



SERVIÇO PÚBLICO FEDERAL
MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE UBERLÂNDIA
FACULDADE DE MEDICINA VETERINÁRIA
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS VETERINÁRIAS



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FACULDADE DE MEDICINA VETERINÁRIA

DOENÇA RESPIRATÓRIA BOVINA E ALTERAÇÕES
MUSCULOESQUELÉTICAS EM BOVINOS CONFINADOS
NO BRASIL: UMA AVALIAÇÃO DOS ASPECTOS DE
MORTALIDADE, MORBIDADE E PREJUÍZOS
ECONÔMICOS

Anderson Lopes Baptista

Médico Veterinário

UBERLÂNDIA – MINAS GERAIS - BRASIL
Fevereiro de 2023



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Orientador: Prof. Dr. João Paulo Elsen Saut

Tese apresentada à Faculdade de Medicina Veterinária - UFU, como parte das exigências para a obtenção do título de Doutor em Ciências Veterinárias (Saúde Animal ou Produção Animal).

UBERLÂNDIA – MINAS GERAIS - BRASIL

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DADOS CURRICULARES DO AUTOR

Anderson Lopes Baptista – nascido na cidade de Presidente Alves, Estado de São Paulo aos oito dias do mês de outubro de um mil novecentos e setenta e três. Ingressou na faculdade de Medicina Veterinária no ano de 1994 concluindo o curso no segundo semestre de 1998 na Universidade do Oeste Paulista (UNOESTE). Desde então trabalhou em assistência em Fazendas na região de Içanga, estado de São Paulo até 2003. Entre 2003 e 2018 trabalhou na função de Médico Veterinário na Empresa AC Proteína, trabalhando com sanidade de bovinos confinados nos Estados de Minas e Goiás. Em dezembro de 2014 foi aprovado no processo seletivo de Pós-Graduação em Ciências Veterinárias (Mestrado) da UFU para ingresso em março de 2015 e conclusão no primeiro semestre de 2017. Atualmente proprietário da Empresa com foco Consultoria que atende 43 confinamentos em 09 Estados Brasileiros e 01 confinamento no Paraguai, com ênfase em Gestão Sanitária desses animais confinados. E acadêmico do curso de Doutorado da UFU desde março de 2019.

A Deus em primeiro lugar e a minha família
que sempre me apoiou nesta jornada.

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“Por vezes sentimos que aquilo que fazemos não é se não uma gota de água no mar. Mas o mar seria menor se lhe faltasse uma gota.”

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Sumário

1. CAPÍTULO 1 – CONSIDERAÇÕES GERAIS	11
1.1 Introdução	11
1.2 Objetivos	12
1.3 Revisão	12
1.3.1 Fatores de riscos nos confinamentos.....	12
1.3.2 Problemas relacionados a criação de bovinos de corte confinados	14
1.3.3 Doença Respiratória Bovina	15
1.3.4 Claudicação	18
1.4 Referências	22
2 CAPÍTULO 2 – THE ECONOMIC IMPACTS OF THE BOVINE RESPIRATORY DISEASE COMPLEX ON BEEF CATTLE FEEDLOTS IN BRAZIL	26
2.1 Introduction	27
2.2 Material and Methods	28
2.2.1 Animals, data collection, and study area	28
2.2.2 Data collection and characterization of BRD.....	29
2.2.3 Production indices.....	30
2.2.4 Economic impacts associated with BRD.....	30
2.2.5 Statistical analyses	31
2.3 Results	31
2.3.1 Epidemiological data	31
2.3.2 Production indices.....	35
2.3.3 Economic impacts	35
2.4 Discussion	37
2.5 Conclusion	40
2.6 References	40
3 CAPÍTULO 3 – AN ASSESSMENT OF THE HOOF LESIONS, SKELETAL FRACTURES, AND SOFT TISSUE AND CUTANEOUS TRAUMATIC ALTERATIONS RESPONSIBLE FOR LAMENESS OBSERVED IN BEEF CATTLE FEEDLOTS FROM BRAZIL	44
3.1 Introduction	45
3.2 Material and methods	46
3.2.1 Study area, animals and data collection	46
3.2.2 Statistical analyses	50
3.3 Results	50
3.4 Discussion	55

3.5 Conclusion	58
3.6 References	59

ESTUDO DE MORBIDADE E MORTALIDADE DA DOENÇA RESPIRATÓRIA BOVINA E AFECÇÕES DO SISTEMA MUSCULOESQUELÉTICO NOS BOVINOS DE CORTE DE CONFINAMENTO

RESUMO – A pecuária intensiva de corte é uma atividade crescente no Brasil e uma forma de obter um produto de maior qualidade e aumentar a produtividade. No entanto, à medida que a densidade de animais aumenta, há maior suscetibilidade a doenças ou lesões devido a vários fatores de risco durante o ciclo de confinamento, como transporte, alimentação com alto teor de carboidratos, socialização, excesso de poeira e condições ambientais adversas. Dentre as doenças mais comuns, destacam-se a doença respiratória bovina e as afecções do sistema musculoesquelético, as quais causam grandes perdas. O objetivo do presente estudo foi avaliar as taxas de morbidade e mortalidade de bovinos confinados em São Paulo, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás e Pará. Os dados foram coletados em 10 e 22 confinamentos comerciais, durante períodos de 2 e 5 anos, totalizando 699.526 e 1.972.884 animais avaliados para doenças respiratórias bovinas e afecções do sistema musculoesquelético, respectivamente. Os resultados mostraram que a morbidade e a mortalidade foram mais elevadas em bovinos com até 30 dias de confinamento, sugerindo que o manejo do transporte tem um impacto negativo. As taxas de morbidade observadas foram de 3,6% e 4,97% para todas as doenças, sendo 2,08% associada a DRB e 1,19% a afecções musculoesqueléticas. Quanto às taxas de mortalidade geral, foram de 0,38% e 0,57%, sendo 0,08% para DRB e 0,171% para afecções musculoesqueléticas. Foram observados prejuízos na produção, com redução no ganho de peso e custos decorrentes da morbidade e mortalidade relacionadas à DRB, resultando em uma perda anual estimada de US\$ 6,9 milhões. As lesões nos cascos foram frequentes, entretanto, as fraturas de membros apresentaram alta letalidade, ambas relacionadas à estação chuvosa. Estes estudos de investigação da incidência de duas doenças comuns que impactam a produção de gado de corte podem ser utilizados como referência importante para compreender as perdas na pecuária local.

Palavras-Chave: consequências econômicas, fraturas, claudicação, gado, doença pulmonar

STUDY OF MORBIDITY AND MORTALITY OF BOVINE RESPIRATORY DISEASE AND INJURIES OF MUSCULOSKELETAL SYSTEM IN BEEF CATTLE FEEDLOT

SUMMARY – Intensive beef cattle farming is a growing activity in Brazil and a way to obtain a higher quality product and increase productivity. However, as animal density increases, there is greater susceptibility to diseases or injuries due to various risk factors during the confinement cycle, such as transportation, feeding with high carbohydrate, socialization, excessive dust, and adverse environmental conditions. Among the most common diseases are bovine respiratory disease and musculoskeletal system injuries, which cause significant losses. The objective of the present study was to evaluate the morbidity and mortality rates of confined cattle in São Paulo, Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás, and Pará. Data were collected from 10 and 22 commercial feedlots, over periods of 2 and 5 years, totaling 699,526 and 1,972,884 animals evaluated for bovine respiratory diseases and musculoskeletal system injuries, respectively. Results showed that morbidity and mortality were higher in cattle with up to 30 days of confinement, suggesting that transport management has a negative impact. The observed morbidity rates were 3.6% and 4.97% for all diseases, with 2.08% associated with bovine respiratory disease and 1.19% with musculoskeletal system injuries. Regarding overall mortality rates, they were 0.38% and 0.57%, with 0.08% for bovine respiratory disease and 0.171% for musculoskeletal system injuries. Production losses were observed, with reduced weight gain and costs resulting from morbidity and mortality related to bovine respiratory disease, resulting in an estimated annual loss of 6.9 million USD. Hoof injuries were frequent, however, limb fractures had high lethality, both related to the rainy season. These studies investigating the incidence of two common diseases that impact beef cattle production can be used as an important reference to understand losses in local livestock production.

Keywords: economic consequences, fractures, lameness, livestock, pulmonary disease

1. CAPÍTULO 1 – CONSIDERAÇÕES GERAIS

1.1 Introdução

A produção de carne bovina é um dos setores mais importantes do agronegócio brasileiro, sendo o Brasil o maior exportador mundial de carne bovina, movimentando 913 milhões de reais em 2021 (ABIEC, 2022a). A criação de bovinos em confinamento tem se destacado como uma alternativa para a produção de carne de qualidade. A terminação de bovinos em confinamento começou a crescer no Brasil na década de 80 e, atualmente, cerca de 15,4% dos bovinos abatidos são animais de confinamento (ABIEC, 2022a). Embora o confinamento de bovinos ofereça ao mercado animais mais jovens e com melhor qualidade de carcaça, também apresenta desafios significativos para a saúde dos rebanhos (PEIXOTO, 1996). Devido ao maior adensamento de animais e tipo de manejo, surgem problemas sanitários, como doenças respiratórias, digestivas, metabólicas, locomotoras, entre outras, podendo resultar em perdas consideráveis nos confinamentos de bovinos de corte (USDA, 2015b).

Embora muitos estudos considerem apenas aquisição de vacinas, remédios e animais mortos como custos de sanidade, as doenças também resultam em perdas econômicas que incluem piora na conversão alimentar, menor ganho de peso, condenações de carcaças, honorários profissionais, custos de tratamentos e morte do animal (Lopes and Magalhães, 2005). Todos esses custos variam de acordo com as taxas de morbidade e mortalidade (Snowder et al., 2006). No Brasil, a incidência e prevalência de doenças no gado confinado ainda são pouco conhecidas, o que resulta em falta de dados relativos aos impactos econômicos das doenças nos confinamentos de bovinos de corte no país.

Portanto, é essencial que os produtores estejam cientes dos desafios sanitários envolvidos na criação de bovinos em confinamento e implementem práticas de manejo adequadas para minimizar a ocorrência de doenças. Além disso, é fundamental que sejam realizados mais estudos para compreender a incidência e prevalência de doenças nos confinamentos de bovinos de corte no Brasil e, conseqüentemente, estimar os impactos econômicos das doenças nos confinamentos. Dessa forma, será possível garantir a rentabilidade da atividade

e a permanência do produtor no mercado, além de promover a produção de carne bovina de qualidade e segura para o consumidor final.

1.2 Objetivos

O objetivo do presente estudo foi identificar as taxas de morbidade e mortalidade das principais afecções que acometem os bovinos de corte confinados, bem como, estimar as perdas econômicas.

1.3 Revisão

1.3.1 Fatores de riscos nos confinamentos

O uso de confinamentos para terminar animais precocemente envolve mudanças no manejo e ambiente, que são ações estressantes para os animais (Buckham Sporer et al., 2008). O desmame, castração, descorna, jejum, transporte, exposição a agentes infecciosos, mudanças de dieta, as variações da temperatura ambiental, ressocialização e outros fatores podem ocorrer antes, na chegada e durante o confinamento (Schaefer et al., 1988).

O transporte inadequado compromete o bem-estar animal, podendo causar contusões, fraturas, arranhões, exaustão metabólica, desidratação, estresse de temperatura e até morte (Schaefer et al., 1988; Gregory, 1994; Deus et al., 1999). Para reduzir tais riscos, manter os animais em pé durante as viagens, mesmo em trajetos longos, é uma prática recomendada. Estudos indicam que a distância do transporte está relacionada ao tempo de jejum dos bovinos, o que pode aumentar o estresse (Deus et al., 1999). A distância percorrida pelos animais tem sido associada a um aumento na susceptibilidade a doenças, sendo que aqueles que viajaram por mais de 480 km apresentaram maior risco (Kent and Ewbank, 1983). Além disso, fatores como a hora do dia e o tempo de transporte também são importantes e podem influenciar as taxas de morbidade e mortalidade dos animais (Kent and Ewbank, 1983). Além disso, o transporte de animais jovens pode alterar os parâmetros fisiológicos sanguíneos ligados ao estresse (Buckham Sporer et al., 2008). Para garantir a saúde e o bem-estar dos animais, é fundamental levar em conta fatores relacionados à

logística de transporte, ao considerar esses fatores, é possível reduzir o estresse dos animais e minimizar a ocorrência de doenças.

A mistura de animais de diferentes origens é um dos principais fatores de risco para a doença do complexo respiratório em bovinos, superando até mesmo outros fatores de estresse (Thompson, 1983). No entanto, é possível que doenças ocorram mesmo sem mistura de animais ou outros fatores estressantes. A organização social do rebanho pode ser afetada pela mistura de animais em um lote e levar a interações agonísticas, como brigas e sodomia, até que a hierarquia de dominância social seja estabelecida novamente (Hubbard et al., 2021). No entanto, essas interações podem causar lesões e afetar a frequência da alimentação (Hubbard et al., 2021). É importante, portanto, escolher lotes homogêneos e fornecer espaço adequado para garantir um bom desempenho do lote (Polli and Restle, 1995).

Tradicionalmente, o gado é criado ao ar livre, o que os torna vulneráveis a condições ambientais extremas e mudanças rápidas (Mader and Griffin, 2015). Para a maioria dos bovinos, as condições ideais de temperatura e umidade relativa do ar são de 13 a 18°C e 60 a 70%, respectivamente (Brown-Brandl, 2018). Quando a temperatura ultrapassa essa faixa de conforto, há uma redução no consumo de alimento, o que pode levar a problemas de saúde (Brown-Brandl, 2018). No entanto, os animais têm a capacidade de se adaptar às condições do ambiente, ajustando seu metabolismo fisiológico e comportamento (Mader and Griffin, 2015).

Para garantir o bem-estar dos animais, é importante considerar as condições climáticas em que estão expostos. Em condições quentes, a disponibilidade de água é essencial, assim como bebedouros grandes e de fácil acesso (Mader, 2003). Além disso, a sombra é uma medida eficiente para reduzir o calor radiante em até 30% ou mais, proporcionando mais conforto térmico aos animais durante o verão. A aspersão de água sobre os animais também pode ajudar a aliviar o estresse causado pelo calor. Já em condições frias, é importante manter as instalações secas para evitar que os animais se molhem. Portanto, é necessário considerar alternativas de manejo e instalações que ajudem os animais a lidar com as condições ambientais e garantam o seu bem-estar (Mader and Griffin, 2015).

A produção de poeira é comum nos confinamentos de gado de corte. A carga de poeira presente nesses ambientes pode causar estresse no sistema respiratório dos bovinos, predispondo-os a infecções por patógenos virais e bacterianos, dependendo do número e dos tipos de microrganismos presentes na poeira. O aumento da incidência de pneumonia nos animais confinados está associado à variação da temperatura e ao aumento do tamanho das partículas de poeira (MacVean et al., 1986). No entanto, outro estudo sugeriu que temperaturas elevadas e baixa umidade associadas à alta atividade dos bovinos com aumento na movimentação contribuem para a produção de poeira e não encontrou microrganismos presentes em suspensão de poeira (Wilson et al., 2002).

A bovinocultura de corte apresenta maior incidência de problemas metabólicos devido à dieta rica em concentrados, que visa obter um elevado ganho de peso diário e reduzir o tempo para abate. A alimentação com dietas ricas em carboidratos pode causar alterações fisiológicas no rúmen, predispondo os animais a distúrbios metabólicos (Paulino et al., 2013).

A garantia da saúde e bem-estar dos animais é essencial na produção de bovinos de corte. Durante o transporte, é importante adotar medidas de manejo para minimizar o estresse nos animais, como a escolha de veículos adequados e a redução do tempo de transporte. A homogeneização do lote e a adoção de medidas de manejo para minimizar o estresse ambiental, como a oferta de sombra e aspersão de água, também são fundamentais para garantir a eficiência da produção e a saúde dos animais. A produção de poeira e os problemas metabólicos são outros fatores que devem ser considerados, exigindo a adoção de medidas de manejo adequadas para prevenir doenças e garantir a qualidade do produto final. Em suma, a implementação de boas práticas de manejo é essencial para garantir a sustentabilidade e eficiência da produção de bovinos de corte.

1.3.2 Problemas relacionados a criação de bovinos de corte confinados

A saúde dos bovinos é crucial para a produção bem-sucedida e, embora muitas doenças possam ser tratadas facilmente, é importante identificá-las e tratá-las rapidamente para evitar complicações graves. Por isso, o manejo

adequado dos animais é a melhor forma de prevenir doenças durante o período de confinamento (Noffsinger et al., 2015). Os responsáveis pela inspeção dos animais devem ser bem treinados para identificar sinais de desordem de saúde e medicá-los de acordo com as prescrições do médico veterinário. As doenças mais comuns em bovinos de corte incluem o complexo respiratório, ceratoconjuntivite, problemas digestivos, locomotores, distúrbios nutricionais e doenças infecciosas (PEIXOTO, 1996).

A compreensão das doenças que afetam os bovinos em confinamentos é essencial para garantir a saúde e o sucesso da produção. O complexo de doença respiratória bovina e os distúrbios do sistema locomotor merecem uma atenção especial, pois são as principais causas de perdas no sistema. Por isso, a avaliação das taxas de morbidade e mortalidade, juntamente com as análises descritivas e quantitativas das doenças e do tempo de ocorrência, oferecem informações valiosas para a compreensão da causa e da patologia desses processos. É fundamental que produtores e veterinários estejam sempre atentos à saúde dos animais e tomem medidas preventivas e terapêuticas quando necessário.

1.3.3 Doença Respiratória Bovina

A Doença Respiratória Bovina (DRB) é uma doença multifatorial que envolve diversos agentes infecciosos, alterações abruptas no manejo e situações adversas do ambiente. DRB causa altas taxas de mortalidade em bovinos leiteiros e bezerros, sendo considerada a principal causa de morte em bovinos confinados nos EUA (USDA, 2015b). No entanto, dados clínico-epidemiológicos sobre a DRB ainda são limitados no Brasil em comparação com outros países. Um estudo retrospectivo realizado no Rio Grande do Sul analisou 33 surtos de DRB ao longo de 12 anos, com 18 em bovinos de leite, 13 em bovinos de corte e apenas um em gado de confinamento (Brasil et al., 2013). A taxa de morbidade das infecções respiratórias variou de 0,06% a 100%, com mortalidade de 0,06% a 34,6%, sendo que todos os animais afetados eram bezerros com menos de 12 meses de idade (Brasil et al., 2013).

Apenas um estudo realizado no Brasil durante dois anos demonstrou as taxas e estimativas de perdas pela DRB nos confinamentos de bovinos de corte.

A DRB teve uma morbidade de 6,13% (11.577/188.862) e uma mortalidade de 0,21% (397/188.862) (Baptista et al., 2017). Além disso, os gastos associados à DRB foram significativos, totalizando US\$ 14.334,00 e US\$ 16.315,40 para cada 10.000 bovinos em mortalidade e morbidade, respectivamente. E as perdas econômicas anuais foram estimadas em US\$ 6,31 milhões e US\$ 5,54 milhões para morbidade e mortalidade, respectivamente, totalizando uma perda anual de US\$ 11,85 milhões (Baptista et al., 2017).

Durante um período de dois anos em um confinamento em Goiás, a DRB foi identificada como o maior problema de saúde em bovinos, representando de 44,1% a 46,7% de todos os casos diagnosticados. Os custos de tratamento foram significativos, totalizando em média de 7% a 15% do peso vivo alvo a ser alcançado no final do sistema tradicional de produção.

O desempenho de 5.976 bovinos de confinamento foi avaliado, encontrando uma incidência de DRB de 8,17%, na qual, também teve efeitos significativos na taxa de ganho de peso diário, redução no rendimento da carcaça e escore de marmoreio da carne (Schneider et al., 2009). Além disso, os efeitos adversos sobre os índices produtivos aumentaram à medida que o número de bovinos tratados para DRB aumentava (Schneider et al., 2009).

Em um confinamento em Oklahoma foi identificado 237 casos fatais de DRB, correspondendo a mais da metade de todas as mortes registradas (53,8%). A morbidade por DRB foi de 14,7%, com uma taxa de mortalidade de 1,3% de todas as causas. Os pesquisadores encontraram relações estatisticamente significativas entre os agentes, lesões e os dados de tratamento animal. De acordo com o estudo, o início da doença ocorreu em média 32,65 dias antes do tratamento, enquanto a mortalidade ocorreu em média 61,81 dias após o tratamento (Fulton et al., 2009).

Durante um período de nove anos, 2.146 bovinos confinados foram estudados retrospectivamente. A morbidade de DRB foi registrada em 20,6% dos casos, com um custo médio de tratamento de US\$ 12,39 por caso. Os bezerros diagnosticados e tratados para DRB apresentaram taxa de mortalidade significativamente menor em comparação com aqueles não diagnosticados. O lucro líquido foi reduzido em US\$ 48.496 para novilhos tratados, principalmente devido à combinação de mortalidade e custos de tratamento. A incidência de DRB foi reduzida por meio de vacinação e desmame de bezerros 14 dias antes

do embarque para o confinamento, mostrando-se medidas efetivas de prevenção (Faber et al., 2000).

Um estudo conduzido na Austrália avaliou os impactos econômicos da DRB em bovinos e constatou que a morbidade foi de 18% e a mortalidade de 2,1%, com uma perda média de AUD\$ 1.647,53 por morte. Além disso, bovinos que foram tratados três ou mais vezes tiveram carcaças mais leves, gerando uma receita AUD\$ 384,9 menor em comparação com os não tratados. Além disso, animais com DRB tiveram carcaças mais leves e menor rendimento de carne, o que resultou em perdas financeiras significativas no momento do abate (Blakebrough-Hall et al., 2020).

Em um confinamento de bovinos localizado próximo a áreas de alta produção de grãos nos EUA, os animais são geralmente jovens, com idades entre seis e doze meses, e apresentam taxas médias de morbidade em torno de 8%, com taxas de mortalidade abaixo de 1%. No entanto, a Doença Respiratória Bovina (DRB) tem um grande impacto nesse sistema, sendo responsável por 75% da morbidade e mais de 50% da mortalidade dos bovinos confinados. A DRB é conhecida por ocorrer logo após o gado chegar ao confinamento, devido ao estresse do transporte (Edwards, 1996b).

Foram avaliadas a prevalência de doenças e patógenos que causam morbidade ou mortalidade em bezerros de 72 confinamentos de carne bovina em Ontário. Apenas foram examinados os animais que morreram ou foram eutanasiados dentro de 60 dias após a chegada. A pneumonia foi a lesão mais frequente, afetando 86% dos vitelos, e também uma causa comum de morte, sendo considerada um importante contribuinte para doenças fatais em 76% dos casos (Gagea et al., 2006b).

Um estudo de corte retrospectivo avaliou mais de 21,8 milhões de bovinos em 121 confinamentos nos EUA entre 1994 e 1999. Embora a taxa geral de mortalidade não tenha aumentado significativamente ao longo do tempo, o risco de morte devido a distúrbios respiratórios aumentou durante a maioria dos anos, sendo responsável por 57,1% de todas as mortes. Os bovinos leiteiros apresentaram um risco aumentado de morte por qualquer causa, enquanto as fêmeas de gado de corte tiveram um risco significativamente maior de morte devido a distúrbios respiratórios em comparação com os machos de gado de corte. O aumento nos distúrbios fatais do trato respiratório pode refletir um

aumento nos distúrbios não fatais durante a maioria dos anos (Loneragan et al., 2001).

As taxas de morbidade, mortalidade e perdas econômicas por DRB apresentam variações consideráveis e no Brasil há poucos dados. A prevenção e o controle da DRB nos bovinos são fundamentais para a redução de perdas econômicas. Além disso, medidas como vacinação, melhoria do estado nutricional, manejo que preza pelo bem-estar animal e redução da exposição a patógenos são essenciais para prevenir a doença e manter a saúde dos animais. É importante ressaltar que essas medidas devem ser implementadas de forma integrada e consistente, a fim de garantir a eficácia no controle da DRB.

1.3.4 Claudicação

A claudicação ocorre quando há dificuldade em se locomover normalmente, devido a alterações na marcha, que podem ser observadas durante a progressão ou em posição quadrupedal. Essa condição geralmente é acompanhada de dor nos membros ou estruturas de suporte e pode ocorrer devido a doenças ou anormalidades do sistema musculoesquelético (Shearer et al., 2013).

Uma das principais causas de claudicação são as afecções podais, que têm uma prevalência de até 97,2% (Souza, 2002). As lesões nos dígitos podem ter várias causas, como doenças sistêmicas, defeitos congênitos, laminites, entre outras (Souza, 2002). Algumas das enfermidades podais mais comuns incluem erosão da camada córnea, dermatite interdigital, pododermatite séptica, dermatite digital e hiperplasia interdigital. Problemas ambientais e de manejo, como umidade excessiva, pisos abrasivos e falta de conforto nas instalações, são fatores de risco importantes para o desenvolvimento dessas enfermidades (Griffin et al., 2016). Animais manejados em sistemas intensivos também têm maior probabilidade de desenvolver patologias digitais, como a laminite (Somers et al., 2003).

Para um diagnóstico correto de claudicação e afecções podais, é fundamental ter um conhecimento anatômico detalhado dos membros locomotores e dígitos. A avaliação clínica e dos exames auxiliares de diagnóstico exigem esse conhecimento e são essenciais para uma interpretação correta.

Além disso, o exame dos membros locomotores é crucial para determinar a localização e extensão da lesão (Stokka et al., 2001).

Estudos apontam que a prevalência da claudicação em bovinos varia consideravelmente, indo de 1,1% a 54,8% e, em alguns casos, chegando a 88% a 97,2%. Em um estudo realizado na Califórnia, a claudicação foi responsável por um dos três maiores gastos com serviços veterinários relacionados a doenças em 57 rebanhos de carne bovina. Além disso, a claudicação é um problema frequente em animais de corte em frigoríficos, atingindo 26,6% em vacas e 36,3% em touros. As afecções podais, por sua vez, são responsáveis por cerca de 90% dos casos de claudicação em bovinos leiteiros e 70% em confinamentos (Newcomer and Chamorro, 2016).

Entre as causas de claudicação devida a lesões fora do casco, as lesões traumáticas são as mais comuns em bovinos, incluindo fraturas, sendo essa a principal causa. Em um estudo, 33 casos de fraturas foram diagnosticados, com o tarso e o carpo sendo as áreas mais afetadas. A idade média de apresentação dos casos foi de 2 anos, sendo que 20% ocorreram em bezerros com menos de 1 ano de idade, decorrentes de traumas durante o parto assistido. Fraturas do metacarpo e metatarso são comuns quanto as de ossos longos. No entanto, em alguns casos de claudicação, a causa do trauma não foi identificada (Newcomer and Chamorro, 2016).

As fraturas em bovinos podem ser causadas por falhas de manejo, temperamento dos animais e terreno acidentado. Essas lesões podem causar grandes prejuízos econômicos, uma vez que os animais podem perder peso e reduzir seus índices produtivos durante a recuperação, além de gerar altos custos para tratamento e, em casos mais graves, levar à morte do animal. Por isso, o tratamento é realizado de acordo com o valor zootécnico do animal.

A claudicação é uma questão preocupante para a indústria pecuária em diversos países, incluindo o Reino Unido, onde um estudo descritivo foi realizado para examinar a ocorrência da condição em bovinos de corte. No entanto, a maioria dos produtores relatou que examinar as patas não era seguro, o que pode contribuir para a persistência da claudicação. Além disso, 35% dos pecuaristas consideram transportar animais com claudicação persistente para o abate como uma solução. A falta de pessoal, tempo, treinamento e conhecimento também foram apontados como barreiras para prevenir e controlar a

claudicação. Sugerindo uma subestimação dos impactos econômicos da condição na produção de carne bovina, por parte dos produtores (Tunstall et al., 2021).

Visando melhorar o bem-estar animal, o Comitê de Bem-Estar Animal do Instituto Norte-Americano de Carne ajudou a criar um sistema de pontuação para avaliar a mobilidade de animais terminados para o abate nos frigoríficos, fornecendo à indústria pecuária uma ferramenta para avaliar e melhorar o bem-estar animal (Edwards-Callaway et al., 2017).

O transporte de longa distância pode ser um fator significativo na mortalidade do gado, como revelado por um estudo anterior no Brasil, no qual o trauma foi a segunda principal causa de mortalidade entre os animais, representando 27,1% (329/1.214) das mortes. No qual, alguns animais desenvolveram múltiplas lesões traumáticas durante o transporte e tiveram que ser eutanasiados. A distância percorrida durante o transporte para o confinamento também foi associada a uma maior mortalidade e morbidade de doenças respiratórias, tornando-se um possível preditor da saúde e desempenho do gado. Outros fatores, como perda de peso, densidade populacional e tempo sem alimentação, também podem contribuir para o alto percentual de mortalidade por trauma durante o transporte (Baptista et al., 2017).

Um estudo realizado por Aleri et al. (2021) e colaboradores analisou a frequência de mortalidade em bovinos de corte e leite durante um período de 38 anos no sudoeste da Austrália Ocidental. De acordo com as necropsias realizadas em um centro de referência em patologia veterinária, das 904 carcaças de bovinos examinadas, 7% (24/358) das mortes foram atribuídas a doenças respiratórias, como pneumonia, enquanto 6% (21/358) foram causadas por claudicação, incluindo fraturas. Esses resultados indicam a importância de controlar e prevenir tanto as doenças respiratórias quanto a claudicação em bovinos de corte e leite.

Recentemente, uma investigação realizada na Irlanda analisou as percepções dos produtores de carne bovina e leiteira sobre o manejo de animais gravemente feridos, como nos casos de fraturas. Os produtores entrevistados demonstraram uma visão positiva em relação ao abate de emergência, mas mencionaram a disponibilidade e o custo como possíveis preocupações (McDermott et al., 2023). Quando se trata de lidar com lesões graves ou agudas

em bovinos, existem quatro opções de manejo disponíveis na fazenda: tratamento, desde que a lesão não seja tão grave; abate de emergência na fazenda; abate, no qual o animal é transportado para um matadouro, desde que um veterinário certifique sua aptidão para o transporte; ou eutanásia (McDermott et al., 2023).

A mortalidade de bovinos é um problema que acarreta prejuízos econômicos e preocupações com a sustentabilidade, o desperdício alimentar e o bem-estar animal. Nesse contexto, o abate de emergência na fazenda surge como uma alternativa para evitar perdas econômicas maiores e uma oportunidade para que os produtores salvem parte do valor econômico do animal. No entanto, a prática e a regulamentação variam consideravelmente entre os países nórdicos e há uma escassez de dados sobre a incidência e as razões para o uso de abate de emergência em bovinos (Skúladóttir et al., 2022a). Em 2018, uma análise de certificados veterinários de abate de emergência em quatro matadouros dos países nórdicos revelou que 46% dos bovinos foram abatidos por problemas de locomoção, sendo que quase metade desses casos foi devido a claudicação (Skúladóttir et al., 2022b). Isso demonstra a importância de avaliar cuidadosamente a condição do animal e considerar o abate de emergência como uma opção viável em casos de lesões graves ou agudas que afetam a locomoção.

Um estudo realizado na República Checa de 2010 a 2019 examinou a frequência de lesões traumáticas em diferentes espécies e categorias de animais abatidos, com base em exames veterinários post mortem realizados em matadouros. Embora as lesões traumáticas tenham sido observadas em baixa frequência, elas foram mais comuns em bovinos, seguidos por porcos e ovelhas. É importante priorizar a prevenção de traumas em bovinos, já que essa espécie apresentou a maior frequência de lesões entre os animais adultos, jovens e terminados. Mais pesquisas são necessárias para identificar fatores que reduzam o risco de lesões em todas as espécies animais, visando aprimorar o bem-estar animal no abate. Embora a baixa frequência de lesões traumáticas seja positiva, ainda é crucial prevenir lesões e reduzir o risco de traumatismos em todas as espécies animais. (Valkova et al., 2021).

A claudicação e lesões traumáticas em bovinos podem afetar negativamente a produtividade e bem-estar dos animais. Os produtores devem

estar atentos aos sinais precoces de claudicação e lesões para intervir rapidamente. Embora as afecções podais sejam as principais causas de claudicação, lesões traumáticas são comuns na pecuária de corte. Medidas preventivas, como manutenção de pisos adequados e manejo cuidadoso, são importantes para evitar essas condições. Com medidas preventivas e tratamento adequado, os efeitos negativos da claudicação e lesões traumáticas podem ser minimizados, promovendo a saúde e bem-estar dos bovinos.

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2 CAPÍTULO 2 – THE ECONOMIC IMPACTS OF THE BOVINE RESPIRATORY DISEASE COMPLEX ON BEEF CATTLE FEEDLOTS IN BRAZIL

ABSTRACT - Bovine respiratory disease (BRD) is a common cause of morbidity and mortality in beef cattle feedlots from the USA, Canada, and Australia. However, data relative to the economic impacts, morbidity, and mortality are scarce in Brazil. This study investigated the incidence of BRD in 10 beef cattle feedlots from different geographical regions of Brazil, during January/2019 to December/2020, with a total of 699,526 cattle on feed. The general morbidity was 3.6 %, while BRD-associated was 2.08 %. The general mortality rate identified was 0.38% and the mortality rate BRD-associated was 0.08%. BRD accounted for 57.9 % and 22.1 % of all disease cases and deaths, respectively. The average body weight was 14.9 kg higher in cattle without BRD compared to cattle with BRD. The costs of BRD-related mortality and morbidity were estimated at 777.98USD/animal and 51.4USD/ animal, respectively, and resulted in an estimated annual loss of \$6.9 million USD due to morbidity and US\$4 million due to mortality. This is the only study in Brazil that investigated the incidence of BRD and the impact on production/economics and the data herein obtained can be used as the starting point to understanding the BRD-related losses in the local cattle industry.

KEYWORDS: economic consequences; financial losses; livestock production; meat industry; morbidity; mortality; pulmonary disease.

2.1 Introduction

The states of Goiás, Minas Gerais, and São Paulo are localized within the central-western and southeastern geographical regions of Brazil, collectively contribute towards 25.8 % (56,355,851/ 218,150,298 cattle) of the effective cattle herds in the country, and were classified, respectively, as the 2nd, 4th, and 9th cattle producing states within all 26 Federative states of Brazil 2021 (IBGE, 2021b). Furthermore, these three states are among the five states that slaughtered the most cattle in 2022 (IBGE, 2022). The beef production industry in Brazil moved approximately 913 billion USD in 2021 (MAPA, 2021a; ABIEC, 2022b). Therefore, livestock production is critical to the Brazilian economy.

The bovine respiratory disease (BRD) complex is a multifactorial and multi-etiological disease entity that is caused by a variety of infectious disease pathogens, associated with problems due to cattle management and drastic changes in climatic conditions (Snowder et al., 2006; Fulton, 2009; Griffin et al., 2010; Taylor et al., 2010). Several agents associated with the development of BRD in cattle herds that resulted in clinical diseases in Brazil have been identified, including *Histophilus somni* (Headley et al., 2014; Headley, 2017; Magalhães et al., 2017), *Mannheimia haemolytica* (Baptista et al., 2017; Magalhães et al., 2017), *Pasteurella multocida* (Baptista et al., 2017), bovine alphaherpesvirus 1 (BoHV1), bovine parainfluenza virus 3 (BPIV3) (Oliveira et al., 2020) bovine respiratory syncytial virus (BRSV) (Driemeier et al., 1997; Flores et al., 2000; Headley, 2017), bovine corona virus (Beuttemuller et al., 2017), and bovine viral diarrhoea virus (BVDV) (Flores et al., 2005).

The respiratory problems have been associated with the highest percentage of losses among almost 3.6 million cattle and calves due to non-predator causes in the USA in 2015 (USDA, 2015a). BRD-infected cattle are generally associated with a higher mortality risk, higher treatment costs, and worse carcass performance as compared with healthy animals, and consequently affects impacts animal welfare, performance, and economic parameters (White and Larson, 2020).

Although a large proportion of cattle in Brazil are reared on pasture systems, the use of feedlots for intensive cattle breeding has expanded annually (DSM, 2021). A study of 144,340 cattle in a feedlot in the state of Goiás revealed that the overall morbidity was 3.18 % in 2012 and 2.81 % in 2013, with BRD being the primary cause

of illness and accounting for 44.1 % and 46.7 % of all cases in 2012 and 2013, respectively (Malafaia et al., 2016). We have demonstrated that the morbidity rate of all cattle on feed was 7.05 % (13,315/ 188,862), with BRD-related conditions accounted for 86.9% of all cattle morbidity during a two-year study from a single beef cattle feedlot in the state of Minas Gerais (Baptista et al., 2017).

It must be highlighted that information relative to the occurrence of BRD and the associated economic impact in Brazil is restricted to one study (Baptista et al., 2017). This data contrasts the fact that Brazil is one of the largest commercial cattle producing country, with little data, when compared to similar information from the USA (Snowder et al., 2006; USDA, 2015a) and Australia (Blakebrough-Hall et al., 2020). Therefore, data associated with the economic impacts of BRD on livestock production in Brazil is lacking when compared with other important beef producing countries. Consequently, this study evaluated the economic impacts on livestock production of BRD in beef cattle feedlots from the three major cattle producing states of Brazil.

2.2 Material and Methods

2.2.1 Animals, data collection, and study area

This study analyzed data from 10 beef cattle feedlots, that contained cattle from the subspecies *Bos taurus indicus* and hybrids (*Bos taurus indicus* x *Bos taurus taurus*) of various breeds (Nelore, Nelore mixed breed, dairy cross, and industrial crossing), located in the states of Goiás, Minas Gerais, and São Paulo, Brazil. Each feedlot had a mean stocking capacity of 40,885 ± 32,974 heads of cattle in 2019 and 29,068 ± 19,162 in 2020. All animals maintained in these feedlots were monitored using the Brazilian System of Individual Identification of Cattle and Buffalo (MAPA, 2002). All cattle were maintained on feed in paddocks as previously described (Baptista et al., 2017).

All cattle from these feedlots originated from different states in Brazil, were non-castrated steers between 24 to 36 months of age, with an initial average body weight of 369.7 ± 74.97 kg. All cattle were maintained on feed for approximately 106.4 ± 18.23 days until attained 525.1 ± 73.89 kg of body weight, with an average daily weight gain (ADG) of 1.46 ± 0.31 kg. The feedlots contained an automated feeding system; all

cattle were fed four times daily with a ration consisting of corn silage, concentrate, and mineral salt. Water was available *ad libitum* from artesian wells at each feedlot.

The initial protocol included the individual examination of the overall health and well-being, immunization and deworming of all steers on arrival at each feedlot. All cattle were dewormed using a commercial solution containing 5 mg of fenbendazole per kg of body weight orally and immunized against the principal causes of BRD in Brazil: BoAHV1 -1, BPIV3, BVDV, *P. haemolytica*, and *P. multocida*. Additionally, cattle at these feedlots were immunized against *Clostridia* spp., *E. coli*, and *Salmonella dublin*.

2.2.2 Data collection and characterization of BRD

This retrospective study collected data from January 2019 to December 2020 and includes a total of 699,526 cattle on feed. All animals exhibiting significant signs of any disease were promptly isolated, examined, and treated individually by the veterinary staff. The data obtained on clinical diagnosis, therapy, morbidity, and mortality were tabulated in a Microsoft Excel spreadsheet and used as data for the results of this study. Furthermore, the morbidity and mortality rates of cattle with and without BRD were determined relative to the total number of cattle on feed.

The respiratory disease assessment was based on the DART system (Zoetis, Florham Park, USA) with modifications and was done by the trained veterinarians at each feedlot. In summary, the symptoms observed were depression, irregular appetite, and/or respiratory distress. Manifestations of depression included, but were not limited to, depressed attitudes, a low head, glazed over or sunken eyes, slow or restricted movements, arched back, difficulty standing or walking, finger joints or dragging toes when walking, and tripping. Signs of abnormal appetite included animals that were completely off feed, eating less than predicted or very slowly, had a lack of intestinal fullness or lean appearance, and evident loss of body weight. Respiratory signs included labored breathing, extended head and neck, and audible breathing noise. Thus, inclusion criteria include animals with coughing, nasal discharge, rapid and shallow breathing, dyspnea, increased rectal temperature ($> 40^{\circ}\text{C}$), rough hair coat, lethargy, lack of appetite, with a clinical diagnosis of BRD, and obligatorily treated for respiratory impairment.

2.2.3 Production indices

The ADG was determined by using 58.2 % (407,425/ 699,526) of the total number of cattle on feed, since complete data were only available for these animals. Additionally, cattle that died (n = 2,661), diseased due to non-respiratory conditions (n = 10,573), and with any incomplete data (n = 278,867) were removed from the total number of cattle on feed and not used to determine the ADG. The entry and exit weight of each animal was determined by using the weight obtained on the first and last day on feed (DOF). In addition, the DOF for each lot of animals on feed were recorded, and the ADG was determined for cattle with and without BRD.

2.2.4 Economic impacts associated with BRD

The economic implications of BRD-related morbidity and mortality during this study were estimated by calculating the cost associated with the following: immunization (1.32USD), therapy (75.00USD), operational costs (3.21USD) per head of cattle entering the feedlot; total operating cost per animal associated with BRD-related morbidity and mortality; average value per head of cattle that died due to BRD. All costs were expressed in USD and were based on the average cost of expenses at these feedlots.

Operational costs included all expenses related with feeding and maintenance of each animal per day at the feedlots. The cost of morbidity was determined by the combination of several factors, including the average operational costs/animal, therapy, and immunization-associated cost, and the number of days on feed. Cattle with BRD were maintained for comparatively longer periods on each feed lot than healthy cattle to obtain the same average weight. Additionally, sick cattle were maintained on each feed lot for approximately 112 DOF with a daily operating expense of 3.21 USD/animal, resulting in 35.92USD per animal on feed.

Alternatively, the cost of mortality was determined by computing the average operational costs/animal average of DOF of deaths (42 DOF) by the daily operating cost (3.21USD), resulting in 134.72 USD. The average cost per animal was calculated by using the purchase price of the animal based on the average entry weight. The cost of the animal considered the average operational costs of the 42 DOF, cost of the animal, vaccinations, and therapy.

2.2.5 Statistical analyses

All graphs and data were tabulated using the GraphPad Prism 9 statistical software (GraphPad Software, San Diego, CA, USA). Cattle were considered as an experimental unit. Data were tabulated initially in Excel spreadsheets and descriptive statistics were presented as mean and standard deviation. Variable considered as quantitative (ADG) was subjected to the Anderson-Darling test to verify whether a parametric distribution was established, then it was used the Mann-Whitney test (non-parametric distribution). Statistical significance was considered as $P \leq 0.05$.

2.3 Results

2.3.1 Epidemiological data

Between January/2019 and December/2020, 699,526 heads of cattle were on feed at the 10 feedlots evaluated and represents 1.1 % (699,526/ 62,332,886) of the total number of cattle slaughtered in Brazil. The geographic location of the ten feedlots monitored during this is shown at Figure 1, with 61.2 % (428,103/ 699,526) animals originated from the state São Paulo, 20.5 % (143,413/ 699,526) from Minas Gerais, and 18.3 % (128,010/ 699,526) from Goiás, and constituted five, four, and one feedlot, respectively.

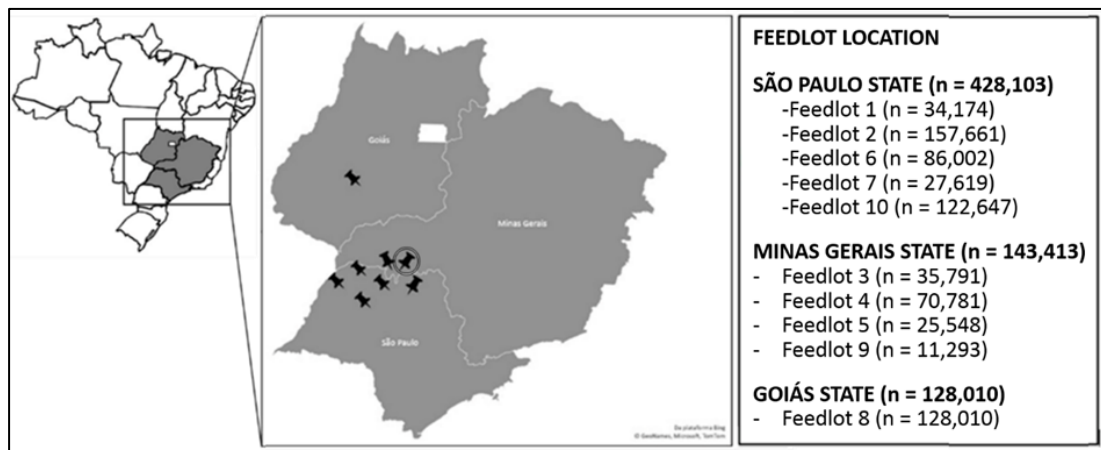


Figure 1. Geographical distribution and total number of cattle at each feedlot (n = 10) within the states of São Paulo (n = 5), Minas Gerais (n = 4), and Goiás (n = 1). Feedlots (n=3) that are within proximity in the state of Minas Gerais are identified within the circle.

The general and BRD-related mortality and morbidity rates of the 10 feedlots evaluated during this study are provided (Table 1). The mean morbidity rate was 3.6% (25,132/699,526) with a variation between feedlots of 1.4 % and 7.2%, with BRD-associated morbidity was being identified as 2.08% (14,559/699,526), with variations of 0.89% and 6.41%. Additionally, the overall mortality was estimated at 0.38 % (2,661/699,526), with a variation of 0.21 % to 0.53 %; with mortality attributed to BRD being 0.08 % (588/ 699,526), varying between 0.05 % to 0.15 %. Furthermore, BRD accounted for 57.9% (14,559/25,132) and 22.1% (588/2,661) of the total number of diseases and deaths in this study, respectively.

Table 1. Mortality and morbidity rates of cattle identified in ten feedlots from three geographical regions of Brazil during January 2019 – December 2020.

FEEDLOT (<i>n</i>)	MORBIDITY - % (<i>n</i>)		MORTALITY - % (<i>n</i>)	
	All diseases ¹	BRD	All diseases ¹	BRD
1 (34,174)	1.4 % (479)	0.89 % (305)	0.35 % (118)	0.08 % (28)
2 (157,661)	1.9 % (3,045)	1.58 % (2,489)	0.44 % (694)	0.06 % (92)
3 (35,791)	7.1 % (2,558)	6.41 % (2,293)	0.31 % (111)	0.15 % (54)
4 (70,781)	3.3 % (2,350)	2.85 % (2,017)	0.35 % (248)	0.12 % (84)
5 (25,548)	4.2 % (1,061)	1.48 % (378)	0.28 % (71)	0.05 % (14)
6 (86,002)	2.8 % (2,426)	2.17 % (1,865)	0.27 % (235)	0.12 % (107)
7 (27,619)	3.2 % (874)	1.98 % (546)	0.21 % (58)	0.05 % (14)
8 (128,010)	4.1 % (5,258)	0.95 % (1,215)	0.53 % (677)	0.09 % (113)
9 (11,293)	7.2 % (811)	5.23 % (591)	0.23 % (26)	0.05 % (06)
10 (122,647)	5.1 % (6,270)	2.33 % (2,860)	0.34 % (423)	0.06 % (76)
Total = 699,526	3.6% (25,132)	2.08% (14,559)	0.38 % (2,661)	0.08 (588)

¹ Including all diseases diagnosed and treated during the period (January/2019 - December/2020), such as BRD (metabolic, digestive, clostridial, lameness, fracture, trauma, and other diseases).

When the distribution of the frequency of morbidity related to BRD was evaluated in all 10 feedlots, it was observed that 29.1 % (4,237/14,559) and 62.4 % (9,082/ 14,559) of the cases occurred in cattle, respectively during the first 15 and 30 DOF, with the number of cattle with BRD-associated morbidity being proportionally reduced during the entire period on feed (Figure 2A). However, when the feedlots were evaluated separately (Figure 2B), each feedlot showed a different trend of BRD-associated morbidity that was grouped around the mean value.

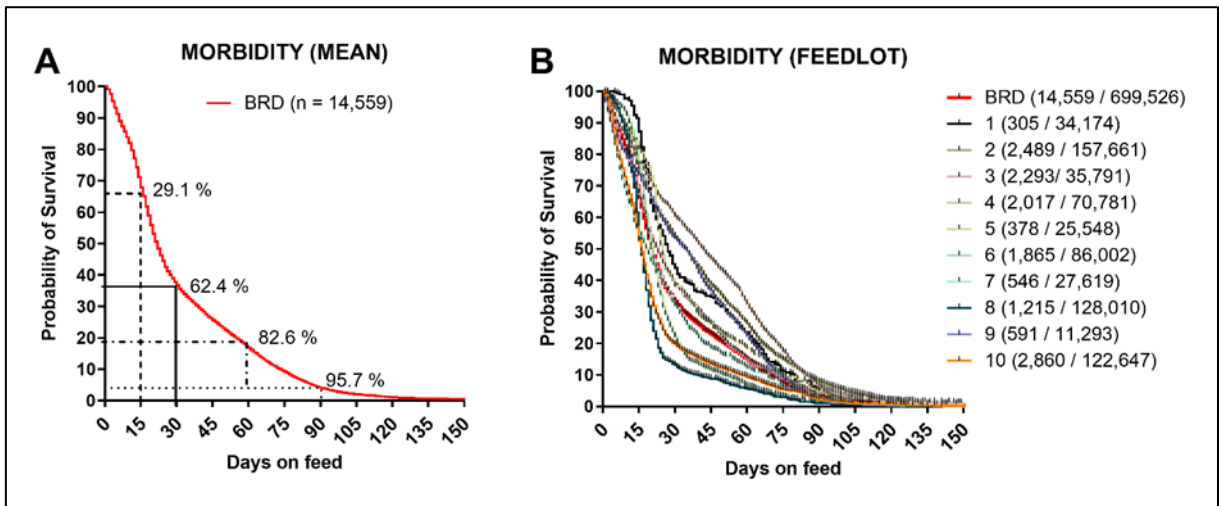


Figure 2. Distribution of the mean occurrence of BRD morbidity in cattle from (a) all 10 feedlots and (b) the individual feedlots relative to the number of days on feed.

When the BRD mortality indices were evaluated, more than half (64.2%; 377/588) of all cattle on feed died within 60 days of entry into feedlots, with the frequency of cattle mortality due to BRD being reduced as the animal is maintained within feedlots (Figure 3A). A similar individual trend of BRD-related mortality, as described for morbidity, was identified with each individual feedlot having different mortality indices that were grouped around the mean BRD-related mortality (Figure 3B).

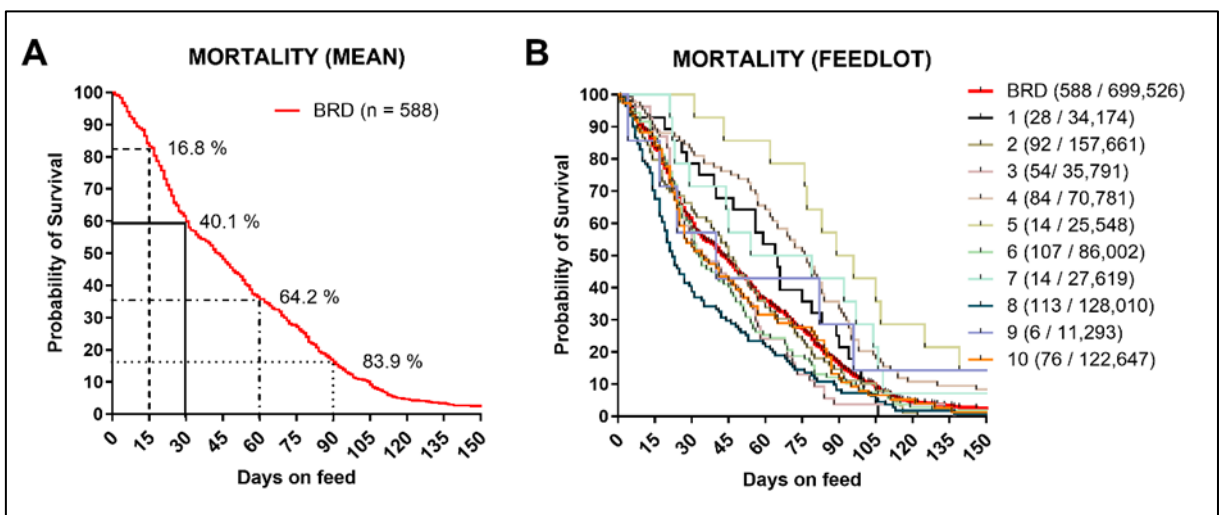


Figure 3. Distribution of the mean occurrence of BRD in cattle mortality from (A) all 10 feedlots and (B) the individual feedlots relative to the number of days on feed.

2.3.2 Production indices

The average duration of cattle on feed varied between 106.4 ± 18.23 DOF, with entry weights of 369.7 ± 74.97 kg and exit weights of 525.1 ± 73.89 kg. During this study, the ADG in cattle without BRD (404,887/ 407,425) was 1.47 ± 0.31 kg/d, with the ADG in cattle with BRD (2,538/ 407,425) being 1.33 ± 0.36 kg/d (Figure 4). A significant difference in ADG ($P < 0.0001$; Mann-Whitney test) was obtained, demonstrating that cattle on feed without BRD-related diseases gained 14.9 Kg in excess than cattle with BRD considering the mean of duration on feed.

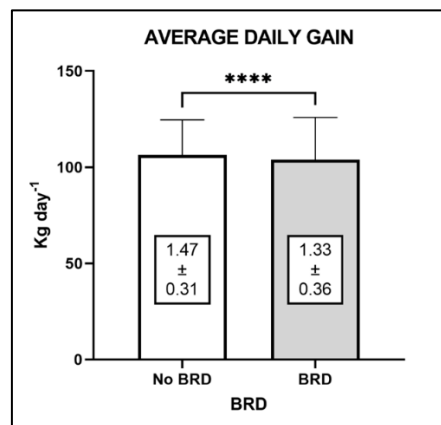


Figure 4. Comparative distribution of the average daily gain (ADG) of feedlot cattle without ($n = 404,887$) and with BRD ($n = 2,538$).

2.3.3 Economic impacts

The projected losses associated with BRD are represented in Table 2. The costs associated with vaccinations and therapy were estimated at 1.32USD and 14.15USD per animal, respectively. The average operational costs for BRD-related morbidity were 35.92USD while mortality was 134.72USD. The maintenance cost of a sick animal at most feedlots was 51.4USD / animal, being less than the 777.98USD/ animal related to mortality. Furthermore, an estimated projection of the economic impacts due to BRD in Brazil revealed that the cost associated with morbidity was 6,930,356.58 USD, while losses due to mortality were 4,034,479.80 USD (Table 3).

Table 2. Estimated costs associated with the mortality and morbidity of feedlot cattle due to bovine respiratory disease.

ESTIMATED COSTS	MORTALITY (USD)	MORBIDITY (USD)
Vaccinations	1.32	1.32
Therapy	14.15	14.15
Average operational costs/animal	134.72 *	35.92 ***
Average cost/animal	627.79 **	-
Cost/animal	777.98	US\$ 51.40

* Average operational costs/animal (mortality) was calculated by multiplying the average DOF of deaths (42 DOF) by the daily operating cost (3.21USD).

** Average value of animal was calculated using the purchase price of the animal based on the average entry weight.

*** Average operational costs/animal (morbidity) was calculated by using the average number of days (n = 112) for cattle with BRD to attain the same average weight as healthy cattle by the daily operating expense (3.21USD).

Table 3. Projected estimates of the economic impacts of bovine respiratory disease on cattle on feed in Brazil during 2020.

Indices	ESTIMATES (USD)		ECONOMIC IMPACTS (USD)
Cattle slaughtered	41,500,000 ^a		
Cattle on feed	15.62 % ^a	6,482,300	
BRD Morbidity	2.08 % ^b	134,831.84	
Morbidity cost/animal	US\$ 51.40 ^b		US\$ 6,930,356.58
BRD Mortality	0.08 % ^b	5,185.84	
Mortality cost/animal	777.98 ^b		4,034,479.80

^a Instituto Brasileiro de Geografia e Estatística (IBGE)

^b This study (Table 2)

2.4 Discussion

This retrospective study reinforced the importance of BRD in cattle on feed in Brazil, as it represented 57.9% and 22.1% of the total diseases and deaths identified during the evaluated period, respectively. An estimated projection of the economic impacts due to BRD in Brazil revealed that the annual cost associated with morbidity was US\$ 6,930,356.58, while losses due to mortality were US\$ 4,034,479.80. BRD-related morbidity was 2.08%, with 29.1% and 62.4% of the cases occurring during the first 15 and 30 DOF, respectively. Regarding BRD-related mortality, it was 0.08%, and more than half (64.2%) of all cattle on feed died within 60 days of entry into feedlots. BRD also significantly impacted the ADG of cattle during the confinement period. Since the main interest of this study was to identify morbidity and mortality rates associated with the clinical manifestations of BRD, the associated infectious disease agents were not evaluated.

This is the first BRD-related study in Brazil to examine BRD-related morbidity and mortality rates, as well as production and economic indices in different feedlots from various states of Brazil, and consequently the data herein identified are more consistent than previous studies. Thus far, there are only one previous study have investigated the indices of BRD morbidity and mortality in Brazil. In the first study, we evaluated the mortality, morbidity, and economic impacts associated with BRD from only one feedlot from the state of Minas Gerais (Baptista et al., 2017). While the second evaluated the economic impacts of digestive and respiratory disease on cattle maintained on feed from two feedlots within São Paulo (Malafaia et al., 2016). Accordingly, the general morbidity described in this study (3.6%) was greater than that identified (1.35%; n=144,340) in São Paulo (Malafaia et al., 2016), but less than the 7.05% (13,315/188,862) described in Minas Gerais (Baptista et al., 2017). However, it must be highlighted that these indices identified during these two previous studies are within the variations (1.4 – 7.2%) observed at the 10 feedlots. Consequently, the general morbidity rates identified in these two previous studies are consistent with the results herein presented, even though these studies evaluated comparatively less animals and feedlots, suggesting that feedlot morbidity in Brazil is probably between 1-7%.

However, when the BRD-related morbidity and mortality rates were compared with the only study from Brazil that effectively investigated pulmonary disease of feedlot cattle, our previous study described indices of 6.13% (11,577/188,862) and 0.21% (397/188,862), respectively (Baptista et al., 2017), which are less than the current mean indices of morbidity (2.08%; 14,559/699,526), but similar to the mean mortality rate (0.08%; 588/699,526) herein identified. Once again, these BRD-associated mortality and morbidity rates previously identified in our previous (Baptista et al., 2017) are also within the variations of the current study.

It must be highlighted that BRD-associated morbidity was the most frequently occurring diseases at these feedlots and contributed towards 57.9% of all diseases. BRD also contributed towards the largest single disease entity (86.9%) in our previous study (Batista et al), and in another study done in São Paulo, where BRD-related disease contributed towards 45.5% of all diseases evaluated. Accordingly, these initial data suggest that BRD is the principal problem at beef cattle feedlots in Brazil and but more elevated that the results identified in studies from the USA (Snowder et al., 2006; USDA, 2015a), and Australia (Blakebrough-Hall et al., 2020). Although the exact reason for the vast differences in these indices between Brazil and other beef producing countries is not known, we believe that the rearing of cattle during prolonged dry seasons in Brazil may predispose cattle to a larger percentage of stress-induced conditions that favor the development of BRD.

During this study, more than half of BRD-associated mortality (62.4%; 377/588) occurred within the first 30 DOF; similar findings were previously described in our previous study of BRD (Baptista et al., 2017) and in studies done in other countries (Ribble et al., 1995a; Ribble et al., 1995b; Edwards, 1996a; Gagea et al., 2006a). The elevated prevalence of BRD during the initial period on feed is probably due to the adaptation, related to transport and stress-induced immunosuppression effects and incomplete seroconversion since immunization is frequently done on entry in feedlots. This then is in accord with the general concept of the complexity of BRD, which is a multifactorial disease entity, having variables such as different infectious disease agents, breed of the affected cattle, stress, abrupt changes to management practices and environmental conditions (Snowder et al., 2006; Fulton, 2009; Taylor et al., 2010).

The estimated impacts due to BRD-associated morbidity at these ten feedlots was 6.9M USD, while lost due to BRD-mortality was 4M USD; these economic costs are similar to those described in our previous study where the associated BRD-mortality was estimated at 6.3M USD and mortality 5.5M. Consequently, these data demonstrate that although these two studies were done with different number of animals and feedlots, the economic impacts are quite similar and can be used to estimate the economic impacts of BRD in Brazil.

During this study, cattle with BRD had comparatively lower ($P < 0.0001$) exit weight (ADG 0.14 kg/d; mean 14.9kg) compared to healthy cattle. Similar findings were described in a commercial feedlot from Southern Australia, where slaughtered cattle with severe lung lesions weighed 14.3 kg (0.3 kg/d) less than animals without pulmonary disease (Blakebrough-Hall et al., 2020), and also in feedlots from Western Canada, where the ADG varied between 0.04 to 0.16 kg/d (Blakebrough-Hall et al., 2020). Collectively, these results demonstrates that animals with respiratory problems, have a lower weight gain and corresponding reduced productivity. It must be highlighted that the initial results from this study are the only available data associating ADG with respiratory disease in cattle from Brazil, since all previously used data were derived from studies done in other countries.

BRD continues to be a major threat for beef cattle maintained in feedlots from Brazil, affecting their health and well-being and leading to increased mortality rates. The data collected clearly shows that the occurrence of BRD in feedlots varies according to the geographical region of the country and may reflect distinct management practices and/or particularities of each feedlot. Furthermore, se have shown that some the rate of BRD in some feedlots is comparable to that existent in other countries, while there is still room for improvement in others. It must be highlighted, that the high costs associated with therapy and the reduced productivity, make it the understanding of the impacts of BRD a critical issue that cannot be ignored in the local livestock industry.

2.5 Conclusion

This study is the only study that demonstrated the incidence of BRD in feedlots from diverse geographical regions of Brazil. It is estimated that the annual loss due to BRD in terms of morbidity amount to 6.9 million dollars, and mortality losses are 4.0 million dollars, representing 57.9% and 22.1% of the total number of diseases and deaths due to BRD, respectively. These findings provide initial data that can be used to evaluate the effects of BRD in beef cattle feedlots and may be a national guide to understand the economic losses in the local livestock industry.

Author Contributions: Conceptualization, J.S. and A.B.; methodology, J.S., A.X., and A.B.; formal analysis, J.S., A.X., and A.B.; investigation, A.B., M.R., R.G, and R.M.; resources, A.B., R.M., and M.R.; data curation, M.R.; writing—original draft preparation, A.X., A.B. and J.S.; writing—review and editing, A.X., S.H., and J.S.; supervision, S.H. and J.S.; project administration, J.S. and S.H.. 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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3 CAPÍTULO 3 – AN ASSESSMENT OF THE INCIDENCE OF HOOF LESIONS, LIMB FRACTURES, AND SOFT TISSUE/CUTANEOUS TRAUMATIC ALTERATIONS OBSERVED IN BRAZILIAN FEEDLOTS

ABSTRACT - Limb lesions is a prevalent condition in livestock, which can have negative consequences for the production, sustainability, and animal welfare. The objective of this study was to investigate the incidence of limb musculoskeletal injuries on feedlot beef cattle in six states from Brazil. Data was collected from 22 feedlots over a period of 5 years (July 2017 to July 2022), with a total of 1,972,884 evaluated animals. Limb musculoskeletal injuries resulted in a morbidity rate of 1.19% and a mortality rate of 0.17%. Hoof injuries were found to be the leading cause of morbidity (0.91%) among limb injuries, while limb fractures resulted in 0.12% of deaths with a high lethality rate of 80.9%. Limb fractures can significantly impair animal welfare and may require on-farm emergency slaughter. During the rainy season, the incidence of musculoskeletal injuries was higher. Moreover, a considerable proportion of soft tissue and cutaneous traumatic alterations occurred during the transportation and management of cattle, before the cattle entry to the feedlot. Conclusion: limb injuries in beef cattle feedlots can have a negative impact on production and animal welfare, particularly during transportation and the rainy season. Hoof injuries are frequent, while fractures carry a high risk of lethality.

Keywords: fractures, foot, incidence, lameness, livestock, morbidity, mortality, orthopedic, sustainability

3.1 Introduction

Brazil is the second largest producer of beef globally, with the local beef production industry responsible for an income of approximately 913 billion USD in 2021 (ABIEC, 2022). Most of beef cattle production from Brazil is concentrated in the states of São Paulo, Minas Gerais, Goiás, Mato Grosso, Mato Grosso do Sul, and Pará, which were important to the livestock industry (MAPA, 2021). In 2021, these six states accounted for a total of 59.1% of all cattle heads in Brazil (IBGE, 2021a), and approximately 60% (5,823.9/9,714.2 million tons) of the total meat production (ABIEC, 2022). Although a significant number of cattle in Brazil are reared extensively on pasture systems, the use of feedlots for intensive animal production has increased annually (MAPA, 2021).

Beef feedlot cattle may have a higher incidence of musculoskeletal system diseases compared to cattle raised exclusively on pasture systems. These differences may be attributed to factors such as poor flooring conditions, reduced space, and inadequate management practices, which increase the risk of slips, falls, hoof crush, and physical contact between animals (Stokka et al., 2001; Mader and Griffin, 2015; Silveira et al., 2018; Macitelli et al., 2020). Furthermore, the proximity of animals in feedlots frequently results in active competition for available resources such as food and water, as well as dominance social, aggressive, and territorial behavior, leading to fights and sodomy cases (Silveira et al., 2018; Hubbard et al., 2021). Musculoskeletal problems in feedlot cattle not only affect animal welfare, causing pain and reduced mobility, but also result in decreased productivity, increased veterinary expenses, and decreased profitability. This highlights the significance of sustainable livestock in the meat production industry, as it emphasizes the need to consider animal welfare, efficiency, environmental awareness, and social responsibility (Nalon et al., 2020). Additional studies may be needed to determine the occurrence and causes of these problems. Consequently, this study evaluated the incidence of limb musculoskeletal injuries and described potential risks on livestock production in six states from Brazil.

3.2 Material and methods

3.2.1 Study area, animals and data collection

This study analyzed the data derived from 22 beef cattle feedlots located in the states of São Paulo (10 feedlots), Minas Gerais (5 feedlots), Mato Grosso (3 feedlots), Mato Grosso do Sul (2 feedlots), Goiás (1 feedlot) and Pará (1 feedlot), during July 2017 to July 2022.

The feedlots had a mean capacity of $11,513 \pm 7,158$ heads of cattle, with the smallest and largest static capacity of 3,147 and 28,170, respectively, and it was a dynamic activity in which animals entered and exited as they reached the desired weight for slaughter. All cattle in these feedlots were derived from different geographical locations and were of the subspecies *Bos taurus indicus* and hybrids (*Bos taurus indicus* x *Bos taurus taurus*) of various breeds (Nelore, Nelore mixed breed, dairy cross, and industrial cross). These animals evaluated were non-castrated, males, with ages between 24 and 36 months. All animals that had just arrived at the feedlot underwent an initial protocol, which included an individual examination of overall health, tracking identification using a tag and an electronic chip for monitoring, as well as immunization and deworming. The cattle were then placed in paddocks with access to food and water and remained there until they reached the required weight for slaughter (figure 1).

Figure 1: A: Feedlot; B: The cattle were then placed in paddocks with access to food; C: immunization; D: feedlot workers on horseback made morning rounds every day.



Upon arrival, the animals were inspected for injuries/lesions or diseases caused during transportation by the boarding and landing cattle management. Once moved to pens, workers on horseback monitored the entire feedlot to identify any sick or injured cattle. They entered the pens, lifted all animals that were lying down, and made all cattle move. Animals remote from the herd or exhibiting clinical signs of any disease were promptly moved to the feedlot hospital, where they were examined and treated individually by the veterinary staff. The responsible veterinarian at the feedlot established the protocol for treatment, which in most cases involved the administration of antibiotics and anti-inflammatory medications. The study included animals with pre-existing limb musculoskeletal injuries at the arrival of feedlot or during their days on feed, but excluded animals affected by diseases of other systems (special senses,

respiratory, urinary, cardiovascular, hematopoietic, endocrine, liver, biliary, alimentary, and nervous systems).

In specific cases where injuries were deemed incompatible with animal survival, such as severe fractures or recumbency, euthanasia or slaughter was carried out at the feedlot. This decision was based on the compromised animal welfare of the cattle, as they were unable to be transported by truck to the slaughterhouse and were unresponsive to administered treatments. Cattle euthanasia/slaughter was included in mortality rate calculations.

The numbers of animals identified with limb musculoskeletal system alterations described during inspection or clinical examination were recorded. The recorded information included individual identification, average body weight on arrival, clinical diagnosis, administered medications, onset date of limb injuries associated within the dry season (June to October) and the rainy season (November to May) (EMBRAPA, 1996), on feed, and finished or death cattle. Additionally, the morbidity and mortality rates of cattle with and without injuries were calculated by dividing the number of cases or deaths by the number of cattle on feed. Lethality was determined by dividing the number of deaths by the number of cases. These data were analyzed and computed to evaluate the impact of injuries on the cattle population under study.

Figure 2: A-C: Skeletal fractures in beef cattle feedlot; D: Cutaneous traumatic alterations in beef cattle feedlot.



Characterization of lesions in feedlot cattle

The pathological conditions of the limb musculoskeletal system were divided into three categories of lesions affecting specific anatomic locations of the limbs: (a) hoof lesions, (b) fractures limb, and (c) soft tissue and cutaneous traumatic alterations (STCTA). Hoof lesions in this study were considered as any alteration including wounds, abrasions, ulcers, or fissures affecting any part of the hoof, deformations to the heel or wall of the hoof, swelling, bleeding, and separation between the digits, and masses at the interdigital space. Skeletal fractures affecting any limb were characterized as a hanging leg, misaligned and/or deformed limb, broken skin with exteriorization of protruding bone (indicating an open fracture) resulting in limited or restricted mobility accompanied with intense pain, swelling, bruising, and/or bleeding. Soft tissue and cutaneous traumatic alterations included damages to the non-osseous

components of any limb and excluded any of the alterations described in the previous categories. Such traumatic lesions were associated with the muscular and cutaneous lacerations and ruptures to ligaments and tendons. These injuries can exhibit signs such as pain, swelling, bruising, stiffness, weakness, tenderness, and a limited range of motion (figure 2).

3.2.2 Statistical analyses

Graphics and data available were executed by GraphPad Prism 9 statistical software (GraphPad Software, San Diego, CA, USA). Cattle were considered as an experimental unit. Data were tabulated initially in Microsoft Excel® spreadsheets (Microsoft Office 365 Software, Redmond, WA, EUA), and descriptive statistics were presented as percentage, mean, standard deviation (SD), confidence interval (IC 95%), and coefficient of variation (CV).

The morbidity (diseased animals / total number of animals), mortality (dead animals / total number of animals), and lethality (dead animals / diseased animals) indices were evaluated for all diseases and diseases affecting the musculoskeletal system of the limbs. The limb musculoskeletal system was divided into three categories of lesions affecting specific anatomic locations of the limb members: (a) hoof lesions, (b) fractures limb, and (c) soft tissue and cutaneous traumatic alterations. These indices were evaluated over the entire period (from July 2017 to July 2022) or in relation to the rainy and the dry season. For qualitative and unpaired variables (intergroup test), the chi-square test was used. Statistical significance was considered as $P \leq 0.05$.

3.3 Results

During this study, the data collected from 22 feedlots (Figure 3) over the period of July 2017 to July 2022, resulted in 1,972,884 evaluated cattle on feed. The rate of morbidity was 4.97 % (98,053/ 1,972,884) and mortality was 0.57 % (11,230/ 1,972,884). Variation was observed in morbidity and mortality among feedlots, for morbidity being 6.29 ± 4.08 % (IC 95 %: 4.48 – 8.10) and for mortality being 0.51 ± 0.17 % (IC 95 %: 0.43 – 0.58).

Figure 3: Geographical locations of the feedlots evaluated during this study.



*The symbol on the map with a circle around the point indicates two closely located farms.

The incidence of morbidity and mortality rates for (a) hoof lesions, (b) limb fractures, (c) soft tissues and cutaneous traumatic alterations, and the sum of these pathological conditions referred to as (d) limb musculoskeletal system was presented in table 1. The pathological conditions of the limb musculoskeletal system resulted in a morbidity rate of 1.19 % (23,515/ 1,972,884) and a mortality rate of 0.17 % (3,371/ 1,972,884). In the lethality assessment, it was noted that skeletal fractures had the highest lethality rate at 80.9 %, followed by STCTA (32.0 %) and hoof lesions (0.50 %).

The frequencies in relation to the seasons of the year were compared between the rainy season (n = 835,802 animals) and the dry season (n =

1,137,082). There was a significant difference between the dry and rainy seasons, with morbidity rates of 1.00 % and 1.45 % ($P < 0.0001$), and mortality rates of 0.15 % and 0.18 % ($P < 0.0001$), respectively (Table 1).

Table 1. Distribution of disease conditions observed at feedlots during the evaluation period (2017-2022), considering all animals (n=1,972,884).

	MORBIDITY (%)		MORTALITY (%)	
<i>GENERAL</i>				
HOOF LESIONS	0.907 % (n = 17,895)		0.005 % (n = 90)	
LIMB FRACTURES	0.154 % (n = 3,030)		0.124 % (n = 2,451)	
SOFT TISSUES/CUTANEOUS	0.131 % (n = 2,590)		0.042 % (n = 830)	
MUSCULOSKELETAL SYSTEM	1.19 % (n = 23,515)		0.171 % (n = 3,371)	
<i>SEASONS</i>				
	DRY	RAINY	DRY	RAINY
HOOF LESIONS	0.736 % ^A	1.139 % ^B	0.003 % ^A	0.007 % ^B
LIMB FRACTURES	0.149 % ^A	0.160 % ^B	0.120 % ^A	0.129 % ^A
SOFT TISSUES/CUTANEOUS	0.115 % ^A	0.154 % ^B	0.036 % ^A	0.050 % ^B
MUSCULOSKELETAL SYSTEM	1.00 % ^A	1.45 % ^B	0.159 % ^A	0.186 % ^B

The contribution of hoof lesions, skeletal fractures, and STCTA to the total number of sick animals (morbidity) and dead animals (mortality) is shown in Table 2. Hoof lesions were the condition with the highest rate of morbidity (19.5 ± 12.5 %) but the lowest rate of mortality (0.85 ± 1.6 %). Skeletal fractures had the

largest impact on mortality, accounting for 21.42 ± 9.4 % of the observed causes of death. When considering all three conditions, limb musculoskeletal system diseases contributed 25.4 ± 13.6 % and 29.0 ± 10.9 % of the total number of sick animals and dead animals, respectively.

The coefficient of variation to morbidity and mortality, between the 22 feedlots evaluated, was 64.2 % and 191.5 % for hoof lesions, 80.7 % and 43.9 % for fractures, and 56.0 % and 69.0 % for STCTA, respectively. When grouping these into limb musculoskeletal system diseases, the coefficient of variation was 53.4% for morbidity and 37.6% for mortality.

Table 2 - The proportion of total sick and dead animals is presented as a mean, standard deviation, and 95% confidence interval.

	Unhealthy (100%)	Dead (100%)
HOOF LESIONS	19.5 ± 12.5 % (13.9–25.0)	0.85 ± 1.6 % (0.13–1.57)
LIMB FRACTURES	3.34 ± 2.7 % (2.14–4.53)	21.42 ± 9.4 % (17.2–25.6)
SOFT TISSUES/CUTANEOUS	2.61 ± 1.5 % (1.96–3.25)	6.70 ± 4.6 % (4.65–8.75)
OTHER DISEASES	74.7 ± 13.7 % (68.6–80.8)	71.0 ± 10.9 % (66.2–75.9)
TOTAL	100%	100%
MUSCULOSKELETAL SYSTEM	25.4 ± 13.6 % (19.4–31.4)	29.0 ± 10.9 % (24.1–33.8)

Note: total number of sick (n = 98,053) and dead (n = 11,230) animals.

When evaluating the distribution of clinical cases on days of feed during the dry and rainy seasons (figure 4), the highest proportion of hoof lesions cases was found in the first month of feed, with 54.4 % dry season, and 41.0 % rainy season, with the values decreased over the days on feed. The highest frequencies were also observed in the first 30 days of feed for both skeletal

fractures and STCTA, with 33.6 % and 39.9 % for fractures and 47.7 % and 49.1 % for STCTA, respectively, in both dry and rainy seasons.

The proportion of STCTA cases was different from other clinical cases in terms of its occurrence before feedlot, between disembarking and the day of entry into feedlot. There was a frequency of 22.1 % for the dry season and 17.7 % for the rainy season, all cases occurring during this phase, which was even higher than other moments of feedlot (> 30 days on feed) (Figure 5).

Figure 4 The proportion of disease occurrences during the period on feed. "Entry" refers to the period between unloading and the day the animals are admitted into feedlot, which encompasses all handling procedures during the entry protocol.

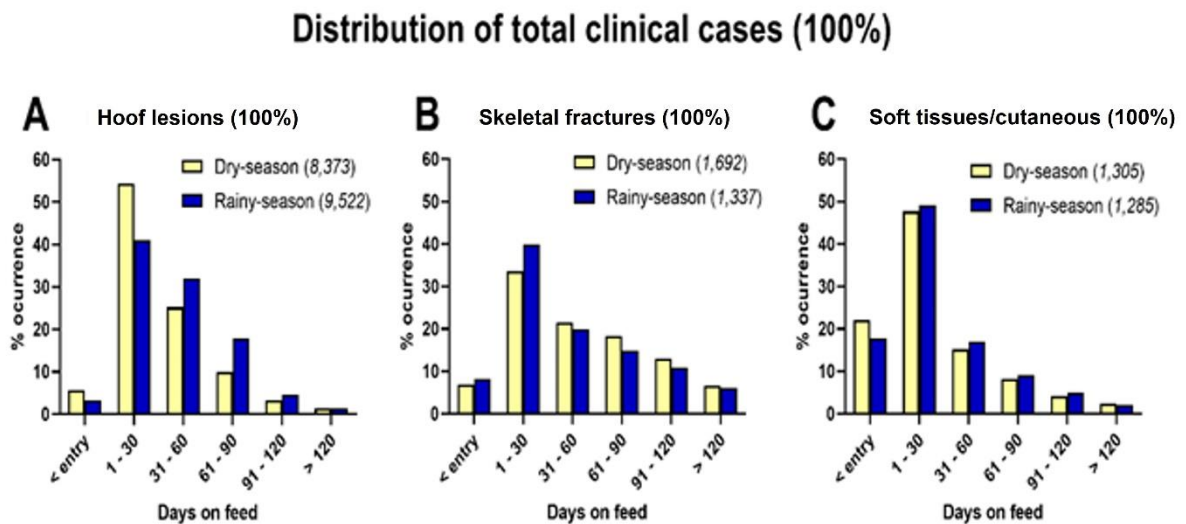


Figure 5 – A-C: muddy environment; D: agonistic interaction/dominance social



3.4 Discussion

The importance of this study results from its broad sample reach, which includes a large number of cattle from different geographical regions and was conducted in a natural environment where diseases occur spontaneously. Therefore, the data can be used to evaluate the effects of injuries on the limb and its associated causes in livestock from Brazil. This study estimated the incidence of morbidity and mortality in feedlots from Brazil to be 4.97 % and 0.57 %, respectively. Comparatively, a previous study found approximate rates of 7.05 % and 0.64 %, respectively (Baptista et al., 2017). Two studies conducted in the USA during the 1990s evaluated the mortality rates of feedlot cattle, with one reporting an average mortality rate of 1.26 % and the other showing rates ranging from 0.18 % to 0.47 % (Vogel, 1994; Loneragan et al., 2001). Therefore, the

mortality rates observed in both the previous and current studies were consistent with each other and were similar to those observed in North America.

In the present study, overall limb musculoskeletal system injuries-related morbidity in beef cattle was 1.19 %, with the most frequently identified causes the hoof lesions (0.91 %). Results of a study from USA on six commercial feedlots during a 12-month revealed an overall lameness incidence rate of 1.04 cases/100 animal-years (Terrell et al., 2017). Another study described a lameness incidence rate of 2.09 %, based on health records for over 1.8 million cattle from five commercial feedlots in the 1990s (Griffin et al., 2016). The initial data suggests that hoof injuries are a common problem in feedlots from Brazil, but it is still lower when compared to the morbidity rates in USA (2.09 %) (Griffin et al., 2016; Terrell et al., 2017).

Overall limb musculoskeletal system injuries-related mortality was 0.17 %. An earlier study in USA on the prevalence of death loss for lameness or injury found that the morbidity rates for cattle and calves were quite different, at 6.4 % (108,710/ 1,694,620) and 1.9 % (36,110/1,904,810), respectively (USDA, 2015). It must be highlighted that limb fractures were the most frequently occurring death at these feedlots and contributed towards 21.42 % of all deaths. A commercial feedlot from USA reported similar findings, where cattle with upper limb lameness (21.6 %) had a significantly higher rate of death or euthanasia compared to those with foot diseases (Terrell et al., 2017). Traumatic injuries in feedlots cause significant morbidity and mortality, often going unrecognized until the animal has deteriorated substantially (Stokka et al., 2001; Shearer et al., 2013). This can have a negative impact on animal welfare, leading to involuntary slaughter remains a major reason for losses in the dairy and beef livestock (USDA, 2015).

One previous study from Brazil has evaluated the epidemiology and clinical findings of foot diseases in 12 farms from the state of Pará, however, clinical examination of the digits was performed only on 498 animals, representing 0.79 % of a total of 62,950 heads (Silveira et al., 2018). No incidence study was found regarding traumatic musculoskeletal injuries of the limbs in beef

cattle feedlot from Brazil, which reinforces the importance of research to investigate the lack of data on these conditions.

Several factors have been identified as risk factors for these limb musculoskeletal system injuries. Inadequate handling practices, including reduced space in feedlots, have been shown to negatively impact animal welfare and lead to chronic stress, as well as alterations in hoof and locomotion (Shearer et al., 2013; Macitelli et al., 2020). Excitable temperament is detected more frequently in *B. indicus* cattle (e.g., Nellore) as compared to *B. taurus*, and increases carcass bruising incidence (Francisco et al., 2015). Breeds of *B. indicus* have also been identified as being at higher risk for traumatic injuries due to their excitable temperament potential. In addition to these factors, social dominance behaviors such as fighting, agonistic interactions, and mounting are more common in non-castrated males (Hubbard et al., 2021). Animals jump repeatedly over others, generating intense weight pressure on the hoof and limb, leading to an increased risk of lesions (Silveira et al., 2018).

During this study, the incidence of morbidity and mortality of limb musculoskeletal injuries were lower during the dry period (1.00 % and 0.159 %) compared to the rainy period (1.45 % and 0.186 %). The incidence of limb musculoskeletal injuries was particularly high in the first month (first 30 days) of both seasons, and then decreased gradually throughout the seasons. We also hypothesize the possible factors associated with the increased lesions during the rainy season, and it can be associated to the structure of floor and the management practices (Mader and Griffin, 2015). Pastures in the rainy season were frequently muddy and slippery, leading to a possible higher occurrence of slips and falls by the cattle. When the ground is not adequately drained, it can result in the accumulation of mud and other residues (Mader and Griffin, 2015). Moreover, high temperatures combined with high humidity ground can cause cracking between the hoof and possible bacterial infections (Stokka et al., 2001).

The high rate of hoof injuries observed in the first 30 days after arrival at the feedlot is in accord with the general concept that transportation and entry handling can make beef cattle more susceptible to diseases with a negative

impact on production and health (Buckham Sporer et al., 2008). Different findings were previously described in a study conducted in the USA, where the average lameness detection time was 57 days on feed (Terrell et al., 2017).

The results of this study demonstrate the need for further research to enhance the diagnosis and prevention of limb musculoskeletal injuries in beef cattle feedlots from Brazil. Given that hoof lesions were the most identified, greater attention must be given to hoof care and management practices in beef cattle. Fractures represent a significant mortality risk in beef cattle feedlots, raising animal welfare concerns and leading to on-farm emergency slaughter. The association between injuries rates and rainy seasons suggests that changes in management and facility design may be necessary to mitigate injury risks.

Moreover, with society becoming increasingly concerned about welfare and quality of life of production animals, there is a growing demand for research to address these questions. The findings of this study highlight the importance of minimizing the incidence of limb musculoskeletal injuries in cattle feedlots. It provides a foundation for future investigations aimed at preventing limb musculoskeletal injuries and improving the welfare of beef cattle in feedlots from Brazil.

3.5 Conclusion

This is the only study to demonstrate the incidence of limb musculoskeletal injuries in feedlots from diverse geographical regions of Brazil, with incidence of morbidity and mortality of 1.19 % and 0.17 %, respectively. It must be highlighted that hoof lesions were the most frequently identified cause of limb lesions in beef cattle. Skeletal fractures show significant welfare concerns and lead to on-farm emergency slaughter. The rainy season was associated with higher injuries rates. A high proportion of soft tissue and traumatic cutaneous alterations in animals occur before they enter to feedlot, often during transport management.

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