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Characterization and frequency of foot injuries and foot-related lameness in a sheep herd with prophylactic measures for foot-related diseases[1]

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ABSTRACT.- Queiroz A.T.Z., Barreto J.V.P., Lazarin M., Crisótomo M.L.L., Cunha Filho L.F.C., Pertile S.F.N., Quintiliano M.H. & Queiroz G.R. 2022. **Characterization and frequency of foot injuries and foot-related lameness in a sheep herd with prophylactic measures for foot-related diseases.** *Pesquisa Veterinária Brasileira 42:e07012, 2022.* Universidade Pitágoras Unopar, Rod. PR-218 Km 1, Araponga, PR 86702-670, Brazil. E-mail: jose.proni@hotmail.com

Foot lesions in sheep herds are responsible for great economic losses, because pain during locomotion interferes with feeding and behavior, leading productivity losses. The objective of this work was to describe the main foot disease found in sheep herd that uses prophylactic measures against foot diseases. A total of 346 ewes of different ages, with or without lameness, were assessed for the presence of foot lesions in all limbs, digits and adjacent structures. Among all the 2768 digits evaluated, 103 (29.76%) had lesions, representing 1.04 lesion per animal. 41.75% (43/103) had only one lesion, 39.81% (41/103) had two lesions, 16 (15.53%) had three lesions, and only 2.91% (3/103) had four or more lesions. Hind limbs were the most affected and the most frequent diseases were white line disease (40.05%), interdigital dermatitis (33.70%) and footrot (12.15%). It was concluded that foot disease in sheep is frequent and constitute a health problem for herds, even on farms that use strategies to prevent it. Therefore, it is essential to classify the lesions, as well as the adoption of effective prophylactic and therapeutic measures.

INDEX TERMS: Foot injuries, lameness, sheep, prophylaxis, trimming, claw disorders, sheep farming.

RESUMO.- [**Caracterização e frequência de lesões podais e da claudicação em rebanho ovino com medidas profiláticas de doenças podais.**] Lesões podais em ovinos são responsáveis por grandes perdas econômicas, pois a dor durante a locomoção interfere na alimentação e no comportamento, levando à perda de produtividade. O objetivo deste trabalho foi descrever as principais doenças podais encontradas em rebanho ovino, que utiliza medidas profiláticas contra as doenças podais. Foram examinadas 346 ovelhas quanto à presença de lesões podais em todos os membros, dígitos e estruturas adjacentes. Entre os 2.768 dígitos avaliados, 103 (29,76%) apresentavam lesões, representando 1,04 lesões por animal. 41,75% (43/103) apresentavam apenas uma lesão, 39,81% (41/103) tinham duas lesões, 16 (15,53%) tinham três lesões, e apenas três animais apresentavam quatro ou mais lesões. Os membros posteriores foram os mais afetados e as doenças mais frequentes foram a doença da linha branca (40,05%), dermatite interdigital (33,70%) e *footrot* (12,15%). Pode-se concluir que as lesões podais em ovinos são frequentes e constituem um problema sanitário para os rebanhos, mesmo em propriedade que realiza medidas profiláticas. Portanto, é fundamental classificar as lesões, assim como adotar as medidas profiláticas e terapêuticas eficazes.

TERMOS DE INDEXAÇÃO: Lesões podais, claudicação, ovinos, profilaxia, casqueamento, doença dos cascos, ovinocultura.

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INTRODUCTION

The increase in sheep herds and the intensification of animal productivity resulted in an increase in animal stocking per area, generating greater challenges in terms of animal welfare and health, with foot problems being one of the main challenges in sheep breeding (Fitzpatrick et al. 2006, Winter 2008, Gelasakis et al. 2019, Moschovas et al. 2021). The health of the hooves and their adjacent anatomical structures is of great importance as it is closely related to weight gain and animal productive efficiency (Aguiar et al. 2011, Smith et al. 2014, Gelasakis et al. 2019, Moschovas et al. 2021), since pain alters the locomotion pattern, interfering with food and water intake, and animal behavior, resulting in production losses (Winter 2004, 2008, Fitzpatrick et al. 2006, Gelasakis et al. 2019), as well as affecting animal welfare due to chronic stress caused by the constant pain associated with foot disease (Stubsjøen et al. 2015).

Differentiate these foot lesions can be challenging because it depends on the characterization and identification of lesions, which is not always performed satisfactory within the farm routine. Lesions classification is critical to determine an accurate diagnosis once those different injuries may have distinct etiologies, treatment and prophylaxis (Winter 2004, 2011, Ferrer & Ramos 2008, Hodgkinson 2010).

Due to the importance of the subject and the few studies on foot injuries in sheep in Brazil (Aguiar et al. 2011, Gargano et al. 2013, Silveira et al. 2016, Lima et al. 2017, Carvalho et al. 2018), the present work aims to classify and describe the frequencies of foot diseases diagnosed in a herd of Santa Inês sheep on a farm that used some prophylactic measures for foot-related diseases.

MATERIALS AND METHODS

Experimental design. The experiment was carried out in accordance with the guidelines of the Ethics Committee on the usage of animals in experiments and was approved by the scientific committee (CEA-UNOPAR 027/19).

The study was conducted in February of 2019, at a farm located in the city of Jaboticabal (21º10'01.96" S and 48º10'49.96" O), São Paulo state, Brazil. During the period in which the research was carried out, the average temperature was 23.6ºC, and the precipitation was 222mm (INMET 2018).

A total of 346 Santa Inês ewes, between three and seven years of age were evaluated. They were kept in pastures of *Cynodon dactylon* during the day, and housed in collective pens overnight, which a portion had a concrete floor and another had dirt floor. Commercial mineral supplements and water were permanently available to the animals in covered troughs. As it is commonplace to deworm the ewes monthly according to the fecal egg count at this farm, fecal samples were collected from the rectum and nematode eggs were counted by the modified McMaster method (Whitlock 1948). Moreover, FAMACHA® method was also used as recommended by Molento et al. (2004) to access clinical parameter for *Haemonchus contortus* infection. The ewes deworming program was instituted according to an anthelmintic resistance test, by administration of levamisole at a dose of 5.5mg/kg when fecal egg count were score up to 500 and FAMACHA® under three. The ewes were vaccinated against rabies, clostridiosis (*Clostridium septicum*, *Clostridium novyi* type B, *Clostridium sordellii*, *Clostridium perfringens* type C and D, *Clostridium tetani, Clostridium botulinum* type C and D, and *Clostridium chauvoei*) and footrot (*Dichelobacter nodosus* serotypes B, C, D, E, F, G e H) were carried out annually. The ewes had not received any injectable anti-inflammatory, antibiotic or analgesic drugs prior to the study, as individual therapy of infected sheep were not carried out. Another important management was the hoof trimming of all sheep, performed at least once a year, and the use of preventive footbath with copper sulfate solution (5%) used daily in the rainy season and once a week in the dry period, always before being released in the pasture. The replacement of the footbath solution occurred every 15 days and the residue was collected by a company specialized in chemical waste.

All sheep were examined, including those animals without changes in the locomotion pattern. The examination of the digits and adjacent structures of the hooves were performed according to Williams (1990) and Ferrer & Ramos (2008). For this, all the digits and adjacent structures of the hooves were cleaned and a thin layer of the sole were removed to facilitate the observation and examination of the lesions. During the entire work, appropriate tools were used such as, hoof knifes and hoof shears.

All limbs, digits and interdigital spaces were exanimated, and then, the injuries found were registered in tables, considering the animal identification number, the affected limb, digit, and location of the lesion in the animal's digits. The lesions found were classified according to already existing classifications methods (Winter 2004, Ferrer & Ramos 2008), as follows: alteration of the interdigital gland, overgrowth of the abaxial wall, claw deformity, contagious ovine digital dermatitis (CODD), white line disease (WLD), interdigital dermatitis, claw fissures, wall fracture, footrot, toe granulomas, sole ulcer, interdigital hyperplasia, chronic lesion of the distal interphalangeal joint, pedal osteitis, diffuse septic pododermatitis and complicated lesions (Ferrer & Ramos 2008).

Statistical analysis. The observed information was grouped in tables, according to the frequency of occurrence of foot injuries, which were analyzed using the Chi-square test. Comparisons were made between the total number of injuries to the forelimbs and hindlimbs. As well as the total number of digital injuries between the fore and hind limbs, and the total of interdigital injuries between the fore and hind limbs. The number of digital lesions between the lateral and medial digits of the fore and hind limbs was also evaluated. It was considered 5% probability and software used was R (R Development Core Team 2019).

RESULTS

A total of 2768 digits of 346 Santa Inês sheep has been exanimated, and 362 claws diseases were diagnosed. Only 103 animals (29.76%) had foot lesions, representing 1.04 injuries per animal. From the sheep that had some type of foot lesion, 41.75% (43/103) had only one lesion, 39.81% (41/103) had two lesions, 15.53% (16/103) had three lesions, and only 2.91% (3/103) had four or more foot lesions. Changes in locomotion pattern were observed in 33 sheep, representing 9.53% of animals with lameness-associated foot disease, and 32.03% of sheep with claw disease. Among the digits and adjacent structures of the hooves evaluated, the most affected were the posterior limbs, with 205 lesions (56.62%) (P=0.0130), which were found in the interdigital spaces (105/205; 51.21%), in lateral digits (49/205; 23.90%), and the medial digits (51/205; 24.87%). The forelimbs contained 43.38%, with 157 lesions, and the interdigital space were also the positions in which most injuries were diagnosed (68/157; 43.31%) followed by the medial digits (49/157; 31.21%) and lateral digits

(40/157; 25.47%) (Table 1). Interdigital injuries occurred more frequently in the hind limbs (P=0.0054).

The WLD was the most diagnosed condition, present in 145 digits (40.05%), followed by 122 lesions of interdigital dermatitis (33.70%), and footrot 44 lesions (12.15%). Other conditions were less frequently diagnosed, as claw fissure (4.4%), complicated lesions (2.20%), diffuse septic pododermatitis (1.93%), and pedal osteitis (1.65%). Alterations of the interdigital gland and the claw deformity had the same frequency of observations (1.10%), and the chronic lesion of the distal interphalangeal joint has been diagnosed only twice (0.55%). The lesion described as overgrowth of the abaxial wall, toe granulomas were observed only once each (Table 1). The lesions classified as complicated were those not possible to distinguish the initial injury, and had extensive involvement of the corneal cover of the claw and/or the interdigital space, as well as of the internal structures, often with large amount of myiasis.

DISCUSSION

The number of lesions found in this study can be considered befitting with the prophylactic practices held in the farm, such as annual hoof trimming, footrot vaccination and routinely footbath. The prevalence of lesions would probably be lower if more frequent hoof inspection/trimming and individual therapy of infected sheep were carried out. But probably, if not even the annual trimming and footrot vaccination were carried out, the occurrence of foot injuries could be higher (Aguiar et al. 2011, Silveira et al. 2016, Carvalho et al. 2018). Moreover, the present study was carried during rainy season, which increases the challenging, because the rainy season by itself is a risk factor for infectious foot diseases (Silveira et al. 2016, Gelasakis et al. 2019).

Although the studied farm used footbath routinely, the second and third most common foot diseases diagnosed had infectious etiology, such as interdigital dermatitis and footrot, respectively. It is important to emphasize that on the farm studied, the animals passed through the foot bath in the

Table 1. Distribution and frequency of foot disease [%(n)] by limbs and digits in Santa Inês ewes

Lesion	LFL			RFL			LHL			RHL			Total
	LD	MD	IS	LD	MD	IS	LD	MD	IS	LD	MD	IS	
WLD	4.9 (18)	6.0 (22)	-	3.5 (13)	4.4 (16)	-	5.5 (20)	5.5 (20)	-	5.5 (20)	4.4 (16)	-	40.0 (145)
ID	-	-	7.4 (27)	-	-	6.0 (22)	-	-	9.3 (34)	-	-	10.7 (39)	33.7 (122)
FR	-	-	3.3 (12)	-	-	1.1 (4)	-	-	2.7 (10)	-	-	4.9 (18)	12.1 (44)
CF	0.5 (2)	-	-	0.2 (1)	1.6 (6)	-	-	0.5 (2)	-	0.2 (1)	1.1 (4)	-	4.4 (16)
CL	-	-	-	0.2 (1)	0.2 (1)	-	0.2 (1)	0.5 (2)	0.5 (2)	-	0.2 (1)	-	2.2 (8)
DSP	-	-	-	0.2 (1)	0.2 (1)	-	0.5 (2)	0.2 (1)	-	-	0.5 (2)	-	1.9 (7)
PO	0.2 (1)	0.2 (1)	-	-	-	-	0.5 (2)	0.5 (2)	-	-	-	-	1.6 (6)
AIG	-	-	0.5 (2)	-	-	0.2 (1)	-	-	-	-	-	0.2 (1)	1.1 (4)
CD	0.2 (1)	0.2 (1)	-	0.5 (2)	-	-	-	-	-	-	-	-	1.1 (4)
CLIJ	-	-	-	-	-	-	0.2 (1)	-	-	0.2 (1)	-	-	0.5 (2)
OAW	-	-	-	-	-	-	-	-	-	0.2 (1)	-	-	0.2 (1)
IH	-	-	-	-	-	-	-	-	0.2 (1)	-	-	-	0.2 (1)
TG	-	0.2 (1)	-	-	-	-	-	-	-	-	-	-	0.2 (1)
SU	-	-	-	-	-	-	-	-	-	-	0.2 (1)	-	0.2 (1)
TDPL	24.4(88)			19.0(69)			27.6(100)			29.0(105)			100(362)
Total	43.3(157[a])						56,6(205[b])						

[a,b] Different letters indicate difference between the number of digital disorders(p<0,05); LFL = left front limbs, RFL = right front limbs, LHL = left hind limbs, RHL = right hind limbs, IS = interdigital space, LD = lateral digit, MD = medial digit, WLD = white line disease, ID = interdigital dermatites, FR = footrot, CF = claw fissure, CL = complicated lesions, DSP = diffuse septic pododermatitis, PO = pedal osteitis, AIG = alterations of the interdigital gland, CD = claw deformity, CLIJ = chronic lesion of the distal interphalangeal joint, OAW = overgrowth of the abaxial wall, IH = interdigital hyperplasia, TG = toe granulomas, SU = sole ulcer, TDPL = total disease per limb.

morning and were directly sent to the pasture, however, only passing through the footbath does not reduce the frequency of these diseases, as it is necessary to keep the animals in a clean and dry area until the hooves dried out (Winter 2008, 2011), so, this study reinforces the obligation to follow the complete footbath protocol to obtain the best result.

It should be noted the cases of footrot occurred three times less than the cases of interdigital dermatitis, indicating that the use of footrot vaccine is of great value to reduce the incidence of this disease, as well as also may improve the recovery of affected animals (Duncan et al. 2012). Even though the general prevalence of foot lesions herein described is similar to other studies (Aguiar et al. 2011, Carvalho et al. 2018), the great differences consists in the proportion of each foot disease. WLD was the most observed lesion, but other studies found the highest prevalence of footrot followed by interdigital dermatitis (Aguiar et al. 2011, Carvalho et al. 2018). This difference may be related with the prophylactic measures carried out on the farm, including footrot vaccination.

In this study, there was a difference between the number of lesions observed in the hind limbs (P=0.0130) in relation to the forelimbs, moreover, interdigital lesions occurred more frequently in the hind limbs (P=0.0054) than in the fore limbs. This difference was also observed by Moschovas et al. (2021), but literature on this subject is well described for cattle (Matias et al. 2020), but not for sheep, and this phenomenon may be explained by the greater contact of hind limbs with feces (Matias et al. 2020).

The WLD is a non-infectious disease of the digits, it occurs when there is a defect in the abaxial region of the hoof sole between the junction of the wall and the sole (Winter & Arsenos 2009). This condition is usually poorly diagnosed (Moschovas et al. 2021), therefore nothing is done to treat it, which leads to a high prevalence, supporting the findings of this study, which this lesion was the most frequent claw disorder, representing 40.0% of the lesions. In most cases, WLD is not directly related to lameness, however, if there is an accumulation of dirt or debris within the open space between the wall and the laminar corium, it predisposes to bacterial proliferation, digit infection, and abscess formation in the white line, causing pain and consequently lameness (Winter 2004, Winter & Arsenos 2009, Moschovas et al. 2021). The causes of WLD are not yet established (Winter 2004), but it is speculated that nutritional causes, the lack of trimming or even the overtrimming of the digits, and also as a consequence of laminitis (Winter 2004, Ferrer & Ramos 2008) as well as genetic factors (Conington et al. 2010).

In a study carried out with dairy sheep, the white line disease was diagnosed in a frequency of 22.7% and as the most diagnosed foot lesion (Moschovas et al. 2021). In contrast, Aguiar et al. (2011) when surveying foot lesions in sheep in the semiarid region of northeastern Brazil, observed that WLD was present in the low frequency of 3.95%, and the main diseases observed were footrot and interdigital dermatitis, but none of the farms studied adopted measures to prevent foot diseases. In a retrospective study about sheep locomotor system diseases, Gargano et al. (2013) found WLD in lower proportions, with only 2% of the reviewed cases. Although, those animals were taken to the veterinary hospital possibly with more severe lesions on the locomotor system, setting a different reality to majority of farming systems.

The interdigital dermatitis was present in 122 digits, representing 33.7% of the lesions and the second most diagnosed foot disease. Usually found during rainy season, the interdigital dermatitis is a major disease of the interdigital space, because the moisture injures the skin and cause interdigital hair loss, favoring the invasion by *Fusobacterium necrophorum*, and this agent may be found in the feces and soil, and the lameness associated with this foot disease is proportional to the extension of the lesion (Winter 2004, 2008), and frequently interdigital dermatitis are associated with other lesions (Aguiar et al. 2011). Hodgkinson (2010) and Lima et al. (2017) classified the interdigital dermatitis as the most common lameness-associated foot disease in sheep herds. In contrast, Gargano et al. (2013) reported 15.6% of interdigital dermatitis in sheep attended at a veterinary hospital.

Footrot frequently occurs in sheep herds (Aguiar et al. 2011, Gargano et al. 2013, Carvalho et al. 2018), but in this study it represents 12.1%. This disease has the *Dichelobacter nodosus* as the infectious agent and requires the presence of *Fusobacterium necrophorum* to remain in the tissue, therefore the interdigital dermatitis could happen before or simultaneously to footrot (Roberts & Egerton 1969, Winter 2008, Witcomb et al. 2014). Alike to interdigital dermatitis, footrot needs moisture, which favors the infection and survival of the bacteria in the environment. Carvalho et al. (2018), Gargano et al. (2013) and Aguiar et al. (2011) reported the footrot as the main foot disease in their studies, being respectively responsible for 51.3%, 60% and 70.5%, of the foot disease frequencies.

Other authors classified footrot in different stages according to the severity, classifying as terminal (8.1%), advanced (27.7%) and initial (15.4%) (Carvalho et al. 2018). In this study all cases of footrot were classified as initial, possibly due to the vaccination, that may reduce the incidence and the severity of this disease (Duncan et al. 2012). This situation highlights the importance of vaccination to reduce the prevalence of this foot disease. However, injuries herein classified as complicated or arthritis of the distal interphalangeal joint possibly may have originated from severe footrot lesions.

Despite the low prevalence of claw fissures (4.4%), the prevalence of 15% was reported to the same condition in dairy sheep (Moschovas et al. 2021). The significance of these lesions is due to its reflection to the animal history, and the transversal fissures are associated with lesions in the coronary edge (Hodgkinson 2010), possibly due to drainage of abscesses, trauma or overweight. On the other hand, the horizontal fissures (parallel to the coronary band) are related to chronic laminitis (Ferrer & Ramos 2008), and also due to the animal nutritional status. Besides this, the deep fissures of the wall are related to diseases in which the animal stopped feeding for a long period (Hodgkinson 2010).

The complicated lesions (2.20%), diffuse septic pododermatitis (1.93%), pedal osteitis (1.65%), alteration of the interdigital gland (1.10%), claw deformity (1.10%), chronic lesion of the distal interphalangeal joint (0.55%), overgrowth of the abaxial wall (0.2%), toe granulomas (0.2%), and sole ulcer (0.2%) for the purpose of the present discussion, were less diagnosed. These diseases are of little importance when it comes to flock health, as their frequency is usually low.

However, other injuries such as chronic interphalangeal joint injury and complicated lesions may occur due to complications

of other diseases such as footrot, the interdigital dermatitis and the severe cases of WLD (Ferrer & Ramos 2008), but in this study a major cause of complication of foot lesions were myiasis. On the other hand, this study evaluated the lesions in a single moment, which did not allow the assessment of progression, representing the limitation of the present study.

It is worth noting that during the assessment of the distal extremity of the locomotor system, it is necessary to examine the digits and regions adjacent to the hooves of the four limbs, in order to identify the origin of pain and lameness. Lameness can be caused by infectious or non-infectious diseases, with non-infectous being more difficult to control (Hodgkinson 2010). From this study, the need for frequent maintenance of the health of the hooves and environmental control is evidenced, since some of the diseases are secondary to less serious diseases, and even these could be avoided with frequent examination of the digits, such as, for example, the possible occurrence of WLD and interdigital dermatitis preceding the footrot lesions. It is essential to classify the lesions, to differentiate non-infectious diseases from infectious diseases, and thus adopt effective prophylactic and therapeutic measures compatible with the diseases that are causing the problems in the herd.

CONCLUSION

Foot disease in sheep is frequent and constitutes a health problem for herds, even on farms that has prevention strategies. Digit inspection must occur periodically, as many sheep have foot disease and still are not lame, setting a silent character for foot disease.

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