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FACULDADE DE CIÊNCIAS AGRÁRIAS E VETERINÁRIAS
CAMPUS DE JABOTICABAL

INTERAÇÃO HUMANO-ANIMAL: IMPLICAÇÕES NO COMPORTAMENTO E DESEMPENHO DE BOVINOS DE CORTE

Joseph Kaled Grajales Cedeño
Engenheiro Agrônomo Zootecnista

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INTERAÇÃO HUMANO-ANIMAL: IMPLICAÇÕES NO COMPORTAMENTO E DESEMPENHO DE BOVINOS DE CORTE

Discente: Joseph Kaled Grajales Cedeño

Orientador: Prof. Dr. Mateus José Rodrigues Paranhos da Costa

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

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Impacto potencial desta pesquisa

Esta tese está alinhada com os Objetivos de Desenvolvimento Sustentável (ODS), principalmente o ODS 2 (Fome Zero e Agricultura Sustentável) e o ODS 12 (Consumo e Produção Responsáveis). A pesquisa destaca que as interações positivas entre humanos e bovinos promovem melhorias no bem-estar animal, eficiência produtiva e na sustentabilidade dos sistemas de produção de carne bovina.

Potential Impact of this Research

This thesis aligns with the Sustainable Development Goals (SDGs), mainly SDG 2 (Zero Hunger and Sustainable Agriculture) and SDG 12 (Responsible Consumption and Production). This research highlights that positive interactions between humans and cattle promote improvements in animal welfare, productive efficiency, and sustainability of beef production systems.

Impacto potencial de esta investigación

Esta tesis está alineada con los Objetivos de Desarrollo Sostenible (ODS), principalmente el ODS 2 (Hambre Cero y Agricultura Sostenible) y el ODS 12 (Consumo y Producción Responsables). La investigación destaca que las interacciones positivas entre humanos y bovinos promueven mejoras en el bienestar animal, eficiencia productiva y la sostenibilidad de los sistemas de producción de carne bovina.

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AUTOR: JOSEPH KALED GRAJALES CEDEÑO
ORIENTADOR: MATEUS JOSÉ RODRIGUES PARANHOS DA COSTA

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Departamento de Zootecnia / FCAV UNESP Jaboticabal

Prof. Dr. REYNALDO VARGAS (Participaçao Virtual)
Departamento de Zootecnia / Universidad de Panamá - Facultad de Ciencias Agropecuarias (UP) - Cidade do Panamá/Panamá

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Dra. JANAÍNA DA SILVA BRAGA (Participaçao Virtual)
BE.Animal Pesquisa e Desenvolvimento Tecnológico Ltda / Piracicaba/SP

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DADOS CURRICULARES DO AUTOR

JOSEPH KALED GRAJALES CEDEÑO – Nascido em 08 de abril de 1991 na cidade de David, Chiriquí, Panamá. Em 2013, obteve um diploma em reprodução bovina pela Universidad Tecnológica Oteima. Em 2014, formou-se como Engenheiro Agrônomo Zootecnista na Universidad de Panamá, na Faculdad de Ciencias Agropecuarias, Campus de Chiriquí. De 2014 a 2015, trabalhou como técnico de transferência de tecnologia em fazendas de gado de leite e corte na Cooperativa de Serviços Múltiplos de Produtores de Leite de Panamá, R.L. (COOLECHE R.L.). Em 2016, atuou como técnico na empresa Serviços Integrados de Buiatria e Reprodução Animal (SIBRA BIOTEC), sendo responsável pela assessoria na cria de bezerras leiteiras e manejo reprodutivo de vacas em fazendas comerciais do Panamá, além de implementar o programa nacional de Rastreabilidade Bovina do Panamá. Em março de 2018, concluiu o mestrado em Ciência Animal na Faculdad de Medicina Veterinaria de la Universidad Austral de Chile, sob a orientação da Profa. Dra. Ana Strapinni. Possui Pós-graduação em Ensino Superior (2020) pela Universidade Tecnológica OTEIMA. Em 2021, tornou-se membro do Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal (Grupo ETCO) ao iniciar o Doutorado no Programa de Pós-graduação em Ciência Animal na Universidade Estadual Paulista "Júlio de Mesquita Filho" – Campus de Jaboticabal, sob a orientação do Prof. Dr. Mateus José Rodrigues Paranhos da Costa. Em outubro de 2023, se tornou Jurado Auxiliar das Raças Zebuínas pelo colégio de Jurado da Associação Brasileira dos Criadores de Zebu – ABCZ. Atualmente é professor e pesquisador no Departamento de Zootecnia de la Facultad de Ciencias Agropecuarias – Universidad de Panamá. Sua atuação profissional concentra-se principalmente nas áreas Bovinocultura de corte e leite, reprodução, etologia aplicada e bem-estar dos animais domésticos.

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SUMÁRIO

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Investigador
JOSEPH KALED GRAJALES CEDEÑO
Facultad de Ciencias Agropecuarias
Universidad de Panamá
E. S. M.

Respetado Investigador:

El Comité de Ética de la Investigación y el Bienestar de los Animales de la Universidad de Panamá CEIBAUP, en su reunión ordinaria celebrada el 17 de agosto de 2021, otorga aval al protocolo de investigación titulado **"EFECTO DE LA ESTIMULACIÓN TÁCTIL EN LA REACTIVIDAD Y DESEMPEÑO PRODUCTIVO DEL TERNERO BRAHMAN"** investigador principal Ing. Joseph Grajales y co-investigadores Dr. Reynaldo Vargas, Ing. Reggie Guerra, Dr. Alex ríos, Ing. Arianis Santos e Ing. Héctor Cedeño.

Atentamente,

Dra. Alicia I. Torres M.
Presidente CEIBAUP

cc. Dr. Jaime Gutiérrez. Vicerrector de Investigación y Postgrado
Dr. Janzel VIllalaz. Director de Investigación
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Investigador
JOSEPH KALED GRAJALES CEDEÑO
Facultad de Ciencias Agropecuarias
Universidad de Panamá
E. S. M.

Respetado Investigador:

El Comité de Ética de la Investigación y el Bienestar de los Animales de la Universidad de Panamá CEIBAUP, en su Reunión Extraordinaria celebrada el 14 de septiembre de 2021, otorga Aval al protocolo de investigación titulado **"EFECTO DE LA HABITUACIÓN A LA INTERACCIÓN HUMANA EN LA REACTIVIDAD, BIENESTAR ANIMAL Y DESEMPEÑO DE TERNEROS CRUZADOS"** investigador principal Ing. Joseph Grajales y co-investigadores Dr. Reynaldo Vargas, Dr. Reggie Guerra, Ing. Arianis Santos e Ing. Héctor Cedeño.

Se le agradece que finalizada la investigación haga entrega de una copia del informe final de esta investigación al CEIBAUP.

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Presidente CEIBAUP

cc. Dr. Jaime Gutiérrez. Vicerrector de Investigación y Postgrado
Dr. Janzel Villalaz. Director de Investigación
Dra. Norma Díaz de Andrade. Directora de Postgrado

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Investigador
JOSEPH KALED GRAJALES CEDEÑO
Facultad de Ciencias Agropecuarias
Universidad de Panamá
E. S. M.

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Se le agradece que finalizada la investigación haga entrega de una copia del informe final de esta investigación al CEIBAUP.

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Dra. Norma Díaz de Andrade. Directora de Postgrado

Resumo

Esta tese tem como objetivo avaliar as implicações das interações humano-animal no comportamento e no desempenho de bovinos de corte. O primeiro capítulo demonstrou que interações táteis positivas ao longo da vida dos bovinos, mesmo que breves, melhoram suas interações com os humanos e possuem o potencial de promover o bem-estar dos animais de produção. O segundo capítulo investigou os efeitos da estimulação tátil (TS) na reatividade e no desempenho de bezerros da raça Brahman. Especificamente, bezerras que receberam TS apresentaram escores de reatividade significativamente menores tanto no tronco de contenção ($p<0,05$) quanto ao sair do tronco ($p<0,05$) em comparação com o grupo controle. No entanto, não houve diferença significativa no ganho médio diário e no peso ao desmame entre os tratamentos ($p>0,05$). O terceiro capítulo teve como objetivo avaliar o efeito da habituação ao manejo no curral (HAB) sobre a reatividade, bem-estar e desempenho de bezerros mestiços. Bezerros que passaram pelo processo de habituação apresentaram escores de reatividade significativamente menores aos dias 17 e 150 após o procedimento, em todas as avaliações de reatividade, em comparação com o grupo controle ($p<0,05$). As variáveis fisiológicas não foram significativamente afetadas pelos tratamentos ($p>0,05$). No entanto, os bezerros HAB apresentaram maior ganho médio diário (105 g/d; $p=0,0007$) e peso ao desmame ajustado aos 205 dias (16 kg; $p=0,004$) comparados aos bezerros do grupo controle. O quarto capítulo avaliou a qualidade das interações humano-animal durante leilões de gado no Panamá e examinou a relação entre a reatividade do gado, o valor de venda e o tempo gasto na comercialização. Observou-se que a reatividade do gado, o grupo genético, o local do leilão e a fase da comercialização influenciaram a ocorrência e a frequência de golpes ($p<0,05$). Interações negativas aumentaram a reatividade do gado ($p<0,001$); 95% dos animais estavam calmos ao entrar na caixa de leilão, mas esse número caiu para 85% após serem atingidos. O valor mediano pago por gado altamente reativo tendeu a ser maior do que por gado calmo (1,85 vs. 1,82 USD/kg; $p=0,06$). Não foram observadas diferenças significativas no tempo gasto na comercialização em relação à reatividade dos bovinos ($p>0,05$). Esses resultados sugerem que interações humano-animal positivas podem influenciar o bem-estar e o

desempenho dos bovinos. Dessa forma, práticas de manejo que promovam interações positivas e reduzam o estresse animal devem ser incentivadas em sistemas de produção e comercialização.

Palavras-chave: Comportamento, bem-estar animal, bovinos de corte, temperamento

Abstract

This thesis aims to evaluate the implications of human-animal interactions on the behavior and performance of beef cattle. The first chapter demonstrated that positive tactile interactions throughout the life of cattle, even if brief, improve their interactions with humans and have the potential to promote the welfare of production animals. The second chapter investigates the effects of tactile stimulation (TS) on the reactivity and performance of Brahman calves. TS heifer calves showed lower reactivity scores in the squeeze chute ($p<0.05$) and when leaving the squeeze chute ($p<0.05$) than control calves. However, there was no significant difference in the average daily weight gain and weaning weight between the treatments ($p>0.05$). The third chapter aimed to evaluate the effect of habituation to handling in the corral (HAB) on the reactivity, welfare and performance of crossbred calves. Calves that underwent the habituation process had significantly lower reactivity scores on days 17 and 150 after the procedure in all reactivity assessments compared to the control group ($p<0.05$). Physiological variables were not significantly affected by the treatment ($P>0.05$). However, calves HAB had higher average daily gain (105 g/d; $p=0.0007$) and adjusted weaning weight at 205 days (16 kg; $p=0.004$) than calves in the control group. The fourth chapter evaluated the quality of human-animal interactions during cattle auctions in Panama and examined the relationship between cattle reactivity, sale value, and time spent marketing. Cattle reactivity, genetic group, auction location, and marketing phase influenced the occurrence and frequency of strikes ($p<0.05$). Negative interactions increased cattle reactivity ($p<0.001$); 95% of the animals were calm upon entering the auction box, but this number dropped to 85% after being hit. The median price paid for highly reactive cattle tended to be higher than for calm cattle (1.85 vs. 1.82 USD/kg; $p=0.06$). No significant differences were observed in the time spent at auction in relation to cattle reactivity ($P >0.05$). These results suggest that positive human-animal interactions can influence cattle welfare and performance. Therefore, management practices that promote positive interactions and reduce animal stress should be encouraged in the production and marketing systems.

Keywords: Behavior, animal welfare, beef cattle, temperament

Resumen

El objetivo general de esta tesis es evaluar las implicaciones de las interacciones humano-animal en el comportamiento y el rendimiento de los bovinos de carne. El primer capítulo demostró que los contactos táctiles positivos a lo largo de la vida de los animales, incluso si son breves, mejoran sus interacciones con los humanos y tienen el potencial de promover el bienestar de los animales de producción. El segundo capítulo tuvo como objetivo evaluar los efectos de la estimulación táctil (TS) en la reactividad y el rendimiento de terneros de la raza Brahman. Específicamente las terneras que recibieron TS exhibieron menores puntuaciones de reactividad tanto en el tronco de contención ($p<0,05$) como al salir del tronco ($p<0,05$) en comparación con las terneras del grupo de control. Sin embargo, la ganancia media diaria y el peso al destete no cambiaron entre los tratamientos ($p>0,05$). El tercer capítulo tuvo como objetivo determinar el papel del proceso de habituación al manejo en el corral (HAB) sobre la reactividad, el bienestar y el rendimiento de los terneros mestizos. Los terneros que recibieron HAB presentaron menores puntuaciones de reactividad en los días 17 y 150 después del procedimiento de habituación en todas las evaluaciones de reactividad en comparación con los terneros del grupo de control ($p<0,05$). Ninguna de las variables fisiológicas fue significativamente afectada por los tratamientos ($p>0,05$). Sin embargo, los terneros HAB mostraron una mayor ganancia media diaria (105 g/d; $p=0,0007$) y un peso al destete ajustado a los 205 días (16 kg; $p=0,004$) en comparación con los terneros del grupo de control. El cuarto capítulo tuvo como objetivo evaluar la calidad de las interacciones humano-animal durante las subastas de ganado en Panamá e investigar la relación entre la reactividad del ganado, el valor pagado y el tiempo invertido en la comercialización. Se observó que la reactividad del ganado, el grupo genético, el lugar de la subasta y la fase de la comercialización influyeron en la ocurrencia y frecuencia de golpes ($p<0,05$). Las interacciones negativas aumentaron la reactividad del ganado ($p<0,001$); el 95% de los animales estaban tranquilos al entrar en la caja de subastas, pero ese número cayó para 85% después de ser golpeados. El valor mediano pagado para el ganado muy reactivo tendío a ser mayor que para el ganado tranquilo (1,85 vs. 1,82 USD/kg; respectivamente; $p=0,06$). No hubo diferencias significativas en el tiempo

invertido en la comercialización en relación con la reactividad de los bovinos ($p>0,05$). Estos resultados demuestran que las interacciones humano-animal positivas pueden influir en el bienestar y el rendimiento de los bovinos, destacando la importancia de prácticas de manejo que promuevan interacciones positivas y reduzcan el estrés animal en sistemas de producción y durante la comercialización.

Palabras clave: Comportamiento, bienestar animal, bovinos de carne, temperamento

Introdução

O Panamá possui um rebanho de aproximadamente 1.509.900 milhões de cabeças de gado, predominantemente manejadas em sistemas de produção extensiva. Nesse contexto, a produção de gado de corte destaca-se como a principal atividade pecuária do país, com a fase de cria representando cerca de 70% do rebanho total (INEC, 2021). As raças zebuínas (*Bos taurus indicus*) e seus cruzamentos predominam devido às suas características adaptativas e benefícios produtivos. O bezerro, nesse ciclo produtivo, é a principal fonte de renda e a categoria mais valorizada.

Devido às características desses sistemas de produção extensiva, os animais têm poucas interações com humanos; quando ocorrem, essas interações são geralmente negativas, envolvendo práticas aversivas de manejo, como marcação a fogo, castração, desmame abrupto, além de desafios ambientais durante o transporte, comercialização e o pré-abate. Essas práticas não apenas comprometem o bem-estar dos animais, mas também podem resultar em acidentes, doenças e morte de animais (Paranhos da Costa et al., 2014).

Atualmente, há um consenso na ciência do bem-estar animal de que os animais devem viver em condições que lhes proporcionem uma qualidade de vida digna, livre de experiências aversivas (Boissy et al., 2007; Mellor, 2016). O modelo dos cinco domínios de bem-estar (1. Nutrição, 2. Ambiente físico, 3. Saúde, 4. Interações comportamentais e 5. Estado mental) foi recentemente revisado para incluir a qualidade das interações entre humanos e animais no domínio das interações comportamentais (Mellor et al., 2020). A literatura destaca que a qualidade das relações humano-animal é um dos principais fatores que influenciam o bem-estar dos animais (Boivin, 2018; Hemsworth et al., 2018; Waiblinger et al., 2006; Waiblinger, 2019). Relações negativas aumentam o medo dos animais em relação aos humanos (Hemsworth e Coleman, 2010), resultando em comportamentos indesejáveis (Ceballos et al., 2018). Além disso, aumentam o risco de lesões tanto para os animais quanto para as pessoas responsáveis pelo manejo (Boivin et al., 1994; Lindahl et al.,

2016), podendo comprometer o desempenho produtivo (Hemsworth & Coleman, 2011; Coleman & Hemsworth, 2014).

Compreender a dinâmica das relações humano-animal é crucial para promover o bem-estar geral, podendo também aumentar a motivação dos trabalhadores e, consequentemente, melhorar o desempenho de suas atividades (Destrez et al., 2018a; Costa, et al., 2021; Paranhos da Costa & Ceballos, 2021). No entanto, ainda existem muitas barreiras técnicas e culturais a serem superadas para a adoção de boas práticas de manejo nas propriedades. Diante disso, propomos estratégias de manejo, como a estimulação tátil e a habituação ao manejo no curral, para promover interações positivas entre humanos e animais, aproveitando períodos sensíveis nas primeiras fases de vida dos animais (Bateson, 1979; Boivin et al., 1992).

Embora a adoção dessas técnicas de manejo tenha apresentado resultados favoráveis na melhoria das relações humano-animal em outras espécies e em bovinos leiteiros (Krohn et al., 2001; Lensink et al., 2000c, d; Westerath et al., 2014), estudos em bovinos de corte, particularmente em zebuínos, ainda são escassos. Em um estudo realizado com bezerros cruzados Limousin, a estimulação tátil inicial mostrou efeitos persistentes de longo prazo na redução do medo em relação aos humanos e na melhoria da qualidade da carne (Probst et al., 2012). Outros estudos indicam que a exposição frequente ao manejo melhora o temperamento e as respostas associadas ao estresse dos bezerros (Boivin et al., 1998b; Jago et al., 1999; Curley et al., 2006), além de facilitar o manejo (Becker e Lobato, 1997; Lensink et al., 2000c). Estudos mais recentes mostraram que a habituação à interação humano-animal teve efeitos positivos no comportamento e nas variáveis fisiológicas de novilhas de corte (*Bos taurus taurus*) com 12 meses de idade (Ujita et al., 2021). Até onde sabemos, ainda não há estudos sobre o impacto dessas práticas em bezerros cruzados jovens (3 meses de idade). Portanto, acreditamos que técnicas de manejo, como estimulação tátil e habituação ao manejo no curral por curtos períodos, podem ser estratégias eficazes para melhorar a interação humano-animal, reduzir a reatividade de bezerros zebuínos e seus cruzamentos a manejos futuros e promover melhor bem-estar e desempenho produtivo, contribuindo para a sustentabilidade da pecuária de corte.

No contexto do manejo durante leilões, é comum que os animais sejam mantidos em movimento contínuo, o que frequentemente envolve interações táteis negativas, como golpes, choques elétricos e outros manejos agressivos por parte dos manipuladores. A comercialização é uma das etapas mais críticas do ciclo de produção de carne e um dos fatores mais estressantes para os animais (Bravo, 2019, 2020; Gregory, 2008). Até o momento, poucos estudos têm investigado as implicações das interações negativas entre humanos e animais durante a comercialização do gado. Os estudos existentes foram realizados em leilões no Chile (Bravo et al., 2019; Sánchez-Hidalgo et al., 2020), Colômbia (Hernan et al., 2017), Reino Unido (Gregory, 2008; Gregory et al., 2009), Bangladesh (Alam et al., 2010) e Brasil (Carvalho et al., 2019, 2020). No entanto, no Panamá, não há estudos a respeito. Com base nessas informações, torna-se necessário estudar o efeito da interação humano-animal durante a comercialização do gado nos diferentes leilões do país, com o objetivo de adotar estratégias que melhorem o bem-estar geral.

O objetivo geral desta tese é avaliar as implicações das interações humano-animal no comportamento e desempenho de bovinos de corte. Os objetivos específicos são: 1) Descrever as implicações da adoção de interações táteis positivas como estratégia de manejo de animais de produção no bem-estar animal, com ênfase nos potenciais impactos na saúde, comportamento, fisiologia e desempenho dos animais; 2) Avaliar os efeitos da estimulação tátil na reatividade e desempenho de bezerros Brahman; 3) Determinar o efeito da habituação ao manejo no curral sobre a reatividade, indicadores fisiológicos de bem-estar e desempenho de bezerros mestiços de corte; 4) Avaliar a qualidade das interações humano-animal durante os leilões de gado no Panamá e a relação entre a reatividade do gado, o valor pago e o tempo gasto na comercialização.

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CAPITULO I – Artigo publicado na Revista Investigaciones Agropecuarias

Contato humano positivo por estimulação tátil tem potencial para promover o bem-estar dos animais de produção[1]

Positive tactile stimulation has the potential to promote farm animal welfare

Joseph K. Grajales-Cedeño [a b d], Mayara Andrioli [a d], Mateus J.R. Paranhos da Costa [c d e]

[a] UNESP, Faculdade de Ciências Agrárias e Veterinárias, Programa de Pós-Graduação em Ciência Animal, Jaboticabal, SP, Brasil

[b] Departamento de Zootecnia, Faculdade de Ciencias Agropecuarias, Universidad de Panamá, Panamá

[c] UNESP, Faculdade de Ciências Agrárias e Veterinárias, Departamento de Zootecnia, 14884-900, Jaboticabal, SP, Brasil

[d] Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal (ETCO), Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brasil

[e] Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brasília, DF, 71.605-001, Brasil

Resumo

A estimulação tátil é definida como o contato manual ou mecânico entre dois ou mais indivíduos, sejam da mesma espécie ou de espécies diferentes, sendo classificada como positiva, neutra ou negativa, dependendo de sua natureza. As interações positivas entre humanos e animais têm recebido maior atenção devido ao seu potencial para melhorar o bem-estar animal. Evidências científicas indicam que a estimulação tátil positiva pode trazer benefícios a curto e longo prazo para os animais de produção, especialmente quando realizada em idade precoce, tornando-os mais capazes de enfrentar os desafios ambientais, o que pode melhorar a sua saúde e desempenho. Além dos benefícios para os animais,

a adoção da estimulação tátil, entre outras boas práticas de manejo, tem potencial para reduzir as perdas de produção e o risco de acidentes entre os trabalhadores, além de tornar o trabalho mais eficiente. Vale ressaltar que esta prática também oferece a oportunidade de melhorar a imagem das cadeias produtivas da pecuária e representa uma valiosa contribuição para a promoção da sustentabilidade do setor pecuário. Portanto, todos os envolvidos na produção animal são responsáveis por melhorar as interações homem-animal através da implementação de boas práticas de manejo.

Palavras-chave: Aprendizagem, comportamento, interação humano-animal, boas práticas de manejo

Abstract

Tactile stimulation is defined as manual or mechanical contact between two or more individuals, whether of the same or different species, being classified as positive, neutral or negative, depending on their nature. Positive interactions between humans and animals have received greater attention due to their potential to improve animal welfare. Scientific evidence indicates that positive tactile stimulation can bring short and long-term benefits for farm animals, particularly when carried out at an early age, making them more capable of facing environmental challenges, which can improve their health and performance. In addition to the benefits for animals, the adoption of tactile stimulation, among other good management practices, has the potential to reduce production losses and the risk of accidents among workers, besides making work more efficient. It is worth highlighting that this practice also offers the opportunity to improve the image of livestock production chains and represents a valuable contribution to promoting the sustainability of the livestock sector. Therefore, everybody involved in animal production is responsible for improving human-animal interactions by implementing good handling practices.

Keywords: Behavior, learning, human-animal interaction, good handling practices.

1. Introdução

Os consumidores estão cada vez mais exigentes em relação ao uso eficiente dos recursos globais e à prevenção de efeitos adversos no bem-estar humano e animal, assim como na manutenção do equilíbrio ambiental (Broom, 2017). Nesse contexto, é essencial entender o bem-estar animal como um elemento fundamental para o desenvolvimento de estratégias sustentáveis para a produção animal (Broom, 2023). Há um movimento crescente junto à comunidade científica que defende que os animais de produção devem ter uma vida que valha a pena ser vivida (Mellor, 2016), o que reforça a necessidade de integrar considerações éticas e práticas sustentáveis no desenvolvimento estratégias para a criação e o manejo dos animais de produção, alinhando-se com as expectativas dos consumidores.

Um passo importante nesse sentido é definir estratégias para melhorar as relações humano-animal, tornando-as mais positivas, o que tem potencial para melhorar o bem-estar de ambos, humanos e animais, e o desempenho dos animais (Paranhos da Costa & Ceballos, 2021). Além disso, essa nova dinâmica de relações, mais favorável, contribui para a melhorar a imagem das cadeias produtivas da pecuária junto aos consumidores.

No contexto dos sistemas de produção animal, as interações táteis entre humanos e animais ocorrem com maior frequência em sistemas intensivos de produção (Hemsworth & Coleman, 2011) e isto nem sempre se dá de maneira positiva (Breuer et al., 2000). A literatura demonstra que quando essas interações são estabelecidas de maneira positiva, podem induzir emoções positivas e alterações hormonais benéficas (Rault et al., 2020) que são indicativos de boas condições de bem-estar animal (Hemsworth et al., 2018; Waiblinger, 2019), além de ter potencial para melhorar a eficiência reprodutiva e produtiva nas fazendas (Hemsworth & Coleman, 2011; Acharya et al., 2022).

Há evidências de que interações táteis positivas são mais efetivas quando aplicadas nas fases iniciais das vidas dos animais, quando se dá a socialização primária, caracterizada pelo estabelecimento de laços sociais duradouros (Petak, 2018) em função dos animais estarem em um período de maior sensibilidade para a formação de vínculos sociais (Bateson, 1979; Boissy &

Bouissou, 1988). Esta janela de tempo pode ser estrategicamente utilizada no manejo para promover interações positivas, criar memórias favoráveis, reduzir a reatividade dos animais e, consequentemente, facilitar o manejo futuro (Paranhos da Costa, 2022).

No caso específico das fazendas de criação de bovinos de corte essas interações são frequentemente negativas desde o nascimento, começando quando o bezerro é laçado e arrastado, para logo ser contido pelo vaqueiro para realizar procedimentos como a cura de umbigo e tatuagem (Paranhos da Costa et al., 2014). Posteriormente, recebem outros procedimentos aversivos como a marcação a fogo, castração, entre outras práticas aversivas ao longo da vida, como por exemplo, bater porteiras contra o corpo do animal, torcer a cauda, conduzir animais batendo com varas ou com uso de aguilhões elétricos durante o manejo nos currais, transporte, leilões e até no frigorifico. Portanto, tudo isso atenta contra não só as premissas das boas práticas de bem-estar animal durante a realização dos manejos e, consequentemente, resulta em efeito negativo para a imagem da cadeia produtiva da bovinocultura de corte.

O objetivo desta revisão é descrever as implicações da adoção de interações táteis positivas como estratégia de manejo de animais de produção no bem-estar animal, com ênfase nos potenciais impactos na saúde, comportamento, fisiologia e desempenho dos animais.

2. Interações entre humanos e animais e suas implicações na pecuária de corte

Nos sistemas de produção, a interação humano-animal envolve qualquer contato entre ambos (Ceballos & Tarazona, 2023). Por sua vez, a relação entre humanos e animais tem sido operacionalmente definida como uma abordagem voluntária e proximidade espacial, evidenciada pelos animais quando positivas, com sinais de antecipação, prazer, relaxamento ou outros indicadores de uma experiência gratificante proveniente da interação com humanos (Rault et al., 2020). A qualidade dessas interações em contextos de produção animal é influenciada por diversos fatores, incluindo as características individuais dos animais, como experiência prévia, variabilidade genética e predisposições comportamentais, bem como as características específicas dos humanos

envolvidos, como familiaridade com os animais, atitudes, habilidades e conhecimentos. Adicionalmente, o ambiente de criação e trabalho desempenha um papel crucial nesse cenário complexo (Hemsworth & Coleman, 2011; Rault et al., 2020).

Essas interações englobam modalidades sensoriais diversas, como dimensões táteis, visuais, olfativas e auditivas, que podem ser interpretadas pelos animais como experiências negativas, neutras ou positivas, como apontado por Waiblinger et al. (2006). Tais interações desempenham um papel significativo na construção de relações a curto e longo prazo entre humanos e animais, conforme destacado por Hemsworth & Coleman (2011). Nesse contexto, esta revisão concentra-se especificamente nas interações táteis, explorando sua influência na dinâmica entre humanos e animais de produção.

Estudos sobre a dinâmica da interação humano-animal durante o manejo de recém-nascidos em fazendas dedicadas à produção de gado de corte indicam que manejo negativo ou aversivo resulta em maior reatividade tanto nos bezerros quanto nas vacas, afetando diretamente seu bem-estar (Costa et al., 2021). Além disso, aumenta o risco de lesões para animais e humanos, bem como em danos às instalações (Paranhos da Costa, 2000).

Existem evidências que o manejo de animais por meio de interações positivas melhora a eficiência do trabalho. Nesse sentido os estudos realizados em bovinos da raça Charolês durante manejos de pesagem em fazenda comerciais, mostraram que existem diferenças entre fazendas no tempo que os funcionários passaram batendo, empurrando, torcendo as caudas nos animais e, consequentemente, influenciando diretamente no tempo de manejo durante a rotina de trabalho (Destrez et al., 2018). Nesse estudo, os animais que receberam práticas de manejo positivas necessitaram de menos tempo para serem pesados em relação aos animais que receberam práticas neutras ou negativas; sendo explicado por uma menor reatividade, o que facilitou o manejo. Isso também foi comprovado na pesquisa de Lensink et al. (2001), em que os bezerros que receberam um manejo positivo precisaram de menos esforço para serem embarcados em um caminhão do que aqueles que receberam tratamento aversivo.

Resultados de estudos com novilhas Nelore também demonstraram que quando o manejo é realizado de maneira inadequada (com golpes e gritos) os

animais ficam mais reativos e estressados, o que aumenta o risco de acidentes e reduz a eficiência reprodutiva quando comparados aos animais que não tiveram problemas durante o manejo (Ceballos et al., 2018a). Esse mesmo grupo de pesquisa fez outro estudo com machos da raça Nelore em pastejo rotacionado de quatro dias, e demostraram velocidades de saída menores em relação ao grupo de manejo de baixa frequência com períodos de pastagem de vinte dias (Ceballos et al., 2018b). O sequestro de bezerros em confinamento durante a estação seca reduziu a reatividade em comparação com aqueles mantidos em pastagem (Vasconcelos et al., 2018).

Técnicas de aprendizagem, como a habituação à interação humana em novilhas Braford e Brahman-Angus, também resultaram na redução da reatividade e da concentração de cortisol plasmático e melhoras no desempenho reprodutivo (Cooke et al., 2009; 2012). Aprimoramentos nas interações humano-animal podem ser alcançados por meio de adaptações nos currais e adoção de práticas de manejo de baixo estresse (Paranhos da Costa, 2022; Grandin, 2021). Em gado Nelore, pequenas alterações no curral e melhorias no manejo, como a eliminação de cães, bastão elétrico e gritos, resultaram em animais menos reativos, redução do tempo de trabalho e menores níveis de cortisol em comparação com um grupo controle (Lima et al., 2018).

Mudanças de baixo custo no embarque e transporte dos bovinos têm repercussões significativas na qualidade e quantidade de carne, afetando a economia do pecuarista, por exemplo, quando o embarque é realizado sem gritos, empurrões, uso de bastão elétrico e sem mistura de grupos foi observada uma redução no número de hematomas nas carcaças (Paranhos da Costa et al., 2008; Huertas et al., 2018). Embora as boas práticas de manejo tenham evoluído em fazendas comerciais de gado de corte nos últimos anos (Paranhos da Costa et al., 2019), a importância do treinamento contínuo é destacada, pois estudos mostram que a capacitação contínua resulta em atitudes e comportamentos consistentemente melhores com os bovinos ao longo do tempo (Ceballos et al., 2018c).

3. Interação tátil

As sensações táteis desempenham um papel fundamental na transmissão de estímulos ao sistema nervoso central, sendo mediadas por terminações nervosas sensoriais conectadas a receptores presentes nas estruturas somáticas (como pele e tecidos musculoesqueléticos) e viscerais. Estes receptores especializados, associados às extremidades das fibras nervosas, como as fibras C, são responsáveis por perceber estímulos táteis. Na pele, por exemplo, encontramos mecanoceptores sensíveis a toques leves, como o corpúsculo de Meissner, e receptores de pressão de toque, como o corpúsculo de Pacini. Este último possui um terminal nervoso circundado por camadas de células e fluido extracelular, resultando na geração de um estímulo elétrico que é transmitido ao cérebro (Riley et al., 2022).

A interação tátil é definida como o contato manual ou mecânico entre indivíduos, podendo ocorrer entre seres da mesma espécie ou de espécies diferentes (McBride et al., 2004; Bolognesi et al., 2019). Essa interação pode ser considerada positiva quando realizada através de práticas como massagem ou escovação, que visam manipular os músculos e os tecidos moles do corpo (McBride et al., 2004), contribuindo para melhorias na interação humano-animal e promovendo estados afetivos positivos (Rault et al., 2020).

Na natureza, a formação de vínculos sociais entre animais é frequentemente mediada por carícias, afagos, toques na pele (Field, 1998) e lambidas (Porter et al., 1994).

Interações táteis, como a execução de massagens após o nascimento, procuram simular a lambida materna que estimula funções vitais nos recém-nascidos, incluindo respiração, circulação, urinação, defecação e termorregulação (Metz & Metz, 1986). Além disso, existe a formação de vínculos sociais dentro do grupo e desempenha funções adaptativas como higiene (Sato et al., 1991), prazer (Boissy et al., 2007) e redução da tensão nos grupos de animais (Sato et al., 1993).

A interação tátil, especialmente através de escovação associada ao treinamento e habituação à presença humana na sala de ordenha, tem demonstrado melhorar a adaptação de novilhas leiteiras, especialmente zebuínas e seus cruzamentos, ao ambiente de ordenha (da Silva et al., 2021).

Isso não apenas reduz o medo dos humanos e das instalações de manejo, com variações individuais significativas (Paranhos da Costa et al., 2021), mas também reduz durante a primeira lactação e melhora a ejeção do leite (Ujita et al., 2021). Um estudo destaca que vacas manejadas de forma calma e positiva, juntamente com interações táteis não aversivas, produzem mais leite em comparação com aquelas que são submetidas a golpes ou torções na cauda (Saito & Seo, 2020).

Embora ferramentas como escovas automáticas sejam utilizadas em alguns casos, eliminando a interação tátil direta com humanos, elas oferecem aos animais a autonomia para decidir quando e quantas vezes interagir com o equipamento para se esfregar ou coçar. Relatos positivos dessa abordagem foram observados em vacas leiteiras (Schukken & Young, 2009), bezerros leiteiros (Strappinni et al., 2021), bovinos em confinamento (Park et al., 2020) e equinos (Lansade et al., 2022). No entanto, esta revisão se concentrará especificamente nas interações táteis entre humanos e animais, especialmente quando ocorrem em idade precoce em animais de produção.

3.1. Efeito das interações táteis no comportamento

Quando um animal é exposto a desafios ou estressores, como as interações táteis negativas promovidas pelos seres humanos, ele pode reagir por meio de quatro tipos de respostas biológicas inter-relacionadas: respostas comportamentais, respostas do sistema nervoso autônomo, respostas do sistema neuroendócrino e respostas do sistema imunológico (Moberg, 2000; Hemsworth & Coleman, 2011). Portanto, é crucial compreender o mundo sensorial e perceptivo dos animais para realizar um manejo adequado (Grandin, 2021).

Em bovinos leiteiros, por exemplo, o contato tátil não aversivo foi associado a emoções positivas durante as interações com humanos (Lange et al., 2020, 2021). No entanto, as reações podem variar dependendo da região do corpo estimulada, como evidenciado por Schmied et al. (2008), que observaram maior expressão de reações positivas, como alongamento do pescoço, ao serem acariciadas na parte ventral do pescoço em comparação com o peito lateral.

Há evidências que quando as interações táteis foram realizadas durante os primeiros dias de vida, independentemente da localização, frequência e duração em que foi feita; diminuiu o medo e facilitou o manejo em diversas espécies, como é o caso das cordeiros (Boivin et al., 2000; 2001; 2002; de Oliveira, 2013; Tallet et al., 2005; Sokołowski et al., 2023), cabritos (Boivin & Braastad, 1996), potros (Ligout et al., 2008; Pereira-Figueiredo et al., 2017; Søndergaard & Jago, 2010), coelhos (Verwer et al., 2009), leitões (de Oliveira et al., 2015) e bezerros (Krohn et al., 2001; 2003). Além de isso, em uma espécie territorial, como é a tilápia do Nilo, reduziu-se a agressividade (Bolognesi et al., 2019).

Por outro lado, em bezerros Holstein × Gir, boas práticas de manejo, incluindo manutenção em grupo, aleitamento com baldes com bicos, estimulação tátil durante a amamentação e desmame progressivo, resultaram em redução do medo aos humanos e melhorias nas interações humano-animal ao longo dos 318 dias de vida (Silva et al., 2017). Resultados similares foram observados um estudo realizado em bezerros cruzados com Limousin, que receberam a estimulação tátil a partir do segundo dia de vida, por seis dias, totalizando 120 minutos de contato, demonstraram efeitos persistentes a longo prazo na redução da distância de fuga (Probst et al., 2012).

Os efeitos do manuseio precoce na reatividade subsequente das novilhas aos seres humanos e a situações desconhecidas foi testada por Boissy e Bouissou (1988). Nesse estudo as bezerras foram escovadas duas vezes por dia e conduzidas com cabrestos, em períodos diferentes da vida: 3 dias por semana de 0 a 3 meses de idade; 3 dias por semana, entre 6 e 9 meses de idade; ou 3 dias por mês de 0 a 9 meses de idade; e indicaram que as bezerras que foram manejadas três vezes por mês durante nove meses, apresentaram menores respostas de evitação aos humanos aos quinze meses de idade, e sugeriram que esses efeitos são melhores quando realizados em idade precoce.

Em ovelhas, a escovação resultou em estados positivos, evidenciados por mudanças na postura corporal, como a posição das orelhas, a proporção de olhos fechados, o abanar da cauda e o comportamento alimentar (Tamioso et al., 2018).

Estudos sobre a estimulação tátil em *Bos indicus*, considerados animais mais reativos em relação ao *Bos taurus* (Cooke 2014), são escassos. Resultados de um estudo com bezerros Aberdeen Angus x Nelore (F1) mostraram que os

bezerros que receberam estimulação tátil apresentaram reações mais positivas aos procedimentos de manejo que os que não receberam, embora tenha sido observadas diferenças individuais na forma com que os bezerros reagiram a estimulação (Parra Cerezo et al., 2021). Além de promover mudanças positivas no comportamento animal, em fazendas que adotaram esse conceito, as atitudes dos vaqueiros em relação aos animais também mudam, como relatado por Paranhos da Costa (2022).

Os estudos mencionados anteriormente corroboram a relevância das interações positivas entre humanos e animais, especialmente no que diz respeito à redução da reatividade. Essa importância fundamenta-se na observação de que bovinos de temperamento tranquilo lidam de maneira mais eficaz com situações novas durante o manejo quando comparados a animais mais reativos (Müller & von Keyserlingk, 2006). Indivíduos reativos, por sua vez, experimentam maior nível de estresse durante as práticas de manejo, devido à maior ativação do eixo hipotálamo-hipófise-adrenal (Curley et al., 2008; Braga et al., 2018). Portanto, é importante a adoção de boas práticas de manejo que promovam interações positivas entre humanos e animais, como é o caso do contato tátil, o qual impacta diretamente na melhoria das respostas comportamentais e facilita o manejo do gado nas fazendas.

3.2. Interações táteis e implicações nos parâmetros fisiológicos

Os primeiros estudos sobre este tema foram conduzidos em ratos e indicam que esses animais, quando expostos à estimulação tátil, abriram os olhos, apresentaram capacidade locomotora e foram desmamados mais precocemente em comparação com os animais que não receberam tal estímulo (Levine et al., 1957). A estimulação tátil durante os estágios iniciais da vida demonstrou impacto na ativação do sistema nervoso simpático e endócrino, levando à maturação do sistema nervoso central, conforme expresso por Levine (1960). Essa estimulação resultou em mudanças nas estruturas cerebrais e na reorganização sináptica neuronal (Kolb et al., 2003), além de promover o aumento no número de dendritos e sinapses nervosas (Kolb et al., 2010).

Os estudos conduzidos por Kolb et al. (2003) indicaram que a estimulação tátil teve um impacto positivo nas habilidades motoras e cognitivas na idade

adulta em ratos, sugerindo que esses animais estavam mais preparados para enfrentar condições ambientais desafiadoras. Na mesma espécie, a estimulação tátil demonstrou promover a liberação de ocitocina, resultando na diminuição da frequência cardíaca, pressão arterial e concentração de cortisol plasmático (Uvnäs-Moberg e Petersson, 2005). Além disso, estudos em humanos mostraram uma redução de 31% nos níveis de cortisol e um aumento de 28% e 31% nos níveis de serotonina e dopamina, respectivamente (Field et al., 2005).

No contexto de animais de produção, os estudos iniciais especularam que as mudanças fisiológicas observadas em ratos também se aplicavam a espécies zootécnicas. Atualmente, há evidências de que a estimulação tátil promove um estado de relaxamento, reduzindo a frequência cardíaca em leitões (Tallet et al., 2014), cordeiros (Coulon et al., 2013), ovelhas (Tamioso et al., 2018) e vacas leiteiras (Schmied et al., 2010; Lange et al., 2021).

Bezerras Girolando, sem a presença da mãe nas primeiras 24 horas, que receberam estimulação tátil por cinco minutos diários durante o aleitamento até o desmame, apresentaram menor frequência cardíaca aos 30 e 90 dias, assim como menor temperatura retal aos 90 e 120 dias em comparação com o grupo controle. Além disso, exibiram maior concentração de ocitocina nas primeiras 48 horas de vida (Magalhães Silva, 2015).

Há evidências de que bezerros leiteiros associam a massagem durante a criação a uma experiência positiva (Lensink et al., 2000a), apresentando frequências cardíacas mais baixas durante o embarque em comparação com aqueles que receberam interações negativas, como bater e gritar (Lensink et al., 2001b, c). Esse mesmo grupo de pesquisa observou menor agitação, menor defecação durante o manuseio durante o transporte e maior potencial glicólico em bezerros submetidos à massagem (Lensink et al., 2000d).

Em equinos, estudos indicam que interações táteis, como massagens prolongadas e suaves em áreas preferidas, resultam em diminuição da frequência cardíaca e induzem um comportamento mais relaxado (McBride et al., 2004). Esta conclusão foi confirmada em estudos com equinos de corrida, nos quais sessões diárias de massagens no pescoço, escápula, nádegas e membros traseiros resultaram em diminuição da frequência cardíaca e cortisol, além de melhoria no desempenho durante as corridas. Vale ressaltar que a

massagem foi mais eficaz quando realizada diariamente em comparação com a realização um dia antes da corrida (Kędzierski et al., 2017).

Resultados de um estudo realizado por Probst et al. (2012) em bezerros Limousin demonstraram uma redução nos níveis de cortisol no matadouro, indicando um efeito a longo prazo na resposta ao estresse. Interações táteis positivas antes de procedimentos aversivos, como a palpação retal em vacas leiteiras, reduziram a frequência cardíaca (Waiblinger et al., 2004; Schmied et al., 2010). Da mesma forma, em cordeiros que receberam interação positiva com os humanos e foram submetidos ao corte de cauda, apresentaram menor frequência cardíaca e redução nas concentrações de cortisol em relação àqueles que foram submetidos a interação negativa (Tosi & Hemsworth, 2002).

Independentemente da idade em que ocorreu a interação tátil e da espécie animal, os resultados mencionados são consistentemente positivos na redução da resposta ao estresse em várias situações e contextos. Isso é atribuído a uma menor ativação dos sistemas simpático e do eixo hipotálamo-hipófise-adrenal, indicando que animais submetidos a um manejo gentil, por meio de interações táteis, apresentam maior plasticidade e enfrentam de forma mais eficiente os desafios ao longo de suas vidas.

3.3. Efeitos da interação tátil no desempenho produtivo e saúde

Em vacas leiteiras, Rushen et al. (1999) observaram que um ordenhador que utilizava métodos aversivos, como bater ou aplicar choques elétricos nas vacas por cinco dias consecutivos, resultou em um aumento de 70% no leite residual. Resultados similares foram reportados por Waiblinger et al. (2002), indicando que a frequência de comportamentos negativos dos criadores estava negativamente correlacionada com a produção de leite em fazendas comerciais. Em contrapartida, um estudo com novilhas zebuínas que receberam estimulação tátil positiva e treinamento de rotina de ordenha demonstrou uma melhoria na ejeção do leite (Ujita et al., 2021).

No contexto da produção animal, poucos estudos exploraram os efeitos da estimulação tátil em filhotes sobre parâmetros produtivos. No entanto, pesquisas com bezerras leiteiras indicaram que a massagem na parte ventral do pescoço resultou em um aumento do ganho de peso diário entre o nascimento e o

desmame (Lürzel et al., 2015). Em fazendas comerciais, interações positivas, como tocar, acariciar, falar suavemente e permitir que os bezerros chupem os dedos dos funcionários, foram associadas a maior ganho de peso e menor mortalidade (Lensink et al., 2000a). Bezerras Girolando que receberam estimulação tátil demonstraram melhor desempenho em termos de peso e ganho médio diário aos 90 e 120 dias de idade (Magalhães Silva, 2015). A autora sugere que esses efeitos positivos podem ser atribuídos a melhorias nas variáveis comportamentais, fisiológicas e de saúde, indicando um impacto positivo no bem-estar animal.

A estimulação tátil diária em cordeiros Santa Inês durante cinco minutos resultou em um maior desenvolvimento corporal (14%) e ganho de peso total em comparação com os animais não estimulados (de Oliveira, 2013). Em bovinos de corte, bezerros cruzados com Limousin que receberam estimulação tátil apresentaram melhor qualidade da carne ao abate (Probst et al., 2012).

Quanto à saúde, bezerras que receberam boas práticas de manejo associadas à estimulação tátil durante a alimentação apresentaram uma redução significativa na taxa de mortalidade (72%) e no uso de antibióticos até o desmame (50%). Os pesquisadores atribuem esses resultados à interação mais próxima, permitindo a identificação precoce de sinais clínicos de doenças e o tratamento adequado (Silva-Antunes e Paranhos da Costa, 2021).

Em cabritos, a estimulação tátil reduziu a frequência de sinais clínicos de doenças respiratórias, como corrimento nasal (Andrioli et al., 2018). Em cordeiros, melhorou a resposta imune (Caroprese et al., 2006) e em bezerros, reduziu as lesões do abomaso durante o transporte (Lensink et al., 2000d). Esses estudos indicam que a estimulação tátil tem um impacto direto na saúde, diminuindo o risco de enfermidades e, consequentemente, as despesas com tratamentos nos animais, o que impacta positivamente na economia do produtor.

Os resultados das pesquisas mencionadas em relação ao bem-estar animal podem ser interpretados à luz do modelo dos cinco domínios do bem-estar animal (Mellor et al., 2020). Por exemplo, animais que experimentaram interações táteis positivas, como massagem ou escovação, apresentaram melhorias nas interações comportamentais (domínio 4), reduzindo a reatividade e facilitando o manejo, o que influencia positivamente o ambiente (domínio 2). Isso resulta em menor estresse para animais e pessoas durante as sessões de

trabalho, apresentando, consequentemente, efeitos positivos na saúde (domínio 3), diminuindo os riscos de acidentes e doenças e reduzindo a mortalidade. Tudo isso permite que os animais tenham uma maior ingestão de alimentos (domínio 1: Nutrição) e, em conjunto, diminuíram a probabilidade de os animais sentirem medo, dor e desconforto, impactando positivamente o estado mental (domínio 5) e promovendo um estado geral de bem-estar positivo. Em contraste, interações táteis negativas podem desencadear círculos viciosos, comprometendo os domínios físicos e estados mentais, resultando em um estado de bem-estar negativo.

4. Considerações finais

Contatos táteis positivos ao longo da vida dos animais, durante breves momentos melhoram suas interações com os humanos. Para assegurar a consistência e positividade dessas interações, é imperativo realizar treinamentos regulares para os funcionários, aliados à prática diária no manejo dos animais em granjas e fazendas. Essa abordagem não apenas repercute de maneira favorável nas respostas comportamentais e fisiológicas dos animais, mas também contribui significativamente para o bem-estar tanto dos animais quanto das pessoas envolvidas. Além disso, reflete positivamente na qualidade do produto, desempenhando um papel crucial na vitalidade econômica das fazendas. Vale destacar que tal prática não só oferece a oportunidade de aprimorar a imagem da pecuária, mas também representa uma valiosa contribuição para a sustentabilidade do setor.

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CAPITULO II – Article accepted in Acta Scientiarum. Animal Sciences

Tactile stimulation reduces reactivity but does not improve the performance of Brahman's calves[2]

Tactile stimulation reduces reactivity in Brahman's calves

Joseph K. Grajales-Cedeño [a b d], Mayara Andrioli [a d] Mateus J.R. Paranhos da Costa [c d e]

[a] UNESP, Faculdade de Ciências Agrárias e Veterinárias, Programa de Pós-Graduação em Ciência Animal, Jaboticabal, SP, Brasil

[b] Departamento de Zootecnia, Faculdade de Ciencias Agropecuarias, Universidad de Panamá, Panamá

[c] UNESP, Faculdade de Ciências Agrárias e Veterinárias, Departamento de Zootecnia, 14884-900, Jaboticabal, SP, Brasil

[d] Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal (ETCO), Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brasil

[e] Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brasília, DF, 71.605-001, Brasil

* Corresponding author:

Mateus Paranhos da Costa, UNESP, Faculdade de Ciências Agrárias e Veterinárias, Departamento de Zootecnia, Jaboticabal, SP, 14.884-900, Brasil. Email: mateus.paranhos@unesp.br.

Tel. +55(16) 99774-2393

Highlights

- Tactile stimulation within 24 h after birth reduced the reactivity of Brahman calves at weaning.
- Tactile stimulation did not affect the performance of Brahman's calves.
- Male calves' reactivity and performance were not affected by tactile stimulation.

Abstract

This study aimed to evaluate the effects of tactile stimulation on the reactivity and performance of Brahman calves. One hundred and nine calves were randomly assigned to two treatments: those that received tactile stimulation (TS, n = 57) and those that did not (NTS, n = 52). Tactile stimulation was performed for eight minutes, 12 hours after birth. The behavioral variables were assessed at weaning (209.50 ± 55.83 days) by assigning reactivity scores in the squeeze chute, which ranged from one to five (one was assigned to a calm calf and five to the most reactive). A flight speed score was assigned when each calf exited the compression ramps. Performance was assessed using the adjusted weaning weight (WW) and daily weight gain (ADG). TS heifer calves showed lower reactivity scores in the squeeze chute ($p<0.05$) and when leaving the squeeze chute ($p<0.05$) than NTS calves, but no significant differences were observed in bull calves between the treatments ($p>0.05$). WW and GMD did not differ between the treatments ($p>0.05$). In conclusion, tactile stimulation performed in Brahman calves at birth resulted in less reactivity in heifer calves without affecting their performance.

Keywords: Animal welfare, Behavior, Beef cattle, Temperament, Human-animal interaction

1. Introduction

Beef cattle production is the most frequent livestock activity in Panama, in which cow-calf operations represent around 68% of the total Panamanian herd (INEC, 2021), with calves being the leading source of income for farmers. Due to the characteristics of the cattle raising system in Panama, animals experience few interactions with humans or, when they occur, they are often negative, resulting from aversive handling such as hot-iron branding, castration and dehorning, among other practices (Hemsworth and Coleman, 2011, Acharya et al., 2022), which affect animal welfare and can result in accidents, illnesses, or even animals' death (Paranhos da Costa et al., 2014).

Positive relationships between humans and animals have been described by livestock farmers as elements of positive animal welfare (Vigors and Lawrence, 2019). In this sense, studies carried out on dairy cattle indicate that tactile stimulation induces positive emotions during interactions with humans (Lange et al., 2020, 2021), and when carried out at an early age (regardless of its frequency and time) reduces fear and facilitates handling procedures in several species, as reported by sheep (Boivin et al., 2000), goats (Boivin and Braastad, 1996), horses (Ligout et al., 2008) and rabbits (Verwer et al., 2009). Furthermore, previous studies have demonstrated that positive relationships between humans and animals have the potential to improve immunity in sheep (Caroprese et al., 2006) and performance in piglets (Oliveira et al., 2015) and Holstein calves (Lürzel et al., 2015).

A study carried out with crossed Limousin calves demonstrated that tactile stimulation in early life had long-term effects by reducing the fear of humans and the stress response at slaughter (Probst et al., 2012). Therefore, we hypothesized that tactile stimulation during the sensitive period of beef calves' lives (Bateson, 1979; Boivin et al., 1992) is an efficient strategy to promote positive interactions with humans, creating good memories that reduce calf reactivity and facilitate handling (Paranhos da Costa, 2022), thereby positively affecting animal welfare and human well-being. Thus, this study aimed to evaluate the effects of tactile stimulation on the reactivity and performance of Brahman's calves.

2. Material and methods

All animals were treated following the practices and experimental protocols reviewed and approved by the Institutional Bioethics Committee of the University of Panama (CEIBA-UP-021-2021).

The study was carried out in a commercial cow-calf operation farm located in Divalá, Alanje, Panama (8°30'40” N and 82°36'43” W, 216 m high from the sea level), where the averages of air temperature and relative humidity are 27 °C (ranging from 26.4 to 28.1 °C) and 83.4% (ranging from 75.5 to 87.9%), and the average annual precipitation of 2374.4. mm (IMHPA 2020).

The study was carried out with 109 Brahman calves (52 bull calves and 57 heifer calves) born between March and August 2020, with an average birth weight of 32.31 ± 4.03 kg (mean ± standard deviation), all descendants of cows with 3.02 ± 2.39 parities. Cows and calves were kept on pasture (*Urochloa brizantha cv. Marandú*) with free access to mineral supplements and water.

Calves were randomly distributed in two treatments: those that received tactile stimulation (TS: n = 57, 26 bull calves and 31 heifer calves) and those that did not (NTS: n = 52, 26 bull calves and 26 heifer calves).

Tactile stimulation was performed 12 hours after calving, after the development of the cow-calf bond (Johnsen et al., 2015). To do this, a cowhand on horseback lassoed the calf calmly and carefully without pulling or dragging it across the maternity paddocks, while another cowhand maintained the cow at a distance. Then, the calf was held by the groin and neck and laid on the ground (Paranhos da Costa et al., 2014). Tactile stimulation was then initiated, massaging the animal's entire body with hands for eight minutes. Tactile stimulation was performed gently, starting in the head, face, ears and nostrils, and then proceeding to the other parts of the body (neck, back, groin area, rump, legs and hooves). After completing the tactile stimulation, the navel was disinfected with 10% iodine, and the calves were identified with a tattoo in the ear and weighed (BW, kg). Furthermore, when they were approximately 15 days old, they were identified using electronic (RFID, EID HDX Tamper-Proof, and Allflex Livestock Intelligence) and visual (Allflex Livestock Intelligence) ear tags. Calves were weighed again at weaning (WW, kg) when they were 209.50 ± 55.83 days old, on average. The average daily gain for each calf (ADG, kg/d) was calculated based on BW and WW.

At weaning, calves were individually subjected to two reactivity tests. Cows and calves were taken from the pasture to the corral and separated, maintaining the calves in one of the corral pens with free access to water and shade for approximately 30 minutes before starting the tests.

First, calf reactivity was scored at the squeeze chute without using any restraint structure by assigning one of the following scores: (1) calm, without movement; (2) agitated; (3) frequent movements with vocalization; (4) frequent movements with vocalizations and shaking the squeeze chute; and (5) violent and continuous struggles struggles (adapted from Cooke et al., 2011).

Immediately after carrying out the first assessment of reactivity, the calves were released from the squeeze chute and the exit score was assigned as described by Vetters et al. (2013), as follows: (1) the calf leaves walking or (2) the calf leaves trotting or running.

2.1. Statistical analyzes

Statistical analyzes were performed using the R software with the RStudio integrated development environment (R version 4.0.4, 2022-02-15, RStudio, Inc.), considering a significance of 5% in all statistical tests. The normality of the residual errors in the adopted models was verified using the Shapiro-Wilk test. Outliers were preserved because they represent individual variations within the reference values for the species.

Weaning weight and daily weight gain were evaluated using generalized linear models, considering the fixed effects of treatment, sex and their interactions, and birth weight, age, parity and cow weight as covariates. The reactivity scores in the squeeze chute were analyzed using generalized linear models adjusted by Poisson distribution, considering treatment, sex, and their interactions as fixed effects and cows' age and parity as covariates. The best adjustment of the model was performed with the 'step-up' procedure using Akaike information classifications (AIC) and Bayesian information classifications (BIC).

Multiple comparisons for the reactivity scores in the squeeze chute, WW and ADG were performed using the post-hoc Tukey test. The Chi-square test (χ^2) was used to compare the number of calves in the TS and NTS treatments that left squeeze chute walking or trotting/running according to sex. Box plots were constructed to facilitate visual interpretation of the results (‘geom_boxplot{ggplot2} and bars geom_col{ggplot2}’).

3. Results and discussion

There was no significant effect of treatment ($p>0.05$), sex ($p>0.05$), nor the interaction between treatments and sex ($p>0.05$) on WW and ADG (Table 1).

Table 1. Adjusted means ± standard errors of weaning weight (WW, kg) and average daily gain (ADG kg/d) of Brahman calves (n=109) according to treatment (TS = received tactile stimulation and NST = not received tactile stimulation) and sex (bull calves and heifer calves).

Performance traits	Treatment		Sex	
	TS	NTS	Bull calves	Heifer calves
WW (kg)	159±3.35	158±3.50	159±3.54	158±3.38
ADG (kg/day)	0.62±0.02	0.62±0.02	0.61±0.02	0.63±0.02

There was a significant interaction between treatments and the sex of calves, with TS heifer calves' treatment showing a lower reactivity score in the squeeze chute compared to NTS ones ($p<0.05$; Figure 1).

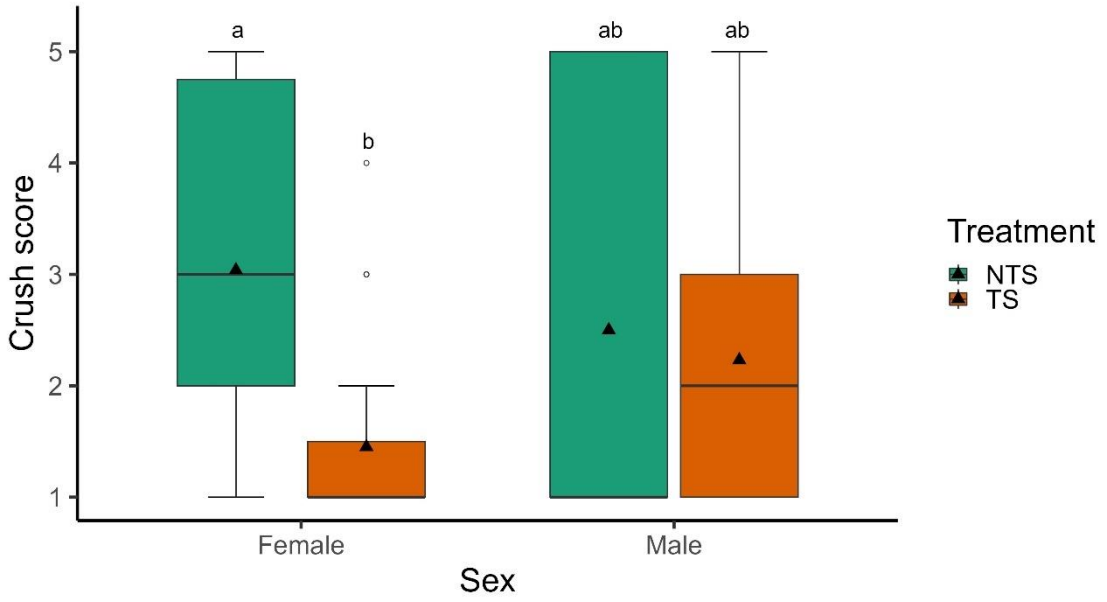

Figure 1. Box plot of the reactivity score in the squeeze chute of Brahman calves (n=109) according to the treatments (TS = received tactile stimulation, NTS = did not receive tactile stimulation) and sex (bull calves and heifer calves). Different letters show statistical differences in the interaction treatment and sex; black triangles indicate the mean; grey circles indicate outliers.

There were also significant effects of the interaction between the treatments and sex of animals (χ^2=17.69, DF = 3; p<0.001). A higher percentage of TS heifer calves walked relative to NTS animals (84% vs 46%, respectively), resulting in a lower percentage of TS heifer calves exiting the squeeze chute by trotting/running than NTS calves (16% vs 54% respectively), as shown in Figure 2.

Figure 2. Percentages of Brahman calves (n=109) that left the squeeze chute walking or trotting/running according to treatments (TS = received tactile stimulation and NTS = did not receive tactile stimulation) and sex (bull calves and heifer calves).

A series of studies have found no effects of tactile stimulation on the performance of animals from birth to weaning, as described for dairy calves (Lensink et al., 2000), lambs (Alonso et al., 2015) and piglets (Muns et al., 2015), which is corroborated by the present results. On the other hand, other studies have shown divergent results with dairy calves, showing that tactile-stimulated calves had a higher average daily gain up to and after weaning (Lürzel et al., 2015). Likewise, tactile-stimulated piglets showed better performance at weaning than those not stimulated (Oliveira et al., 2015).

Although our results did not show any effect of tactile stimulation on the calves' performance, it was observed that the tactile-stimulated heifer calves (TS) were less reactive than those not stimulated (NTS). Such behavioral changes

may have positive effects when carrying out handling routines, resulting in better reproductive performance as described by Cooke et al. (2012, 2017), for example, or in lower animal stress and reactivity at the time of slaughter, with positive implications for meat quality (Probst et al., 2012). It is worth noting that the assessment of the calves' reactivity occurred approximately seven months after the application of tactile stimulation, making our results more interesting, as its implementation resulted in a beneficial effect on positive long-term memory formation, potentially improving human-animal interactions during handling routines. Previous studies have shown that female cattle are more reactive than male (Voisinet et al., 1997a), and probably by being more temperamental, they can respond better when getting used to handling conditions (Parham et al., 2019b), as was the case with the reduction in reactivity in our heifer calves.

There are reports on commercial farms that have adopted this concept, indicating that in addition to promoting positive changes in animal behavior, there are also changes in the attitudes of cowboys towards animals (Paranhos da Costa, 2022).

On the other hand, the results of a study carried out on commercial beef cattle farms focusing on human-animal interactions during the handling of newborn calves showed that when handling is aversive, calves and cows become more reactive, which directly affects their well-being and increases the risk of accidents for both animals and people responsible for handling livestock (Costa et al., 2021).

4. Conclusions

In conclusion, tactile stimulation 12 hours after birth in Brahman's calves resulted in a reduction of their reactivity at weaning, with a marked effect in heifer calves, without changes in their performance.

Author Contributions:

Joseph Kaled Grajales-Cedeño: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Writing - Original Draft, Visualization. **Mayara Andrioli:** Investigation, Resources, Writing - Original Draft, Visualization.

Mateus J.R. Paranhos da Costa: Conceptualization, Methodology, Investigation, Supervision, Writing - Original Draft, Writing - Review & Editing, Visualization. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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CAPITULO III – Article published in Applied Animal Behavior Science

Habituation of crossbred beef calves to corral handling reduces their reactivity and improves performance[3]

Joseph K. Grajales-Cedeño [a b d], Mateus J.R. Paranhos da Costa [c d e]

[a] UNESP, Faculdade de Ciências Agrárias e Veterinárias, Programa de Pós-Graduação em Ciência Animal, Jaboticabal, SP, Brasil

[b] Departamento de Zootecnia, Faculdade de Ciencias Agropecuarias, Universidad de Panamá, Panamá

[c] UNESP, Faculdade de Ciências Agrárias e Veterinárias, Departamento de Zootecnia, 14884-900, Jaboticabal, SP, Brasil

[d] Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal (ETCO), Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brasil

[e] Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brasília, DF, 71.605-001, Brasil

* Corresponding author:

Mateus Paranhos da Costa, UNESP, Faculdade de Ciências Agrárias e Veterinárias, Departamento de Zootecnia, Jaboticabal, SP, 14.884-900, Brasil. Email: mateus.paranhos@unesp.br.

Tel. +55(16) 99774-2393

Highlights

- Beef calves' habituation reduces their reactivity and facilitate handling.
- Habituating beef calves to handling improve their performance.
- Habituating beef calves to handling has potential to promote their welfare.

Abstract

The study aimed to determine the role of the habituation process of crossbred beef calves to corral handling on their reactivity, welfare and performance. Thirty-nine calves aged 87.69 ± 19.93 days were randomly divided into two treatments according to their weight, sex, and reactivity, as follows: 1) calves habituated to corral handling (HAB, N = 21) and 2) calves not habituated to corral handling, control group (NHAB, N = 18). The habituation process to corral handling was performed for 15 minutes twice a week for two weeks to reduce the animals' flight distance from humans. Calves' reactivities were scored when keeping them inside a scale and a squeeze chute (by applying scores ranging from 1 to 5 in both situations) and by scoring the speed at which they exited the squeeze chute (1 = walking or 2 = trotting and running). The assessments of physiological (heart rate, respiratory rate, and rectal temperature) and performance (average weight gain and weaning weight adjusted to 205d) indicators were carried out before (d-10), just after (d17) and 150 days after finishing the habituation process (d150). Mixed linear models were used to evaluate the fixed effects of treatments, assessment moments, and sex on most dependent variables, except for flight speed, which was analyzed using the Chi-square test. The HAB calves showed lower reactivity scores in d17 and 150 than NHAB calves in both measurements, scale and squeeze chute. Furthermore, a higher percentage of HAB calves exited the squeeze chute walking than NHAB calves in d17 and d150 (62% vs 11% and 24% vs 5%, respectively). None of the physiological variables was affected significantly by treatments. HAB calves showed greater ADG (p=0.0007) and reached a higher adjusted weaning weight to 205d (p=0.004) than NHAB calves. In conclusion, habituation to corral handling reduces reactivity and improves the performance of crossbred beef calves.

Keywords: animal welfare; beef cattle; behavior; human-animal interactions; learning process.

1. Introduction

In countries within the intertropical belt, beef herds are composed mainly of Zebu cattle (Bos indicus) and its crosses, which are more reactive than European cattle (Bos taurus) (Sant'Anna et al., 2012). In the context of pasture-based extensive production systems, cattle usually experience few interactions with humans, and when they occur, they are often negative because of aversive handling that potentially compromises the welfare and increases cattle reactivity (Grandin, 1997).

It is well-established that the quality of human-animal relationships is one of the main factors influencing animal welfare (Boivin, 2018, Hemsworth et al., 2018; Mellor et al., 2009; Waiblinger et al., 2006). When these relationships are negative, there is an adverse effect on the physical and mental state of the animals (Paranhos da Costa and Ceballos, 2021), resulting in undesirable behavior by cattle (Ceballos et al., 2018), which leads to an increased risk of injuries for both, cattle and cowhands responsible for carrying out handling (Boivin et al., 1994, Lindahl et al., 2016) and may also compromise cattle performance (Coleman and Hemsworth, 2014, Hemsworth and Coleman, 2011).

Habituation is a non-associative learning process that results in a behavioral response decrement after repeated exposure to a specific stimulus (Grissom and Bhatnagar, 2009, Rankin et al., 2009). The literature indicates that previous experiences affect the behavior of animals during subsequent handling (Grandin, 1997). In this sense, the habituation of cattle to most frequent handling in the corral (e.g., driving cattle thought the facilities, veterinary care and weighing) can be used to reduce stress during daily handling routines that involve interactions with humans (Grandin and Shivley, 2015), improving labor efficiency and reducing the risk of accidents (Destrez et al., 2018, Paranhos da Costa and Ceballos, 2021), even when dealing with temperamental cattle (Parham et al., 2019).

Temperament, defined as "…the phenomenon that individual behavioral differences are consistent over time and/or across situations…" (Réale et al., 2007), is usually described based in cattle reactivity to human handling (Boivin et al., 1992; Chang et al., 2020). It has been shown that beef cattle with greater reactivity are more susceptible to stress (Burdick et al., 2011, Cafe et al., 2011, Braga et al., 2018), have lower dry matter intake (Cafe et al., 2011) and, consequently, lower average daily gain (Petherick et al., 2002, Behrends et al., 2009, Cafe et al., 2011, Gellatly et al., 2020) when compared to less reactive animals.

Handling can be stressful to cattle and the way that they respond is highly dependent on its previous experiences and inherited traits, such as temperament (Grandin and Shivley, 2015). According to Chen et al. (2015), stress results in behavioral changes, including an increase in reactivity to stressful events. Thus, it is expected that stressed cattle become more reactive and, consequently, have higher reactivity scores and leave the squeeze chute at a faster speed (flight speed). In addition, they also present physiological changes associated with stress (Kubkomawa et al., 2015), with increased heart and respiratory rates and rectal temperature, which are valid indicators and widely used measures to assess acute stress responses in animals during handling procedures (Waiblinger et al., 2004, Lange et al., 2020). Thus, the habituation process results in cattle getting used to corral handling and reducing stress, as confirmed by the results of previous studies, showing that the habituation to humans had positive effects on behavioral and physiological variables of Angus, Simental, Hereford and Charolais heifers (Ujita et al., 2021), and that the habituation to corral handling (called acclimation by Cooke et al., 2009a) improved the reproductive performance of Brahman-crossbred heifers.

As far as we know, no study addressed this subject in beef calves at early ages. Therefore, the study aimed to determine the effect of habituation to corral handling on the reactivity, physiological indicators of welfare and performance of crossbred suckling beef calves. We hypothesize that habituation to corral handling for a short period reduces calves' reactivity and promotes their welfare and performance.

2. Material and methods

All animals were treated according to acceptable practices of animal welfare, being reviewed and approved by the Institutional Bioethics Committee of the University of Panama (CEIBA-UP-026-2021).

2.1. Study site and animals

The study was carried out at the experimental farm of the Faculty of Agricultural Sciences of the University of Panama, located in the Chiriquí district (8°23´15, 12´´ N and 82°19´47,48" W, with an elevation of 26 meters above sea level).

Thirty-nine crossbred calves (Simmental x Brahman) took part in the experiment. From birth to three months of age, all calves were kept with their mothers on the same *Urochloa brizantha*, cv. Marandu in rotational grazing, with free access to mineral supplements and water, were driven to the corral only once, for navel healing and individual identification. During this period, they were not handled in the squeeze chute, and the interaction between calves and humans was limited. Electronic (RFID, EID HDX Tamperproof, Allflex Livestock Intelligence) and visual ear tags were used for individual identification, as defined in the Harmonized Bovine Traceability System of Panama (OIRSA, 2013).

At the beginning of the study, all calves were around three months old and were in good health and body condition. Calves were randomly distributed into two groups according to their body weight, sex and reactivity, as follows: 1) HAB, calves habituated to corral handling (HAB, N = 21) and 2) NHAB, calves not habituated to corral handling (NHAB, N = 18). At the beginning of the experiment, calves from the HAB and NHAB groups were 87.14 ± 13.09 (mean ± standard deviations) and 88.33 ± 26.18 days old and weighed on average, 128.43 ± 2.82 and 129.25 ± 5.53 kg, respectively.

After sorting HAB and NHAB calves, each experimental group was housed with their respective dams in a different paddock with the same forage availability. The habituation process to corral handling started ten days later.

2.2. Habituation procedures

The habituation procedures to corral handling were carried out by 14 handlers (7 men and 7 women), all fourth-year students at the University of Panama and previously trained in good cattle handling practices in the corral, as described by Paranhos da Costa et al. (2019). Initially, the handlers underwent theoretical instruction that covered the fundamental concepts of cattle behavior and welfare, along with the best handling practices in the corral. They then participated in a practical session in which they were able to apply the acquired knowledge directly. The training program lasted for one week. The assessment of handlers' competence was conducted by a professor from the University of Panama and included both a written assessment and a practical assessment carried out in the corral, interacting with the animals.

HAB cows and calves were driven to the corral together. After sorting them, each calf was subjected to habituation procedures. Firstly, the handlers used cords, smoothly thrown repeatedly over the animal's body, and then they performed tactile stimulation using a wooden rod attached to a bag in one of its ends, in the shape of a cotton swab, as described by (Paranhos da Costa et al., 2021). These procedures aimed to reduce the flight distance of the calves, and they were carried out in the crowding pen for 15 minutes for each calf twice a week for two weeks. After that, each calf was driven through the corral structures (crowding pen, chute, scale, and squeeze chute) with all gates open and without screaming or using aggressive instruments. Immediately after leaving the squeeze chute, the calves met their dams, which were housed in an adjacent corral pen. Soon after, all of them were driven back to their paddock.

The dependent variables (crush score, flight speed, heart and respiratory rates, rectal temperature, and average weight gain and weaning weight) were measured 10 days before starting the habituation process, and again 17 days after the beginning of the habituation process and at weaning, 150 days after the beginning of the habituation process, as summarized in (Fig. 1). All calves from both groups (HAB and NHAB) were maintained in a corral pen for approximately 30 min before the behavioral, physiological and performance assessments began, with free access to water and natural shade.

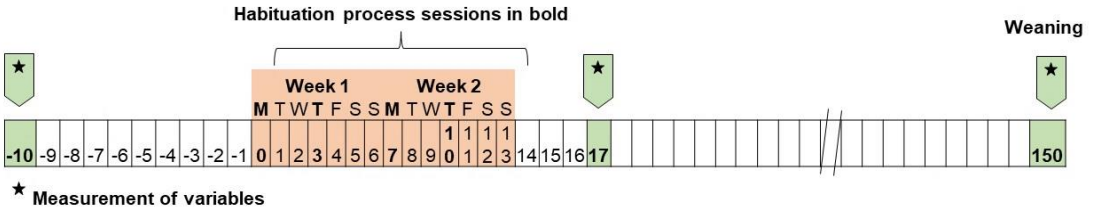

Fig. 1. Timeline of the habituation process to corral handling of Simental x Brahman calves and the moments of behavioral and physiological variables assessment carried out 10 days before start habituation process (d-10), 17 days after start of habituation process (d17) and 150 days after start habituation process (d150). The habituation process to corral handling was performed four times over two weeks, on days 0, 3, 7 and 10.

2.3. Calf reactivity assessments

Calves' reactivity was assessed three times by applying the crush score twice, when the calves were inside the scale and the squeeze chute (without using the restraint structures) and by scoring their flight speed when exiting the squeeze chute. The application of crush scores were carried out 10 seconds after each calf entered the scale and squeeze chute, by assigning one of the following scores: (1) calm, no movement; (2) agitated, but with little movements; (3) frequent movements, with vocalization; (4) frequent and intense movements, with vocalizations, moving the scale or squeeze chute box; and (5) violent and continuous blows; and flight speed was scored when calves left the squeeze chute by scoring 1 when a calf left the squeeze chute walking or (2) when a calf left the squeeze chute trotting or running, which is a simplification of the flight speed score used by Vetters et al. (2013). Both, crush and flight speed scores, were assigned by a previously trained researcher, who was not able to identify from which treatment the calves were subjected.

2.4. Physiological and performance variables assessments

Heart (bpm) and respiratory (breaths/min) rates were recorded using a stethoscope (Littmann Classic III). The rectal temperature (°C) was measured using a digital clinical thermometer, introduced into the animal's rectum, keeping it slightly inclined so the bulb was in contact with the rectal wall. All these measurements were carried out by a veterinarian.

Animals were weighed at baseline (d-10) and at weaning, and the average daily gains (ADG, kg/d) were calculated. Weaning weight was adjusted to 205 days of age (WW205, kg).

2.5. Statistical analysis

All statistical analyzes were performed in the R software (R version 4.2.2, 2022-10-31, RStudio, Inc.), considering a significance of 5% in all statistical tests. The normality of the residual errors was tested using the Shapiro-Wilk test, and the Box-Cox transformation was applied for respiratory rate ('powerTransform{car}'). Outliers were identified and conserved in data analyzes because they were understood as individual variations within the reference values for the species.

Scale and crush scores were analyzed using generalized linear mixed models using the "lme4" package (Bates et al., 2022) and the "glmer" adjusted for Poisson distribution. The best fit of the model was performed with the 'step-up' procedure by the Akaike information criterion (AIC) and Bayesian information criterion (BIC). In these cases, the models considered treatment, moment, sex and the interactions between them as fixed effects and animal as random effect. The effects of the explanatory variables were calculated using the "anova" function, running Type III Wald chi-square trials. Multiple comparisons between adjusted means were performed using Tukey's post hoc test ('lsmeans{lme4}' and 'cld{multcomp}').

The chi-square test (χ2) was used to compare the number of calves walking or trotting/running when exiting the squeeze chute according to the treatment (HAB and NHAB) on each day (d-10, d17 and d150).

Physiological variables data were analyzed using a mixed linear model ("lme4" package, Bates et al., 2022), considering the fixed effects of treatment (HAB vs. NHAB), days (d-10, d17 and d150), sex and interaction between them, and the random effect of the animal. Performance variables (average daily gain and adjusted weaning weight adjusted to 205 days of age) were analyzed using general linear models, considering treatments, sex, and their interactions as fixed effects.

Box plots ('geom_boxplot{ggplot2} and ('geom_col {ggplot2}') were used to represent data variation.

3. Results

3.1. Reactivity variables

There was a significant interaction between treatment and assessment day on the crush score in both assessments, scale and squeeze chute (χ^2=12.03; p=0.002 and χ^2=7.62; p=0.02; Table 1). Post hoc tests showed that HAB calves had lower crush scores than NHAB calves on d17 and d150 when the assessments were carried out in the scale (p=0.001 and p=0.01 respectively) and when it was done in the squeeze chute (p=0.006 and p=0.05 respectively). It is worth noting that NHAB calves showed relatively constant crushing scores throughout the evaluation days, while HAB calves showed significant reductions in crushing scores in both evaluations, scale and squeeze chute, over time (Table 1).

Table 1. Means ± standard error of the crush scores assessed when the calves were inside the scale and the squeeze chute of 39 Simmental x Brahman calves according to the treatments (HAB = habituated and NHAB = not habituated to corral handling), sex (male and female) and assessment days (d-10 = 10 days before start habituation process, d17 = 17 days and d150 = 150 days after start habituation process). Different lowercase letters indicate significant differences ($p<0.05$) between treatments on the different evaluation days.

Assessment days	Crush score - Scale		Crush score – Squeeze chute	
	Treatments		Treatments	
	HAB	NHAB	HAB	NHAB
d-10	4.10±0.44[a]	4.00±0.47[a]	4.48±0.46[a]	4.44±0.49[a]
d17	1.81±0.29[b]	4.22±0.48[a]	2.33±0.33[b]	4.39±0.49[a]
d150	2.14±0.32[b]	3.39±0.43[a]	2.10±0.31[b]	3.11±0.41[a]

There were also significant effects of the interaction between the groups of animals and days evaluated ($\chi^2=70.23$, DF = 6, $p<0.001$). A higher percentage of HAB calves exited the squeeze chute walking in d17 and d150 than NHAB calves (62% vs 11% and 24% vs 5%, respectively), resulting in a lower percentage of HAB calves exiting the squeeze chute trotting/running in d17 and d150 than NHAB calves (38% and 89% and 76% and 95%, respectively (Fig. 2).

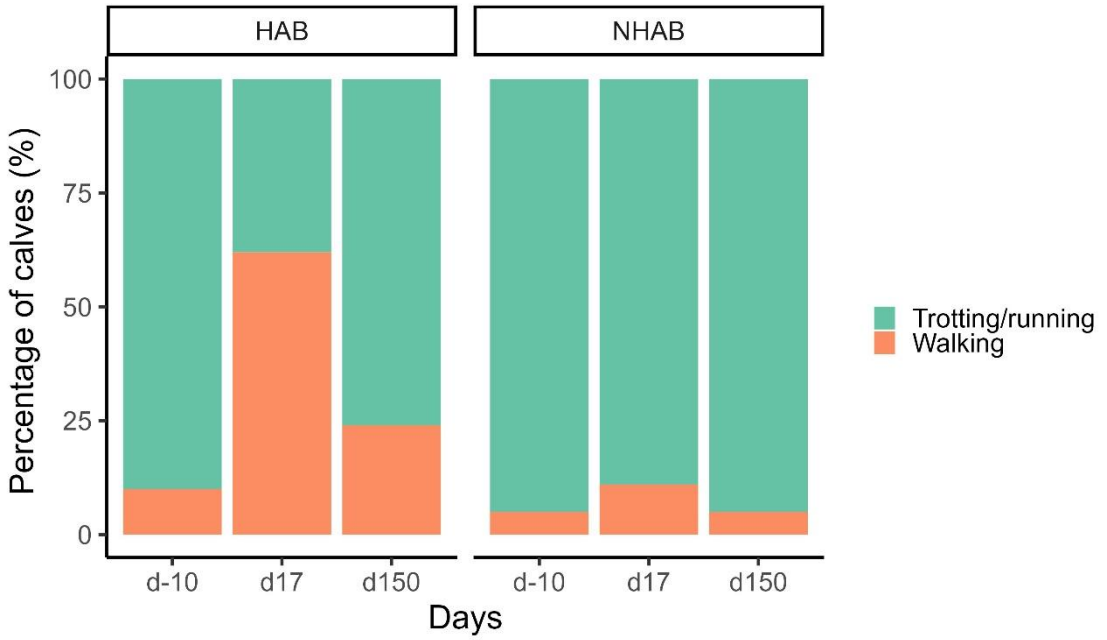

Fig. 2. Percentages of Simmental x Brahman calves that left the squeeze chute walking or trotting/running according to the treatments (HAB = habituated and NHAB = not habituated to corral handling) in each of the assessment days (d-10 = 10 days before start habituation process, d17 = 17 days and d150 = 150 days after start habituation process).

3.2. Physiological variables

No significant differences were observed in heart rate between the HAB and NHAB treatment groups, with mean values of 107±5.57 and 110±5.19 bpm, respectively (p=0.75). Likewise, respiratory rate (41.1±2.03 and 43.41±2.18 breaths/min, respectively, p=0.16) and rectal temperature (40.3±0.11 and 40.4±0.11 °C, respectively) did not show significant differences between treatments (p=0.26). Furthermore, there was no significant effect of sex nor was there an effect of interactions between the fixed effects on any of the physiological variables evaluated (p=0.69; p=0.91; p=0.91, respectively).

However, a significant effect of time was observed on heart and respiratory rates as well as rectal temperature (p=0.001). Heart rate decreased over the evaluation period in both treatments (p=0.001; Fig. 3a). In contrast, respiratory

rate and rectal temperature were statistically lower on day 150 (d150) than on days -10 and 17 (p=0.001; Figs. 3b and 3c, respectively).

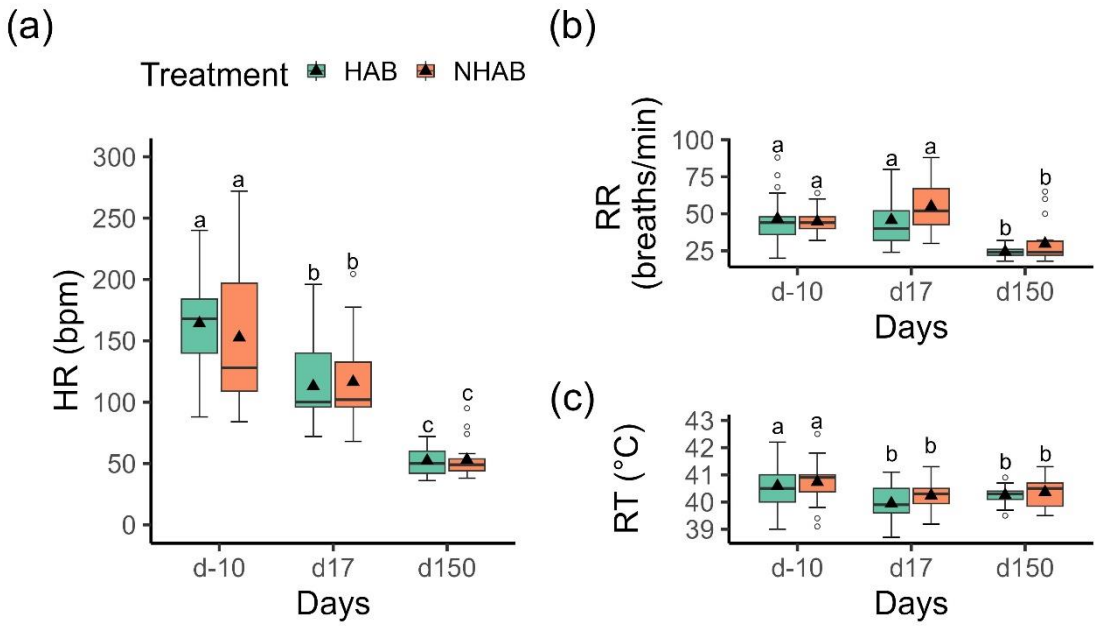

Fig. 3. Box plots of heart (a) and respiratory (b) rates, and rectal temperature (c) of Simmental x Brahman calves habituated (HAB) and not habituated to corral handling (NHAB) according to the assessment days (d-10 = 10 days before start habituation process, d17 = 17 days and d150 = 150 days after start habituation process). Different letters indicate significant differences between assessment days ($p<0.05$). Triangles represent means and the circles outliers. The respiratory rate was transformed using the Box-Cox procedure ($\lambda = -0.5050505$) for better adherence of the model residues with the Gaussian distribution, and the data in Fig. 3b are in the original scale.

3.3. Performance variables

Significant effects of treatment were observed on ADG and WW205 (Table 2), and HAB calves showed higher ADG (Fig. 4a) and WW205 (Fig. 4b) than NHAB calves (p=0.0007 and p=0.004 respectively).

Table 2. Parameters estimated by the general linear model for the average daily gain (ADG, kg/d) and weaning weight adjusted to 205 days of age (WW205, kg) of Simmental x Brahman calves according to their sex (female and male) and treatment (HAB = habituated and NHAB = not habituated to corral handling).

Fixed effects		Estimates	Standard error	T-values	CI 95%	P-values
Average daily gain (ADG, kg/d)						
	Intercept	0.30	0.03	11.94	132.22 – 150.69	<0.001
Treatment	NHAB	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
	HAB	0.105	0.03	3.70	5.66 – 26.50	<0.001
Sex	Females	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
	Males	-0.01	0.03	-0.40	11.70 – 9.15	0.69
Weaning weight adjusted to 205 days of age (kg)						
	Intercept	141.46	4.71	30.02	132.22 – 150.69	<0.001
Treatment	NHAB	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
	HAB	16.08	5.32	3.02	5.66 – 26.50	0.004
Sex	Females	*Ref*	*Ref*	*Ref*	*Ref*	*Ref*
	Males	-1.27	5.32	-0.24	-11.70 – 9.15	0.81

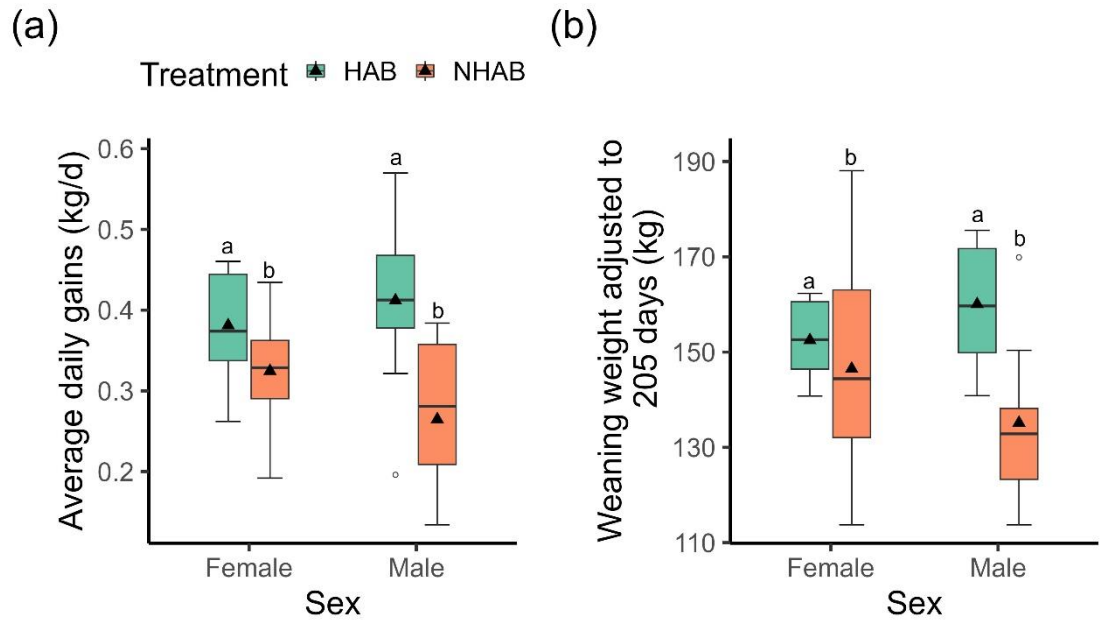

Fig. 4. a) Box plots of average daily gain (ADG, kg/d) and b) weaning weight adjusted to 205 days of age (WW205, kg) of Simmental x Brahman calves according to treatment (HAB = habituated and NHAB = not habituated to corral handling) and sex (female and male) of the calves. Different letters indicate significant differences between treatments ($p<0.05$). Triangles represent means and circles outliers.

4. Discussion

To our knowledge, no study has evaluated the effect of habituating beef calves to corral handling, but, as reported in previous studies carried out with adult cattle and older calves (Boissy and Bouissou, 1988, Petherick et al., 2009, Paranhos da Costa et al., 2021, Ujita et al., 2021), our results showed that the application of this procedure had a positive effect on calf welfare, by reducing calves reactivity and improving performance.

Due to the different management strategies adopted for the two experimental groups (one subjected to the habituation process and the other not), it would be impractical to maintain all cow-calf pairs in the same herd. This condition of working with separate herds can be assumed as a pseudoreplication ("…defined as the use of inferential statistics to test for treatment effects with data from

experiments where either treatments are not replicated (though samples may be) or replicates are not statistically independent…" (Hurlbert, 1984)). We could not avoid this condition without causing another problem by keeping all the animals in the same herd, which would also result in conflicting results. Therefore, we assumed the flaw in the experimental design, believing that the negative effect would be smaller than that resulting from keeping the animals in the same herd.

4.1. Reactivity variables

Our results showed a reduction in flight speed and reactivity scores (assessed on the scale and in the squeeze) of HAB calves over time, while NHAB calves did not change their behavior. These results indicate that the habituation reduced fear of HAB calves when subjected to corral handling. These results are in line with what was recently reported by Ujita et al. (2021), who compared the reactivity of 12-month-old Bos taurus beef heifers subjected to three treatments, one habituated to walk along the corral structures (WCS), another that received tactile stimulation (brushing) for 10 minutes/heifer for seven consecutive days in the chute (TS) and the control group (CON), which was not handled. The authors observed that the heifers from WCS and TS groups improved their behavioral scores in relation to those from CON group, which led them to conclude that both habituation protocols (WCS and TS) reduced the animals' reactivity. The authors emphasized that the TS heifers showed better behavior during handling besides being less reactive.

Complementarily, the results of Paranhos da Costa et al. (2021) showed that the habituation of F1 Holstein-Gyr heifers to humans significantly reduced their flight distance. The authors highlighted the importance of considering the individual differences in the way that heifers responded to the habituation process, which seems to be the case in this study since our results showed high inter-individual variability in calves' behavioral responses, which, in some cases, were assumed as outliers.

In addition, our results showed that habituation resulted in a positive long-term effect (of at least 5 months) on calves reactivity, which is consistent with the studies carried out by Probst et al. (2012), showing that gentle touches at the beginning of life in beef calves, with a duration of 120 minutes, during six days for four weeks, resulted in a reduction of the flight distance and less movements backwards in the box slaughterhouse at 10 months of age.

After the habituation process, more HAB calves left the squeeze chute walking compared to NHAB calves. However, an unexpected reduction was observed in the percentage of animals from both treatments that left the squeeze chute walking at d150, this was probably because all handling procedures for weighing and assigning the scores were carried out with care, without threatening the calves. Our results corroborate previous reports showing that early gentle handling in calves can reduce fear responses and facilitate handling (Boissy and Bouissou, 1988, Boivin et al., 1992, Petherick et al., 2009), being expected that cattle become more reactive when exposed to constant aversive handling (Grandin, 1997), making handling more difficult (Breuer et al., 2003, Pajor et al., 2000) and, consequently, results in more forceful interactions with humans, increasing the risk labor accidents and injuries for both, people and cattle (Lindahl et al., 2016).

Reactivity scores decreased during the habituation process. This reduction in reactivity was expected since similar results were previously reported by Curley et al. (2006), Grandin and Shivley (2015) and Ujita et al. (2021), as cattle get used to the work routines and livestock people involved in it, if they do not represent a threat (Paranhos da Costa and Tarazona, 2011).

The results of our study are also in agreement with those reported by Cooke et al. (2009b), who reported a reduction in the reactivity of Braford and Brahman-Angus heifers after habituation to humans, by Cooke et al. (2012), who observed that Angus × Hereford heifers reduced their flight speed after being subjected to a habituation process to corral handling, and by Petherick et al. (2009), who reported a reduction of flight speed of 5/8 Brahman × 3/8 Shorthorn male calves subjected to good, poor and minimum handling/yarding, leading the authors to conclude that good handling/yarding reduce fearfulness of people.

4.2. Physiological variables

Although the habituation process resulted in differences in the calves' behavior, we did not observe a significant difference between HAB and NHAB calves for any of the evaluated physiological variables. This result partially corroborates the results reported by Lange et al. (2020), who assessed the reactions of beef heifers when subjected to tactile stimulation in different parts of their bodies and did not observe significant differences between treatments in heart rate and vaginal temperature. Nevertheless, the authors reported a reduction of these variables when comparing day -21 and day 14, which was also consistent with our results when considering the first (d-10) and second (d17) assessments.

Regardless of the treatment, there was a significant effect of the assessment day in all physiological indicators. Both rectal temperature and heart rate decreased significantly in the second (d17) compared to the first (d-10) assessment, which suggests that the animals at d-10 were more stressed, probably due to the novelty represented by the corral environment and handling (Braga et al., 2018) and, due to this, showing higher physiological parameters. The reduction of these responses at d17 probably resulted from those calves perceiving corral handling as a non-aversive event.

The significant decrease of all physiological variables from d-10 to d150 in both treatments can be explained by the variation in these parameters as the calves age (3 to 8 months old). These results are consistent with those reported by Bergamasco et al. (2021), who observed higher heart rates in three-month-old calves compared to six-month-old calves, probably due to greater sympathetic tone in younger calves, and with Silva et al. (2017), who described a decrease in heart and respiratory rates in Holstein-Gyr crossbred calves as the time pass and they grow older.

Positive contact with people can also influence cattle heart rate. For example, Waiblinger et al. (2004) reported heart rates of 75.3 and 82.1 bpm for dairy cows that received additional positive handling or not (control) during the experimental tests, which comprised rectalisation and sham insemination.

Independent of the treatments, the values observed by the authors were lower than those observed in our study for HAB and NHAB calves in the d-10 and d17. These differences may be associated with closer contact of dairy calves with people and because they were not separated from their mothers at the assessment time, as was the case in the present study. Independently of the treatment, the heart rates of the HAB and NHAB calves were higher than the reference values for the cattle at the same ages (Feitosa, 2004). On the other hand, respiratory rate and rectal temperature were like those reported by Silva et al. (2016) in both treatments, being within the values considered as reference (Feitosa, 2004, Gonçalves and Barioni, 2000).

4.3. Performance variables

An interesting finding in our study was the difference in the performance variables, with HAB calves showing higher ADG and WW205 than NHAB calves. This best performance, observed for males and females HAB calves, can be explained by the lower demand for energy for HAB calves due to the low stress associated with a reduced fear response when subject to corral handling, as previously described by Turner et al. (2011), which implies in a positive economic impact on cow-calf operation systems.

Few studies have addressed the effects of cattle habituation to corral handling on their performance. In this sense, our results differ from those reported by Cooke et al. (2009a), who showed that habituated heifers had lower average daily gain than non-habituated ones (0.50 vs 0.58 kg/d, respectively). The authors attributed these differences to changes in grazing behavior and extra physical activity to which habituated heifers were submitted. However, this was not the case in our study, probably due to the small number of habituation sessions and the short distances the animals covered when driven from the pasture to the corral and back.

On the other hand, our results are in line with those reporting that more reactive cattle showed lower daily weight gain (Petherick et al., 2002, Behrends et al., 2009, Cafe et al., 2011, Gellatly et al., 2020) and it happens most likely

because they are more susceptible to stressors (Burdick et al., 2011), which may result in lower dry matter intake (Cafe et al., 2011) and, consequently, poor performance.

5. Conclusions

Our results emphasize the importance of promoting positive interactions with the animals during handling, besides exposing them to the corral facilities from an early age without performing aversive handling to create good or neutral memories. Thus, we concluded that habituating beef calves to corral handling improves their welfare, as evidenced by the reduction in calves' reactivity, which probably resulted from having less fear when subjected to handling in the corral and, consequently, less stress and a lower risk of accidents, both for the animals and for the people carrying out the handling, which potentially has a positive effect on calves' performance. Nevertheless, more studies are needed to define the sensitive learning period of calves more precisely, aiming to optimize the work during the habituation process and to determine for how long the effects of habituation last.

Credit authorship contribution statement

Joseph Kaled Grajales-Cedeño: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Writing - Original Draft, Visualization. **Mateus J.R. Paranhos da Costa:** Conceptualization, Methodology, Investigation, Supervision, Writing - Original Draft, Writing - Review & Editing, Visualization.

Declaration of Competing Interest

None.

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CAPITULO IV – Article published in Applied Animal Behavior Science

Quality of human-animal interactions during beef cattle auctions in Panama[4]

Joseph Kaled Grajales Cedeño[1,2,3], Mateus J. R. Paranhos da Costa[3,4,5]

[1] Departamento de Zootecnia, Facultad de Ciencias Agropecuarias, Universidad de Panamá, Panamá.
[2] Programa de Pós-Graduação em Ciência Animal, Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brasil.
[3] Grupo de Estudos e Pesquisas em Etologia e Ecologia Animal (ETCO), Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brasil.
[4] Departamento de Zootecnia, Faculdade de Ciências Agrárias e Veterinárias, UNESP, Jaboticabal, SP, Brasil.
[5] CNPq, Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brasília, DF, 71605-001, Brasil.

* Corresponding author:
Joseph Kaled Grajales Cedeño, Universidad de Panamá, Facultad de Ciencias Agropecuarias, Departamento de Zootecnia, 9MVC+X2H, Panamericana, Chiriquí, Panamá. Email: joseph.grajales@up.ac.pa
Tel. +507 6925 2249

Highlights

- Cattle reactivity affected the human-animal interactions during cattle auctions.
- Calm cattle were sold at a lower value in the Panamanian Auctions.
- Commercialization times for calm, reactive, and highly reactive cattle were similar.

Abstract

This study aimed to determine the quality of human-animal interactions during cattle auctions in Panama and to assess the relationship between cattle reactivity, value paid, and time spent on commercialization. Data were recorded by watching video records of 4531 individual cattle sold in the main Panamanian auctions. Cattle reactivity was assessed by one previously trained observer when the animals entered the box where they were exposed for sale, assigning one of three scores: 1 = calm, 2 = reactive, and 3 = very reactive. Human-animal interactions were assessed using a binary score to assess the occurrence of hitting (1) or not (0) during commercialization. When cattle were hit to stimulate movement, their reactivity was assessed again to determine whether hitting altered their behavior. The value paid (USD/kg of live weight), and the time spent on commercialization (s) of each animal were also recorded in a subsample of 704 animals. Cattle reactivity, genetic group, animal category, auction location and phase of commercialization influenced the occurrence of hits ($p<0.05$). Hitting altered cattle reactivity ($p<0.001$); 95 % of the animals scored calm when they entered the auction box, dropped to 85 % after being hit. There was a significant effect of the reactivity score ($p<0.05$), genetic group ($p=0.01$), location ($p<0.001$) and auction phase ($p=0.002$) on the number of hits received by the cattle when inside the auction box. The median value paid for very reactive cattle tended to be higher than for calm cattle (1.85 vs 1.82 USD/kg; respectively; $p=0.06$). There were no differences in the time spent on commercialization according to cattle reactivity ($p>0.05$). In conclusion, cattle reactivity, and auction phase, in addition to other factors such as genetic group, animal category, and auction location, affected the frequency of negative human-animal interactions during commercialization. Cattle reactivity tended to affect the price paid per head of cattle but not the time spent in marketing.

Keywords: Animal welfare, Behavior, Cattle commercialization, Temperament.

1. Introduction

Panama has a herd of 1,509,900 million cattle heads, managed by an extensive production system (INEC – Instituto Nacional de Estadística y Censo, 2021). Cattle sales are occasionally carried out directly from the producer to the slaughterhouse, and on a large scale, through auctions. The commercialization of the beef cattle auction market is one of the most stressful factors for animals (Gregory, 2008, Bravo et al., 2019, Bravo et al., 2020). During auctions, cattle face additional transportation challenges, such as the novelty of the environment, intense noise, mixing with other animals, food and water restrictions, and aversive handling (Leon et al., 2020, Stojkov et al., 2020). These factors significantly compromise animal welfare (Bravo et al., 2019).

The quality of human-animal interactions is recognized as a key indicator of farm animal welfare (Mellor et al., 2020). Nevertheless, little has been done to understand the implications of the interactions between humans and animals during live cattle auctions on television. Some studies were carried out in auction markets in Chile (Bravo et al., 2019, Sánchez-Hidalgo et al., 2020), Colombia (Herrán et al., 2017, Leon et al., 2020), the United Kingdom (Gregory, 2008, Gregory et al., 2009), and Bangladesh (Alam et al., 2010) and, to the best of our knowledge, only one study (Parish et al., 2018) reported value discounts in calves with greater reactivity sold in auction markets.

At auction facilities, cattle are housed in small pens and identified with numbers corresponding to their order of arrival. Subsequently, they are often driven to a stall or commercialization box, where the animals are stimulated to move continuously when they are auctioned, which most of the time results from negative interactions, such as hits, electric prodding, and other forms of aggressive manipulation by handlers (Bravo et al., 2019). Such aggressive handling causes discomfort and is painful, resulting in behavioral changes (Ceballos et al., 2018), which affect cattle reactivity (Grandin, 1993). These conditions compromise cattle welfare and productive efficiency (Acharya et al., 2022, Hemsworth and Coleman, 2011), negatively affecting the image of the

cattle production chain due to the visibility that such events have been achieved over the years.

Thus, more studies are needed to assess the effects of human-animal interactions during cattle auctions. We hypothesize that hitting cattle to make them move when auctioned, alters their reactivity and that cattle reactivity impacts the value paid, and the time spent for commercialization. Therefore, the objectives of this study were 1) to determine the quality of human-animal interactions during cattle auctions in Panama and 2) to assess the relationships between cattle reactivity, the value paid, and time spent for commercialization.

2. Material and methods

This study was approved by the Institutional Bioethics Committee of the University of Panama (CEIBA-UP-025-2021).

2.1. Auction places, animals, and handling procedures

This study was conducted using data from video recordings of auctions at Subasta Ganadera de Panamá (https://subastaganadera.com/#!/Live) in January 2021. In total, 57.16 h of videos were watched involving 4531 heads of cattle auctioned in five locations: A (7°40’0”N | 80°35’0”O); B (8°28’14.8”N | 82°32’14.3”O); C (8°27’43.8”N | 80°25’17.1”O); D (8°37’30.0”N | 78°06’00.8”O) and E (8°04’39.1”N | 80°52’06.9”O). A trained observer performed all the assessments. The average cattle body weight was 328.70 ± 121.70 (mean ± standard deviation) and the body condition score was 3.02 ± 0.23 (scale from 1 to 5).

Cattle categories were defined by trained personnel from the auction companies, considering sex and body weight, as follows: bulls and heifers calves weighing ≤ 270 kg; steers and heifers weighing 351–500 kg; bulls weighing > 500 kg; and cows weighing 351–500 kg. The animals were allocated into groups according to their arrival order in the reception pens, which were connected to a corridor linked to the weighing and marketing areas. The handlers drove the animals through the corridor in groups to the pen adjacent to the marketing area, from there, cattle were individually driven to the auction box, for sale.

2.2. Assessed variables

2.2.1. Cattle reactivity

Cattle reactivity cattle was assessed by assigning one of three scores (Table 1) adapted from Lanier et al. (2001), Schmidt et al. (2014) and Carvalho et al. (2020). It was always done by a previously trained observer, assigning a score when an animal entered the commercialization box (which has non-slip flooring and follows a standard dimension of 2.30 m high, 2.80 m wide and 4.20 m long for all auction places available) and after being hit with a wooden rod.

Table 1. Scores used to assess cattle reactivity during commercialization at auctions in Panama (adapted from Carvalho et al., 2020; Lanier et al., 2001; Schmidt et al., 2014).

Scores		Cattle behavior
(1)	Calm	Cattle walk slowly, without showing aggressive behavior or sudden movements. The head and neck are down, in a relaxed position.
(2)	Reactive	Cattle walk or run continuously and show vigilant behavior. His head and neck were slightly elevated, and it maintain a fixed gaze, moving his ears in the direction of a noise.
(3)	Very reactive	Cattle keep their head high, are very attentive to the environment, and show violent and continuous movements, turning or fighting violently, trying to go under, cross, or jump the barrier.

2.2.2. Human-cattle interactions, value paid, and commercialization time

The human-cattle interactions were assessed using a binary scoring system by recording the occurrence or not of hits (1 = yes, 0 = no). The handler, located at the top of the box (2.3 m high) where the cattle were auctioned, used to hit cattle with wooden rods when they did not move. Hitting frequency during the commercialization process of each animal was recorded.

The sales value of each animal was recorded (USD/kg of live weight). The time taken to sell each animal (in seconds) was recorded in a subsample of 704 cattle, considering the time each cattle entered the auction box until the hammer went down.

2.3. Statistical analyses

All statistical analyses were performed using the R software with the RStudio integrated development environment (R version 4.3.0; 2023-04-21). For all tests used, significance was considered when $p \leq 0.05$, and trends when p values were between >0.05 and ≤ 0.10.

The normality of residual errors in the adopted models was tested using the Anderson-Darling test, quantile-quantile graph (‘qqnorm{stats}’) and histogram (‘hist{stats}’). The best adjustment of the models adopted for the analyzes was carried out with the 'step-up' procedure using the Akaike information criterion (AIC) and Bayesian information criterion (BIC).

A generalized linear model (GLM) adjusted by a binomial family with logistic coverage was used to evaluate the occurrence of not of wooden rod hits when cattle were inside the auction box, considering sex (female and male), genetic group (crossbred cattle and zebu), animal category (calf, heifers, steer, heifer, cow, bull), reactivity score (calm, reactive, and very reactive), and auction place (A, B, C, D, E) and phase (initial, intermediate and final) as fixed effects. The number of hits was also assessed using GLM considering the reactivity score, sex, genetic group, animal category, auction place and phase as fixed effects. The model was adjusted using the 'step-up' procedure based on the Akaike information criteria (AIC) and Bayesian information criteria (BIC). Multiple comparisons between the adjusted means were performed using the Tukey test. The chi-square test ($\chi 2$) was used to assess the changes in cattle reactivity from before (R1) and after (R2) being hit.

The impact of cattle reactivity on sales value was assessed in a subset of data (n=754), extracted from the large data set (n=4531) using Microsoft Excel® random function to ensure a balance in the number of individuals classified as calm (n=254), reactive (n=254), and very reactive (n=246). In the subset of data obtained after this procedure, a low occurrence was noted for some categories

of animals (calves, heifers and bulls). To solve this problem, the data were regrouped considering the weight of the animals. Thus, characterizing the new categories of animals as bull and heifer calves; steer and heifer; and bull and cow.

The statistical analysis of value paid and the time for commercialization of each animal, which did not meet the statistical assumption of normality, were carried out using the Kruskal-Wallis test, performing the Bonferroni-adjusted Dunn as a post-hoc test. Violin, box and bar plots were used to illustrate the results.

3. Results

3.1. Human-cattle interactions

Overall, 45 % (2064/4531) of the evaluated animals were wooden rod hit when inside the auction box. As summarized in Table 2 ($p \leq 0.05$), cattle classified as reactive were less likely to be hit than those classified as calm; zebu cattle had a lower risk of being hit than crossbred cattle; B, C, D, and E location places had a lower risk of being hit than those in location A and, finally cattle sold in the intermediate phases of the auction were less likely to be hit than those sold at the initial phase of the auction. Trends ($p \leq 0.10$) were observed between calm and very reactive cattle, bull and heifer calves and bulls and cows, and between the initial and final phases of the auction. No significant difference was observed between the sexes.

Table 2. Odds ratios and confidence intervals of hit occurrence on cattle sold at auctions in Panama according to the fixed effects included in the statistical model.

Fixed effects	n	Occurrence (%)	No occurrence (%)	OR	IC 95%	P value
Intercept	754	320 (42.44)	434 (57.56)	5.40	2.73 – 10.96	<0.001
Reactivity Score						
Calm	254	127 (50.00)	127 (50.00)	*Ref*	*Ref*	*Ref*
Reactive	254	102 (40.16)	152 (59.84)	0.67	0.45 – 0.99	0.046
Very reactive	246	91 (36.99)	155 (63.01)	0.71	0.47 – 1.06	0.095
Sex						
Female	259	92 (35.52)	167 (64.48)	*Ref*	*Ref*	*Ref*
Male	495	228 (46.06)	267 (53.94)	1.32	0.88 – 1.98	0.184
Genetic group						
Crossbred	175	85 (48.57)	90 (51.43)	*Ref*	*Ref*	*Ref*
Zebu	579	235 (40.59)	344 (59.41)	0.47	0.31 – 0.72	0.001
Animal category						
Bull and cow	135	45 (33.33)	91 (66.67)	*Ref*	*Ref*	*Ref*
Bull and heifer calves	273	122 (44.69)	151 (55.31)	1.67	0.96 – 2.94	0.072
Steer and heifer	346	153 (44.22)	193 (57.56)	1.47	0.87 – 2.51	0.156
Auction place						
A	113	84 (74.34)	29 (26.66)	*Ref*	*Ref*	*Ref*
B	160	26 (16.25)	134 (83.75)	0.06	0.03 – 0.10	<0.001
C	126	32 (25.40)	94 (74.60)	0.11	0.06 – 0.19	<0.001
D	204	97 (47.55)	107 (52.45)	0.30	0.17 – 0.52	<0.001
E	151	81 (53.64)	70 (46.36)	0.42	0.24 – 0.72	0.002
Auction phase						
Initial	261	121 (46.36)	140 (53.64)	*Ref*	*Ref*	*Ref*
Intermediate	245	90 (36.73)	155 (63.27)	0.57	0.38 – 0.84	0.005
Final	248	109 (43.95)	139 (56.05)	0.70	0.47 – 1.04	0.076

CI 95% = Confidence interval of 95 %; OR = Odds ratio; Ref = Reference value

Likewise, as summarized in Table 3, there was a significant effect of the reactivity score ($p<0.05$), genetic group ($p=0.01$), location ($p<0.001$) and auction phase ($p=0.002$) on the number of hits received by the cattle when inside the auction box. On the other hand, sex and animal category did not present significant differences ($p=0.24$ and $p=0.11$, respectively). Cattle classified as very reactive received more aggressions than the calmer ones ($p=0.05$), and the frequency of aggressions was lower in zebu cattle than in crossbred cattle ($p<0.05$; Table 3). It was also observed that cattle sold at location A received a significantly higher number of attacks than those sold at locations B, C, D and E ($p<0.05$) and that animals sold in the intermediate and final phases of the auction had a significantly lower number of attacks than those sold in the initial phase ($p<0.05$).

Table 3. Adjusted means ± SEM of the number of hits with wooden bars according to reactivity score, sex, genetic group, animal category and auction place and phase in beef cattle sold at auctions in Panama.

Fixed effect	n	LSM± SEM	F value (DF)	P value
Reactivity score				
Calm	254	1.47 ± 0.10[a]		
Reactive	254	1.23 ± 0.11[ab]	2.96 (2)	0.05
Very reactive	246	1.14 ± 0.12[b]		
Sex				
Female	259	1.20±0.10	1.34 (1)	0.24
Male	495	1.36±0.09		
Genetic group				
Crossbred	175	1.51±0.12[a]	10.55 (1)	0.001
Zebu	579	1.05±0.07[b]		
Animal category				
Bull and cow	135	1.07±0.15		
Bull and heifer calves	273	1.45±0.11	2.13 (2)	0.11
Steer and heifer	346	1.31±0.09		
Auction place				
A	113	3.09±0.15[a]		
B	160	0.37±0.12[d]		
C	126	0.47±0.14[cd]	62.92 (4)	<0.001
D	204	0.94±0.13[c]		
E	151	1.52±0.14[b]		
Auction phase				
Initial	261	1.55±0.11[a]		
Intermediate	245	1.18±0.11[b]	5.99 (2)	0.002
Final	248	1.11±0.11[b]		

Means followed by different letters indicate statistically differences ($p<0.05$). DF = degrees of freedom.

The occurrence of hits increased cattle reactivity ($\chi2=13.52$, DF=2, $p=0.001$). Initially, 94 % of the animals were calm when entering the auction box; however, after being hit, this percentage decreased to 85 % (Fig. 1). The

percentage of reactive and very reactive animals increased from 5 % to 11 %, and from 1 % to 4 %, respectively, after being hit in the auction box (Fig. 1).

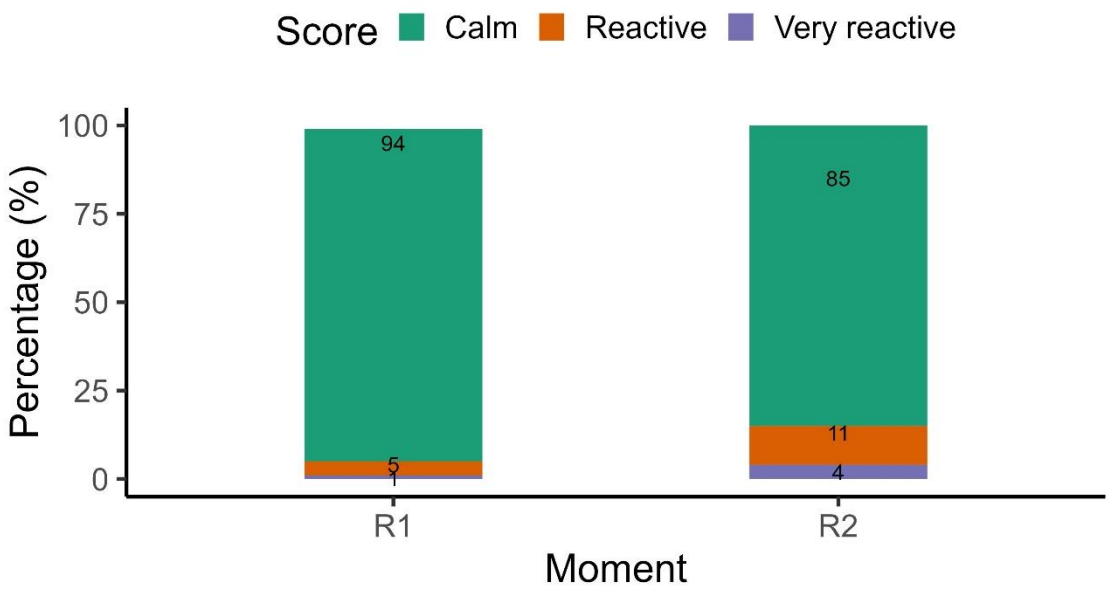

Fig. 1. Effect of aggressive handling on changes in the reactivity index of cattle auctioned in Panama (n=2064). Reactivity was assessed when the cattle entered the auction (R1) and again after being hit (R2).

3.2. Value paid and time spent for commercialization

The analysis of the price of traded cattle revealed a tendency towards significance in relation to animal reactivity (KW= 5.74, df = 2, p=0.06), with only animals classified as calm and highly reactive demonstrating a trend (p=0.06). For animals classified as calm, reactive and very reactive, the medians and (interquartile ranges) were 1.82 [0.31], 1.82 [0.32] and 1.85 [0.27] USD/kg, respectively (Fig. 2).

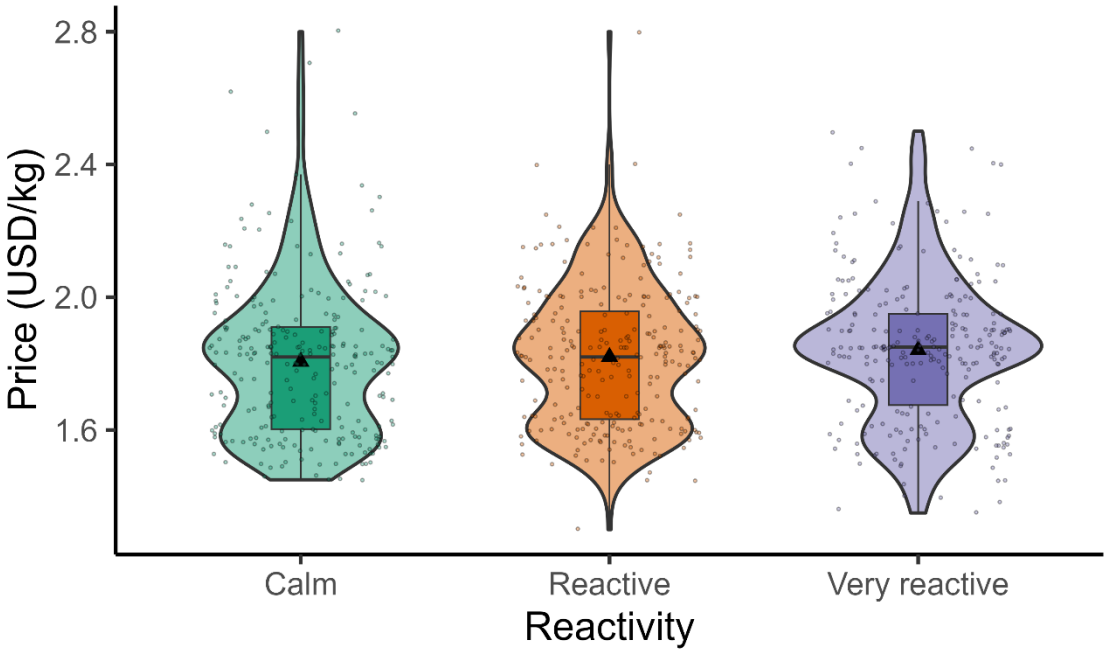

Fig. 2. Amount paid (USD/kg) according to reactivity score of auctioned cattle in Panama (n=754). The upper and lower box lines represent the interquartile range (25–75 %); the black line indicates the median and the black triangle indicates the mean; ° indicates individual variation, and the width of the figures represents the distribution of the data (wider sections represent a greater number of data). Different letters indicate statistical significance ($p<0.05$).

The commercialization time did not differ significantly between the reactivity scores (KW=0.72; df=2; p=0.69). The medians and interquartile ranges (between brackets) for calm, reactive and very reactive cattle were 22.10 [11.0], 21.60 [10.9], and 24.10 [13.1] seconds, respectively; Fig. 3.

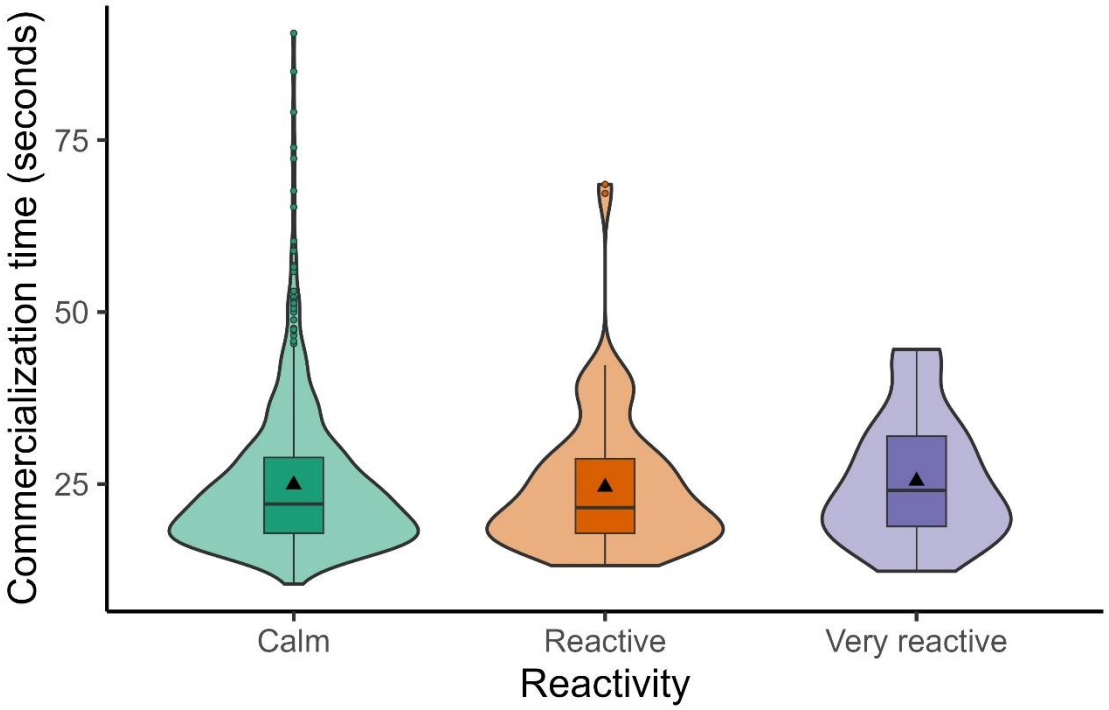

Fig. 3. Commercialization time (s) of cattle during auction according to reactivity score (n=704). Upper and lower box lines represent the interquartile range (25–75 %); The black line indicates the median and the black triangle the mean; ° indicates individual variation and the width of the figures represents the distribution of the data (wider sections represent a greater number of data).

4. Discussion

As far as we know, this is probably the first study to address the implications of human-animal interactions during cattle commercialization at Panamanian auctions. Our results indicated that 45 % of the assessed cattle received at least one aversive handling, being hit with wooden bars when inside the auction box. However, we did not carry out a complete assessment of human-animal interactions during the handling procedures since we were not able to assess the human-cattle interaction in the other areas of the auction facilities (e.g., unloading ramp, aisles and corrals), where they were handled before being driven to the auction box. An additional limitation of our data was that we were not able to identify who was in charge of cattle handling in the auction box, considering that more than one person was responsible of doing it in each auction place.

Our results agree with those of Sánchez-Hidalgo et al. (2020), who reported that the most common negative tactile interactions in dairy cows were caused by electric shock and hitting them with wooden bars or plastic tubes. Additionally, a study conducted by Bravo et al. (2019) suggested that one of the main challenges related to animal welfare at auctions is inadequate handling, probably caused by a lack of training and infrastructure problems. In a study at an agricultural fair in Brazil, Carvalho et al. (2019) reported that 57 % of the batches sold at the fair received negative interactions (screams, hits, and electric shocks).

Upon entering the auction box, calm cattle were more susceptible to a higher incidence of hits than the reactive ones. These results could be partially explained by the fact that Bos indicus cattle are usually more reactive than Bos taurus (Sant'Anna et al., 2012), although individual differences should be considered (Boissy and Bouissou, 1995). Our results confirmed this expectation because zebu cattle were less likely to be hit and at the same time received fewer hits than crossbreed cattle.

The study revealed that the animal category significantly influenced both the occurrence and number of hits received by cattle. Bull and heifer calves showed a trend to have a lower risk of being hit than bulls and cows but did not differ in the number of hits than the other categories. However, it is important to note that the incidence of hits was more than one for all the categories analyzed. It is likely that many adult animals sold at auctions were commercialized for slaughter, raising concerns about the quality of handling, which could affect the incidence of bruising. Previous studies have highlighted that such adverse interactions compromise animal welfare and increase the likelihood of bruising carcasses. This occurrence not only harms meat quality but also has significant economic implications (Bethancourt-Garcia et al., 2019, Sullivan et al., 2022).

Several studies have indicated that cattle that go through auctions before slaughter exhibit more bruises on their carcasses than those sold directly in slaughterhouses (Weeks et al., 2002, Strappini et al., 2010, Strappini et al., 2012). It is worth considering that during the auction, some animals received up to 33 hits, which further increased the risk of bruising in animals that would later be slaughtered.

Another factor that influenced the quality of human-animal interactions during cattle trading was the location where the auction took place. Auction place A showed higher risk and more hits compared to the other auction places. These results can be attributed to various factors not assessed in this study, such as cultural aspects, levels of education, experience in cattle handling, and worker training.

Studies conducted in Colombia by Leon et al. (2020) demonstrated that both the attitudes and empathy of handlers affect the quality of human-cattle interactions, corroborating the findings of Hemsworth and Coleman (2011). Moreover, motivation and job satisfaction can influence the quality of human-animal interactions, directly impacting animal welfare.

Our results showed that animals sold at the intermediate and final phase of the auction received less aggression than those sold at the initial phase, suggesting an effect of workers' tiredness, which increased throughout labor day.

In support of our hypothesis, we observed that the presence of negative human-animal interactions had a significant effect on cattle behavior. Initially, 94 % of the cattle were calm when they entered the auction box. However, this percentage decreased to 85 % after being hit. These results agree with those of previous studies that described aversive actions, such as hits, increasing fear in animals (Grandin, 2014), a consequence of the occurrence of undesirable behaviors (Ceballos et al., 2018), such as an increase in reactivity (Petherick et al., 2009), which represents a danger for the handlers (Grandin, 1993). In line with our results, Herrán et al. (2017) also reported that negative interactions such as hitting and screaming caused greater reactivity and agonistic behaviors in animals sold at auctions.

The value paid and time spent in cattle commercialization at auctions are essential to ensure the business's success. The times required for the commercialization of calm, reactive, and highly reactive animals were similar. Therefore, hitting cattle to move when auctioned does not provide any practical benefits; however, it negatively impacts animal welfare. The results of a survey conducted at Brazilian auctions showed that 79 % of the respondents indicated that hitting cattle could interfere with purchasing decisions (Carvalho et al., 2019), in addition to creating a negative image of the livestock production chain.

Cattle classified as reactive and very reactive tended to have a higher value when sold (USD$0.05 and USD$0.02/kg of live weight, respectively) than those classified as calm. Considering a calf weighing 200 kg, it is reasonable to expect animals classified as very reactive to generate an income of USD$370.00, in contrast to US$364.00 generated by an animal classified as calm. This result presents a discrepancy in relation to the study carried out by Parish et al. (2018), who observed a significantly higher value associated with calves that demonstrated calm or mildly alarmed behavior compared to those classified as moderately alarmed, nervous, or aggressive.

The fact that buyers seem to pay a higher price for very reactive cattle than calm ones could be attributed to a lack of knowledge. Therefore, the results should be interpreted with great caution, as there is a large body of research indicating that cattle with higher reactivity are less efficient both productively and reproductively than calm animals (Acharya et al., 2022, Brandão et al., 2021).

It is worth considering that frequent training of handlers and the adoption of good practices of animal welfare as a routine in farms are essential to reduce negative interactions between humans and animals. For example, Paranhos da Costa and Ceballos (2021) suggest that positive interactions between humans and animals could promote handlers' motivation and improve their professional performance. Furthermore, good handling practices offer safer labor conditions, promoting the welfare of cattle and the well-being of people carrying out work during their daily routine (Paranhos da Costa et al., 2019).

Furthermore, employee training and knowledge transfer to all members of the cattle production chain can improve animal welfare, and consequently, productivity, economy, and business vitality. This is supported by the results of studies carried out in Brazil, Chile, and Uruguay, which demonstrated that the application of good practices for animal welfare during pre-slaughter handling could reduce aggressive handling, and consequently, the incidence of bruises on cattle carcasses (Paranhos da Costa et al., 2012).

Finally, our results can be explained according to the model of the five domains of animal welfare (Mellor et al., 2020), because the cattle that were hit altered their behavior due to the negative interactions (domain 4), resulting in increased reactivity, which in turn makes it difficult to carry out handling procedures that, in turn, result in more stress for both cattle and people. This

could potentially harm health (by increasing the risk of accidents and depression of the immune system) and reduce food intake. Together, these conditions increase the likelihood of animals experiencing fear, pain, and discomfort, thereby affecting their mental state, and resulting in a negative welfare state.

5. Conclusions

In conclusion, cattle reactivity, genetic group, animal category, auction location, and commercialization phase affected the frequency of negative tactile interactions received by cattle in Panamanian auctions. Hitting cattle changed their behavior, resulting in more reactive animals. Cattle reactivity tended to influence the monetary value paid for each cattle; however, it did not affect the time required to sell each animal.

Credit authorship contribution statement

Joseph Kaled Grajales-Cedeño: Conceptualization, methodology, software, formal analysis, investigation, resources, writing–original draft, and visualization. **Mateus J.R. Paranhos da Costa:** Conceptualization, methodology, investigation, supervision, writing–original draft, writing–review and editing and visualization.

Declaration of Competing Interest

The authors declare no conflict of interest.

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Considerações finais

No primeiro capítulo, é apresentada uma revisão da literatura que demonstra como o contato tátil positivo, independentemente da duração e da frequência, ao longo da vida dos animais pode melhorar suas interações com humanos e promover o bem-estar em espécies de interesse zootécnico. No entanto, é importante salientar que as respostas a estímulos como o contato tátil positivo podem variar entre indivíduos e espécies, dependendo de suas histórias evolutivas e experiências anteriores. Essa variabilidade ressalta a necessidade de estratégias de manejo adaptadas às características de cada espécie e indivíduo.

O segundo capítulo revela que a estimulação tátil realizada até 24 horas após o nascimento, por um período de oito minutos, foi eficaz em reduzir a reatividade de bezerras ao desmame. Este achado sugere que tal prática pode ser uma estratégia eficiente para facilitar o manejo, reduzir o estresse durante futuras interações em curral e, consequentemente, promover o bem-estar animal. Ademais, é possível que essa prática contribua para a melhoria da eficiência reprodutiva nesta categoria animal ao reduzir a reatividade e o estresse durante sessões de manejo. Estudos futuros devem explorar a variabilidade temporal e os impactos de médio e longo prazo da estimulação tátil para compreender melhor seus efeitos.

No terceiro capítulo, os resultados indicam que a habituação ao manejo no curral reduziu a reatividade e melhorou o desempenho de bezerros mestiços de corte. A redução das respostas de medo e o aumento no ganho médio diário de peso e no peso ao desmame destacam a importância de um manejo prévio adequado para minimizar o estresse e promover o bem-estar animal. Estes achados sugerem que a habituação poderia melhorar a eficiência operacional durante as sessões de manejo, agilizando e facilitando o trabalho no campo. Além de diminuir o risco de acidentes.

O quarto capítulo aborda as interações humano-animal durante a comercialização de bovinos em leilões. Os resultados indicam que interações negativas, como agressões aplicadas para estimular o movimento dos bovinos durante a comercialização, aumentaram sua reatividade, o que pode ter implicações negativas para o bem-estar animal e para a imagem da pecuária.

Além disso, a reatividade dos bovinos apresentou uma tendência a influenciar o valor pago por animal, sugerindo que compradores podem avaliar os animais de maneira diferenciada com base em seu comportamento durante a venda. No entanto, a valorização de animais mais reativos não deve ser considerada um aspecto positivo, pois pode haver um componente cultural que erroneamente considera esses animais mais vigorosos, sem compreender as implicações negativas das práticas agressivas e do temperamento sobre os indicadores zootécnicos. Além disso, uma alta incidência de agressões durante a comercialização em leilões pode resultar em contusões nas carcaças, causando riscos de perdas econômicas significativas e descontos para o produtor e para toda a cadeia produtiva. Esses achados reforçam a necessidade de aprimorar as práticas de manejo em leilões, minimizando interações negativas e promovendo um ambiente que favoreça tanto o bem-estar dos animais quanto o sucesso comercial.

De modo geral, os estudos apresentados nesta tese enfatizam a importância da adoção de boas práticas de manejo, como a estimulação tátil positiva e a habituação ao manejo no curral, para promover interações positivas entre humanos e bovinos de corte em diferentes contextos de produção. Esses achados reforçam a necessidade de práticas que respeitem o bem-estar animal, contribuam para um manejo eficiente e promovam uma pecuária mais ética e sustentável.

Os estudos pioneiros realizados no Panamá, descritos nesta tese, proporcionaram uma contribuição científica significativa que sustentou a criação da disciplina de Comportamento e Bem-Estar Animal na Facultad de Ciencias Agropecuarias da Universidade do Panamá, tanto em nível de graduação quanto de pós-graduação. Além disso, os resultados obtidos já estão sendo incorporados em algumas práticas de manejo de fazendas comerciais mais progressistas, criando oportunidades de melhorias ao longo de toda a cadeia produtiva. No entanto, ainda existem muitas barreiras técnicas e culturais a serem superadas para a adoção ampla de boas práticas de manejo. Portanto, é essencial o treinamento contínuo e a educação dos envolvidos, bem como a implementação consistente dessas práticas no manejo diário dos animais.