Routine hoof-trimming data provides insight into the occurrence of claw lesions in Holstein herds in the central region of South Africa

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Abstract

Claw lesions in dairy cows contribute significantly to lameness, causing distress and discomfort for affected cows and raising welfare concerns. Despite increased awareness, lameness incidence continues to rise. Defining and recording claw traits are particularly problematic. In South Africa (SA), claw data is limited to paper-based records kept by private hoof trimmers. This research analysed claw-trimming data from five dairy farms over 6 years to examine the occurrence and recording of claw lesions in SA Holstein cattle. Lesion identification followed the *Claw Lesion Identification in Dairy Cattle* brochure. Among the recorded lesions, digital dermatitis (DD) had the highest prevalence (64.02%), followed by sole ulcers (SU; 8.59%), white line disease (WLD; 6.27%), and sole haemorrhage (SH; 4.28%), and most lesions occurred in the rear feet. Chi-square tests and correspondence analysis (CA) were employed to explore the relationships between lesions, feet, and housing. Results indicated that the prevalence of SU and SH showed high similarity for foot and lesion association, and that these were more highly associated with the rear feet. Additionally, the prevalence of DD and interdigital phlegmon were strongly associated, and closely associated with SU, and all these lesions were associated with both dirt lot and free-stall housing systems. CA further confirmed a close association between WLD and SH, and the prevalence of these lesions in the combination housing system. Results of this study highlight the complexity of lesion data and that specific associations between lesions could lead to simplifying the recording thereof. Consolidating the most informative claw lesions into categories will aid in the practical prevention, management, and treatment of lameness on-farm.

Keywords: Dairy cattle; Claw lesions; Digital dermatitis

Introduction

Claw lesions are the primary cause of lameness in dairy cattle (Garvey 2022), with serious implications for animal welfare due to the distress and discomfort experienced by the cows (Oehm et al. 2019; Bell et al. 2022). Claw lesions are classified as either infectious lesions such as digital dermatitis, interdigital dermatitis, heel erosion, and interdigital phlegmon, or non-infectious lesions (including white line disease, sole ulcer, and sole haemorrhage) (Sadiq et al. 2020; Garvey 2022). Infectious lesions are mostly related to environmental hygiene, while non-infectious lesions are generally caused by metabolic and/or mechanical factors (Chapinal et al. 2013; Charfeddine and Pérez-Cabal 2017; Sadiq et al. 2020). The majority of researchers have reported digital dermatitis, sole haemorrhage, sole ulcer, and white line disease as the primary causes of dairy cattle lameness (Charfeddine and Pérez-Cabal 2017; Sölzer et al. 2022; Bell et al. 2022). There are several risk factors that influence the prevalence of claw lesions in dairy cattle, including environmental factors, design of housing facilities, and hygiene and management practices (Cook and Nordlund 2009; Oehm et al. 2019; Garvey 2022). In addition to environmental factors, there is a heritable component to claw lesions (Van der Waaij et al. 2005; Chapinal et al. 2013; Heringstad et al. 2018) that has probably been underestimated due to the poor quality of recording (Afonso et al. 2020; Bell et al. 2022).

Despite an increased awareness of lameness, its major causes have remained unchanged over the past 30 years, with a continued increase in the occurrence of lameness in dairy herds (Heringstad et al. 2018; Bell et al. 2022). Minimising the occurrence and impact of lameness is one of the greatest challenges for the dairy industry (Ring et al. 2018; Oehm et al. 2019; Sadiq et al. 2020), but it is complex with regard to accurately defining and recording claw traits, and inconsistencies in the measures and terminology applied in terms of lesion identification and scoring systems (Charfeddine and Pérez-Cabal 2017; Oehm et al. 2019; Afonso et al. 2020). Lameness and claw lesion recording systems differ between and within countries and data may be collected by a variety of people, including producers, veterinarians, and hoof trimmers (Afonso et al. 2020; Garvey 2022). In addition, there are large discrepancies between farmer-recorded lameness and the rates of lameness recorded by trained professionals (Sadiq et al. 2019; Bell et al. 2022).

Claw trimming is used as a management tool to control claw lesions (Sadiq et al. 2020; Garvey 2022). In South Africa (SA), claw data are limited to the use of private hoof trimmers, who record lesions on paper, and data is not necessarily captured in an electronic recording system (Mhlongo 2019). Traits associated with claw health and lameness are seldom included in goal-driven selection in SA dairy herds (Visser et al. 2020). Except for a review of foot health in housed cattle by Du Plessis (2007) and an investigation of hoof-trimming data for improving claw health by Van Marle-Köster et al. (2020), claw health has not been investigated in SA. More accurate diagnosis and recording of claw lesions will provide the data necessary to identify the major lesions expressed in SA dairy cattle so that we can further our understanding of causative factors of significant lesions affecting herd performance (Van Marle-Köster et al. 2020; Garvey 2022).

The total number of commercial dairy cattle in SA is estimated at approximately 1.6 million (DALRRD 2022), of which the Holstein breed is by far the most numerous (Banga et al. 2014). Dairy cattle farmers mainly employ one of two production systems, either intensive or extensive management systems. Cows that are managed more intensively in the inland regions are generally housed in free-stall (FS) or dirt lot (DL) systems and fed a total mixed ration (TMR), while coastal dairy farms are pasture-based with cows receiving varying degrees of supplementary dairy meal in addition to grazing on planted pastures (Meissner et al. 2013; Ducrocq et al. 2022).

In this study, routine trimming data from five intensively managed dairy farms over a 6-year period (2014–2019) were analysed to find the prevalence and distribution of claw lesions in Holstein cattle in the central region of SA in order to inform more effective recording and management thereof.

Material and methods

Ethical approval for the study was granted by the University of Pretoria Ethics Committee in the Faculty of Natural and Agricultural Sciences (NAS292/2020). The five herds included in this study (Table 1) represent the central region of SA and include both DL (farms A and E) and FS (farms C and D) housing systems. Farm B employs a combined DL+FS housing system. Farms A, D, and E are geographically within less than 150 km from each other, while farm C is approximately 350 km south of the mid-point between these three farms. Farm D is in the country's northern region, on the border with Botswana. Four of the five farms incorporate routine hoof trimming in their dry cow programme as well as lameness treatment (DC+LT), while farm A only employs hoof trimming as a lameness treatment tool (LT).

Hoof trimmers in SA are only allowed to perform basic trimming and management procedures, including placement of blocks, while any medical treatments are performed by veterinarians. It is important to note that farmers in SA subscribe to different schools of thought when it comes to hoof trimming, including the ABC methodology developed by Karl Burgi, Dörte Döpfer, and Nigel B. Cook, the ICAR Claw Health Atlas (2020), as well as recommendations by the International Lameness Committee.

Herd size data received from the SA Stud Book Association (SA Stud Book, Bloemfontein, South Africa) refer to all female animals on the farm, including young heifers, first-calving heifers, dry cows, and all milking cows in the herds. Average herd sizes over the 6-year period were 696, 1590, 620, 740, and 1719 for farms A, B, C, D, and E, respectively.

The hoof trimmer provided on-farm data in hard copy, which included all available hoof-trimming records collected during routine hoof-trimming visits to the five herds between January 2014 and December 2019. The hoof-trimming sheets included general information such as the date of visit, farm ID, and cow ID, as well as information relating to the identification of lesions by limb, foot, and claw, and data regarding the treatment of lesions. *The Claw Lesion Identification in Dairy Cattle brochure* (Zinpro® Corporation, 2008) and the International Lameness Committee, was used as the reference for lesion identification by a local hoof trimmer. The data manually recorded by the hoof trimmer were electronically captured into Microsoft Excel worksheets (Microsoft Corporation, 2018) by the student team. For the purposes of this study, only information in common between this *Hoof-Trimming Report* and *The Claw Lesion Identification in Dairy Cattle* brochure are included (Table 2).

Table 1 Description of study herds and regional climatic data (CustomWeather, © 2022)

Farm	Region	Housing system[a]	Trimming regularity[b]	Hottest month (avg. temp.)	Coldest month (avg. temp.)	Wettest month (avg. rainfall)	Annual precipitation
A	Gauteng	DL	LT	Feb. (24 °C)	July (13 °C)	Jan. (128.3 mm)	583.1 mm
B	Limpopo	DL+FS	DC+LT	Feb. (24 °C)	July (15 °C)	Jan. (134.6 mm)	621.4 mm
C	Mpumalanga	FS	DC+LT	Jan. (21 °C)	July (8 °C)	Jan. (140.2 mm)	687.8 mm
D	Gauteng	FS	DC+LT	Jan. (20 °C)	July (11 °C)	Dec. (74.6 mm)	357.6 mm
E	Free State	DL	DC+LT	Jan. (20 °C)	July (10 °C)	Dec. (170.3 mm)	774.0 mm

[a]Housing system: *DL*, dirt lot; *FS*, free-stall; *DL+FS*, combination dirt lot and free-stall housing system

[b]Trimming regularity: *DC*, dry cow programme only; *DC+LT*, combination of a preventative dry cow programme and trimming as a treatment for lameness

Table 2 Claw lesion classification and abbreviation

Classification	Abbrev.
Infectious lesions	
Digital and interdigital dermatitis (including hairy attack)	DD
Heel erosion	HE
Interdigital phlegmon (also foul/phlegmon)	IP
Non-infectious lesions	
Axial fissure	AX
Corkscrew claw	CC
Hardship grooves or horizontal fissures	HG
Interdigital hyperplasia	IH
Sole haemorrhage or bruising	SH
Sole ulcer or pododermatitis	SU
Thin sole	TS
Toe ulcer or necrosis	TU
Vertical fissure or sandcrack	VF
White line lesion (WL) and white line separation (WS)	WLD

Trim data were imported into a Microsoft SQL Server database (Microsoft Corporation, 2018) for quality control, data editing, and further analysis, after which views were exported back into Microsoft Excel for visualisation. Data for a total of 8754 trimming events, including repeated trimmings, were input for the five farms (Farm B only started trimming in 2017; no data for the period 2014–2016). This amounts to 262,650 data points, including lesion identification, treatment description, POL data, and other observations by the hoof trimmer. The total number of trimming events was recorded per farm, together with the number of unique trimming events in order to investigate how many cows were subjected to repeated hoof trimming each year. Trimming data were further subdivided per farm into trimming year, trimming season (spring, summer, autumn, winter), and trimming month for evaluation of trimming practices across these various subdivisions. Only six animals were presented for trimming that showed no lesions and were not trimmed, and were excluded from further analysis. The final data file comprised 8748 total trimming events for the five farms for the period 2014–2019, amounting to 262,470 data points.

Data analysis was performed using SAS/STAT software version 9.4 (SAS Institute Inc., 2015). A PROC FREQ and a chi-square test for independence were applied to assess whether the prevalence of lesions and foot position, and lesions and housing are independent. The SAS correspondence analysis (Benzécri 1973) was used to analyse and explore the relationships between the categorical variables of lesion occurrence and foot position, and lesion occurrence and housing system.

Results

The number of lesions identified per farm over the 6-year study period is shown in Table 3. There were no recorded incidences of IH of VF , so these were excluded from further discussion. The occurrence of non-infectious lesions SH, SU, and WLD represented more than 75% of all recorded non-infectious lesions; consequently, non-infectious lesions CC, HG, TU, AX, and TS were excluded from further discussion as their counts were insufficient for statistical analysis.

Table 3 Total lesion count per foot, and the percentage occurrence of each lesion as a percentage of total lesions recorded and as a percentage of total observations by the hoof trimmer

	Left front (LF)	Right front (RF)	Left rear (LR)	Right rear (RR)	Total	Occurrence (% of total lesions)	Occurrence (% of total observations)
None	25,968	25,918	24,329	24,473	100,688		
DD	213	228	1428	1224	3093	64.02%	2.93%
HE[a]					543	11.24%	0.51%
IP	7	20	27	27	81	1.68%	0.08%
SU	8	6	191	210	415	8.59%	0.39%
WLD	25	41	94	143	303	6.27%	0.29%
SH	5	2	96	104	207	4.28%	0.20%
Total lesions					4831		4.58%
Total observations					105,519		

[a]Heel erosion data were not split by foot position by the hoof trimmer

The SAS frequency procedure output for lesion by foot (location) and lesion by housing system are given in Online Resource 1. Independence of both the prevalence of lesions and foot (location) and the prevalence of lesion and housing were confirmed using chi-square analysis ($p < 0.0001$).

CA was performed between lesions and foot (location) (Fig. 1) and lesion and housing system (Fig. 2) in order to further explore the dependencies identified by the frequency procedure (Online Resource 2).

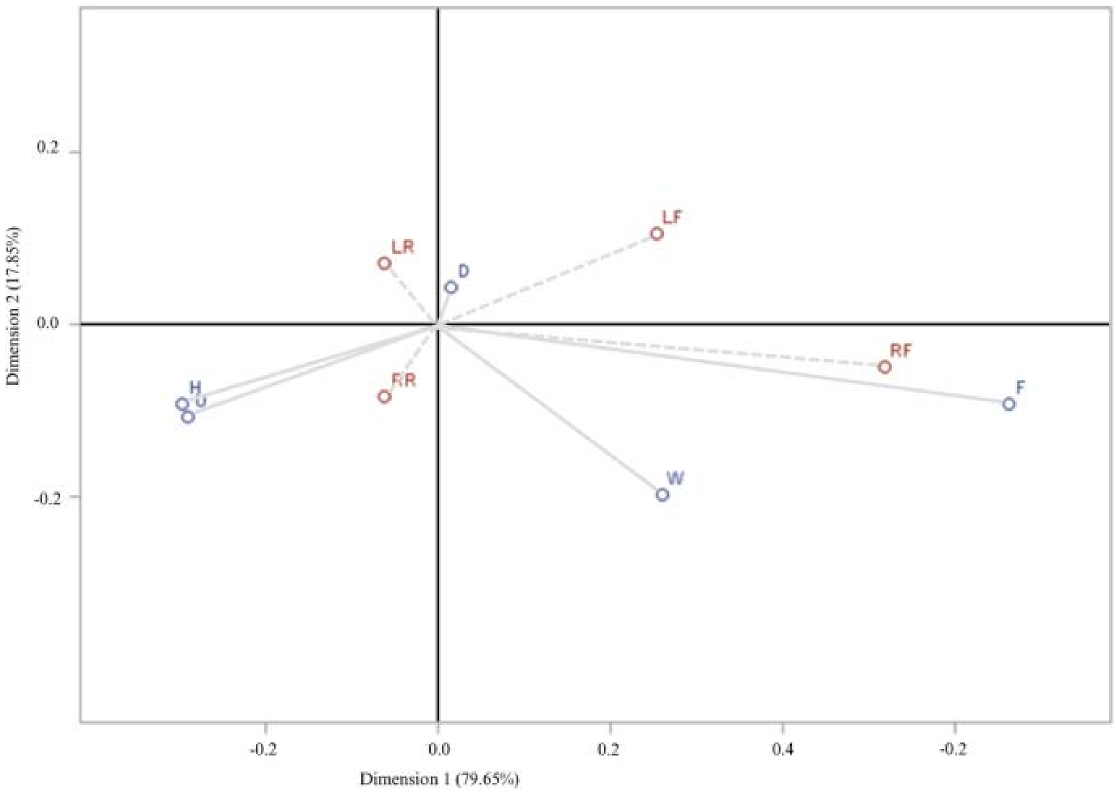

Fig. 1. Correspondence analysis between lesion and foot (location)

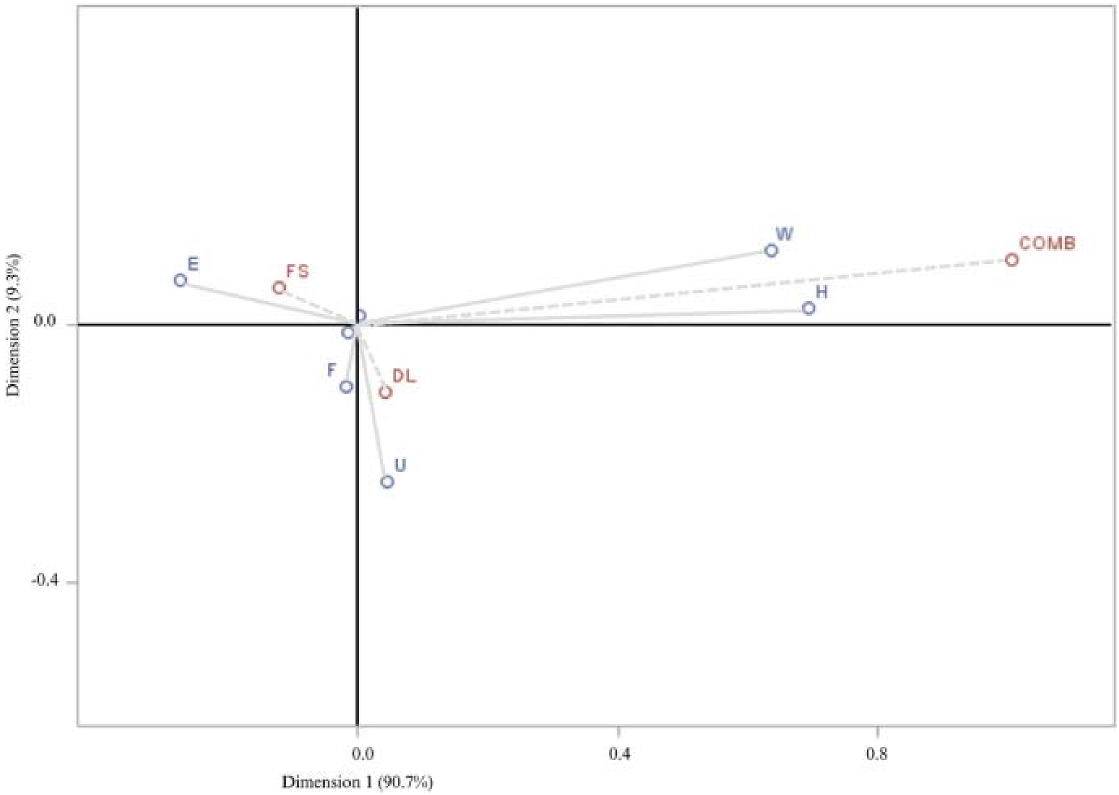

Fig. 2. Correspondence analysis between lesion and housing system

Discussion

The recording, identification, and management of claw lesions add to the complexity of finding sustainable solutions to reduce the occurrence of lameness in dairy cattle. In this study, hoof-trimming data from five intensively managed dairy farms in the central region of SA were analysed, including both DL and FS systems. The system for identification and classification of claw lesions was based on hoof-trimming data received in the form of a local hoof trimmer's *Hoof-Trimming Report* that was also common to *The Claw Lesion Identification in Dairy Cattle* brochure.

Infectious lesions were the most common claw disorder, accounting for 77% of all recorded lesions on farms between 2014 and 2019. These results are similar to reports on Dutch and Canadian dairy cattle, where infectious lesions were also more prevalent compared to non-infectious lesions (Van der Waaij et al. 2005; Chapinal et al. 2013). Of infectious lesions recorded in this study, DD accounted for 64% of all recorded lesions, followed by HE (11%) and IP (1.7%). Numerically, SU (8.59%), WLD (6.27%), and SH (4.28%) accounted for most of the non-infectious lesions. This agrees with previous research in which digital dermatitis was consistently recorded as the most prevalent lesion (DeFrain et al. 2013; Solano et al. 2016; Charfeddine and Pérez-Cabal 2017). These authors also noted sole ulcer and white line disease as the most prevalent non-infectious claw lesions recorded, similar to this study, while DeFrain et al. (2013) and Solano et al. (2016) recorded toe ulcers as another significant lesion. In a study on German Holstein Friesian cows using the official ICAR nomenclature, Stock et al. (2013) reported digital dermatitis as the most prevalent infectious lesion, with sole ulcer and interdigital hyperplasia as the most prevalent non-infectious lesions (Sölzer et al. 2022), which agrees with the results of the current study. Despite using different claw classification systems and lesion descriptions, most studies confirmed dermatitis and heel horn erosion, and sole haemorrhage and sole ulcer, respectively, as the two most prevalent infectious and non-infectious claw lesions (Buch et al. 2011; Chapinal et al. 2013; Charfeddine and Pérez-Cabal 2017; Afonso et al. 2020).

In studies that made the distinction between lesions occurring in rear and front feet, lesions occurred more frequently in the rear feet (Van der Waaij et al. 2005; Chapinal et al. 2013; Solano et al. 2016), similar to results in the current study. This is likely due to rear claws being more exposed to manure and urine, which, in FS housing systems, may be attributed to the front feet being placed in the stall and the rear feet in the aisle. Additionally, claw horn lesions (sole ulcer, sole haemorrhage, white line disease, and toe ulcers) tend to develop more regularly in the rear claws because of overloading of the lateral hind claws (Sadiq et al. 2020).

Results from the SAS frequency procedure, which included chi-square tests for independence between lesion and foot (location) and between lesion and housing, in both cases were highly significant ($p < 0.0001$), indicating potential associations. In the first CA, lesions SU and SH showed high similarity for foot and lesion association. In addition, the occurrence of these two associated lesions is more highly associated with rear than front feet. SU is a continuous break in the epidermis of the sole horn that exposes the corium, of which SH is regarded as an early sign (Van der Waaij et al. 2005; Van Amstel and Shearer 2006; Solano et al. 2016), which may explain the association between these two lesions here.

DD and IP are important infectious claw diseases, with bacteria often entering the tissue as a result of mechanical injury and/or softening of the skin and claw horn, which may occur as a result of a non-infectious lesion and/or mechanical damage to the claw and foot tissues. DD is manifested as an ulceration on the planar surface of the foot, often extending into the interdigital space, while interdigital phlegmon is defined as a necrotic infectious disease that results in decay of the foot tissues (Abubakar and Manzoor 2018; Garvey 2022). In cases of IP, the bacterium often isolated is *Fusobacterium necrophorum* (Abubakar and Manzoor 2018). In this study, the infectious lesion DD showed the greatest association with non-infectious lesions SH and SU in terms of lesion by foot (location), while infectious lesion IP differed from this group. The weak association between IP and the other claw lesions under study may be a result of its low prevalence recorded (only 1.68% of total lesions recorded, compared to 64% for DD). IP was also more closely associated with the front feet, which was opposite to the higher association of DD with the rear feet. According to Garvey (2022), approximately 90% of DD is found in the rear feet, similar to the current study.

Globally, dairy cattle are managed under a wide variety of housing systems, including tie-stall barns, cubicle or FS housing systems, DL, and on pastures (Shearer and Van Amstel 2007; Cook and Nordlund 2009; Garvey 2022). Indoor systems offer animals improved protection from extreme weather, improved access to feed and water, and a comfortable place for cows to lie down (Shearer and Van Amstel 2007), but do expose cows to more concrete walkways, which predispose claws to non-infectious lesions (Somers et al. 2005; Garvey 2022). Excess manure and moisture have been shown to predispose cows to infectious lesions (Chapinal et al. 2013; Garvey 2022), and indoor housing systems generally show the highest rate of lameness (Shearer and Van Amstel 2007; Cook and Nordlund 2009).

In this study, the CA between lesion and housing system showed higher associations between DD, IP, and SU, while HE differed, while the categories of lesions expressed as a percentage were similar for both the DL and FS housing systems for all four of these lesions. Somers et al. (2005) noted that the presence of HE may predispose cows to other infectious claw lesions (e.g., DD and IP). In the current study, DD, IP, and HE were not highly associated in the lesion by housing CA. The foot (location) of HE was, however, not recorded and it was excluded from the lesion by foot (location) CA. It has previously been reported that the odds of DD occurring are two times higher in cows housed indoors with access to an exercise area, but an outdoor area that is wet or unhygienic could lead to increased prevalence (Solano et al. 2016). In general, DD, SU, and WLD are reported as the three most frequently recorded disorders indoors, and shared risk factors included the presence of other non-infectious lesions and housing type (Solano et al. 2016).

Non-infectious lesions WLD and SH showed a higher association with each other than with other lesions under study, and these were more highly associated with the combination housing system (DL+FS). The white line forms the flexible junction between the hard claw wall and the softer sole horn. It is the softest part of the claw and is susceptible to mechanical damage due to its location on the weight-bearing surface (Shearer and Van Amstel 2007; Van der Spek 2015). The prevalence of foot lesions has been reported to differ among housing types, but DD remains the most common lesion, followed by SU and WLD (Buch et al. 2011; Solano et al. 2016; Garvey 2022).

The data included in this study were captured in hard copy with over 30 different lesion identification codes recorded by the hoof trimmer. Given these results, it seems that this number may be drastically reduced. In terms of infectious lesions, DD was by far the most prevalent in the current study, and, based on the correspondence analyses, one could argue that infectious lesions may be broadly recorded as present or absent. The three non-infectious lesions that were numerically the most prevalent were SH, SU, and WLD, albeit each at very low rates (less than 0.5% of all observations recorded). It is important to note that, compared to the total number of cows subjected to hoof trimming, the overall occurrence of lesions was only 4.58%, with DD at 2.93%, E at 0.51%, SU at 0.39%, and WLD at 0.29%. This suggests that the identification of specific claw lesions might be a heavy-handed approach to the management of lameness in dairy herds. Infectious and non-infectious lesions have different risk factors and, hence, different strategies for prevention and management (Buch et al. 2011; Chapinal et al. 2013; Garvey 2022). Dividing the recording sheet simply into two sections, infectious versus non-infectious lesions, may provide sufficient information for the hoof trimmer and the farmer to effectively manage the risk factors associated with each lesion category.

Researchers agree that prevention, early diagnosis, and prompt, effective treatment are the cornerstones of effective lameness management (Afonso et al. 2020; Bell et al. 2022; Garvey 2022). The results of this study indicate that claw recording remains an early detection tool for an infectious versus a non-infectious problem in the herd.

Electronic record-keeping will be more convenient from a practical perspective and allows faster, more accurate recording by hoof trimmers, while facilitating the creation of a practical summary for the farmer to promptly address lameness issues (DeFrain et al. 2013). From a data analysis perspective, electronic record-keeping is useful for benchmarking and genetic improvement (Chapinal et al. 2013), as well as increasing efficiency and accuracy of data collection for research purposes (Shearer and Van Amstel 2007). The results of this study indicate that recording in the SA dairy system may be simplified, which might facilitate more routine trimming and a larger database for subsequent studies and potential inclusion in selection.

In conclusion, results of this study not only highlighted the complexity of lesion data but also indicated that specific associations between different lesions could lead to simplifying the recording thereof. It is important that the description and recording of claw lesions are made as easy as possible for accurate and consistent recording. Consolidating the most informative claw lesions into categories will aid in the practical prevention, management, and treatment of lameness on-farm.

Data availability

The datasets generated during and/or analysed during the current study are not publicly available due to post-graduate research still being in process but are available from the corresponding author on reasonable request.

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Contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by RCJ. The first draft of the manuscript was written by RCJ and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics approval

Ethical approval for the study was granted by the University of Pretoria Ethics Committee in the Faculty of Natural and Agricultural Sciences (NAS292/2020).

Competing interests

The authors declare no competing interests.

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