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Associations between hoof lesions and locomotion score in 1098 unsound dairy cows in the South of Chile.

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Abstract

To investigate the association between locomotion score and types of hoof lesion, cows from 91 convenience selected dairy herds from the Xth Region of Chile, were studied. The locomotion score of all the lactating cows (n=10,699) was recorded. The mean prevalence of lame cows, when all locomotion scores >1, were included was 33.2% in large herds and 28.7% in small herds. There were 39.7%, 42%, 17.9% and 0.4% cows with locomotion scores 2, 3, 4 and 5 respectively. The feet of 676 cows (with locomotion scores representative of all severities of lameness) from 34 large herds and 422 cows' feet from 57 small herds were examined. The prevalence of lesions by type ranged from 65% of cattle with at least one white line lesion to 2% of cattle with an interdigital growth. A hierarchical model with adjustment for between farm variability and within farm correlation was used to investigate which types of lesions were associated with increasing locomotion score. The lesions linked with increasingly poor locomotion were sole ulcer, double sole and interdigital phlegmon. Other lesions present, including white line disease, heel erosion, haemorrhage and digital dermatitis were not significantly associated with increasingly poor locomotion. There was correlation between claw skin lesions and also between sole ulcer and double sole within cows. We conclude that the presence of a lesion does not imply that it is necessarily associated with an increasing severity of locomotion score. This lack of association between certain lesions and poor locomotion scores indicates that either these lesions do not cause different severities of lameness, or that the case definitions used were not precise enough to link only those lesions within a type of lesion that were associated with increasingly poor locomotion. It is also possible that locomotion score is not sufficiently sensitive to detect all lesions (and possibly discomfort) on cows' feet. Future research studies would benefit from a refined case definition for some lesions, that includes factors such as size, depth, location, duration and an indication of pain to improve our understanding of whether and when these

lesions cause discomfort in dairy cows and whether discomfort is always indicated by abnormal locomotion.

Key Words: Cattle, Lameness, Hoof lesions, Locomotion score

Introduction

Lameness in dairy cows is a serious welfare issue. It is a painful condition and causes economic losses (Esslemont and Kossaibati, 1997) through early culling (Booth et al., 2004) and reduced milk yield (Amory et al., 2008).

A useful research and practitioner tool for monitoring herd and individual lameness is locomotion scoring. Routine scoring of locomotion in a dairy herd fulfils a number of functions: it identifies cows that require treatment, provides a baseline of the current estimate of prevalence of lame cows on the farm, and it raises awareness of the number of lame cows on the farm (Whay, 2002). Almost all of the scoring systems emphasise the leg placement and back posture of the cow and score the locomotion in 5 grades, where 1 is sound and 5 is very lame (Manson and Leaver, 1988; Tranter and Morris, 1991; Whay et al., 1997; Sprecher et al., 1997; Whay, 2002). The usefulness of any assessment method is limited by its validity, reliability, and sensitivity (Flower and Weary, 2006).

There are a number of studies on the prevalence and incidence of lameness in dairy cows (Whitaker et al., 1983; Alban et al., 1995; Clarkson et al., 1996; Bargai 2000; Warnick et al., 2001; Manske et al., 2002; Cook, 2003; Espejo et al., 2006). The prevalence estimates range from 8% to 60%. In a recent study carried out on 91 dairy farms in the south of Chile, the mean prevalence of lame cows was 33.2% in large herds and 28.7% in small herds, when all locomotion scores >1 (using the Sprecher et al., 1997 system for scoring), were considered lame; when locomotion score >2 was taken as the cut off to define lameness, the mean prevalence of lameness decreased to 16.7% in large herds and 13.3% in small herds (Flor and

Tadich, 2008). There are also studies on the types of lesions that affect cows' claws (Petersen and Nelson, 1984; Murray et al., 1996; Shearer, 1998; Enevoldsen et al., 1991a and b).

However, there are few publications (Logue et al., 1994, Manske et al., 2002; O'Callaghan et al., 2003; Flower and Weary, 2006*)* that have investigated the relationship between locomotion score and the types of foot lesion present. Possible scenarios are that only certain foot lesions are associated with poor locomotion (e.g. Flower and Weary (2006) reported that cows with sole haemorrhage did not have a different locomotion from sound cows), or that only certain severities of some types of foot lesion are associated with poor locomotion (e.g. Berry (2006) reported that only certain stages of digital dermatitis cause pain). It is also possible that locomotion scoring is not sufficiently sensitive to detect all claw lesions, even if they are painful.

The hypothesis addressed in the current paper is that whilst veterinarians and hoof trimmers might assume that the presence of lesions in a lame cow is the cause of lameness, this is not necessarily correct. The aim of the current study was to determine which hoof lesions were associated with increasing lameness and thus likely to be causally associated with lameness, in a stratified sample of unsound cattle, with a range of locomotion scores from very mild (1) to severely lame (5) using the Sprecher et al., (1997) scale, from cattle on 91 dairy herds in the South of Chile.

Materials and Methods

Ninety one dairy herds from the Xth Region of Chile were studied in spring 2004, between August and November. Thirty four herds were large dairy herds with a milk production of over one million litres / farm / year (22.6 ± 4.1 l/cow/day), where cows were milked twice a day. In these large herds, cows were housed partially or totally during autumn and winter and

were at pasture partially or totally during spring and summer. Fifty seven herds were small dairy herds that produced less than 100,000 litres/year / farm (16± 6.1 l/cow/day), with cows milked once or twice per day; many of these cows were hand milked but some were machine milked. These cows were at pasture all year round.

Farms were accessed via their veterinarian. Herds were convenience sampled, based on willingness of the owner to participate, distance between the farm and the university, appropriate roads to access the farms, easy access to the cows, facilities to examine the feet, herd size and milk production. Dairy farms were visited once during the study.

The number of herds examined was calculated assuming a within herd prevalence of lameness of 10% (Tadich et al., 2005) with a confidence level of 95% and a precision of 5%. At the visits the locomotion score of all the lactating cows (n=10,699) was recorded. The locomotion score was determined by two observers working together, as the cow exited the milking parlour. The animal was observed standing, and walking (on a concrete surface whenever possible) using the Sprecher et al. (1997) scoring system. A list of all numbers of cows with locomotion score >1 was made: 20 cows were randomly selected from this list proportional to the number of cows with each locomotion score in the herd. Twenty cows were the maximum number of cattle that it was possible to examine in a crush in one day, without interfering with the routine management of the farm. In large dairy herds the selected cows (n= 676) were examined the day following selection. There were 6/57 small dairy farmers with more than 20 cows where cows were selected for examination as above, on the remaining 51 farms with less than 20 cows all cows (n=422) were examined on the day of the visit.

The lesions were recorded by observation of all four feet with the cow standing in a metal crush. The data from each cow were recorded on an individual recording sheet, including the name of the owner, date of the visit, identification of the herd, identification of

the cow, locomotion score, foot and claw affected, and type and location of the lesion. The definition of the hoof lesions is presented in Table 1 (Greenough and Weaver, 1997). Data were entered into a spread sheet (Microsoft® Excel 2002) and checked for outlying or incorrect data values.

Statistical Analysis

The number of lesions, the number of different types of lesion and the sum of each type was calculated per cow whose feet were examined and compared with the locomotion score of all these cows. The pattern of correlation of lesions within cow was investigated and those correlated at $P<0.05$ and $r>0.2$ were noted. A hierarchical model MLwiN version 2.01 (Rasbash et al., 2000) with the continuous outcome variable locomotion score was used to investigate the association between lesion presence and number and locomotion score adjusted for between farm variability and within farm correlation to investigate which lesions were associated with increasing locomotion score (i.e. poorer locomotion).

The model took the form

$$Yij = \alpha + \beta Xij + \upsilon j + \varepsilon ij$$

Where Yij = the locomotion score of cow i in herd j, α is intercept, the mean locomotion score across farms and cattle and βXij is a series of vectors of lesion types for cowij. The between herd variance was υ and residual error ε.

Results

There were 39.7%, 42%, 17.9% and 0.4% cows examined that had locomotion scores 2, 3, 4 and 5 respectively. Cattle had between zero and eight lesion types across all four feet. The median number of types of lesion was three. The prevalence of lesion type ranged from 2% of cattle with an interdigital growth to 65% of cattle with at least one white line lesion.

The most prevalent lesions are illustrated in Figure 1. The number of feet with each lesion varied from 1-4 but was generally less than 3.

Not all lesion presence was associated with increasing locomotion score (Table 2, Figure 1). For example, the percentage of cattle with locomotion score 2 and 4 with at least one white line disease lesion was 64% and 55%, respectively. In contrast, for sole ulcer the respective figures were 11% and 58%, indicating a closer association between the presence of sole ulcer and poorer locomotion.

From the multivariable model, the mean (s.e.) locomotion of cattle with a score >1 after adjusting for lesions observed was 2.58 (0.06). Cattle with at least one white line lesion, haemorrhage, heel erosion or interdigital dermatitis did not differ significantly in their locomotion from this mean locomotion score (confidence intervals included 0), (Table 4). However, cattle with at least one sole ulcer double sole or interdigital dermatitis lesion had significantly poorer locomotion with a mean increase in locomotion score of 0.51, 0.17 and 1.06 respectively.

There were significant correlations between heel horn erosion/interdigital dermatitis and heel horn erosion; between interdigital hyperplasia and interdigital dermatitis and between sole ulcer and double sole. No other coefficients were above 0.20 (Table 3).

Discussion

A key finding from this study is that when the feet from a representative proportion of cows with varying severities of locomotion score were examined, only some of the many lesions observed were linked with increasing severity of lameness. Other authors have reported that non-lame cows have hoof lesions (Manske et al., 2002, O'Callaghan et al., 2003). It is unfortunate that, due to time restrictions, cows with normal locomotion were not examined in the current study, but there is no reason to think that the patterns between

locomotion score 2 and lesion observed would be very different from that using a locomotion score of 1 (sound) as the baseline, because cattle with scores 1 and 2 are not usually considered lame.

Many feet had more than one type of lesion, highlighting the issue that the cause of lameness might be one or all of the many lesions present. The correlation between sole ulcer and double sole (0.22) was similar to the correlation between these two lesions (0.26) reported by Capion et al (2008). According to Ossent and Lischer (1998) these conditions have laminitis as a common aetiology. These lesions have been associated with pain and discomfort (Enevoldsen et al, 1991 a,b; Berry 2001) and poor locomotion (Flower and Weary, 2006). Double sole was the fourth most prevalent claw lesion in a study in 50 dairy farms of the south of Chile where the authors concluded that double sole was associated with a lack of a routine functional trimming of the claws (Hettich et al, 2007). In the current study double sole was rarely present on cows with locomotion score 2 (Table 2) and was associated with increasing locomotion score in the final model independent of sole ulcer (Table 4). Sole ulcer has recently been reported to cause the greatest drop in milk yield of all common foot lesions in a study investigating lesion specific causes of lameness and reduction in milk yield (Amory et al., 2008) and has been associated with longer calving intervals, longer intervals from calving to first service (Sogstad et al, 2006) and greatest risk of failure to conceive at first service and longer calving intervals (Hultgren et al, 2004). These poor production indices indicate that the presence of sole ulcer on a bovine hoof strongly suggests that they are causing pain (although even some (11%) sole ulcers did not cause definite lameness (Table 2)).

In contrast to sole ulcers in the present study, the horn lesions heel horn erosion, white line disease and sole haemorrhage were not significantly associated with increasing

locomotion score. Flower and Weary (2006) reported that sole haemorrhage was not associated with poor locomotion and Logue et al. (1994) reported no correlation between the presence of heel erosion and the locomotion score of cows. However, white line lesions are a commonly attributed cause of lameness (Hedges et al., 2001; Barker et al., 2007) and associated with milk loss (Amory et al., 2008). It is therefore a challenge that white line lesions were observed on cows with locomotion score 2 as commonly as those with locomotion score 4 or 5 in the current study. This result might explain why studies that investigate risks for white line disease appear unfruitful; maybe it is only when the white line lesion includes the sensitive laminae (through trauma or infection) that it causes pain and lameness. However, ignoring non-lame cows with white line disease might reduce the probability of detecting risks for white line lesion development through misclassification of non-lame cows with white line disease as unaffected.

Interdigital phlegmon, prevalent at only 4%, impacted significantly on cows' locomotion scores whilst digital dermatitis, prevalent in approximately 10% of cattle was not significantly associated with increasing locomotion score. Berry (2001, 2006) suggested that whilst herd lameness was higher in herds with a high prevalence of digital dermatitis, not all affected cattle were lame and that the size and maturity of digital dermatitis lesions affected their association with lameness. Other authors have proposed that the severity of lameness is related to the severity of the clinical presentation of the lesion (Leach et al., 1997), how long it has been present (O'Callaghan et al., 2003) and whether the lesion is infected (Petersen and Nelson, 1984). This might indicate that a more refined definition for lesions such as heel erosion, white line disease and digital dermatitis, than listed in Table 1, is required to investigate their role in lameness in dairy cows but that investigation of non-lame cows with these lesions might assist in determining their aetiology.

This might be particularly important for the claw skin associated lesions heel horn erosion, digital and interdigital dermatitis that were correlated in the current study and have been reported to be correlated in various combinations by Petersen and Nelson (1984), Manske et al (2002) and Berry (2001) The associations between heel and interdigital skin lesions might occur because these areas contact the floor surface and are likely to be affected by adverse conditions e.g. wet or slurry which have an important infectious or environmental component (Capion et al, 2008).

The importance of the results from the current study is to highlight that inferences made on hoof lesions observed from only lame cattle (typically defined as locomotion 3+) will underestimate the prevalence of some lesions e.g. white line disease and digital dermatitis and might over estimate the association of these lesions with lameness. Another important inference is that use of locomotion scoring to identify poor foot health in herds will highlight an increase in the presence of lesions such as sole ulcer but will not necessarily highlight a high prevalence of lesions such as white line disease or digital dermatitis. This might be important for management. In addition, research studies of management risks and higher locomotion score (e.g. Barker et al., 2007; Amory et al., 2006) will not have detected risks for the presence of digital dermatitis or white line disease lesions, but rather, risks associated with these lesions in lame cows. Thus, affecting the management recommendations that might prevent these lesions occurring at all.

A more philosophical question might be, does it matter if a cow has a lesion and is not lame – is the presence of any lesion an abnormality? It might be that lesions resolve and never cause lameness and so we need only concern ourselves with lesions that cause lameness. However, it might be that treatment of lesions in non-lame cows prevents them from becoming lame. It might also be that locomotion score is insufficiently sensitive and that these lesions are causing the cows discomfort, but not sufficient discomfort to change their

gait (it takes effort and energy to walk abnormally and so a change in gait will only be made when it is less costly than maintaining normal gait). Until longitudinal studies monitor the development of lesions and lameness these questions remain unanswered but very important for herd health.

We conclude that the presence of sole ulcer, double sole and interdigital phlegmon was associated with increasing locomotion score in the current study and that recording the presence of these lesions was sufficient to capture this relationship. In contrast, the presence of other lesions was not associated with increasing locomotion score. This suggests that the purpose of the measurement of lesions and locomotion score need to be carefully considered before a research study or health programme is implemented. We still require more information on the importance of foot lesions that are not associated with poor locomotion and the likelihood that they are currently affecting a cow's health or will affect a cow's locomotion in the future.

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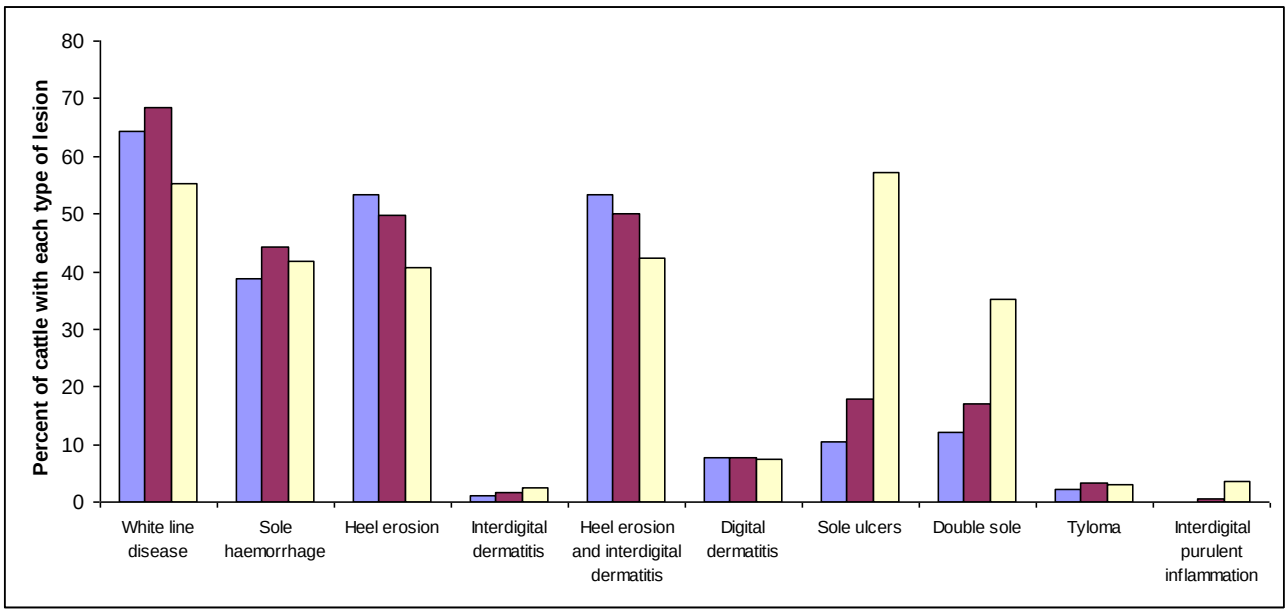

Figure 1. percent of cattle with each type of lesion

Table 2. Number and percent of cattle by number of each lesion type by locomotion scores 2 - 5

Lesion type	N. lesions/cow	N. cows	% cows	% Locomotion score			
				2	3	4	5
White Line Disease	0	391	36	36	32	45	50
	1	305	27	27	26	34	25
	2	402	37	37	42	21	25
Hemorrhage of the sole	0	641	58	61	56	59	25
	1	265	24	21	24	30	75
	2	99	18	18	20	11	0
Sole Ulcer	0	854	78	89	82	42	75
	1	179	16	9	15	38	0
	2	65	6	2	3	20	25
Double sole	0	896	82	88	83	65	50
	1	177	16	11	16	29	25
	2	25	2	1	1	6	25
Heel horn erosions	0	554	50	47	50	58	100
	1	274	25	26	26	21	0
	2	270	25	27	24	21	0
Interdigital dermatitis	0	1081	99	99	98	97	100
	1	17	2	1	2	3	0
Heel horn erosion/ Interdigital dermatitis	0	550	50	47	50	57	100
	1	279	25	26	26	23	0
	2	269	24	27	24	20	0
Digital dermatitis	0	1013	92	92	92	93	75
	1	66	6	6	6	5	25
	2	19	2	2	2	2	0
Interdigital hyperplasia (Tyloma)	0	1067	97	98	97	97	100
	1	26	2	2	2	3	0
	2	5	1	0	1	0	0
Interdigital phlegmon	0	1089	99	100	100	96	100
	1	9	1	0	0	4	0

Table 3. Correlation coefficient between lesions within cow, (first row = correlation coefficient, second row = probability value), 1098 cows, 91 dairy cow farms in Chile.

Lesion code		1	2	3	4	5	6	7	8	9
1	White line disease	1.000								
2	Haemorrhage of the sole	-0.086								
		<0.01								
3	Heel horn erosions	0.003	-0.083							
		0.92	0.01							
4	Interdigital dermatitis	0.032	-0.046	0.023						
		0.32	0.09	0.45						
5	Heel Erosion/interdigital dermatitis	0.004	-0.089	0.982	0.126					
		0.92	<0.01	<0.01	<0.01					
6	Digital dermatitis	-0.155	-0.044	0.081	0.102	0.086				
		<0.01	0.18	0.01	<0.01	<0.01				
7	Sole ulcer	-0.042	0.020	-0.096	-0.032	-0.100	-0.007			
		0.16	0.5	<0.01	0.74	<0.01	0.74			
8	Double sole	0.009	0.028	-0.043	-0.041	-0.051	-0.006	0.227		
		0.74	0.32	0.16	0.16	0.09	0.74	<0.01		
9	Interdigital hyperplasia (Tyloma)	-0.011	-0.010	0.007	0.246	0.039	0.074	-0.025	0.004	
		0.74	0.74	0.74	<0.01	0.16	0.01	0.35	0.92	
10	Interdigital phlegmon	-0.059	-0.015	-0.029	0.152	0.010	0.049	-0.049	0.009	-0.015
		0.05	0.16	0.62	<0.01	0.74	0.09	0.09	0.92	0.5

1 – 9 corresponds to the lesion names in the rows

Table 4. Hierarchical model of association between locomotion score and lesion adjusted for farm variability

Variable	Mean	S.E.	Lower 95% CI	Upper 065% CI
Intercept	2.58	0.06	1.47	1.69
White line disease	0.06	0.05	-0.03	0.15
Haemorrhage of the sole	-0.02	0.04	-0.10	0.06
Heel horn erosions	-0.39	0.24	-0.88	0.09
Interdigital dermatitis	0.08	0.19	-0.31	0.46
Heel erosions / interdigital dermatitis	0.33	0.24	-0.16	0.82
Digital dermatitis	-0.06	0.08	-0.21	0.10
Sole ulcers	0.51	0.05	0.41	0.61*
Double sole	0.17	0.05	0.07	0.27*
Interdigital hyperplasia (Tyloma)	0.14	0.12	-0.10	0.38
Interdigital phlegmon	1.06	0.22	0.62	1.50*

* *confidence intervals do not include zero*

Between farm variance 0.06 s.e. 0.01

Between cow variance 0.39 s.e. 0.01