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REGULAR ARTICLES

Association between bovine digital dermatitis and annual periods of lower pluviometric precipitation in Central Brazil

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Abstract

We aimed to follow the epidemiologic evolution of bovine digital dermatitis (BDD) and other podal diseases grouped in a dairy farm in Central Brazil between the years 2010 and 2016. This study was carried out in a farm in Jataí, Goiás, Central Brazil, where the prevalence data of bovine digital dermatitis (BDD) and other podal diseases, as well as the composition, history, and management of the herd, was collected. We analyzed the collected data into the two annual pluviometric precipitation values in Central Brazil: rainy season and dry season. The cumulative frequency for comparison of prevalence between seasons throughout the years was calculated from 2011 to 2016. The comparison was carried out by post hoc chi-square test with the Bonferroni correction adopting a level of significance of 5% ($p < 0.05$). BDD was not diagnosed at the property in 2010; however, the disease became endemic from 2011, which coincides with the arrival of new animals to the herd. The comparison of the accumulated frequencies for prevalence of the diseases in the herd between 2011 and 2016 revealed BDD, as well as the grouped nutritional and metabolic foot diseases, has the highest prevalence in the period of lower annual precipitation in Central Brazil, which occurs between May and October. For a better control of BDD, we recommend greater attention in cattle management in the dry season of the year in Brazil, as well as in any other place in the world in which rainfall is seasonal.

Keywords BDD · Claw disorders · Dairy cattle · Epidemiology · Lameness

Introduction

Bovine podal diseases compose one of the main economic and productive barriers to bovine culture worldwide (Coetzee et al. 2017). Studies carried out in Brazil and in other countries have reported these diseases have relatively high prevalence in herds, and they may vary according to nutritional, genetic, and management factors. Bovine digital dermatitis (BDD) has been emphasized as one of the diseases with higher prevalence in several dairy herds (Souza et al. 2006; Oberbauer et al. 2013). BDD, therefore, has been one of the main podal diseases described in bovine herds, and it may represent 10–40% of all causes of lameness in bovines (Wilson-Welder et al. 2015a). Worldwide, it is estimated that this disease causes a loss of 190 million dollars a year due to lameness and associated decrease in milk production (Wilson-Welder et al. 2015b).

BDD was initially described in Italy in the 1970s. From this description, the disease has been widely studied. After 43 years of research, BDD has been clinically characterized, the infectious agents have been isolated in characteristic lesions, and histopathological aspects have been described (Krull et al. 2014). However, the etiopathogeny of BDD has not been elicited and the set of risk factors for the development of the disease is complex and sometimes controversial (Krull et al. 2014; Palmer and O'Connell 2015). Clinically, as a result of the interaction between etiological agents and the immune response of the host, BDD is characterized by a skin inflammation in the interdigital palmar/plantar or dorsal space, and it may also occur in neighboring regions between the skin and the coronary band of the digits, or between the skin and the coronary band of the abaxial wall of the hoof. Initially, it is characterized by a small circumscribed pink area that might become bigger and ulcerated throughout time, besides presenting dyskeratosis and excessive growth (Leão et al. 2005; Wilson-Welder et al. 2015a).

In general terms, regarding the risk factors, the rearing system, the adoption or disregard of biosafety measures

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during the insertion of new animals to the herd or during trimming, diet, and nutrition, and the management practices such as grouping of different categories within the herd seem to affect the levels of susceptibility to the development of BDD. There are also genetic and non-genetic factors that are related to the animals, such as parturition, lactation stage, breed, behavior, hoof conformation, some skin and hair follicle properties, and the individual immune response (Palmer and O'Connell 2015).

BDD is an infectious-inflammatory disease that has a complex and multifactorial etiopathology; thus, it is important to carry out epidemiologic studies that show how the disease behaves in specific herds around the world. Several studies have described the prevalence and some risk factors in different countries and regions of Brazil (Silva et al. 2001; Martins et al. 2002; Souza 2002; Somers et al. 2003; Leão et al. 2009; Silveira 2009; Oberbauer et al. 2013). However, these studies have not described BDD epidemiology throughout the years in the same bovine farm. This lack of research makes it harder to understand the epidemiologic behavior of the disease in time.

The aim of this study was to follow the epidemiologic evolution of bovine digital dermatitis and other podal diseases grouped in a dairy farm in Central Brazil between the years of 2010 and 2016.

Materials and methods

The study was carried out on a rural property dedicated to the production of dairy bovines, in the municipality of Jataí, State of Goiás, Brazil, between November 2010 and March 2017. This study was conducted during clinical care provided in extension projects authorized by the Ethics Committee for the Use of Animals under the protocol numbers 150/2010 and 21/2016. During the whole duration of the study, a veterinary doctor handled the sanitary, nutritional, and improvement programs of the herd monthly. Continuous evaluations were carried out every month, and the catalog of the podal affections observed was produced. These practices allowed the data collection. Data regarding the composition, history, and management of the herd were also collected and allowed us to make conjectures about it even without quantitative analysis.

The quantification of podal affections was distributed between two pluviometric seasons. We considered the dry season from May to October and the rainy season from November to April. Therefore, for a better understanding of the evaluation calendar, we established the beginning of each year as coinciding with the beginning of the dry season and the end of each year as coinciding with the end of the following rainy season. In the municipality of Jataí, the mean pluviometric precipitation values in the dry and rainy season are 46.3 and 228.6 mm, respectively.

For differential diagnosis and classification of cattle foot diseases, we used the Icar Claw Health Atlas description (Egger-Danner et al. 2015). This study focused mainly at analyzing the prevalence of bovine digital dermatitis (BDD) throughout the years. Other podal diseases were also quantified; however, they were distributed and analyzed in four groups: other infectious diseases (OID), nutritional and metabolic diseases (NMD), traumatic affections (TRA), and granulomatous lesions (GRL). Diseases such as heel horn erosion, interdigital phlegmon, and arthritis formed the group of other infectious diseases. Lesions related to laminitis and complications such as ulcers, sole hemorrhage, double sole, thin sole, and white line disease made the group of nutritional and metabolic diseases. Traumatic lesions comprised fractures and luxation. Finally, granulomatous lesions were represented by the cases whose diagnosis was not concluded due to the severity and clinical evolution of the lesion.

From the determination of the prevalence of podal diseases in the herd, we carried out the retrospective and prospective analysis of the occurrence of these affections and bovine digital dermatitis in the farm. We paid particular attention to BDD due to the interest in establishing some factors related to the introduction of the disease in the farm and its epidemiologic evolution in the following years. Cases of reinfection were included in the general calculation.

The prevalence in the rainy season of the year 2010 was the starting point of the study; however, as the complete data regarding dry and rainy seasons were only recorded from 2011, the cumulative frequency for comparison of prevalence between seasons throughout the years was calculated from 2011 to 2016. The comparison was carried out by post hoc chi-square test with the Bonferroni correction (MacDonald and Gardner 2000). The analyses were performed with the aid of the Statistical Package of Social Sciences (SPSS, 23.0), adopting a level of significance of 5% ($p < 0.05$).

Results

The mean number of bovines in the farm during the evaluation period was 453 animals, distributed across different categories. Of the total, the constitution of the herd was, on average, 60 male animals, including four breeders, and 394 female animals; from these, 81 were at 0–12 months, 109 at 12–24 months, and 204 over 24 months of age. The whole herd was developed from the year 1978, with Gir animals from the farm and some Holstein bulls acquired from other farms in the region. At the beginning of the study, the herd was composed of 80% Girolando bovines and 20% (Gir × Holstein) crossbred bovines.

The prevalence of DD and other podal affections are displayed in Table 1. The data can be observed according to the seasonality of the pluviometric precipitation divided into dry season and rainy season. For each season, the prevalence is distributed according to the year of the evaluation. In Fig. 1, the prevalence distribution of podal affections during the years of evaluation may be observed as graphics.

By analyzing the information obtained throughout the 7 years following the general, sanitary, and nutritional management employed on the farm, we verified that in the first evaluation, which took place in the rainy season of 2010, no case of DD was diagnosed in the herd. After the first cases of DD diagnosed in 2011, we observed the disease became endemic, with prevalence varying between dry and rainy seasons. According to the history obtained in the farm, the appearance of DD in the herd coincided with the acquisition of Holstein animals of high genetic value and some Girolando animals.

The cumulative frequency of podal diseases grouped between 2011 and 2016 by season and the respective comparisons by post hoc chi-square test may be seen in Table 2.

By analyzing the cumulative frequencies compared between the rainy and dry seasons, we observed a significant statistical difference for bovine digital dermatitis (BDD), other infectious diseases (OID), nutritional and metabolic diseases (NMD), and between the number of healthy animals (HLTH). As for the traumatic affections (TRA) and granulomatous lesions, there was no difference regarding the seasons in the evaluated years.

Discussion

Studies have shown that Holstein and crossbred bovines have greater susceptibility to developing BDD than other breeds (Rodriguez-Lainz et al. 1999; Holzhauer et al. 2006; Relun et al. 2013). Moreover, an analysis of the prevalence of lameness in dairy herds in England and Wales showed that, on farms where there are no Holstein animals, there is a lower prevalence of lameness (Barker et al. 2010).

Besides the genetic factor, the lack of a general evaluation of the herd and the absence of podologic assessment of the acquired bovines may have contributed to the occurrence of BDD. Other aggravating factors were the transportation of bovines in trucks without hygiene before boarding the animals and the absence of quarantine before introducing the new bovines to the herd of the farm. The introduction of new animals to the herd has been associated with the prevalence of BDD in Chile and the USA since the 1990s (Rodriguez-Lainz et al. 1996, 1999; Wells et al. 1999).

BDD presented greater occurrence during the dry season. This finding contradicts other authors who mentioned a greater susceptibility of animals that remained longer periods in contact with mud (Laven 2000; Barker et al. 2010; Palmer and O'Connell 2012). There is even a greater permeability of digital skin when in experimental contact with mud for 24 h (Palmer et al. 2013). On the other hand, dairy farms in the State of Goiás, Brazil, presented a greater prevalence of BDD in the dry season (Leão et al. 2009), confirming the findings of the current study.

Table 1 Distribution of digital dermatitis and other bovine podal diseases grouped (group) according to the seasonality of the pluviometric precipitation (season) and years of evaluations, in a dairy farm in Central Brazil

Season	Group	Year of evaluation						
		2010	2011	2012	2013	2014	2015	2016
Dry	BDD	–	108 (20.6)	52 (12)	60 (12.6)	106 (24.1)	101 (20.1)	98 (21.8)
	OID	–	2 (0.4)	9 (2.1)	10 (2.1)	7 (1.6)	8 (1.6)	11 (2.4)
	NMD	–	19 (3.6)	13 (3)	21 (4.4)	16 (3.6)	14 (2.8)	17 (3.8)
	TRA	–	0 (0)	1 (0.2)	0 (0)	2 (0.5)	1 (0.2)	0 (0)
	GRL	–	0 (0)	1 (0.2)	2 (0.4)	0 (0)	1 (0.2)	1 (0.2)
Total	HLTH		395 (75.4)	359 (82.5)	385 (80.5)	309 (70.2)	377 (75.1)	322 (71.7)
	HERD		524 (100)	435 (100)	478 (100)	440 (100)	502 (100)	449 (100)
Rainy	BDD	0 (0)	34 (6.2)	22 (4.9)	25 (5.4)	31 (6.9)	38 (7.4)	35 (6.3)
	OID	5 (1.1)	14 (2.5)	17 (3.8)	16 (3.4)	22 (4.9)	21 (4.1)	18 (3.2)
	NMD	8 (1.7)	6 (1.1)	5 (1.1)	7 (1.5)	4 (0.9)	6 (1.2)	6 (1.1)
	TRA	1 (0.2)	0 (0)	1 (0.2)	1 (0.2)	0 (0)	1 (0.2)	0 (0)
	GRL	4 (0.9)	2 (0.4)	3 (0.7)	1 (0.2)	2 (0.4)	1 (0.2)	2 (0.4)
Total	HLTH	442 (96.1)	496 (89.9)	399 (89.3)	414 (89.2)	389 (86.8)	445 (86.9)	494 (89.0)
	HERD	460 (100)	552 (100)	447 (100)	464 (100)	448 (100)	512 (100)	555 (100)

The data are presented as absolute frequency and, between parentheses, as relative frequency (%)

BDD bovine digital dermatitis, *OID* other infectious diseases, *NMD* nutritional and metabolic diseases, *TRA* traumatic affections, *GRL* granulomatous lesions, *HLTH* the total of healthy animals that did not present podal injuries, *HERD* the total number of evaluated animals in the herd

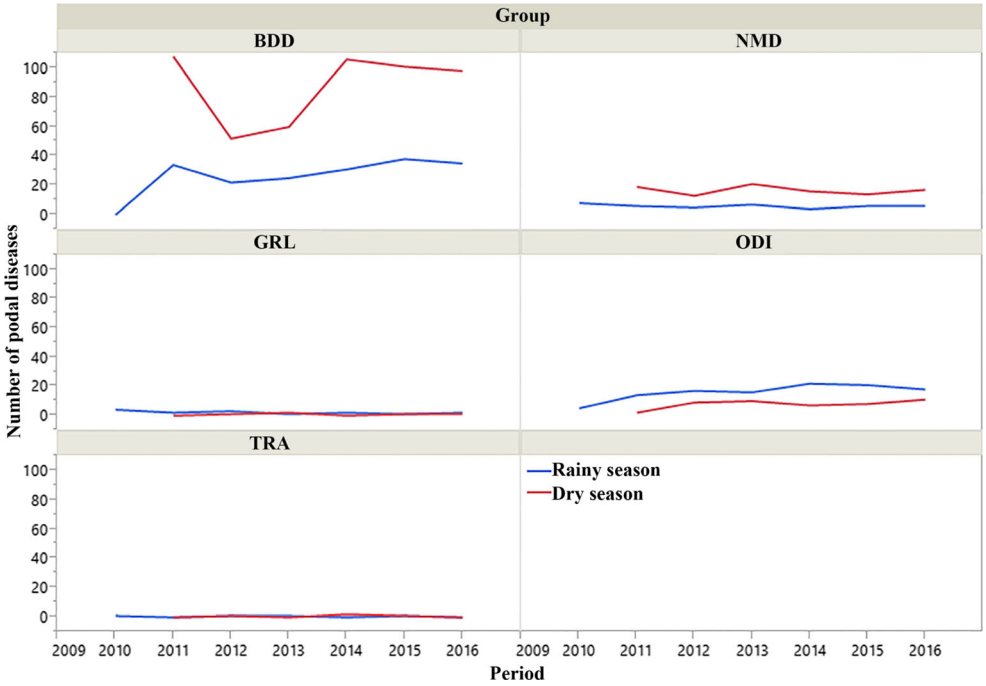

Fig. 1 Distribution of the prevalence of podal affections in rainy and dry seasons between the years of 2010 and 2016 in a study on the epidemiologic evolution of digital dermatitis in a dairy farm in the municipality of Jataí, Goiás, Brazil. BDD bovine digital dermatitis, OID other infectious diseases, NMD nutritional and metabolic diseases, TRA traumatic affections, GRL granulomatous lesions, HLTH the total of healthy animals that did not present podal injuries, HERD the total number of evaluated animals in the herd

As BDD, the NMD had a greater cumulative frequency in the dry season. The type of diet offered to the animals in this period may explain the higher prevalence of BDD and NMD in the dry season throughout the years in the mid-western region of Brazil. The intense management with a greater supply of carbohydrates in the diet favors the occurrence of ruminal and metabolic acidosis in bovines (Krause and Oetzel 2006). In an acidosis state, vasoconstriction of the digital region of bovines might occur (Freitas 2015). On the interdigital skin of healthy bovines, there are microorganisms that may be observed without any lateral inflammatory infiltrate. They are considered as saprophytes (Romani 2003). Ischemia and consequent digital anaerobiosis in bovines that present metabolic acidosis may be the causes of proliferation of the resident microbiota of the digital subcutaneous space of healthy bovines, mostly spirochetes of *Treponema* genus, strict anaerobic bacteria, and main etiological agents of BDD (Trott et al. 2003; Wilson-Welder et al. 2015a; Tremblay et al. 2016).

Besides acidosis leading to vasoconstriction of the digital region of bovines (Freitas 2015), studies in humans have shown acidosis causes losses to the blood coagulation process, predisposing the patients to hemorrhage (Engstrom et al. 2006a, b). During the septic shock in humans, the course of time of plasminogen activator inhibitor (PAI) was the best way to predict lactate course of time, which leads to the conjecture that PAI and lactate are correlated and responsible for the inhibition of the activation of fibrinolysis (Hartemink et al. 2010). As the imbalance between coagulation and fibrinolysis may contribute to tissue hypoxia and even to the death of human patients in septic shock (Hartemink et al. 2010), the

Table 2 Results of the comparison of the cumulative frequencies of podal diseases in the rainy and dry seasons in a study of the epidemiologic evolution of digital dermatitis in a dairy farm in the municipality of Jataí, Goiás, Brazil. BDD bovine digital dermatitis, OID other infectious diseases, NMD nutritional and metabolic diseases, TRA traumatic affections, GRL granulomatous lesions, HLTH the total of healthy animals that did not present podal injuries, HERD the total number of evaluated animals in the herd

Cumulative frequency of podal diseases	Season, *n* (%)		Total	*p*
	Rainy	Dry		
BDD	185 (6.2)	525 (18.6)	710 (12.2)	< 0.001
OID	108 (3.6)	47 (1.7)	155 (2.7)	< 0.001
NMD	34 (1.1)	100 (3.5)	134 (2.3)	< 0.001
TRA	3 (0.1)	4 (0.1)	7 (0.1)	0.65
GRL	11 (0.4)	5 (0.2)	16 (0.3)	0.16
HLTH	2637 (88.5)	2147 (75.9)	4784 (82.4)	< 0.001

Comparison was done by using post hoc chi-square

acidosis and consequent imbalance of coagulation/ fibrinolysis in bovines may be related to tissue hypoxia and contribute to the etiopathogeny of BDD.

Regarding the other infectious diseases (OID), the comparison between the cumulative frequencies of both seasons showed a greater prevalence to the rainy season, opposed to BDD. Therefore, for infectious diseases such as septic pododermatitis, interdigital phlegmon, arthritis, and paronychia, factors as the accumulation of waste related to mud and moisture might be associated to the etiopathogenies. The accumulated frequency of animals with healthy hooves was statistically higher in the rainy season, which occurred mostly because of the high prevalence of animals with BDD during the dry season.

As this study showed, the management of dairy herds in Central Brazil must be carried out taking the essential precautions to avoid BDD becoming endemic. The introduction of new animals must always be preceded by a podologic examination of acquired bovines, and the transportation of animals must be done under adequate hygienic conditions. The establishment of quarantine with periodical clinical examinations before introducing the new bovines to the herd may avoid the dissemination of BDD and other diseases. The supply of diets with high levels of carbohydrates in the annual dry period may be performed initially with the gradual adaptation of the animals to the diet to avoid the occurrence of metabolic acidosis and the likely complications in the podal region of bovines.

In conclusion, bovine digital dermatitis has the highest prevalence in the period of lower annual precipitation in Central Brazil, which occurs between May and October. The same epidemiological trend observed for digital dermatitis could be noted for nutritional and metabolic diseases, while the other infectious diseases occurred more frequently in the rainy season. For a better control of BDD, we recommend greater attention in cattle management in the dry season of the year in Brazil, as well as in any other place in the world in which rainfall is seasonal.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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