Communication

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Simple Summary: Beef cattle farming is an extremely important economic activity in Brazil, mainly in the northern region. Bovine hoof disorders impair the beef production chain; however, there are few studies on the subject, such as on the incidence of bovine digital dermatitis (BDD). Thus, this is a pioneering investigative study to highlight the main BDD predisposing factors in beef cattle herds in the Amazon Biome. The study shows that epidemiological factors related to climate, pasture conditions, and the physical structure of animal management facilities are directly linked to BDD onset in herds, affecting the beef production sector.

Abstract: BDD is a hoof disease characterized by inflammation of the second and fifth accessory digits and the skin in this region. This pathology is scarcely described in the literature; however, it has recently been observed in beef cattle in the Amazon Biome region. The objective of this study was to identify the epidemiological factors associated with BDD onset in cattle in the analyzed biome. Samples were collected from eight farms with extensive breeding systems located in Xinguara, Rondon do Pará, Curionópolis, and Ipixuna do Pará, in the state of Pará, Brazil. A total of 706 Nellore and Nellore crossbred with taurine animals of both sexes were evaluated, with males aged between 2–4 years and a mean weight of 650 kg and females aged between 2–11 years and a mean weight of 400 kg. Distal extremities were inspected during cattle management, and in case of accessory digit lesions, a specific examination was carried out after proper restraint. Animals were diagnosed with BDD in all farms analyzed. Of the 706 cattle inspected, 49 (6.94%) showed BDD, of which 19 (38.77%) were Nellore and 30 (61.22%) were crossbred. This was the first study to determine BDD's occurrence in extensive farming systems in the Amazon region, also showing that pastures with large amounts of stumps and stones, the physical structure of pens, and trauma and injury incidence during animal management are the most important predisposing factors for the onset of BDD.

Keywords: foot injuries; production systems; cattle breeding; Amazon

1. Introduction

Brazil is in a prominent position in global agribusiness, mainly in meat production, and has one of the largest cattle herds, with 224,602,112 heads. The country has stood out as a major global meat exporter, with a total of 1,867,574 tons exported in 2021 [1]. According to McManus et al. [2], Brazilian livestock farming showed rapid growth and modernization, mainly in the north (Amazon Biome)

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and Midwest regions. Freitas Junior and Barros [3] studied the spatial distribution of cattle herds in Brazilian microregions between 1995–2016, reporting that herd and cattle densities grew more quickly and significantly in the Amazon regions and that this production growth was particularly due to increased pasture sizes, mainly resulting from deforestation for cattle production. Additionally, animal production intensified, changing production systems due to greater animal density per hectare and consequently changing nutritional, health, reproductive, and facility management [4,5]. An increased number of animals associated with production intensification directly increases foot diseases that cause considerable economic losses in the beef cattle production chain, such as septic digital dermatitis, laminitis, heel and sole erosion and ulcers, white line disease, and accessory digit lesions. Foot diseases are estimated to reduce weight gain by up to 25% in sick beef animals, consequently reducing meat production, productivity, and profit for producers and the agricultural sector [6].

Bovine digital dermatitis (BDD) is characterized by inflammation of the second and fifth accessory digits and the skin in this region. Inflammation is usually associated with necrosis and loss of corneal substance. BDD onset is associated with a wide variety of epidemiological factors, mainly due to differences between production systems, geographic location, climate factors, and pastures in different regions and farms, in addition to the physical structures of the pens [5–7]. BDD is not a frequently described lesion in the world literature; however, in the Brazilian Amazon Biome region, it has been constantly observed in dairy and beef cattle raised in extensive production systems [8,9]. Even though BDD is not a frequently reported and studied foot injury, it can be considered aggressive and has a negative impact on the cattle production system. BDD's epidemiology has not yet been elucidated, being generally associated with traumatic accessory digit injuries in animals raised in recently deforested or cleared pastures with the presence of tree stumps [7].

Almost all studies on hoof injuries are related to dairy herds raised in an intensive production system [3,6,10]. There is a lack of studies on the reality of extensive production systems and beef herds and a lack of data on the incidence and epidemiology of hoof diseases in these animals and production systems, especially regarding accessory digit injuries [8,9,11]. Therefore, the objective of this study was to be a pioneer in describing the epidemiological factors involved in BDD onset in beef cattle raised in an extensive production system in the Brazilian Amazon Biome.

2. Materials and Methods

The Animal Research Ethics Committee of the Federal University of Pará (CEUA/UFPA) approved this study under protocol n. 080/9838260522. The research was conducted over a year (including the dry and rainy seasons), totaling approximately ten thousand heads of beef cattle from eight farms with extensive breeding systems located in Xinguara, Rondon do Pará, Curionópolis, and Ipixuna do Pará, in the state of Pará, Brazilian Amazon Biome. All farms analyzed had a history of animals with BDD. The distal extremities of animals with suspected or present accessory digit lesions were inspected during vaccination or reproductive management. These animals were separated, identified, and restrained in individual containment pens. Organic matter was removed, and the feet of each animal sampled were washed with water and neutral soap before undergoing specific clinical examination for macroscopic lesions and location described according to Dirksen et al. Epidemiological factors were analyzed according to the following parameters: farm history, pasture characteristics (maintenance, topography, and presence of stones, stumps, and tree trunks), and physical structure of the cattle management facilities [6,7,10].

3. Results

Distal extremities of 706 animals of both sexes were evaluated, with males aged between 2–4 years and females aged between 2–11 years, with a mean weight of 550 kg. Of these, 506 animals were of the Nellore breed, and 200 were crossbred (Nellore X taurine breeds), as shown in Table 1. Of the total number of animals inspected and clinically examined, 49 (6.94%) presented with BDD (Figure 1), of which 19 (38.77%) were Nellore, and 30 (61.22%) were crossbred, with 30 (61 %) females and 19 (39%) males. Also, 15 animals (30.61%) presented with lesions in more than one accessory digit on

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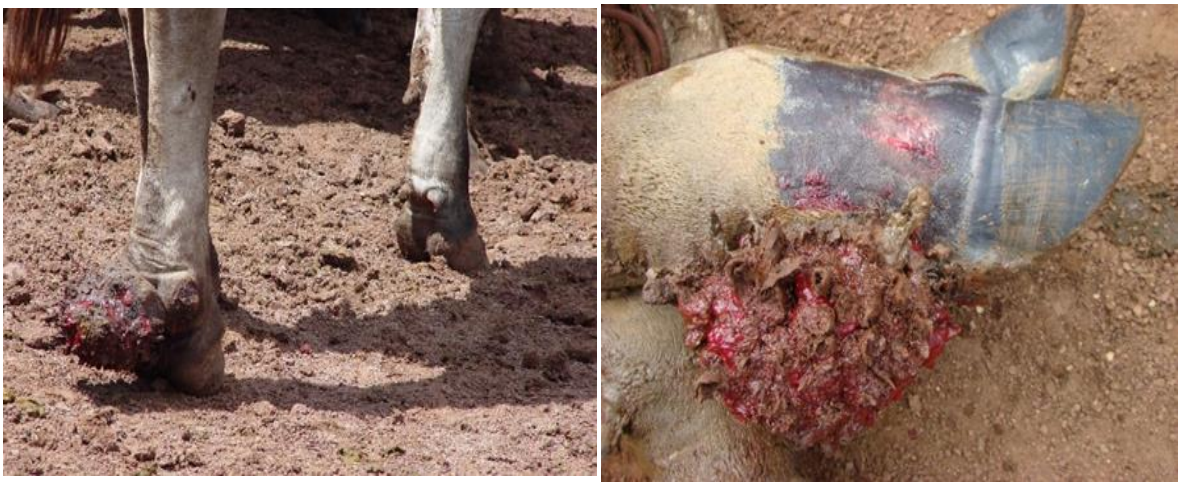
different limbs. Pelvic limb accessory digits were affected in 45 animals (92.42%), with only four animals (7.57%) affected in the thoracic limbs.

Table 1. BDD lesions in beef cattle raised in extensive systems in the state of Pará, Brazilian Amazon Biome.

Farms	Inspected animals	Animals with BDD	Limbs		Animals with BDD in more than one limb
			TL*	PL**	
A	90	8	1	7	2
B	75	5	1	4	1
C	30	2	0	2	0
D	80	5	1	4	1
E	120	10	1	9	6
F	115	11	0	11	4
G	120	6	0	6	1
H	76	2	0	2	0
Total	706	49 (6.94%)	4 (7.57%)	45 (92.42%)	15 (30.6%)

*Thoracic limbs, **pelvic limbs.



(a) (b)

Figure 1. BDD lesions in beef cattle from farms in the Amazon Biome. a) BDD on the left pelvic limb in a pen with stones. b) Chronic BDD, with corneal tissue loss and granulation tissue proliferation.

Of the epidemiological factors identified, five (62.5%) farms (A, E, F, G, and H) had recently cleared or deforested pastures with trunks and stumps, in addition to stones and gravel on the roads used to transport cattle (Figure 2).

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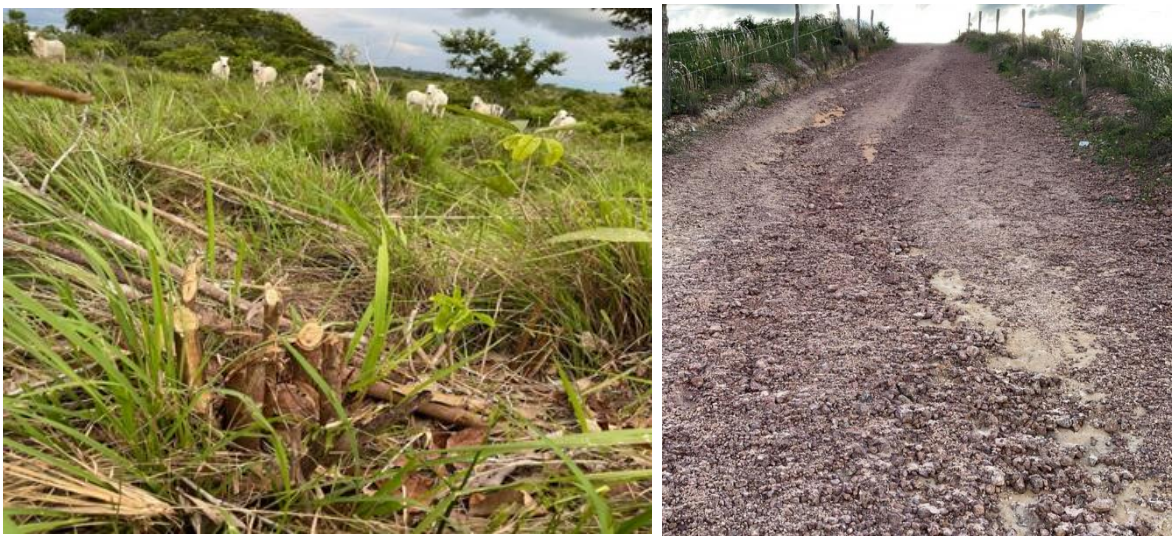
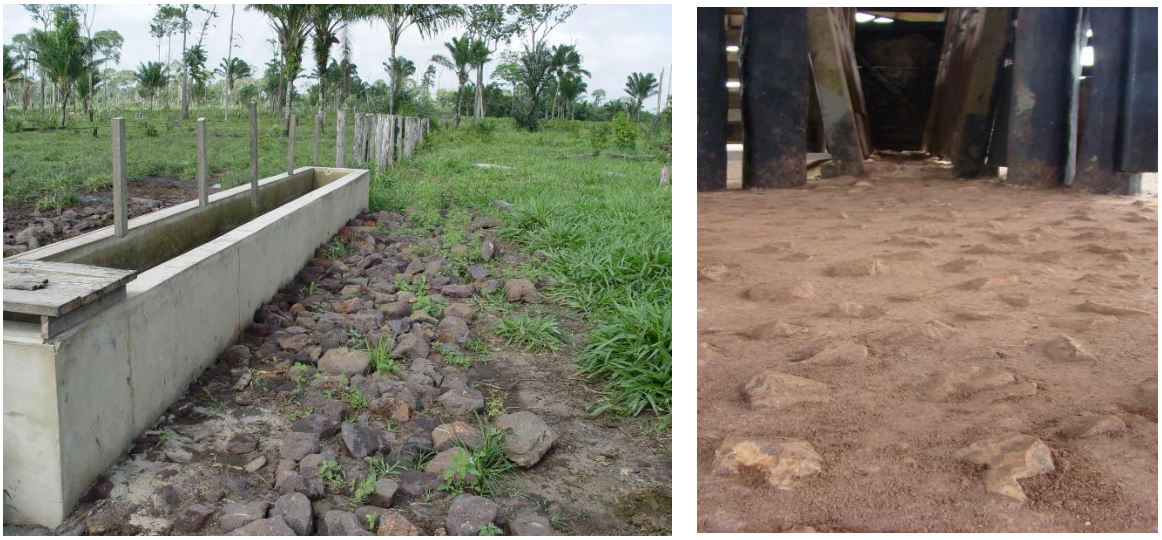


(a) (b)

Figure 2. Pasture conditions and roads used for the cattle on farms in the Amazon Biome. a) Farm G with cattle in recently cleared pastures with branches and stumps. b) Road with stones and gravel on farm E.

A large number of stones was observed in the pastures of six (75%) farms, mainly near water troughs and cattle management areas (Figure 3). There was also mud accumulation in the pens, and organic matter adhered to the hooves, especially in the rainy season (Figure 4).



(a) (b)

Figure 3. Places where the cattle stayed: a) Farm F with stones around the cattle drinking trough. b) Farm B with stones used on the pen and containment pen floor as non-slip objects.

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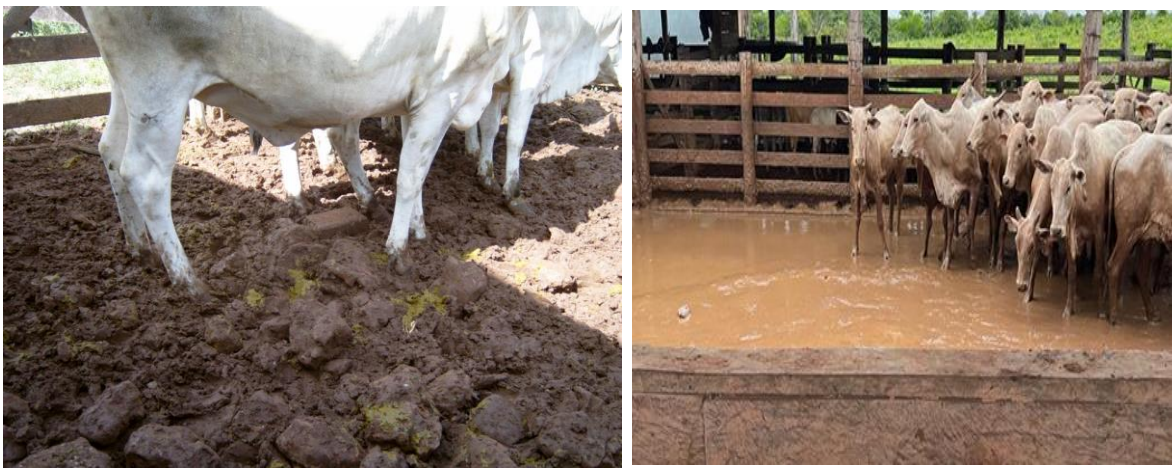
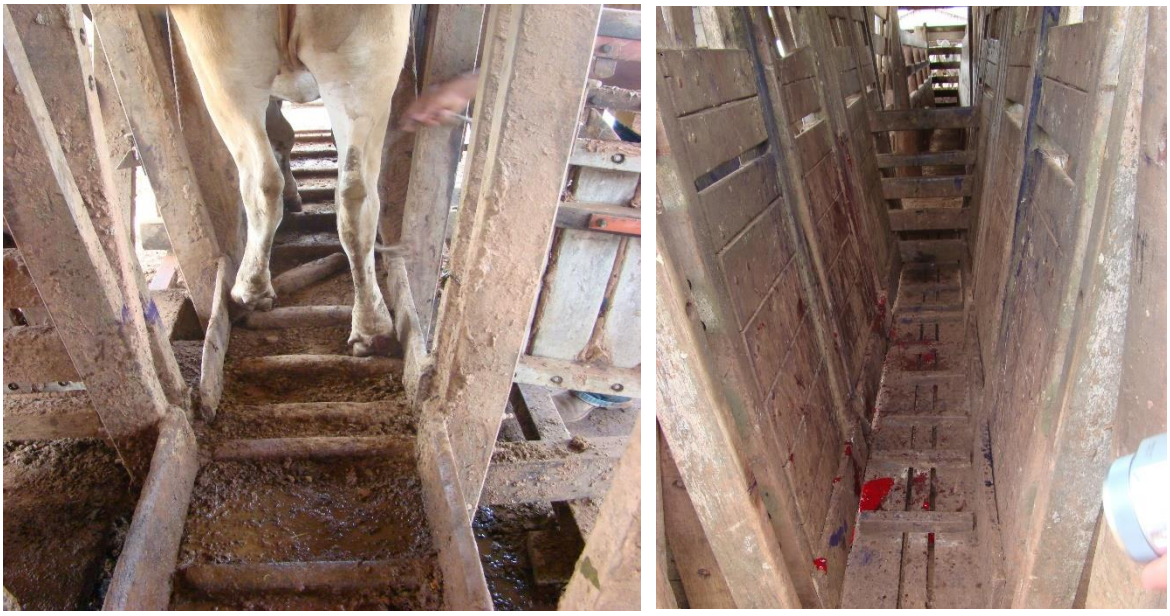


(a) (b)

Figure 4. Cattle management pens on the properties studied in the Amazon Biome. a) Management pen with a large amount of stones on farm D. b) Mud accumulation in a pen during the rainy season on farm C.

The physical facilities used for the animals were not in adequate maintenance conditions on the farms analyzed, with the presence of broken boards (Figure 5) and exposed nails and screws. There was a high density of animals in the pens during management, which exceeded the maximum facility capacity, in addition to stressful animal management with the use of sticks and shocks, making the animals visibly agitated.



(a) (b)

Figure 5. Physical conditions of animal management facilities on the properties studied in the Amazon Biome. a) Individual containment pen on farm B with broken boards. b) Blood on the pen floor, indicating distal extremity injuries in the cattle after management on farm A.

Farm A had the largest territorial extension, with cattle being transported in vehicles from one area to another due to the long distances between pastures. Trucks with cages were used to transport the animals. On the floor of these vehicles, we noticed the presence of non-slip iron railings that were not in good condition, not maintained, misaligned, and with loose iron spikes facing upwards (Figure 6).

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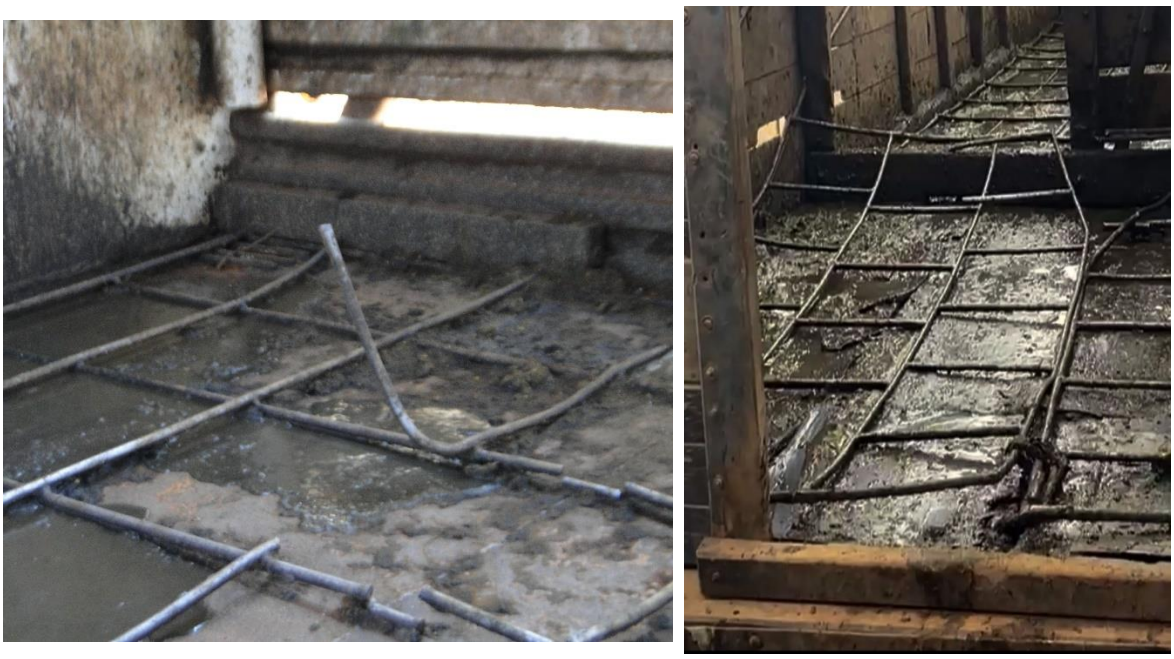

(a) (b)

Figure 6. Vehicles used to transport cattle on farm A. a) and b) Loose transport truck grilles, with misaligned and prominent metal parts with exposed ends.

4. Discussion

In 1990, the cattle herd in the states that make up the Brazilian Legal Amazon included 26.2 million heads. In 2013, this number increased to 80.7 million heads, an increase of 207.38%. The states of Pará and Mato Grosso contributed with an increase of 32.3 million heads, being responsible for almost 60% of the total increase [12]. This increased agricultural production, especially in cattle farming, is the main cause of deforestation due to the opening of new cattle farming areas, causing serious environmental, social, and cultural damage to the Amazon Biome [13]. Increased cattle farming in recently deforested pastures has also been associated with an increased incidence of hoof injuries in these animals [7]. The study by Silveira et al. [8] reported epidemiological characteristics of foot lesions, such as the fact that 91.7% (11/12) of the farms had tree-trunk paddocks, 66.7% (8/12) had sloping terrains and stones, and 16.7% (2/12) had flooded areas. Those data corroborate the epidemiological factors reported in this study, which include the presence of stones in pastures and roads, mud in management pens, and frequent grazing in recently cleared areas with stumps, stones, and branches. Dirty recently cleared areas are a practice adopted by most rural farmers in the Amazon Biome, who do not clean deforested areas before introducing animals due to cleaning and tree stump removal costs, keeping stumps, branches, and roots in the pastures [14]. Therefore, pastures in newly cleared areas increase the onset of traumatic accessory digit lesions caused mostly by stumps, justifying the presence of BDD in 6.94% of the animals analyzed in this study.

The animals were evaluated in 2022, a year with increased rainfall (September, 57.8 mm; October, 98.6 mm; November, 132.6 mm; and December, 180.79 mm) [15], much higher than the expected for 2023, justifying the accumulation of mud and organic matter in animal management areas on the studied properties, with rainfall and humidity being important epidemiological factors in the Amazon Biome. However, Celso et al. [16] and Klitgaard et al. [17] studied foot disorders in dairy cows, determining *Treponema* sp as the possible agent involved in hoof injury cases, including BDD, and suggesting that humidity is not a relevant factor in BDD pathogenesis, differently from what was observed in the present study, especially during the rainy season in which it was conducted.

Another factor evaluated in the present study was the physical structure of animal management facilities. Costa et al. [18] stated that zootechnical facilities should not cause physical harm to the animals, ensuring the welfare and safety of animals and rural workers. All farms analyzed in the

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present study managed animals in pens and containment pens not adapted to best practices aimed at animal welfare, with stressful procedures leading to fear and aggressive behaviors such as restlessness, kicking, agitation, and escape attempts, considerably increasing the risk of digits and accessory digit lesions in the cattle [19,20]. The pens also had containment trunks with broken boards and access ramps with holes and stones, favoring traumatic foot injuries and the consequent onset of BDD.

Crossbred animals were more affected by BDD (61.22%) than zebu animals (38.77%). Burrow et al. [21] reported a predominance of zebu breeds and crossings in beef farming, which are considered more agitated, aggressive, and temperamental than European breeds. Furthermore, human-animal interaction in the extensive farming system is minimal, and with less frequent contact between animals and rural workers, animals with more agitated temperaments demonstrate more intense and traumatic behavioral responses when exposed to stress situations or human presence [22,23]. Breed, temperament, and extensive breeding systems with reduced management and animal-human contact may have contributed to the agitated behavior of the animals in this study, which possibly increased BDD onset.

The physical conditions of the trucks and cages used to transport animals on farm A may be a predisposing factor associated with accessory digit injuries because the floors of these vehicles had misaligned non-slip iron railings, with loose iron spikes facing upwards, which may increase the risk of injuries during transportation, aspects corroborated by Nielsen et al. [24], who reported that transport-related factors play a major role in the incidence foot injuries in cattle. The poor maintenance of transport vehicles and the lack of road paving and maintenance cause animal stress during transportation, with less balance in the trucks, which consequently increases the risk of slips and falls, resulting in injuries such as accessory digit lesions.

Rueda et al. [25] also report that frequent and recurrent management in pens can affect regulatory and behavioral responses typical of animals with poor welfare, increasing cattle reactivity and predisposing them to injuries. This factor was observed in the present study, with most animals with BDD being females (61%) subjected to reproductive management, which requires at least three transportations to the management pen in a short period of time. This greater animal management frequency increases stress levels, making beef females used for reproduction more prone and exposed to the risk of accessory digit injuries for being transported more often to management areas, for being subjected to higher stress levels, and for walking greater distances on soils with stones.

Another factor related to the greater incidence of BDD in females is age. Molina et al. [26] reported a higher frequency of hoof problems in older animals, which are exposed several times to predisposing factors, reinforcing the results of this present study, in which most animals with BDD were older females that stayed for long periods on breeding farms, being more exposed to conditions predisposing traumatic accessory digit lesions.

Inappropriate mounting is a behavioral disorder that predisposes digit and accessory digit lesions [27]. Silveira et al. [8] reported corneal tissue erosions in the heels, at the base of the accessory digit, in the pasterns, and in the crown of the pelvic limbs as a result of mounting. In this study, inappropriate mounting was a common practice between females on properties 5 and 8 (62.5%), which were intended for breeding and used the fixed-time artificial insemination technique. Therefore, on the insemination day, cows in heat constantly mounted on the others, predisposing foot injuries. In males, mounting was observed during the period they were trapped in the pen before immunization.

Another important factor in digit and accessory digit lesions is parasitism by the fly *Cochliomyia hominivorax*, considered the main species associated with primary myiasis in Brazil [28]. Fly parasitism is facilitated in environments with excess humidity and organic matter, associated with infrastructure problems and management difficulties, consequently increasing the incidence of primary traumatic injuries with hemorrhage, which end up attracting flies to deposit eggs in the region [29]. This is a significant factor that cannot be discarded in the epidemiology of accessory digit injuries. Myiasis can be a gateway for foot injury agents, hindering the visualization and diagnosis of primary foot diseases [30].

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Escaping and kicking reactions were observed in the study animals, which caused accessory digit injuries, mainly in the pelvic limbs. This kicking behavior was repeatedly observed during management in the pens, resulting in 92.42% BDD injuries in the pelvic limbs, being, therefore, another important epidemiological factor in beef cattle in the Amazon Biome. The lateral accessory digit (60.60%) was more affected than the medial accessory digit (39.40%), which may be justified by the fact that this structure is more exposed to mechanical trauma [31]. There was greater occurrence of injuries in the right limbs (60.60%). Gargano et al. [32] reported that the right limb is more affected in cattle, possibly due to decreased blood circulation in this limb, since sternal rest commonly exerts greater pressure on this limb.

More studies are needed on this subject to evaluate the real losses and impacts of BDD on Brazilian and global agribusiness, as well as studies on the etiology of BDD in beef cattle farming.

5. Conclusions

The epidemiological factors analyzed in the study, such as pasture conditions and the physical structure of management facilities, directly increased BDD onset in the animals. BDD affects cattle of both sexes, with varying ages and weights, raised in an extensive system. Stressful inappropriate management practices are also an important factor associated with BDD onset since we know the importance of animal welfare in disease prevention. Together with epidemiological factors, they should be critical points to be monitored by veterinarians and producers, always focusing on preventive veterinary medicine, especially for hoof infections such as BDD in beef cattle in the Amazon Biome.

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