The relationship between Digital Dermatitis and other claw disorders.

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Abstract

The objective of this study was to investigate the relationship between DD and other claw disorders at the moment of routine claw trimming. Between June 2017 and July 2018, data of the presence of claw disorders was collected at 80 farms in the Netherlands spread over the country. Interns of GD Animal Health collected data of DD lesions based on the M-scoring method described by Döpfer et al. (1997) and modified by Berry et al. (2010), (1,2). Data of other claw disorders is collected using Digiklauw by certified claw trimmers of the agricultural business care organization AB.
The mean heard size of the study population was 81 cows.
An inter-observer agreement between the interns of GD Animal Health for the scoring of DD using the M-score method was performed and the overall result was moderate (k=0.51).
DD was present in 51% of the study population according to the M-scoring method, where 23% had a lesion on 1 foot and 28% had lesions on both feet. The cow-level herd prevalence varied between herds from 8% to 93%. In 20,8% of the cows that had DD, IDD was also present. An increased risk for having IDD was found when DD is present at the moment of routine claw trimming (OR=9.11). In 11,2% of the cows that had DD, IH was present. An increased risk for having IH was found when DD is present at the moment of routine claw trimming (OR=5.18).

Introduction

Lameness is, beside mastitis and reproduction disorders, one of the most important reasons of involuntary culling of dairy cattle (3,4). A UK research found that in 96% of the episodes of lameness a definable clinical important lesion in the claw was associated. The other 4% was due to lesions in the leg above the claw. Furthermore 92% of the lesions were in the hind limbs of the cow (5). Claw disorders are responsible for high economic losses and decreased welfare and longevity (1,4-7). Economic losses are due to decreased milk production, treatment costs, premature culling and serious lower slaughter incomes (3,6–8). So for optimal productivity and welfare the claw health is very important.
Claw disorders can be divided into non-infectious claw disorders (NICD) and infectious-claw disorders (ICD). NICD is nowadays classified as Claw Horn Disruption (CHD) (9). The most important CHD's in the Netherlands, based on the cow-level prevalence are sole hemorrhage (26%), white line lesion (18%) and sole ulcer (9%) at the moment of routine claw trimming according to Digiklauw data 2012-2016 (10). The most important ICD's in the Netherlands, based on the cow-level prevalence are digital dermatitis (DD)(21%) and interdigital dermatitis (IDD) (18%) (10).
The estimated herd prevalence of both DD and IDD in Dutch dairy cattle is >90% and cow prevalence was estimated at 21% and 18% respectively (10–12).

DD is the most important ICD, related to the pain associated with the ulcerative stage, resulting in lameness, decreased welfare and economic losses (5,8,13). The clinical presentation of DD's most prominent stage is an ulcerative lesion localized just above the coronary band between the heel bulbs, 80-90% found mainly on the hind claws of the cows (8,13). The last decennium different classifications are used to score DD (e.g. 0/1, Digiklauw, Iowa score and M-score system (1,2,7,11,14). The last years the usage of the M-score system instead of a 0/1 score system is more common, especially in research projects (15).

In earlier research it was estimated that in 19% of the cows infected with DD, IDD was present as well (16). Furthermore earlier research estimated the risk on DD in presence of other claw disorders, such as IDD, interdigital hyperplasia, and interdigital phlegmone (11). It was concluded that absence of those disorders at the study population, respectively, 32.2%, 9.0%, and 1.1% of the DD cases could have been prevented (11). On the other hand it may be interesting to know what the prevalence of other disorders is in in relation to DD using a 0/1 score. Recording of these disorders in the Digiklauw scoring system by certified-claw trimmers at the moment of routine claw trimming will provide information of the prevalence of these other claw disorders in relation to DD. This information will give the farmers and their advisors insight in the presence of different M-stages and the risk of other claw disorders.

The objective of the study was to investigate the on cow level relationship between DD and other claw disorders at the moment of routine claw trimming.

Materials and Methods

Study design

Data was collected between June 2017 and July 2018, at dairy farms located in the Netherlands, spread over the country. Farms participating in the current recording system (Digiklauw) of CRV (Dutch Breeding Organisation) with different DD prevalence's were selected, to guaranty a diverse study population. Selected farms had low, average and high prevalence of DD, according to Digiklauw data at the latest routine claw trimming (low: DD Digiklauw score <10%, average: DD Digiklauw score ≥10% but <50% and high: DD Digiklauw score ≥ 50%).
Participating farms had to meet the following requirements:

- Being attendees of Digiklauw
- Giving permission to use these data.
- Herd size had to be between 50-150 cows
- The participating herdsman had to do routine claw trimming of the complete herd and completing a survey about the relevant risk factors (housing, management, etc.).

The final dataset included M-scores, Digiklauw scores of other claw disorders of the hind limb for each individual cow and survey results.

Data collection was during the routine claw trimming, executed by certified-claw trimmers who work for the agricultural business care organization AB. Data from Digiklauw was collected by the claw trimmers. Data of DD M-scores was collected by 7 interns of GD Animal Health. A claw expert trained these interns how to interpret the DD lesions and give a M-score based on the macroscopic classification of DD lesions described by Döpfer et al. (1997) and modified by Berry et al. (2010) (1,2).

Inter-observer agreement

In many studies more than one observer is used to collect data and therefore it would be favorable to know the inter-observer agreement. During data collection at one of the participating farms 23 photographs of different DD lesions are made. After their training in interpretation of the M-lesions, the seven attendees of GD Animal Health were asked to visually score those photographs using the M-score method according to Döpfer et al. (1997) and modified by Berry et al. (2010), (1,2). A claw-health specialist of GD Animal Health was also asked to visually score the photographs, his results were used as a reference.

M-scores

The M-scoring system is a macroscopic DD classification described by Döpfer et al. (1997) and modified by Berry et al. (2010), (1,2) (Table 1). This model describes 6 different stages of DD.

To score the DD lesions the M-score method was used. For analysis the M-score method was reclassified into a binary scale. Cows were positive (1) if DD was present (M1-M4.1) in at least one of their hind feet or DD negative (0) if cows had no sign of a (pre)-existing lesion (M0) on both hind feet.

Table 1. Description of the different M-stages of DD described by Döpfer et al. (1997) and modified by Berry et al. (2010), (1,2).

Scale	Description	Reclassified scale
M0	No sign of (pre)-existing lesion	0
M1	Normal skin, Small (<2 cm across) focal active state. Circumscribed lesion. Surface is moist, ragged, mottled red–grey with scattered small (∼1 mm diameter) red foci	1
M2	Larger (>2 cm across) ulcerative active stage. Extensively mottled red-grey. Can be painful upon manipulation.	1
M3	Healing stage. Typically seen within a few days after antibiotic treatment. The ulcerated surface is now transformed to a dry brown, firm rubbery scab. No pain on manipulation.	1
M4	Alteration of the skin Chronic stage. Surface is raised by tan, brown, black, rubbery, irregular, proliferative hyperkeratotic growths that vary from papilliform to mass-like projection.	1
M4.1	Chronic stage with small active painful M1 focus.	1

Digiklauw scores

The participants had to be attendees of Digiklauw, a scoring method offered by CRV (Dutch Breeding Organisation) for claw trimmers to score and record claw disorders during routine claw trimming and developed by GD Animal Health and the Board of the Dutch Claw Trimmers Organisation. Digiklauw provides the herdsman insight into the prevalence and persistence of claw disorders in the herd, related to the herd management. Data is scored categorical in Digiklauw for interdigital dermatitis (IDD), sole ulcer (SU), sole hemorrhage (SH) and white line disease (WL) (Table 2). For interdigital phlegmone (IP) and interdigital hyperplasia (IH) Digiklauw uses a binary scale (0 = no disorder, 1 = disorder).
For analysis the categorical scale of claw disorders was reclassified into a binary scale. Cows were positive (1) if a claw disorder was present in at least one of their hind feet or negative (0) if cows had no sign of a claw disorder on both hind feet.

Table 2. Categorical scale of disorders based on Digiklauw

Scale	Description	Reclassified score
0	No disorder	0
1	Slight disorder	1
2	Moderate disorder	1
3	Severe disorder	1

Statistical analysis

The overall inter-observer agreement was estimated using Fleiss' kappa coefficient. The agreement between each individual intern and the claw expert was estimated using Cohen's Kappa. The results of the agreement analysis were interpreted according to Landis and Koch (1997): <0.00 poor, 0.00 – 0.20 slight, 0.21 – 0.40 fair, 0.41 – 0.60 moderate, 0.61 – 0.80 substantial, and 0.81 – 1.00 almost perfect (17).

The association between left and right DD infected hind limbs is evaluated using a Chi-Square Test with critical value $P<0.05$.

To calculate the OR, P-value and 95% C.I. of DD for other claw disorders on cow level, first a univariable regression was performed and corrected for farm specific influences. The dependent variable was one of the claw disorders and the independent where the other claw disorders including DD. This was repeated until all claw disorders have been used as a dependent variable. The variables with $P<0.25$ where entered in a multivariable model. Next, the variable with the highest P-value was removed (if $P>0.05$) and the model was run again to evaluate if the variable was a confounder. If the change in any β of the remaining variables was >25% or >0.1 if $-0.4<\beta<0.4$, the removed variable was considered as a confounder and remained in the model. If the variable was no confounder the variable was removed from the model. This was repeated until all variables where found to add significantly to the model or were judged as confounder.

All calculations are executed in IBM SPSS Statistics or Microsoft Excel.

Results

Inter-observer agreement and M-scores

The overall inter-observer agreement of scoring DD with the different M-scores was moderate (k=0.51). The agreement between each individual intern and the claw expert of GD Animal Health ranged between moderate and substantial (k=0.44 - 0.71). Inter-observer agreement of the reclassified binary scale (DD present or no DD) was fair (k=0.38). To visualize the agreement of the M-scores of the claw expert and the 7 interns a crosstab is made (Table 3).

Tabel 3. Crosstab of the M-scores of 23 photographs between the claw expert and the 7 interns of GD Animal Health.

	Scores of the 7 interns						
Claw expert	**M0**	**M1**	**M2**	**M3**	**M4**	**M4.1**	**Total**
M0	16	5	2	-	4	1	28
M1	3	1		-	2	1	7
M2			55	-		1	56
M3	-	-	-	-	-	-	-
M4	10	1	1	-	13	3	28
M4.1	3	3	2	-	12	22	42
Total	32	10	60	-	31	28	161

Relationships between DD and other claw disorders

Data collection took place at 109 dairy farms at the moment of regular preventive claw trimming from June 2017 till January 2018. Unfortunately because of missing Digiklauw data, 29 farms had to be excluded from the study population.
Data of 5972 cows was transferred into SPSS Statistics and due to missing value 126 cows had to be excluded from the dataset.
This resulted in a final dataset with a total number of valid observations of 11692 hind limbs as two hind limbs of 5846 cows were observed. Herd size varied between 50-150, (n=80) (Mean=81) (SD=21.5)(Figure 1).

Table 4 shows the distribution of DD M-scores on the hind limbs. Most feet showed no DD lesion (n=7088; 60.6%). If DD was present, the most frequent score was M4 (n=2432; 20.8%), followed by M4.1 (n=1088; 9.3%) and M2 (n=864)(7.4%). M3 was the least scored lesion (n=50; 0.4%).
The difference between left hind and right hind limbs was not significant (p=0.72). The difference between left hind and right hind limbs was not significant per farm as well (P>0.05).

Table 4. M-scores of digital dermatitis on left and right hind limb observed on 5846 cows.

M-scores	**LH**	**RH**	**Total**	**Prevalence**
0	3553	3535	7088	0.61
1	87	83	170	0.01
2	417	447	864	0.07
3	29	21	50	0.00
4	1207	1225	2432	0.20
4.1	553	535	1088	0.09
Total	5846	5846	11692	

Based on the reclassified M-scores half of the cows are completely free of DD (n=2872). The other half of the cows suffer from some form of DD: 23% at one foot (n=1344), 28% at both feet (n=1630), resulting in a prevalence of DD in the study population of 0.51 (Table 5). Cow-level herd prevalence of DD (DD present on at least one hind feet) based on the reclassified M-scores varied from 0.08 to 0.93 (Figure 2a).
Based on the reclassified Digiklauw scores, 75% of the cows are completely free of DD (n=4392). 25% of the cows suffer from DD, 16% at one foot (n=929), 9% at both feet (n=525), resulting in a DD prevalence of 0.25 in the study population (Table 5). Cow-level herd prevalence of DD (DD present on at least one hind feet) based on Digiklauw varied from 0.02 to 0.68 (Figure 2b).

Table 5. Frequencies of cows with no DD (0) or DD at one (1) or both feet (2) observed on 5846 cows based on M-scores and Digiklauw.

	M-scores		**Digiklauw**	
DD present yes/no	**Frequency**	**Prevalence**	**Frequency**	**Prevalence**
0	2872	0.49	4392	0.75
1	1344	0.23	929	0.16
2	1630	0.28	525	0.09
Total	5846		5846	

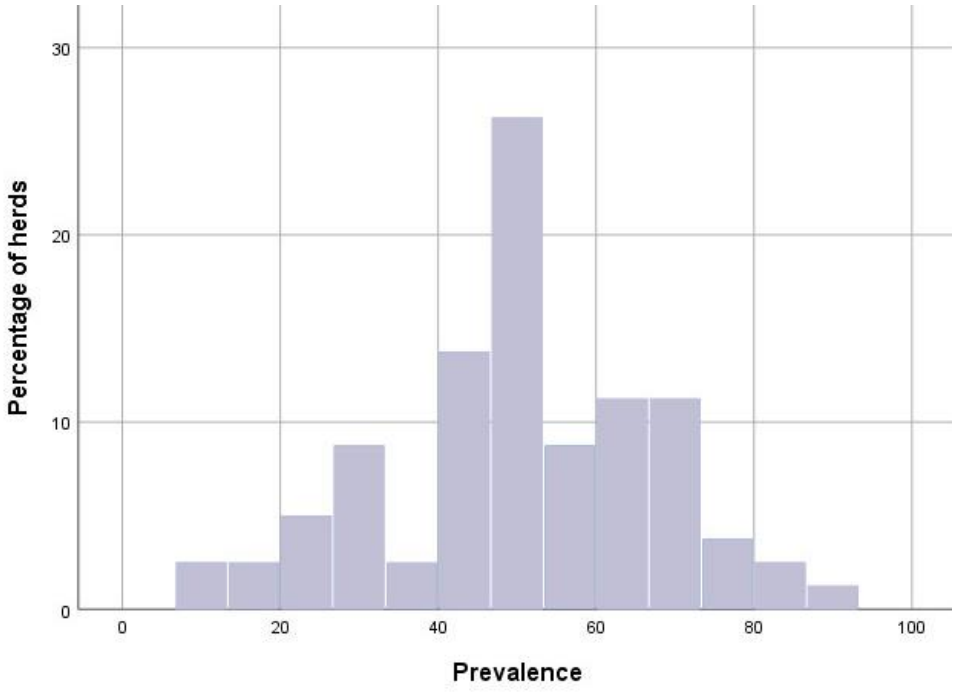

Figure 2a. Histogram of the cow-level herd prevalence of DD based on the M-scores.

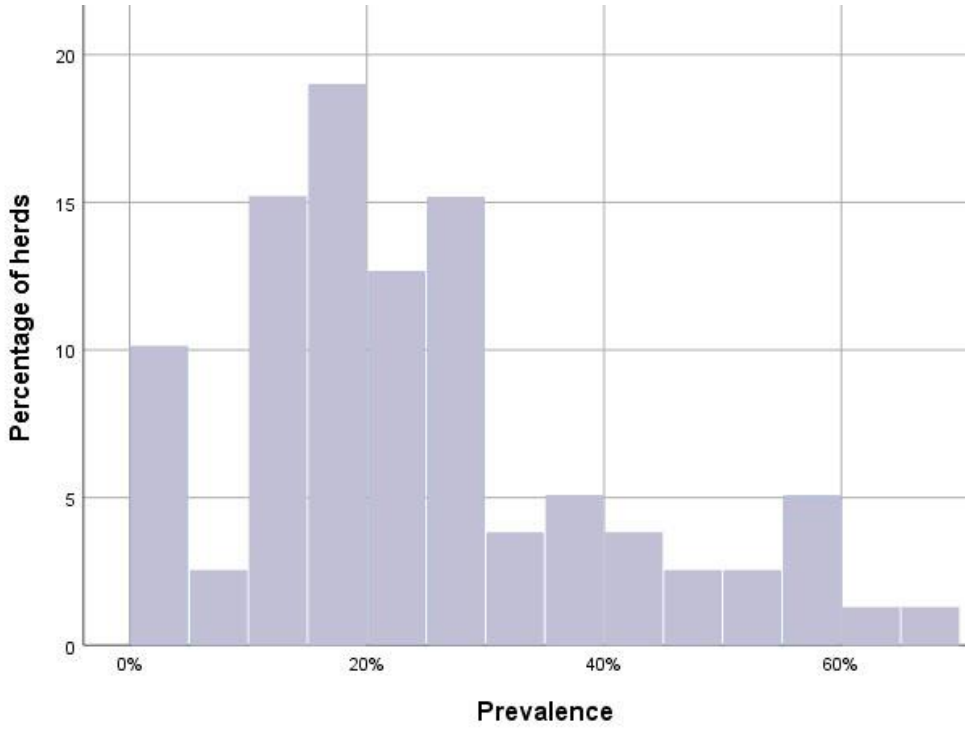

Figure 2b. Histogram of the cow-level herd prevalence of DD based on the Digiklauw scores.

Table 6a-f show DD frequencies and the other claw disorders in a crosstab on cow level. Meaning that a cow is found positive for a disorder if present on at least one hind feet. IDD and IH where the claw disorders with the highest difference in prevalence between DD present and no DD. Therefore it is likely that those two disorders are related to DD.

Table 6a. Crosstab of DD * IDD. In 4.1% (n=119) of the cows that did not have DD, IDD was present. In 20.8% (n=620) of the cows that had DD, IDD was present (P=0.00). Prevalence of IDD was 12.6%.

		IDD present yes/no		**Total**
		0	**1**	
DD present yes/no	**0**	2753	119	2872
	1	2354	620	2974
Total		5107	739	5846

Table 6b. Crosstab of DD * IH. In 1.9% (n=55) of the cows that did not have DD, IH was present. In 11.2% (n=332) of the cows that had DD, IH was present (P=0.00). Prevalence of IH was 6.6%.

		IH present yes/no		**Total**
		0	**1**	
DD present yes/no	**0**	2817	55	2872
	1	2642	332	2974
Total		5459	387	5846

Table 6c. Crosstab of DD * IP. In 0.1% (n=4) of the cows that did not have DD, IP was present. In 0.5% (n=15) of the cows that had DD, IP was present (P=00.1). Prevalence of IP was 0.3%.

		IP present yes/no		**Total**
		0	**1**	
DD present yes/no	**0**	2868	4	2872
	1	2959	15	2974
Total		5827	19	5846

Table 6d. Crosstab of DD * WL. In 14.8% (n=425) of the cows that did not have DD, WL was present. In 14.2% (n=423) of the cows that had DD, WL was present (P=0.53). Prevalence of WL was 14.5%.

		WL present yes/no		**Total**
		0	**1**	
DD present yes/no	**0**	2447	425	2872
	1	2551	423	2974
Total		4998	848	5846

Table 6e. Crosstab of DD * SU. In 5.4% (n=156) of the cows that did not have DD, SU was present. In 7.6% (n=225) of the cows that had DD, SU was present (P=0.00). Prevalence of SU was 6.5%.

		SU present yes/no		Total
		0	1	
DD present yes/no	0	2716	156	2872
	1	2749	225	2974
Total		5465	381	5846

Table 6f. Crosstab of DD * SH. In 17.7% (n=507) of the cows that did not have DD, SH was present. In 21.6% (n=642) of the cows that had DD, SH was present (P=0.00). Prevalence of SH was 19.7%.

		SH present yes/no		Total
		0	1	
DD present yes/no	0	2365	507	2872
	1	2332	642	2974
Total		4697	1149	5846

Table 7 shows the P-values of the univariable regression. Based on these results WL was not entered into the multivariable analysis because P>0.25 (P=0.89).

Table 7. P-values of the univariable regression.

	P-value					
Claw disorders	**IDD**	**SU**	**SH**	**WL**	**IP**	**IH**
DD	0.00	0.01	0.05	0.89	0.08	0.00
IH	0.00	0.00	0.01	0.01	0.00	-
IDD	-	0.13	0.01	0.92	0.30	0.00
IP	0.30	1.00	0.33	0.37	-	0.00
WL	0.92	0.00	0.00	-	0.37	0.01
SU	0.13	-	0.00	0.00	0.99	0.00
SH	0.01	0.00	-	0.00	0.33	0.00

Table 8a-e show the OR, 95% C.I. and P-value of the multivariable regression for other claw disorders. SU, SH and IP were entered into the multivariable analysis, but removed from the model because P>0.05 and not considered as a confounder. However a significant increased risk was found for IDD (OR=9.11) and IH (OR=5.18) when DD is present in a cow at the moment of routine claw trimming.

Table 8a. OR, 95% C.I. and P-values of the multivariable regression for IDD.

Claw disorders	OR	95% C.I.	P-value
DD	9.11	6.99-11.88	0.00
IH	1.89	1.37-2.61	0.00

Table 8b. OR, 95%C.I. and P-values of the multivariable regression for IH.

Claw disorders	OR	95% C.I.	P-value
DD	5.18	3.80-7.06	0.00
IDD	2.01	1.46-2.77	0.00
IP	7.67	2.54-23.10	0.00
WL	1.43	1.07-1.91	0.02
SU	2.34	1.67-3.26	0.00

Table 8c. OR, 95%C.I. and P-values of the multivariable regression for SU.

Claw disorders	OR	95% C.I.	P-value
IH	2.36	1.70-3.29	0.00
WL	1.68	1.29-2.20	0.00
SH	3.90	3.06-4.95	0.00

Table 8d. OR, 95%C.I. and P-values of the multivariable regression for SH.

Claw disorders	OR	95% C.I.	P-value
IDD	1.34	1.06-1.69	0.01
WL	2.17	1.81-2.60	0.00
SU	3.94	3.11-4.99	0.00

Table 8e. OR, 95%C.I. and P-values of the multivariable regression for IP.

Claw disorders	OR	95% C.I.	P-value
IH	6.45	2.22-18.70	0.00

Discussion

The objective of the study was to investigate the on cow level relationship between DD and other claw disorders at the moment of routine claw trimming.

The overall M-score inter observer agreement was moderate (k=0.51) and the same as found in earlier research (18). In earlier research kappa values of 0.51 were found for scoring DD using the M-score method in the milking parlor (18). This means that for gathering valuable information claw trimmers and researchers must be provided with clear definitions and where possible good photographs.

Prevalence's of the most important CHD lesions (SH, WL and SU) found in this study were 19.7%, 14.5% and 6.5% respectively. Reported prevalence's of SH, WL and SU where 26%, 18% and 9% respectively, based on Digiklauw data in 2012-2016 (10). Prevalence's of the CHD's are lower in this study. Maybe CHD's are just lower in 2017. At the other hand, lower prevalence's may be due to selection of the farms. Participants are farm owners who use Digiklauw and therefore may be more aware of claw disorders at their farm. Because the farm owners participate in a study, they may be more willing to suppress claw disorders at their farm, resulting in lower prevalence's of the CHD's in the study population.

Prevalence's of the most important ICD's (DD and IDD) found in this study were 50.9% and 12.6% respectively.
The prevalence of IDD is lower than found in the Digiklauw data of 2012-2016 where it was 18%. This is probably due to the same reason as the lower prevalence's of the CHD's and probably higher percentage of herds applying pasturing.
Furthermore we found a much higher prevalence of DD using the M-scores (50.9%). Compared with 21% according to Digiklauw data 2012-2016 (10). This may be due to the fact that this study includes scores M1, M3, M4 and M4.1. Digiklauw does not include M1, M3, M4 and M4.1. Digiklauw data of DD in this study showed a prevalence of 25% and is almost the same as was found in Digiklauw data 2012-2016. However M4 and M4.1 are the most frequent scored stages and also very important stages based on the reproduction ratio (R0) of these stages (15). Therefore M4 and M4.1 are also included in the reclassified binary M-score of DD in this study.

In 20.8% of the cows that had DD, IDD was present in the same cow. This is comparable to the study of Read et al. (1998), where 19% of the cows with DD had IDD(16). Another result of the analysis was an higher risk of having IDD when DD was present (OR=9.11), however it is not known in which order these disorders appear in a cow. Therefore we cannot say that a cow with DD has 9.11 more chance of developing IDD. But more correctly would be to say that at the moment of routine claw trimming, cows with DD are 9.11times more likely to also have IDD.

In 11.2% of the cows that had DD, IH was present in the same cow. This is almost the same as what was found in the study of Holzhauer et al. (2006) where 9% of the DD cases could have been prevented if IH was not present (11). Analysis of the data found a higher risk on having IH when DD is present in a cow (OR=5.18). As well as with IDD we do not know in which order these disorders appear in a cow. Therefore we cannot say that a cow with DD is 5.18 times more likely to develop IH. More correctly would be to say that at the moment of routine claw trimming, cows with DD are 5.18 times more likely to also have IH. But it is imaginable that IH is a consequence of chronic irritation of the interdigitale skin.

For both claw disorders however, the variables of this analysis were not very extended. Correction was done for farm specific influences and independent variables were other claw disorders. But other influences such as housing, time of the year, floor type and pasture where not put into the analysis, because these data were not usable in the way they were put down in the survey that was taken. Therefore further research is needed to see what the effect of these other influences is on the higher risk of having IDD and IH if DD is present in the cow at the moment of routine claw trimming.

Conclusion

In this study the inter-observer agreement of scoring DD using the M-score method is found to be moderate.
Much higher prevalence's of DD are found using the M-scores, compared with the prevalence's found using Digiklauw. Furthermore, the results of this study showed that other claw disorders are associated with the presence of DD in a cow. At the moment of routine claw trimming, cows with DD are significant more likely to also have IDD and IH.

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