Corbet, 2000) to 0.40 (Burrow, 2001). Additionally in Australia, Kadel et al. (2006), working with crossbred animals (Brahman, Belmont Red and Santa Gertrudis), obtained heritability estimates of 0.30 ± 0.02 and 0.34 ± 0.03 at 246 and 564 d of age, respectively. A similar result (0.49 ± 0.18) was found for a synthetic cattle breed of European origin (Angus, Charolais, Hereford and Simmental; Nkrumah et al., 2007). However, our heritability estimate for FS was similar to or greater than some estimates obtained for European breeds, with values of 0.11 ± 0.08 for Limousin, 0.15 ± 0.06 for Angus, and 0.33 ± 0.10 for Hereford (Hoppe et al., 2010).

The model applied can affect the estimation of variance components for FS; however, the genetic variability estimated in the present study using a multitrait animal model was close to those found by Prayaga and Hernshall (2005), using different single-trait models. These authors compared different statistical models, from simple (e.g., considering only the animal as a random effect) to more complete models (e.g., including direct and maternal genetic effects and permanent environmental effects of the animal). They obtained heritability estimates for FS ranging from 0.19 ± 0.03 to 0.58 ± 0.02 for a crossbreed of *Bos taurus* (Hereford, Simmental, Shorthorn, Charolais) with *Bos indicus* (Brahman; Prayaga and Henshall, 2005).

Despite the differences in heritability estimates found in the literature for different breeds and with different statistical methods, it was possible to infer that the reaction of the animals when leaving a condition of physical restraint represents sufficient genetic variability to respond to selection. The results of the present study corroborate prior findings on the additive genetic variability of FS.

The heritability estimates for growth traits obtained in the present study are within the range found in the literature for Nellore cattle. Furthermore, the heritability estimates for WW and ADG were similar to those found by Dias et al. (2003), Boligon et al. (2007) and Yokoo et al. (2007) for SC, and by Eler et al. (1995) and Albuquerque and Meyer (2001).

The genetic correlation estimates between FS and growth traits were negative and low (Table 3). Scrotal circumference is used as a selection criterion in breeding programs, because it is positively associated with sexual precocity in heifers (Toelle and Robison, 1985; Forni and Albuquerque, 2005; Eler et al., 2006), semen production and semen quality (Sarreiro et al., 2002) and growth traits (Silva et al., 2006). The results of the present study show that selection for larger SC will not lead to correlated response in FS, even in the long term. Our result is similar to that described by Barrozo et al. (2012) for the genetic correlation of SC with a temperament visual score (-0.07) in Nellore cattle. The estimated correlation between the FS and SC obtained in the present study is less than that reported by Burrow (2001) for purebred and crossbred Brahman cattle when SC was measured at yearling age (-0.22); however, it was similar to the estimate of Burrow (2001) when SC was obtained at weaning (-0.13).

Table 3. Estimates for genetic (above diagonal) and phenotypic (below diagonal) correlations (± SE) for FS[1], WW[1], and SC[1].

Trait	FS	WW	ADG	SC
FS	-	-0.12 ± 0.07	-0.13 ± 0.08	-0.11 ± 0.07
WW	-0.07 ± 0.01	-	0.25 ± 0.03	0.22 ± 0.03
ADG	-0.06 ± 0.01	-0.06 ± 0.01	-	0.13 ± 0.03
SC	-0.07 ± 0.02	0.21 ± 0.01	0.21 ± 0.01	-

[1]FS = flight speed; WW = weaning weight; SC = scrotal circumference.

Our results, with the support of the literature, suggest that a low genetic association exists between SC and FS. Consequently, the selection for one of these traits will not result in a correlated response in the other.

The estimates of genetic correlations of FS with WW and ADG were also low and negative. This result leads to the conclusion that selection for greater WW and ADG will have no effect on FS in the short and medium term. It should be noted that all genetic correlations of WW and ADG with FS were negative, indicating a favorable relationship between these traits, i.e. long-term selection for increasing WW and ADG will reduce FS.

Few studies have been conducted to assess the genetic correlation between temperament and performance traits in Nellore cattle (Figueiredo et al., 2005; Barrozo et al., 2012). Moreover, in these studies, FS was not used as an indicator of temperament; rather, they assessed temperament via visual scores. For instance, a study by Figueiredo et al. (2005) used flight distance score (ranging from 1= worst temperament to 5= best temperament) and obtained genetic correlation estimates of

0.04, 0.36 and 0.38 with BW at 120 d, weaning age, and yearling age, respectively, and 0.20 with ADG. The authors concluded that individuals with the best temperaments also presented greater performance for growth traits. Furthermore, Burrow (2001) found negative genetic correlation estimates between FS and WW (-0.03), 1 yr (-0.02) and yearling age (-0.05) for Brahman cattle and their crosses, although the estimates were close to 0. Genetic correlation estimates between FS and ADG for different genetic groups of European breeds (Angus, Charolais, Hereford, Limousin, and Simmental) were similar to or stronger than those observed in the present study (ranging from -0.04 for Angus to -0.41 for Limousin), and all correlations were negative, indicating a favorable genetic association between FS and performance traits (Hoppe et al., 2010). Stronger genetic correlations than those in the present study were reported by Nkrumah et al. (2007) for confined *Bos taurus*, with estimates of -0.25 and -0.57 for the correlation of FS with final BW and ADG, respectively.

The phenotypic correlation estimates between FS and performance traits (WW and ADG) were also negative and low. According to Burrow (2001), this low association is expected in an extensive production system, because short-term stressful situations resulting from management are less likely to interfere with long-term BW gain. Conversely, in intensive systems, due to the close proximity between humans and animals, individual differences in temperament may affect performance (Burrow and Dillon, 1997; Voisinet et al., 1997).

Despite the studies described above reporting an association between temperament and performance, their results do not provide concrete evidence regarding which mechanisms underlie the expression of temperament, nor do they explain the reason for the relationship of temperament with performance traits. Animals with worse temperaments are known to have greater concentrations of plasma cortisol (Curley et al., 2006), glucose and lactate (Cafe et al., 2011). Furthermore, these animals require a longer time to return to baseline concentrations of glucose when subjected to handling in the corral (Cafe et al., 2011). However, further studies are needed to explain why this association can be observed only under certain conditions, whereas in others, (e.g., in the present study) there is no phenotypic evidence to suggest that temperament affects BW gain.

It can be concluded that the selection criteria currently used in breeding programs for beef cattle are not effective for improving the temperament of animals. Therefore, to obtain genetic improvement for this trait, the selection indices for Nellore cattle should include temperament-based criteria. Flight speed is an appropriate measure for this purpose, because it represents sufficient genetic variability to respond to selection. Furthermore, FS is easy and inexpensive to measure, and it can be used to assess temperament objectively.

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CAPÍTULO 4 - Genetic variability for temperament indicators of Nellore cattle[1]

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ABSTRACT: The aim of this study was to estimate genetic parameters of four temperament indicator traits for Nellore cattle, and to evaluate the possibility of using such traits as selection criteria in breeding programs. Temperament was assessed for 23,420 male and female animals at 550 d of age, which were born between 2002 and 2009. A temperament score (**TS**) was used, which is based on a scale from 1 to 5 and considers the reaction of animals after exiting the crush. Moreover, 9,150 individuals born in 2008 and 2009 were measured for the following characteristics: movement score (**MOV**), where animals were scored from 1 to 5 according to their movement inside the crush; crush score (**CS**), which assigns scores from 1 to 4 for the general reactivity inside the crush; and flight speed (**FS**), which is a recording of the speed (in m/s) at which the animals exit the crush after being weighed. Weaning weight (**WW**) was included in the multitrait analysis to reduce the effect of the selection performed at weaning. Bayesian Inference using Gibbs Sampling was applied to estimate (co)variance components and breeding values of the animals. The model included the random direct additive genetic and residual effects, fixed effects of contemporary groups, age of the dam (classes), and age of the animal as covariate (linear and quadratic effects for WW and TS, and only linear effects for the other traits). A linear model was applied to WW and FS, while a threshold model was used for TS, CS, and MOV. Heritability estimates for FS, TS, CS, and MOV were 0.35, 0.15, 0.19, and 0.18, respectively. The genetic correlation estimates of FS with TS (0.85), CS (0.85), and MOV (0.76) were high, although the phenotypic correlations were low (between 0.18 and 0.25). For CS and MOV, the genetic and phenotypic correlation estimates were high (0.99 and 0.71, respectively). We concluded that all of the temperament indicator traits addressed in this study presented enough genetic variability to respond to selection; however, the use of FS would result in a faster genetic gain. With regard to the practical applicability in breeding programs, the use of FS is also favorable, since it produces data on a continuous scale, allows for recording of the data electronically and requires low investment.

Key words: behavior, flight speed, genetic correlation, heritability, Zebu cattle

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1. INTRODUCTION

Cattle temperament is usually defined as the behavioral responses of animals to being handled by humans and is assessed in different ways (Burrow, 1997). Some authors have categorized the behavioral indicators of temperament based on the type of measurement or the handling situation in which the test is applied (Manteca and Deag, 1993; Burrow, 1997). Manteca and Deag (1993) detail three forms of evaluating individual behavioral differences: behavioral tests, observer ratings, and scales with predefined scores (also known as visual scores), which is the most common method for assessment of beef cattle temperament on farms (Fordyce et al., 1982; Grandin, 1993).

Another way to classify the methods used for cattle temperament assessment was proposed by Burrow (1997), who defined two categories: restrained and non-restrained tests. A commonly used restraining method is the crush test, in which visual scores are used to measure the reactions of an animal when it is physically restricted in a cattle crush. This method usually records the frequency and intensity of movements, audible respiration, and the frequencies of bellowing and kicking (Fordyce et al., 1982; Grandin, 1993). In contrast, animals are free to move during non-restrained tests, and they are usually kept in corral pens where the tests are conducted. These include a flight distance test, which measures the distance by which an observer can approach an animal before it expresses any intent to move away (Fordyce et al., 1982), a docility test, which evaluates an animal’s response when it is driven to and maintained in a corner of a corral pen (Le Neindre et al., 1995), and flight speed (**FS**), which assesses the speed at which an animal exits the cattle crush (Burrow et al., 1988). Some authors have suggested that tests with and without physical restraint assess different aspects of cattle temperament (Kadel et al., 2006; Kilgour et al., 2006).

Several studies have reported genetic parameter estimates for cattle temperament, with heritability ranging from low to moderate (0.11 to 0.40) for flight speed (Burrow and Corbet, 2000; Kadel et al., 2006), crush score (Fordyce et al., 1982; Hearnshaw and Morris, 1984; Hoppe et al., 2010), visual scores based on the reactions after exiting the crush into a corral pen (Barrozo et al., 2012), and flight distance (Fordyce et al., 1996). The importance of genetic improvement of beef cattle temperament has been widely recognized; however, there is currently no consensus regarding the ideal methodology that should be applied for on-farm assessments. Several initiatives have described cattle temperament as assessed by different methodologies (Grandin, 1993; Kilgour et al., 2006; Schwartzkopf-Genswein et al., 2012), but a few studies have compared the advantages and limitations of those different measures for genetic evaluations of cattle temperament (Kadel et al., 2006; Benhajali et al., 2010). Moreover, we were unable to find any paper addressing this subject specifically in the Nellore breed, and there is currently no consensus among the breeding programs as to which indicators should be used.

The aim of this study was to estimate the genetic parameters of four temperament indicator traits in Nellore cattle, and to evaluate the possibility of using such traits as selection criteria in breeding programs.

2. MATERIAL AND METHODS

This research was approved by the Committee of Ethical Use of Animals from the Faculty of Agricultural and Veterinarian Sciences, São Paulo State University, Jaboticabal-SP, Brazil, Certified n.007808/11. The study was conducted using a Nellore commercial herd from *Agropecuária Jacarezinho Ltd.* (Jacarezinho Agricultural Ltd.). The company owns two farms: one located in the Southeast and one in the Northeast of Brazil. At both farms, calves are assigned to management groups after birth and raised in tropical pastures with access to mineral supplementation. At weaning, which occurs around 210 d of age, a performance evaluation is carried out, which includes BW and visual scores for conformation, precocity, and muscling. At the yearling stage (around 550 d of age), another performance evaluation was conducted that considered the previous traits besides temperament.

For the present study, temperament assessments were performed simultaneously with the performance evaluation at the yearling age to avoid interfering in the cattle handling routine. In addition to the temperament score (**TS**), which is usually conducted by *Agropecuária Jacarezinho* to assess cattle temperament (since 2002, n = 23,420 records), three other methods were applied to 9,150 cattle (born in 2008 and 2009) as follows: i) Movement Score (**MOV**) – this was recorded at the time of weighing, with the animals inside the cattle crush, but without physical restraint in the head bail; the following scores were applied: 1 = no movement; 2 = little movement (for less than half of the observation time); 3 = frequent movements (half of the observation time or more), but not vigorous; 4 = constant and vigorous movements; and 5 = constant and vigorous movements, animal jumps and raises the limbs off of the ground (adapted from Grandin, 1993). ii) Crush Score (**CS**) – this was recorded in the same conditions as MOV, applying the following scores: 1 = animal does not offer resistance, remains with head, ears, and tail relaxed; 2 = some movement, with head up and ears erect; 3 = frequent movement but not vigorous, head, ear, and tail movements, sclerotic membrane may be visible; 4 = offers great resistance, abrupt and vigorous movements of the animal head, ear, and tail, sclerotic membrane visible, audible breathing, and it may jump or fall (adapted from Hearnshaw and Morris, 1984). iii) Flight Speed – a measure of the speed (m/s) at which each animal leaves the cattle crush after weighing (Burrow et al., 1988). The measurements were performed with an electronic device composed of two pairs of photoelectric cells, a chronometer, and a small processor programmed to record the time taken by each animal to cover a known distance, which ranged from 1.6 to 2.0 m (depending on the facilities). Time data (s) were converted to speed (m/s); faster animals were considered to have a less desirable temperament. iv) Temperament Score – this method has been used in the *Agropecuária Jacarezinho* breeding program as an independent criterion of selection (Conexão Delta G, 2011). A score is given to the reaction of the animal after leaving the cattle crush and entering the corral pen as follows: 1 = the animal walks slowly, allowing close proximity to the observer; 2 = trots or runs for a few seconds, allowing a moderate proximity to the observer; 4 = runs during the entire observation time, looking for an escape with constant movement of the tail, and does not allow approximation; and 5 = runs during the entire observation time, jumps against fences, and threatens or attacks the observer. Individuals that receive a score of 5 are eliminated from the breeding program. To avoid the tendency of observers to concentrate their grades on an intermediary level (TS = 3), this score was eliminated from the scale, and the animals were scored as 1, 2, 4, or 5.

Weaning weight (**WW**) was included in the analysis to minimize the influence of selection at weaning on the genetic parameter estimates. Contemporary groups (**CG**) were formed for each trait using the following criteria: i) for WW, farm and year of birth, management groups at birth and at weaning, and animal sex; ii) for temperament traits, farm of birth, management group at weaning and at yearling, date of measurement, and animal sex.

For all traits, CG with fewer than five animals were not considered in the analyses. For FS and WW, the records that were outside a mean range of CG ± 3 SD were excluded from the analysis. A description of the data set is presented in Table 1.

Table 1. Descriptive statistics for WW[1], FS[1], TS[1], CS[1], and MOV[1] data used for the genetic parameters estimate.

Trait	n	CG[1]	Mean	Median	SD	CV, %
WW, kg	108,537	1,685	172.29	-	26.46	15.36
FS, m/s	7,402	350	2.26	-	1.00	44.16
TS	23,420	741	-	2	-	-
CS	7,411	349	-	3	-	-
MOV	7,415	349	-	2	-	-

[1]CG = number of contemporary groups; WW = weaning weight; FS = flight speed; TS = temperament score; CS = crush score; MOV = movement score.

The (co)variance components and breeding values were estimated with Bayesian Inference via Gibbs Sampling using the THRGIBBS1F90 software (Misztal et al., 2002). The analyses were performed by applying a multitrait animal model with three traits, including WW as an anchor trait and two temperament indicators. For WW and FS, a linear animal model was utilized as well as a threshold model for TS, CS, and MOV. The Bayesian threshold model was chosen because it is considered the most adequate method for genetic analyses of categorical traits, which is based on the assumption that the distribution of the categorical variable is related to an underlying continuous scale containing the fixed and random effects (Van Tassell et al., 1998).

For all traits, the model included random additive genetic and residual effects, the fixed effects of CG, age of the dam at calving (in classes ranging from 2 to 14 yr), and age of the animal at the time of measurement as a covariate (linear and quadratic effects for WW and TS, and only linear effects for the other traits). The model is represented as: **y** = X**b** + Z_1**a** + **e**; where: **y** = vector of the observed traits; **b** = vector of the fixed effects; **a** = vector of direct additive genetic effects; **e** = vector of residual effects, and X, Z are incidence matrices relating **b**, and **a**, to **y**. It was assumed that E[**y**] = X**b**; Var(**a**) = A $\otimes$ Sa; and Var(**e**) = I $\otimes$ Se; in which Sa is the additive genetic covariance matrix; Se is the residual covariance matrix; A, is the numerator of genetic-additive relationships matrix; I, is the identity matrix; and $\otimes$ the direct product of matrices. It was also assumed that vectors **a** and **e** have no correlation with each other. For WW, the model included the additive genetic and permanent environmental maternal effects.

In the threshold model, it was assumed that the underlying scale (U) to the categorical variable have a continuous, normal distribution: U | Θ ~ N (W Θ, Iσ_e^2); where: U is the vector of the underlying scale of order r; Θ = (**b**, **a**, **m**, **c**) is the vector of location parameters of order s with b (as fixed effects) and order s with a (as direct additive genetic effects); W is the incidence matrix known of order r by s; I is the identity matrix of order r by r; and σ_e^2 is the residual variance. Because the underlying variable cannot be observed, it is assumed σ_e^2 = 1, which aims at obtaining the identifiability in the likelihood function (Sorensen and Gianola, 2002). The pedigree contained a total of 128,702 animals, 1,042 sires, and 39,285 dams.

The Gibbs sampling analysis was carried out through a single chain of 800,000 iterations without an initial burn-in period. The sampling interval was 100 iterations, generating chains of 8,000 cycles that were used to compute the marginal posterior distributions. The analysis of convergence followed the approaches of Raftery and Lewis (1992), which determine the burn-in period, and of Geweke (1992), which tests the null hypotheses of the stationary chain generated, achieving convergence when $P > 0.05$ using the Bayesian Output Analysis Package (BOA) of the software R 2.9.0 (The R Development Core Team, 2009). The mean, SD, Monte Carlo error, and confidence interval (95% of the posterior density) were calculated for each genetic and phenotypic parameters estimated. For each trait, the means of the additive genetic and residual variances obtained with the multitrait analyses were used to estimate the *posterior* means of heritability.

To assess the correlation between the rankings of all individuals and sires for the different temperament indicator traits, the Spearman's rank correlations of EBV were calculated for all animals of the pedigree (n = 128,702) and for sires that had more than five progenies with temperament records (n = 189 bulls).

3. RESULTS AND DISCUSSION

For all of the analyses performed, convergences were attained according to the Geweke test ($P > 0.05$). The burn-in length required, or initialization period, was always less than 154 samples according to the Raftery and Lewis test. Therefore, 200 samples were discarded as a fixed burn-in period; the remaining 7,800 iterations were retained.

The heritability estimates obtained for all traits indicate that they would respond to selection (Table 2), with a greater probability of response expected for FS than for the others. The heritability estimated for FS was within the range reported in the literature for Zebu cattle and their cross-breeds (0.35, Burrow and Corbet, 2000; 0.35, Paranhos da Costa et al., 2002; 0.31, Kadel et al., 2006). For CS and MOV, which were the visual scores obtained in the crush, the estimates of the present study were lower than those estimated by Burrow and Corbet (2000) for a crush score (0.30), but similar to those described by Kadel et al., (2006) (from 0.15 to 0.19). Both studies were conducted in Australia with tropically adapted breeds (including Brahman and their crosses).

Table 2. Estimates of variance components and heritability for FS[1], TS[1], CS[1], MOV[1], and WW[1].

Trait	σ^2_a[1]	σ^2_c[1]	σ^2_d[1]	σ^2_e[1]	h[1]
FS	0.303	-	-	0.552	0.354
TS	0.024	-	-	0.133	0.152
CS	0.117	-	-	0.502	0.189
MOV	0.249	-	-	1.094	0.185
WW	75.040	30.550	45.272	128.770	0.268

[1]FS = flight speed; TS = temperament score; CS = crush score; MOV = movement score; WW = weaning weight; σ^2_a = additive genetic variance; σ^2_c = maternal genetic variance; σ^2_d = maternal environmental variance; σ^2_e = residual variance; h = heritability.

In a recent study performed in Brazil with Nellore herds, a low heritability estimate was obtained (0.15) for a visual score similar to TS (Barrozo et al., 2012). These types of visual scores are the most common temperament traits used in Nellore breeding programs in Brazil and are used as independent selection criteria; thus, animals receiving the highest score (worst temperament) are discarded. Our results found that although the use of such a trait can promote genetic gain in these populations, a larger response to selection could be obtained by using FS.

The heritability estimates for the scores obtained with the animal restrained in the crush (CS and MOV) were lower than for FS. Similar results were reported by Hoppe et al. (2010) using a flight speed score (walk, trot, run, or jump out) and a chute score (calm, restless shifting, squirming, vigorous movement, or violent struggling) in various European breeds, including German Angus (0.20 for FS score and 0.15 for chute score), Charolais (0.25 and 0.17), Hereford (0.36 and 0.33), and German Simmental (0.28 and 0.18), respectively. It seems that, in general, heritability of FS is greater than that obtained for the scores performed in the crush. Moreover, Burrow and Corbet (2000) reported a greater heritability estimate for FS measured on a continuous scale (0.35) than in scores (0.08).

The genetic correlation estimates of FS with TS, CS, and MOV were high (0.84, 0.84, and 0.76, respectively), suggesting that a large portion of the genes that determine such traits were the same (Table 3). Regarding the association of FS and CS, our findings differed from the results of Burrow and Corbet (2000) and Kadel et al. (2006). These studies found a moderate genetic association between both traits in Brahman cattle and its crosses (-0.45 and -0.35, respectively), concluding that CS and FS addressed different aspects of cattle behavior.

Table 3. Posterior estimates of genetic and phenotypic correlations for FS[1], TS[1], CS[1], and MOV[1].

Trait	Mean ± SD	Median	95% HPD[1]	MC[1]
Genetic correlations				
FS-TS	0.847 ± 0.050	0.851	0.761 to 0.932	0.005
FS-CS	0.844 ± 0.054	0.849	0.752 to 0.939	0.005
FS-MOV	0.759 ± 0.064	0.762	0.645 to 0.878	0.007
TS-CS	0.819 ± 0.075	0.826	0.683 to 0.953	0.009
TS-MOV	0.762 ± 0.089	0.768	0.611 to 0.933	0.010
CS-MOV	0.993 ± 0.015	0.994	0.989 to 0.999	0.001
Phenotypic correlations				
FS-TS	0.178 ± 0.014	0.178	0.151 to 0.205	0.001
FS-CS	0.246 ± 0.023	0.247	0.202 to 0.292	0.001
FS-MOV	0.215 ± 0.024	0.214	0.170 to 0.260	0.001
TS-CS	0.155 ± 0.020	0.156	0.116 to 0.192	0.001
TS-MOV	0.139 ± 0.021	0.139	0.095 to 0.179	0.002
CS-MOV	0.715 ± 0.035	0.715	0.655 to 0.775	0.002

[1]FS = flight speed; TS = temperament score; CS = crush score; MOV = movement score; HPD = highest posterior density interval; MC = Monte Carlo error.

The genetic correlation estimate between CS and MOV scores were close to 1, suggesting that both traits were under the control of the same genes. In the literature, different types of scores have been proposed to assess the reactivity of cattle in the crush, and some of them have only considered the frequency of movements (Benhajali et al., 2010), while others have also included the intensity of the movements, such as MOV, which was measured in the present study (Fordyce at al., 1982; Grandin, 1993; Burrow and Corbet, 2000). In other studies, head, ear, and tail movements were also included as elements of CS (Hearnshaw and Morris, 1984). Based on our results, the use of just one indicator would be sufficient for selection purposes, because they assess the same trait. These results are in agreement with those of Schwartzkopf-Genswein et al. (2012) who found a strong association between three visual scores performed in the crush (during entry into the chute, restraint, and at the time of exit from the chute), as well as Benhajali et al. (2010), who also found high estimates of genetic correlations for different temperament traits measured in the crush.

In contrast to the estimates of genetic correlation, phenotypic correlation estimates of FS with TS, CS, and MOV were low (between 0.18 and 0.24), indicating that these traits are subject to distinct environmental effects; on the other hand, the phenotypic correlation estimate between CS and MOV was high (0.70) (Table 3). These results were expected, because the measurements were carried out under different environmental circumstances (i.e., CS and MOV were evaluated with the animal kept inside the crush, whereas FS was measured when the animal escaped from the crush, and TS was measured with the animal free in a corral pen with an observer present). It is also important to consider that Zebu cattle have different behavioral expressions of fear when kept in the crush, such as exhibiting great agitation and attempts to escape, which would increase MOV and CS scores, but also sometimes react by freezing and showing muscle tremors. This may also contribute to the low phenotypic association of FS with MOV and CS, as some individuals may have high values of FS without demonstrating any movement or agitation in the crush.

Most of the rank correlations between all individuals' EBVs and sires' EBVs for temperament indicator traits were moderate, and the values were high only for CS with MOV (Table 4). Such values suggested that although the genetic correlation between these traits were high, applying different temperament indicator traits as selection criteria could lead to selecting different sires. For CS and MOV, the rank correlation was high, reinforcing the idea that selection by one indicator or another produces a similar response to selection, because the selected sires would be mostly the same.

Table 4. Sperman's rank correlation of EBV for FS[1], TS[1], CS[1], and MOV[1], above the table's diagonal all individuals' EBV and below the diagonal the sires' EBV.

Trait	FS	TS	CS	MOV
FS	-	0.61	0.46	0.33
TS	0.58	-	0.66	0.47
CS	0.50	0.58	-	0.71
MOV	0.39	0.49	0.75	-

[1] FS = flight speed; TS = temperament score; CS = crush score; MOV = movement score.

Based on the results above, it is important to take into account the production systems and specific breeding objectives in order to choose the most adequate temperament indicator trait for genetic evaluation. The use of a non-restrained test, such as FS, as a selection criterion would reduce the general fear and agitation of beef cattle, thereby improving tameness and easiness to drive them from the paddocks to the corral. However, in specific situations where a reduction in animal reactivity during physical restraint is needed (e.g., when using reproductive biotechnologies, such as fixed time artificial insemination or embryo transfer, which requires intense handling with cows and heifers in a crush), it would also be appropriate to combine the FS data with information obtained from restrained methods, CS or MOV.

The genetic correlation estimates between WW with FS, TS, CS, and MOV were low and negative, with values of -0.081 ± 0.069, -0.187 ± 0.070, -0.149 ± 0.087, and -0.008 ± 0.080, respectively. The phenotypic correlation estimates were also low: -0.077 ± 0.015 (WW–FS), -0.066 ± 0.017 (WW–TS), -0.084 ± 0.025 (WW–CS), and -0.063 ± 0.017 (WW–MOV). These results indicate that the selection for higher WW, which is commonly performed on beef cattle farms, would result in a low genetic gain for temperament regardless of the method used. Recent studies using Nellore cattle have reported a favorable genetic correlation, though of low magnitude, for FS with scrotal circumference, ADG (Sant'Anna et al., 2012), and reproductive traits, such as age at first calving and the occurrence of precocious pregnancy (Paranhos da Costa et al., 2012). Therefore, one important element that supports the utilization of FS for assessment of cattle temperament on farms is that its use as a selection criterion would most likely not have a negative effect on animal performance.

In addition to heritability estimates and the association between traits, other elements should be considered to define the most appropriate temperament indicator trait for practical use on farms. Two of these elements are the feasibility and ease of obtaining the measurement. Visual scores are easily obtained; however, they depend upon the availability of trained assessors. In contrast, FS can be obtained electronically in an easier and more objective manner. Another element to be considered is the cost required to obtain the measurement. In the case of visual scores, there is the additional cost of labor; on the other hand, for FS, an electronic device is required. In Brazil and other Latin American countries, it is possible to buy this device for a reasonable price. However, it is still not being produced at a commercial level, making it difficult for breeders to find it on the market. In addition, it is necessary to have a corridor at the exit of the cattle crush to install the device, which is not common in most of the Brazilian corrals currently used for cattle handling. This could be an important limitation in the use of FS as an indicator of cattle temperament in genetic breeding programs, and therefore the use of visual scores continues to prevail in many beef cattle breeding programs.

In conclusion, all of the temperament indicator traits addressed in this study presented enough genetic variability to respond to selection; however, the use of FS would result in a faster genetic gain. With regard to the practical applicability, the use of FS is also favorable, since it produces data on a continuous scale, allows for recording of the data electronically, and requires low investment, which makes it appropriate for application in large populations. Based on these findings, we recommend using FS to standardize the genetic evaluation of cattle temperament among the several existing genetic breeding programs of Nellore cattle. In addition to the selection for lower FS, which reduces the general fear and agitation of cattle, other indicators could be used to achieve the breeding objectives specifics of some farms. For example, CS may be used as an independent selection criterion by allowing for the identification of some individuals that systematically show struggle / violent reactions inside the crush.

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CAPÍTULO 5 - Genetic association between temperament and growth traits in Nellore cattle

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ABSTRACT: The aims of this study were to estimate the genetic association between four temperament indicators and growth traits in Nellore cattle, and to evaluate the possibility of including the former traits as selection criteria in breeding programs. The growth traits evaluated were weaning weight (WW) and post weaning average daily gain (ADG), for male and female animals born from 1990 and 2009. The temperament was evaluated at yearling age (550 days) using four methods: temperament score (TS) that is routinely measured using a scale from 1 to 5 applied to assess the reactions of the animals after exiting the crush, recorded from 23,420 individuals born between 2002 and 2009; movement score (MOV), also assessed using a scale from 1 to 5 recording the movements of the animals inside the crush; crush score (CS), in which scores from 1 to 4 for an animal's general reactivity inside the crush was assigned; and flight speed (FS), which is a recording of the speed (in m/s) at which the animals exit the crush after being weighed. These last three methods were applied to assess the temperament of 9,150 individuals born in 2008 and 2009. Bayesian Inference using Gibbs Sampling was applied to estimate the components of (co)variance. The model included random direct additive genetic and residual effects, and fixed effects of contemporary group (CG), age of the dam (classes), and age of the animal as covariable (linear and quadratic effects for ADG, WW and TS, and linear effects for the other traits). A linear model was applied to ADG, WW and FS, while for TS, CS, and MOV, a threshold model was used. Heritability estimates for the temperament traits ranged from 0.15 (TS) to 0.35 (FS). The genetic correlation estimates of temperament traits with ADG and WW were favorable, with the following estimates: -0.12 and -0.11 (FS), -0.22 and -0.23 (TS), -0.32 and -0.31 (CS), and -0.19 and -0.04 (MOV), respectively. The phenotypic correlation estimates were negative and low (from -0.03 to -0.10). Therefore, in general, the temperament traits had favorable genetic correlation estimates with growth. However, indirect selection for temperament using growth traits would be inefficient, since the values of correlation were low. Therefore, to genetically improve temperament would be necessary to include one of these indicator traits as selection criteria.

Key words: behavior, flight speed, genetic correlation, heritability, welfare

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Implications

Several breeding programs for Zebu cattle have recognized the importance of assessing cattle temperament with selective breeding purpose. But, until now there is no consensus in relation to which temperament measure to be used, neither about the implication of this choice on other traits of economic interest. In this study it was compared four temperament indicators according to genetic and phenotypic association to growth traits, with the aim of indicate the most adequate method for genetic evaluations of beef cattle.

1. INTRODUCTION

Temperament can be defined as individual differences in behavioral responses that are persistent over time and across situations (Bates, 1989). Cattle temperament is usually assessed considering the behavioral responses (such as reactivity) of the animals under human influences during handling procedures (Burrow, 1997). There are several evidences that this trait is related to important aspects of production, e.g. reproductive efficiency (Cooke et al., 2011), growth rate (Voisinet et al., 1997a), meat quality (Voisinet et al., 1997b), labor safety (Grandin, 1999), and animal health and welfare (Cafe et al., 2011a; Hulbert et al., 2011). Due to this, cattle temperament has been the focus of several researches.

Most of the genetic and phenotypic correlations reported between temperament and growth traits were from cattle under feedlot conditions (or raised on pasture and confined after weaning), and for cattle frequent handled and habituated to contact with humans (Nkrumah et al., 2007; Hoppe et al., 2010; Turner et al., 2011). Results from cattle raised under extensive conditions come predominantly from Australia, based on herds kept for research purpose, which, according to Prayaga and Henshall (2005), were more frequently handled than commercial cattle herds (Burrow and Corbet, 2000; Burrow, 2001). To date, there is a lack of information about the relationship between cattle temperament and growth traits in extensive conditions, with cattle raised exclusively on pasture, and only occasionally handled on a corral. This condition is representative of Nellore beef cattle production system in large Brazilian farms which is also present in other areas of the world. As suggested by some authors (Fordyce et al., 1985; Burrow and Corbet, 2000), the frequency of handling and the productive system could affect the association of temperament and growth rate, requiring caution when extrapolating the findings throught systems. So, we agree with Turner et al. (2011), who proposed that the relationship should be evaluated at most diverse conditions.

The trait used as cattle temperament indicator is another important point to consider when estimating genetic correlation with cattle performance. In most of the studies one of the following was used: flight speed (FS) (Burrow, 2001; Prayaga and Henshall, 2005, Nkrumah et al., 2007), crush test (Fordyce et al., 1985), pen score (Barrozo et al., 2012), and docility test (Phocas et al., 2006); or a combination of more than one trait (Fordyce et al., 1996; Burrow and Corbet, 2000; Hoppe et al., 2010), leading to several divergent conclusions.

Therefore, the aims of this study were to estimate the genetic association between four temperament indicator traits and growth traits in Nellore cattle under extensive conditions, and to evaluate the possibility of including such traits as selection criteria in selective breeding programs.

2. MATERIAL AND METHODS

This research was approved by the Committee of Ethical Use of Animals from the Faculty of Agricultural and Veterinarian Sciences, São Paulo State University, Jaboticabal-SP, Brazil (Certified n.007808/11).

The study was conducted in two Nellore commercial herds, from *Agropecuária Jacarezinho Ltda*. In both herds the same procedures for the formation of management groups are adopted, calves are weighed immediately after birth and assigned into groups, and raised with the dams in pastures with access to mineral supplementation. At weaning (around 210 days of age) calves are weighed and visual scores of conformation, finishing precocity, muscling and navel (considers the size and positioning of the navel and sheath) are attributed. A second performance evaluation occurs at yearling age (around 550 days), repeating the measures carried out at weaning, plus scrotal circumference measurements and temperament score (TS).

This study was carried out using two growth traits and four temperament indicators, as follow: 1) weaning weight (WW), included in the data analysis also to minimize the influence of sequential selection and culling on genetic parameter estimates; 2) post weaning average daily gain (ADG) calculated based on weaning weight and yearling weight; 3) the temperament traits, as reported by Sant'Anna et al. (2013), considering: **(a)** temperament score (TS), that assigns scores to the reaction of the animal in a pen of the corral from 1 = the animal walks slowly, allowing close proximity to the observer to 5 = the animal runs during the entire observation time, jumps against fences, and threatens or attacks the observer. To avoid the tendency of the evaluators to concentrate the grades in the intermediary level (TS = 3), it was removed from the scale, scoring the animals as 1, 2, 4, or 5. This method is adopted by the breeding program of the *Agropecuária Jacarezinho Ltda* (Conexão Delta G, 2011) as an independent criterion of selection; **(b)** movement score (MOV), performed at the time of weighing, with the animals inside the crush, applying scores from 1 = no movement to 5 = constant and vigorous movements, animal jumps and raises the limbs off of the ground (adapted from Grandin, 1993); **(c)** crush score (CS), also assessed with the animals inside the crush, applying a score from 1 to 5 where, 1 = animal does not offer resistance, remains with head, ears, and tail relaxed; 4 = offers great resistance, abrupt and vigorous movements of the animal and the head, ear, and tail, sclerotic membrane visible, audible breathing, and may jump or fall, and 5 = animal that offers or not great resistance, always present sclerotic membrane visible and “freezing” reaction; **(d)** flight speed (FS), measuring the speed (m/s) by which each animal leaves the crush after being weighed, and the fast animals were considered as presenting the worse temperament (Burrow et al., 1988). This measurement was taken using an electronic device that records the time (s) taken by each animal to cover a known distance (which ranged from 1.6 to 2.0 m, depending on the facilities), later converted to speed (m/s). The TS information was recorded from 23,420 animals born between 2002 and 2009; and MOV, CS and FS, from 9,150 animals born in 2008 and 2009.

Contemporary groups (CG) were formed for each trait, using the following criteria: for WW – farm and year of birth; management groups at birth and weaning; and calf sex. For post-weaning traits (ADG and temperament traits) – farm, year and management group at yearling were added to CG at weaning. For all traits, CG with fewer than five animals were not considered in the analyses. For FS, WW and ADG the records out of the range given by the mean of the CG ± 3 standard deviations were excluded from the analysis. A description of the data set is presented at Table 1, and the distribution for the temperament visual scores at Figure 1.

Table 1. *Descriptive statistics for the data set used for genetic parameters estimate.*

Trait	*n*	CG	Mean	Median	s.d.	CV (%)
WW (kg)	108,386	1,685	172.29	-	26.47	15.36
ADG(kg/day)	76,432	3,110	0.30	-	0.09	30.00
TS	23,420	741	-	2	-	-
MOV	7,415	349	-	2	-	-
CS	7,411	349	-	3	-	-
FS(m/s)	7,402	350	2.26	-	1.00	44.24

WW = weaning weight; ADG = average daily gain; TS = temperament score; MOV = movement score; CS = crush score; FS = flight speed; CG = contemporary groups; CV = coefficient of variation.

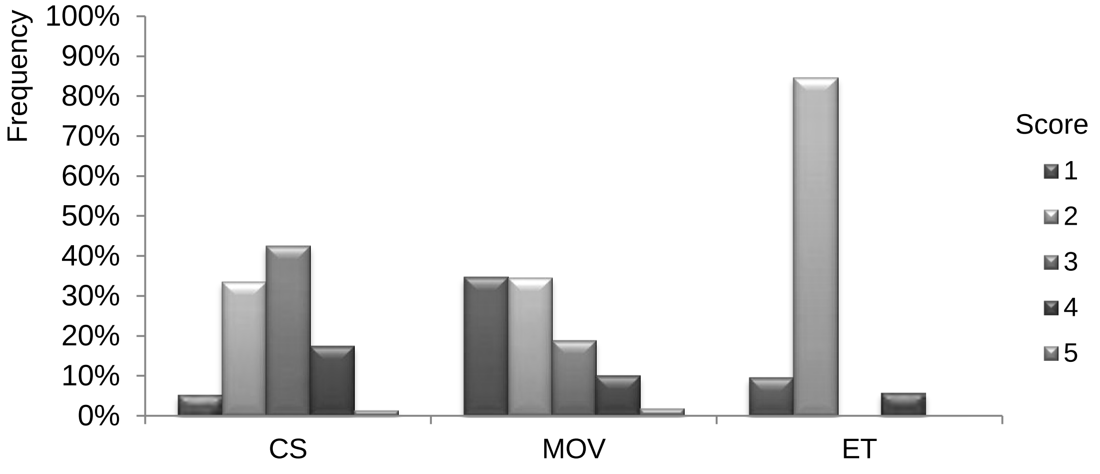

Figure 2. *Distribution of crush score (CS, N=* 7,411*), movement score (MOV, N =* 7,415*) and temperament score (N =* 23,420*) for Nellore beef cattle.*

The (co)variance components were estimated with Bayesian Inference via Gibbs Sampling using the THRGIBBS1F90 software (Misztal et al., 2002). The analyses were performed applying a multitrait animal model with three traits (WW, ADG and one of the temperament traits). For WW, ADG and FS, a linear model was used and a threshold model for TS, MOV and CS. The Bayesian threshold model was chosen because it is considered the most adequate method for genetic analyses of categorical traits, which is based on the assumption that the distribution of the categorical variable is related to an underlying continuous scale containing the fixed and random effects (van Tassell et al., 1998).

The model included additive genetic and residual effects as random, and fixed effects of CG, age of the dam at calving (in classes ranging from 2 to 14 years), and age of the animal at the time of measurement as covariates (linear and quadratic effects for WW, ADG and TS, and only linear effects for the other traits). The model, in matrix notation, can be represented as:

$$y = Xb + Z_1a + Z_2m + Z_3c + e;$$

where: *y* = vector of the observed traits; *b* = vector of the fixed effects; *a* = vector of direct additive genetic effects; *m* = vector of maternal additive genetic effects; *c* = vector of maternal permanent environmental effects, *e* = vector of residual effects, and X, Z_1, Z_2 and Z_3 are incidence matrices relating *b*, *a*, *m*, *c* and *e*, to *y.* In this study, it is assumed that E[*y*] = X*b*; Var(*a*) = A $\otimes$ S*a*; Var(*m*) = A $\otimes$ Sm*;* Var(*c*) = I $\otimes$ Sc*;* and Var(*e*) = I $\otimes$ S*e*, in which S*a* is the additive genetic covariance matrix; Sm, maternal genetic covariance matrix; Sc, maternal permanent environmental covariance matrix; Se, is the residual covariance matrix; A, is the numerator of genetic-additive relationships matrix; I, is the identity matrix; and $\otimes$ the direct product of matrices. It is still assumed that the vectors *a, m, c* and *e* have no correlation with each other. For the post-weaning traits (ADG and temperament traits), the additive genetic and permanent environmental maternal effects were not included in the model.

In the threshold model, it is assumed that the underlying scale (U) of the categorical variable presents a continuous, normal distribution: U | Θ ~ N (W Θ, Iσ_e^2); where: U is the vector of the underlying scale of order r; Θ = (*b*, *a*, *m*, *c*) is the vector of location parameters of order *s* with *b* (as fixed effects) and order *s,* with *a, m* and *c* (as direct additive genetic effects, additive genetic and permanent environmental maternal effects); W is the incident matrix known of order *r* by *s*; I is the identity matrix of order *r* by *r*; and σ_e^2 is the residual variance. Since the underlying variable cannot be observed, it is assumed σ_e^2 = 1, aiming identifiability in the likelihood function (Sorensen and Gianola, 2002).

The Gibbs sampling analysis was carried out through a single chain of 800,000 iterations. The sampling interval was 100 iterations, generating chains of 8,000 cycles that were used to compute the marginal posterior distributions. The analysis of convergence followed the approach of Raftery and Lewis (1992), which determine the burn-in period, and the Geweke test (1992), achieving convergence when P > 0.05, using the Bayesian Output Analysis (BOA) Package of the software R 2.9.0 (The R Development Core Team, 2009). The mean, standard deviation, Monte Carlo error, and the mean confidence interval (95% of the posterior density) were calculated for each genetic and phenotypic parameters estimated. For each trait, the means of the additive and residual genetic variances obtained with the four multitrait analyses were used to estimate the *posteriori* means of heritability.

3. RESULTS

For all of the analyses performed, the convergence was attained according to the Geweke test (P > 0.05). According to the Raftery and Lewis test, 200 samples was discarded as a fixed burn-in period in every analysis and the remaining 7,800 iterations were used.

The heritabilities estimated for temperament traits were low to moderate, ranging from 0.15 (TS) to 0.35 (FS). Likewise, heritability estimates for growth were from 0.19 to 0.25 (Table 2).

Table 2. *Estimates of variance components and heritability for WW, ADG, TS, MOV, CS and FS.*

Trait	σ^2_a	σ^2_e	h^2
WW	61.77	128.64	0.25
ADG	0.001	0.002	0.19
TS	-	-	0.15
MOV	-	-	0.19
CS	-	-	0.19
FS	0.303	0.552	0.35

WW = weaning weight; ADG = average daily gain; TS = temperament score; MOV = movement score; CS = crush score; FS = flight speed; σ^2_a = additive genetic variance; σ^2_e = residual variance; h = heritability.

The genetic correlation estimates between WW and temperament traits were negative and low for TS, MOV, and FS and moderate for CS (Table 3). As well, all the temperament indicators were negatively correlated to ADG, with values ranging from -0.12 to -0.32. The highest genetic correlation estimates were between both growth traits and CS, followed by TS and MOV (Figure 2). In spite of FS being the most heritable temperament trait, it presented the lowest genetic correlation with ADG.

Table 3. *Posterior estimates of genetic and phenotypic correlations between growth (ADG and WW) and temperament traits (TS, MOV, CS and FS).*

Growth	Temperament	Mean (±s.d.)	Median	95% HPD	MC error
		Genetic correlations estimates			
ADG	TS	-0.22 ± 0.07	-0.22	-0.35 to -0.08	0.004
ADG	MOV	-0.19 ± 0.10	-0.20	-0.38 to -0.01	0.008
ADG	CS	-0.32 ± 0.10	-0.32	-0.51 to -0.14	0.010
ADG	FS	-0.12 ± 0.08	-0.12	-0.27 to 0.05	0.005
WW	TS	-0.23 ± 0.07	-0.23	-0.38 to -0.09	0.004
WW	MOV	-0.04 ± 0.11	-0.04	-0.26 to 0.16	0.009
WW	CS	-0.31 ± 0.12	-0.31	-0.51 to -0.07	0.012
WW	FS	-0.11 ± 0.08	-0.11	-0.25 to 0.04	0.004
		Phenotypic correlation estimates			
ADG	TS	-0.06 ± 0.01	-0.06	-0.08 to -0.04	0.001
ADG	MOV	-0.03± 0.02	-0.03	-0.06 to 0.002	0.001
ADG	CS	-0.05± 0.02	-0.05	-0.08 to -0.02	0.001
ADG	FS	-0.06 ± 0.01	-0.06	-0.09 to -0.04	0.001
WW	TS	-0.10 ± 0.01	-0.10	-0.12 to -0.08	0.001
WW	MOV	-0.03± 0.02	-0.03	-0.06 to 0.005	0.001
WW	CS	-0.07 ± 0.02	-0.07	-0.10 to -0.04	0.001
WW	FS	-0.08± 0.02	-0.08	-0.11 to -0.05	0.001

WW = weaning weight; AGD = average daily gain; TS = temperament score; MOV = movement score; CS = crush score; FS = flight speed; HPD = highest posterior density interval; MC = Monte Carlo error.

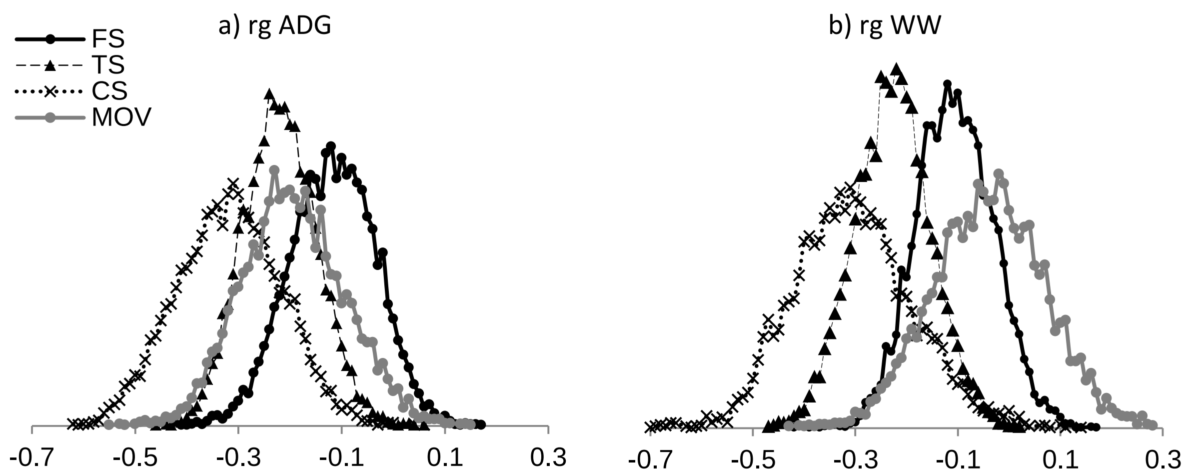

Figure 2. *Posterior distribution of genetic correlation estimates between every temperament trait (FS, TS, CS and MOV) with (a) ADG and (b) WW.*

The phenotypic correlation estimates between ADG and WW with the temperament traits were also negative, but lower than genetic correlations estimates (Table 3). All phenotypic correlations estimates between growth and temperament traits were practically zero.

4. DISCUSSION

The heritability estimated for FS was higher than those obtained for the other temperament traits, indicating that the use of FS as selection criterion would result in faster genetic gain. In general, the estimates obtained were within the variation reported in the literature for Zebu breeds and its crosses, around 0.15 for TS (Barrozo, et al., 2012), 0.30 for FS, and from 0.15 to 0.30 for CS and MOV (Burrow and Corbet, 2000; Prayaga et al., 2009). The heritability estimates for growth traits are also within the range reported in literature for Nellore cattle (Albuquerque and Meyer, 2001).

The genetic correlation estimates of temperament traits with WW and ADG were negative (favorable), indicating that better temperament (lower scores) is genetically associated with higher ADG and WW. Crush score was the temperament indicator with the stronger genetic association with WW and ADG, suggesting that part of the genes regulating these traits also influence CS. Flight speed presented low genetic correlations with both growth traits, suggesting that the genetic controls of these traits are independent.

Long term selection for WW or ADG would produce a correlated response in the temperament traits, mainly in the reactivity of individuals inside the crush (CS). But it is not recommended to select Nellore cattle for calm temperament using only growth traits as selection criteria, since the correlated response would be low. Consequently, in order to promote genetic change for temperament, an indicator trait should be included as selection criterion in Nellore breeding programs.

The genetic correlation estimates between FS with both growth traits corroborate the findings of Prayaga and Henshall (2005), who found -0.12 for FS with ADG and 0.01 for FS with WW, and Burrow (2001), who found -0.02 for both traits. These studies were conducted with Zebu crossbreed cattle kept under pasture systems. Otherwise, our estimates were lower than those reported for European crossbred cattle, composed mainly of Angus and Charolais (-0,25 for FS – ADG, and -0,57 for FS – final body weight) (Nkrumah et al., 2007); and also for European pure breeds (Angus, Charolais, Hereford, Limousin and Simmental), that ranged from -0.04 for Angus to -0.41 for Limousin (Hoppe et al., 2010).

There are few studies reporting genetic correlation estimates between the scores performed inside the crush and growth traits. Fordyce et al. (1996) estimated low to moderate genetic correlation estimates between weight at different ages and a compose score performed in the crush (that included movement, audible respiration, bellowing and kicking). In contrast to most of the studies on temperament and performance traits (including the present), those authors reported that the selection for WW would result in animals with bad temperament inside the crush at the 24^{th} months of age (rg = 0.36). Our findings corroborate with the results of Hoppe et al. (2010) that reported favorable genetic correlations between ADG and CS, in spite of the wide range of values for the different breeds assessed: -0.13 for German Angus, -0.16 for Charolais, -0.27 for Limousin, -0.34 for German Simmental, and -0.58 for Hereford. The authors concluded that selection for better temperament would positively affect performance traits in Limousin, German Simmental and Hereford breeds.

There is a belief in beef cattle productive sector that animals with bad temperament (high level of reactivity and agitation) would show poor performance. Our phenotypic correlation estimates were low (close to zero), indicating that lower WW and ADG would not indicate worse temperament. Burrow (2001), Burrow and Prayaga (2004) and Prayaga and Henshall (2005) also obtained no phenotypic association between FS and growth traits. They proposed that in pasture extensive systems, similar to the present study, the economic value of temperament, probably, is derived from easier handling through the increased efficiency and reduction in production costs. In less extensive or in intensive production systems such as feedlots would be more likely that the economic value of temperament also come from increasing productive and reproductive performance (Burrow, 2001). In such conditions, several other authors have reported higher phenotypic correlations between cattle performance and temperament traits (Voisinet et al., 1997a; Burrow and Dillon, 1997; Nkrumah et al., 2007; Behrends et al., 2009; del Campo et al., 2010; Cafe et al., 2011b).

There were some attempts to explain the association between temperament and productivity through physiological and behavioral mechanisms that are probably complementary. Petherick et al. (2002) proposed that cattle with excitable temperament would spend more energy in a state of high arousal, affecting negatively their growth. It was also found that individuals with excitable temperament would present the mechanisms of response to stress more active (higher activity of hypothalamus – pituitary – adrenal axis), suggesting differences in energetic metabolism, that would compromise their performance (Curley et al., 2008; Burdick et al., 2010; Cafe et al., 2011a). From this point of view, the results of the present study should be explained by the fact that for cattle raised on pasture, handled only on certain occasions, the sporadic stressing situations of humans contact would not be enough to cause long-term effects on their performance.

It was reported that temperamental cattle (faster FS) spends less time eating and had lower feedlot feed intake than their calmer counterparts, suggesting that temperament affects weight and ADG also throughout behavioral mechanisms (Nkrumah et al., 2007; Cafe et al., 2011b). We did not find any research reporting differences in grazing behavior related to cattle temperament in the conditions of the present study, with cattle exclusively raised on pasture. This is a new field for future research that could better explain the low relationship between temperament and growth traits found in our study and in others with cattle under pasture systems.

5. CONCLUSION

Long term selection for increasing Nellore cattle growth traits can change crush score in a desirable direction. However, indirect selection for temperament using growth traits such as weaning weight and post-weaning average daily gain as selection criteria is inefficient. Therefore, to improve temperament trough selection, a temperament indicator trait has to be included in the selection indexes or be used as independent selection criterion.

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CAPÍTULO 6 – Considerações Finais e Implicações

O temperamento é uma característica fenotípica de expressão complexa, trazendo como desafio a identificação de medidas objetivas e que possam ser aplicadas a grandes populações. Atualmente nos sumários das empresas com programas de melhoramento genético da raça Nelore a característica “temperamento” é apresentada como um critério de seleção, com estimação de herdabilidade e de DEPs para seus touros. No entanto há uma divergência entre esses sumários com relação ao tipo de medida utilizada (escore de temperamento, distância de fuga adaptada, medidas de movimentação na balança). Com base nos resultados do presente estudo, concluímos que os diferentes indicadores utilizados na avaliação do temperamento correspondem a distintos aspectos desta característica. Assim, as medidas de reatividade no tronco de contenção, como os escores de movimentação no tronco de contenção (MOV) e crush score (CS) abordam a reação de medo dos animais a uma situação de restrição do espaço físico, que difere da velocidade de fuga (VF), a qual se trata de uma medida mais relacionada à atividade, agitacão e ao medo de modo geral. Desta forma, faz-se necessário uma padronização entre os distintos programas na escolha de qual metodologia utilizar, ou uma maior especificidade ao nomear o critério utilizado.

Embora todos os indicadores de temperamento tenham apresentado variabilidade genética suficiente para responder à seleção, a resposta seria maior com uso de VF, já que sua estimativa de herdabilidade foi mais alta em relaçao aos demais testes. Como a correlação genética entre VF e os demais indicadores avaliados também é alta, espera-se que a seleção para esta característica produza resposta correlacionada nas demais medidas estudadas.

Além da variabilidade genética suficiente para responder à seleção, aspectos referentes à aplicabilidade prática também são favoráveis ao uso de VF, já que trata-se de um indicador com baixo custo de obtenção, que possibilita o registro dos dados eletronicamente, facilitando sua aplicação a grandes populações. Os dados obtidos apresentam-se em escala contínua aumentando a amplitude das respostas encontradas. No entanto, para que seu uso nas fazendas seja bem sucedido será necessário melhorar o acesso dos produtores ao equipamento eletrônico que registra o tempo de saída dos bovinos, já que este produto ainda não é produzido em escala comercial no Brasil.

Consideramos a possibilidade de padronização de um indicador de temperamento entre os diferentes programas de melhoramento genético da raça Nelore, com a finalidade de garantir que a resposta à seleção seja a mesma dentro da raça, permitindo a comparação da superioridade genética dos reprodutores. Para isso, o temperamento poderia ser avaliado por meio da VF, tendo em conta sua aplicabilidade e variabilidade genética. Embora tal padronização seja positiva entre os diferentes programas de melhoramento da raça, objetivos de seleção particulares de cada fazenda podem ser levados em consideração na escolha de outro método como critério independente de seleção. Por exemplo, em fazendas onde se pretende reduzir a reatividade dos animais durante a contenção física, como nos rebanhos com intenso uso de biotécnicas reprodutivas (inseminação artificial em tempo fixo ou a transferência de embriões), que exigem manejo intensivo das fêmeas no curral, pode ser vantajosa a seleção de fêmeas por meio da medida de CS, com descarte daqueles animais que atingem um nível considerado inaceitável de reatividade dentro do tronco.

Além da implicação no bem-estar animal e na facilidade de manejo, o setor produtivo tem voltado sua atenção para a característica temperamento, em virtude das possíveis correlações com o desempenho produtivo. Segundo os resultados do presente estudo, todos os indicadores de temperamento avaliados apresentaram associação genética favorável com o ganho médio diário pós-desmama (GMD), indicando que a seleção para o temperamento não afetaria negativamente o desempenho dos animais, podendo inclusive promover ganho genético em GMD. No entanto, como os valores de correlação genética foram baixos, concluímos que o peso à desmama e o ganho de peso não são bons preditores do temperamento e, que resposta correlacionada obtida por meio da seleção para crescimento será baixa, apenas em longo prazo. Desta forma, para a obtenção de ganho genético rápido no temperamento dos animais, é recomendada sua inclusão como objetivo de seleção nos programas de melhoramento genético da raça Nelore.

Consideramos que alguns dos entraves para que o ganho genético para temperamento seja mais rápido não se devem à sua baixa variabilidade genética, mas sim à forma de coleta dos dados fenotípicos e ao tipo de seleção aplicado. Primeiramente, a avaliação fenotípica do temperamento dos bovinos deve ser realizada de forma mais criteriosa. O segundo ponto é que um maior ganho genético poderia ser obtido com a inclusão desta característica nos índices de seleção. Sabemos que, para tal inclusão são necessárias mais informações sobre o valor econômico para temperamento, comparado com outras características de interesse.

Em linhas gerais os resultados do presente estudo demonstraram algumas direções para que se maximize o ganho genético para o temperamento da raça Nelore no Brasil. Com relação às direções futuras para a pesquisa científica sobre a genética do temperamento em bovinos de corte, consideramos relevante o estudo da associação dos indicadores de temperamento com outras características comportamentais desejáveis. São escassos os resultados de pesquisas revelando o efeito da seleção para menor reatividade na habilidade materna das fêmeas bovinas. Até o momento não encontramos nenhuma pesquisa que avalie a correlação genética entre os indicadores de temperamento avaliados no presente estudo e a defesa da cria para as raças zebuínas. Outra característica comportamental de interesse, que pode estar negativamente correlacionada com as características apresentadas no presente estudo, é a facilidade de condução dos animais no curral. Resta entender se a seleção para animais de temperamento menos reativo poderá, em longo prazo, aumentar a frequência de animais “mansos” nos rebanhos, que são difíceis de serem conduzidos, causando implicações negativas para a eficiência do manejo e para o bem-estar animal.

Assim, no âmbito da genética quantitativa, seria importante a estimação de parâmetros genéticos para tais características comportamentais, avaliando a associação genética entre elas e os indicadores de temperamento apresentados nesta tese. Uma dificuldade para que tais objetivos sejam alcançados é o fato de que os indicadores de comportamento são de difícil aplicação a grandes populações, limitando a obtenção de dados fenotípicos suficientes para avaliação genética. Com o sequenciamento do genoma bovino e os recentes avanços na àrea de seleção genômica, poderão surgir novas perspectivas para o entendimento das bases genéticas do comportamento, bem como oportunidades para aplicação da seleção genômica para tais características, que são de difícil avaliação fenotípica.