Miguel-Pacheco, Giuliana G. and Thomas, Heather J. and Kaler, Jasmeet and Craigon, Jim and Huxley, Jonathan N. (2016) Effects of lameness treatment for claw horn lesions on lying behaviour in dairy cows. Applied Animal Behaviour Science, 179 . pp. 11-16. ISSN 0168-1591

Original Article

Effect Of Claw Horn Lesion Type At The Time Of Treatment On Lameness Prognosis

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ABSTRACT

Claw horn lesions are some of the most common causes of lameness and it is accepted that prompt diagnosis and treatment affects the likelihood of recovery; however, it is still unknown if the type of lesion influences the likelihood of recovery. The aim of this study was to investigate whether the type and frequency of claw horn lesions in newly lame cows at the time of corrective foot trimming affected the probability of recovery from lameness after treatment. The images of 119 feet from newly lame cows, which were treated with a standardised therapeutic hoof trim, were used to measure and count the presence of claw horn lesions (sole ulcer, sole haemorrhage, white line haemorrhage and white line separation). The majority of cows (n=114) were classified as mildly lame at the time of treatment. The recovery rate two weeks after therapeutic hoof trimming was 79.8% (n=95 cows). A multilevel logistic regression model found that severely lame cows with lesions on a single claw were less likely to recover than those that were mildly lame and had lesions on both claws. White line haemorrhage lesion was the only lesion to decrease the likelihood of recovery; however, cows with longer white line haemorrhage lesions were more likely to recover. This latter finding may be associated with the severity of the lesion, as this study also observed that mild claw horn lesions were significantly larger than severe lesions. Further work is needed to better understand the factors that influence recovery from this painful and costly disease.

Keywords: Lameness, dairy cows, claw horn lesions, recovery rate, lameness prognosis

INTRODUCTION

The most common causes of lameness in dairy cows in the UK are the lesions of claw horn disruption, which include sole ulcers (SU), sole haemorrhage (SH) and white line disease (WLD) (Green et al., 2014; Leach et al., 2012). SU and WLD can cause milk losses of approximately 570 and 370 kg respectively (Amory et al., 2008). SU and SH have been positively associated with a reduction in longevity and earlier culling (Booth et al., 2004; Sogstad et al., 2007a). Further, claw horn lesions are painful and can propagate hyperalgesia; Whay et al. (1998) reported that this continued for up to 28 days. SU is considered to be the most severe of the claw horn disruption lesions and has been associated with poor locomotion, asymmetric steps, increased back arch and joint flexion, all indicating a pain response (Chapinal et al., 2009; Flower and Weary, 2006; Tadich et al., 2010).

Early diagnosis and treatment may improve prognosis and recovery rates in lame cows (Leach et al., 2012). These authors reported that earlier lameness interventions were more likely to be carried out on less severe lesions, improving the likelihood of recovery. Early treatment of cows with mild lameness, within 2 days of detection, reduced herd lameness prevalence when compared with protocols, which led to a delayed time to treatment. In this early intervention study, milder lesions (i.e. haemorrhage) were observed in early treated cows, with more ulcers present when treatment was delayed.

As previously described, claw horn lesion type has been linked to different production traits and survival rates. However, the effect of claw horn lesion type at the time of treatment on the likelihood of recovery has not been studied. The primary aim of this study was to examine whether the type and frequency of claw horn lesions in newly lame cows identified at the time of corrective foot trimming had an effect on the probability of recovery from lameness after treatment. The null hypothesis stated that the type and frequency of claw horn lesion(s) did not affect recovery from lameness after treatment.

MATERIALS AND METHODS

Study dataset

The present study used data collected during a randomised clinical trial (RCT) described by Thomas et al. (2015). In brief, the RCT was designed to compare three treatments for claw horn lesions against a positive control group that only received a therapeutic trim only. The RCT protocol was reviewed and approved by the University of Nottingham’s School of Veterinary Medicine and Science Ethical Review Committee prior to the start of the study.

Animals. Data from cows selected for the present study were a subset drawn from the study population described in Thomas et al. (2015). In brief, cows on 5 farms were mobility scored every two weeks and were eligible for examination and treatment if they had two non-lame scores followed by a lame score, and only presented with one of the hind limbs lame. Cows with claw horn lesions classified into one of three categories were included in the study (SH or SU, WLD or ‘Other’ (other types of claw horn lesion or a combination of SH, SU and / or WLD); those with infectious lameness conditions were not enrolled. The treatment group had been randomly assigned and the dataset used in this study included *only* cows that received a therapeutic foot trim alone (Standard Dutch 5 step therapeutic foot trim involving trimming and balancing of both claws, investigation of lesions and removal of diseased horn (Toussaint-Raven et al., 1985)). If study cows were still lame on the same leg at the two-week outcome point they were kept in the dataset, cows that became lame on a different leg after treatment were excluded.

Sample size. Sample size was calculated based on the rate of recovery published by Groenevelt et al. (2014). Using a one-proportion score test in Stata/SE 12.0 (Stata Corp 2011, USA), with an expected 80% rate of recovery after 2 weeks with a confidence level of 95% and a power of 80%, the calculation estimated a sample size of 86 cows was required.

Hoof photographs

At the time of treatment, pictures were taken of the plantar surface of the hoof of the lame leg, after a very thin layer of claw horn had been removed. The claw's surface was cleaned with water and dried with paper towels. Photographs were taken using a Sony Cybershot camera (DSC-W170 10.1 megapixels, Sony Europe Limited). A small identification board (101 x 228 mm) was held next to the hoof to mark each image.

Lesion identification and scoring

Lesions present on hoof photographs were identified, classified and located according to a standard methodology developed at the University of Nottingham; lesion classifications are described in Table 1, adapted from published literature (Greenough and Vermunt, 1991; Leach et al., 1998; Sogstad et al., 2007a). A single observer identified, classified and severity scored all the lesions by claw (Table 1). Then, the area or length of each lesion and the identification board width were measured using the ImageJ 1.49p software (Schindelin et al., 2012). This software calculated length and area in pixels. In order to transform the lesion size data (length of WLD lesions and area of SH or SU lesions) to millimetres, the identification board width was used as a reference to adjust the size data to account for small variations in camera distance from the foot. Data were transferred to an Excel® Lesion Scoring Input Form (developed by RN), where the location of each lesion was added (Figure 1).

Zones of the sole were identified following the map described by Greenough and Vermunt (1991) (Figure 1-A). Information on the presence or absence of heel horn erosion (i.e. irregular horn surface with or without deep horn grooves that may expose the corium), double sole (i.e. horn is separated at the grooves and formed a flap at the bulb of the heel as it has two or more layers of under-run sole horn) and interdigital hyperplasia was recorded (ICAR, 2015).

The intra-observer reliability to measure correctly the lesions was assessed through measuring the outline of a claw at the beginning and at the end of the picture session on three occasions though out the study. The intra-observer reliability for the lesion identification was tested using the same series of 25 pictures of lesions assessed at each of four testing sessions. Images were presented in a random order at each session. These four sessions were prior to commencing, twice during and at the end of the picture observations.

Statistical analysis

Descriptive analyses and reliability analysis were carried out using Stata/SE 12.0 (Stata Corp 2011, USA). The weighted kappa (k_w) was used to calculate the intra-observer reliability for lesion scoring and the interpretation of the k_w was conducted using Landis and Koch (1977). Area for each lesion severity category was not normally distributed, so the Kruskall Wallis test was used to compare severity categories for each lesion type (Petrie and Watson, 2006). A P-value of ≤ 0.05 was considered as significant.

A multilevel logistic regression model was built using MLwiN version 2.27 (Rasbash et al., 2009). The two level (claw within cow) model examined if claw horn lesions type area and presence (yes or no) affected the likelihood of recovery. Fixed effects included farm, cow ID, limb of foot treated (right or left), claw (lateral or medial), recovery at 2 weeks (a binary outcome), mobility score before treatment, one claw affected, lesion type (Table 1) present (yes or no), area/length measurement and frequency for each lesion type, HHE (yes or no) and double sole (yes or no). An additional variable was included to distinguish between operators at the time of treatment (categorised as either the primary operator or other operators). Data for severity category for each type of lesion was not included in the final model, this data was consolidated to obtain a total area and frequency per claw horn lesion type to evaluate the main aim of the study.

Results from the model are presented as odd ratios (OR) and confidence intervals [CI]. Frequency and presence of claw horn lesions by type showed high collinearity, therefore only the presence of claw horn lesions by type variables was kept in the final model.

RESULTS

Reliability of lesion identification

The intra-observer overall average K_w agreement for lesion classification was very high K_w = 0.87 (95% CI: 0.75-0.96) with a range of 0.64 – 1.00. When measuring the same claw 6 times, the standard deviation was on average 3% of the mean of each measurement assessed (range 1.38% - 7.18%).

Animals

Data from 143 cows were available for analysis, of which 11 became lame on a different leg two weeks after treatment, 6 were diagnosed with DD, and pictures from 7 cows were excluded because image quality was too poor or they were ambiguously identified. The final dataset consisted of images of 238 claws from 119 cow lameness events.

Prevalence and description of claw horn lesions

One hundred and twelve cows were diagnosed with claw horn lesions (seven cows had no visible lesions). Lesion prevalence varied according to claw: three cows had SH lesions on both claws, three cows had WLD on both claws (haemorrhage and separation), 51 cows had both claws affected by different combinations of lesions, and the remaining 55 cows had different combinations of lesions by claw (e.g. one claw with SH and the other claw with a SU).

SH was the most frequently observed lesion; 216 lesions were observed, predominantly on the lateral claw (Table 2). WLH was the second most frequently observed, followed by WLS (Table 2). SU were the least frequent claw horn lesion observed, with a total of 47 observations most of them located on the lateral claw.

Claw horn lesions and recovery 2 weeks after treatment

The recovery rate from lameness 2 weeks after therapeutic hoof trimming was 79.8% (n=95 cows). Results from the final model showed that only WLH lesions had a significant impact on the likelihood of recovery from lameness. Recovery of cows with WLH was positively associated with the length of the lesion (OR: 0.11 [0.03-0.42], Table 3). Cows assigned a mobility score of 3 at the time of treatment were significantly less likely to recover compared to cows with mobility score 2 (OR: 0.06 [0.01-0.54], Table 3), and cows with a single claw affected were significantly less likely to recover than those with both claws affected (OR:0.37 [0.15-0.93]). Hoof trimming operator had a significant effect on the likelihood of recovery, animals treated by the primary operator were more likely to recover. There was no significant effect of other type of lesions on the likelihood of recovery.

Association between size of lesions and categorical descriptors of severity

The mean measured SU area categorised as mild was significantly greater than the area categorised as severe (H=4.6, 1d.f.; P= 0.0001) (Figure 2). The mean measured SH area categorised as mild was significantly greater than the areas categorised as both moderate and severe (H=91.02, 2d.f.; P= 0.0001) (Figure 2). Similarly, the mean WLH and WLS lengths categorised as mild were significantly longer than the lengths categorised as moderate and severe (WLH: H=40.2, 2d.f.; P= 0.0001; WLS: H=7.6, 2d.f.; P=0.0001) (Figure 2).

DISCUSSION

The presence of WLH at the time of treatment decreased the likelihood of recovery from lameness following a therapeutic trim. White line lesions have been linked to both milk loss and lameness (Amory et al., 2008; Barker et al., 2007). Interestingly, the length of WLH was positively correlated with the likelihood of recovery i.e. cows with longer lesions were more likely to recover from lameness 2 weeks after treatment. It is possible that the haemorrhage observed at the white line was caused several weeks before and the lesions observed were the vestiges of more severe damage (Flower and Weary, 2006). Alternatively, mild white line haemorrhage lesions were significantly larger than the other severity categories of WLH; longer lesions were more likely to be mild, which could be more likely to recover. It is hard to compare these results with previous studies, which often have not discerned between white line haemorrhage and white line separation (Blackie et al., 2013; Chapinal et al., 2009). To the author's knowledge, this is the first study to report associations between lesion type at the time of treatment and the likelihood of recovery. The results can provide useful prognostic information for clinicians and foot trimmers treating lesions in the field.

Sole haemorrhage has commonly been reported as the most prevalent lesion in similar work (Groenevelt et al., 2014; Leach et al., 2012); the current study agrees with these findings. Sole haemorrhage lesions were the largest of all lesions identified in this study. In a previous study, sole haemorrhages was not associated with poor locomotion score (Flower and Weary, 2006), on the other hand SU have been strongly associated with poor locomotion score even 4 weeks before diagnosis (Chapinal et al., 2009). In this study 47, of the 286 claws observed, were diagnosed with SU; though, most claws/ feet in this study displayed a combination of lesions. Therefore, it is difficult to make comparisons between studies as some combine all the lesions observed per foot or have only considered moderate to severe lesions in their results (Chapinal et al., 2009; Tadich et al., 2010).

Most of the lesions observed were classified as mild and were also the largest lesions, regardless of the type. As suggested by Groenevelt et al. (2014), it is possible that these lesions may have been previously undereported. Cows in the present study became lame within the previous 2 weeks before treatment. The fact that animals were lame suggests that there could have been trauma at the level of the corium manifested through the presence of haemorrhages, which may predispose to more serious lesions if left untreated or allowed to pregress (Groenevelt et al., 2014; Sogstad et al., 2007b). Most of the claw horn lesions were observed in the lateral claw, in concurrence with previous work (e.g. Ahrens et al., 2011) and has been explained by the anatomical and loading differences between digits (Van der Tol et al., 2002).

It is interesting to observe that severity of a lesion was inversely proportional to size, which was true for every claw horn lesion type observed. This might be caused by how the pressure forces in the corium are distributed. When forces are distributed over a large area, the pressure at an specific site is lower than when the forces are distributed over a small area, causing less pressure therefore less lameness (Van der Tol et al., 2002). On the other hand, the descriptors used in the present study were developed by the authors, based on descriptors reported previously (Leach et al., 1998; Sogstad et al., 2005). Descriptors reported previously have not included size; they have been based solely on the appearance of lesions. The work reported here suggests that lesion size may well be an important aspect of lesion pathogenicity. Future studies investigating lesion type and severity should include the area of the lesion as part of the analysis as this may be of biological importance. Further work is needed to investigate how the combination of area and severity and lesion type and severity impact on recovery (the analysis employed in this study did not allow both lesion type and lesion severity to be included in the final model).

Lame cows that were lameness score 3 (severly lame) before treatment were less likely to recover than those that were score 2 (mildly lame). Score 3 cows did not have a particular lesion, all animals had different combinations of lesions per claw. Whay et al. (1997) observed that lameness severity was positively associated with an increase in sensitivity to mechanical noxious stimuli. This hyperalgesia persisted for at least 28 days after the lameness was treated (Whay et al., 1998). Then, it is possible that these animals may have been in a higher hyperalgesic state making them less likely to recover sooner in comparison to cows that were score 2. This finding must be taken into consideration by the industry as additional care should be taken when treating cows which are severly lame. Specifically, operators treating lame cows should consider the administration of NSAIDs not to only more severely lame cows, but to all lame cows when they are treated (Thomas et al., 2015).

Cows with one claw affected were less likely to recover. There were 28 cows with a single claw affected, from these only 8 cows had a single type of lesions, the remaining 20 cows had different combinations of claw horn lesions. In addition, 24 cows had lesions on the lateral claw and 4 on the medial claw. Van der Tol et al. (2002) observed that the lateral claw of the hindlimbs bears more weight than the medial claws when cows are standing even after trimming. Consequently it may be more difficult to remove pressure from the lateral claw using corrective trimming alone, which could explain the delayed recovery in these animals.

The recovery rate two weeks after treatment was 79%, which is similar to that observed by Leach et al. (2012): in their study approximately 75% of the newly lame cows recovered 2 weeks after treatment. A prompt intervention is more likely to encounter mild lesions that are less complicated to treat, increasing the chances of a rapid recovery and consequently less lameness in the following lactations (Groenevelt et al., 2014). It is possible that the type of lesion and its severity, measured by area or frequency, might not be as important as the early diagnosis and treatment of these lesions.

Animals in the present study were treated using the 5 step Dutch Foot Trimming technique (Toussaint-Raven et al., 1985). Previous research has suggested that foot trimming may cause pain and discomfort (Chapinal et al., 2010; Van Hertem et al., 2014). None of these previous studies specified which hoof trimming technique was used. Findings from the present study suggest that following a standard technique, a good recovery rate can be achieved in newly and predominantly mildly lame cows. There is little research on hoof trimming techniques and their impact on recovery rates; further work is urgently required to understand how different hoof trimming techniques influence recovery. In this study, case selection was limited to cases of newly lame cows with only one hind limb affected with a claw horn lesion. This enabled our case definition to be precise, but means that care should be taken when generalizing our findings to the wider population.

CONCLUSION

Cows that were severely lame at the time of treatment, with one claw affected and with white line haemorrhage were less likely to have recovered from lameness 2 weeks after treatment. In addition, cows with longer white line haemorrhage are more likely to recover; this may be linked to the severity of the lesion, because larger lesions tended to be less severe. Further work is needed to better understand the factors that influence recovery from lameness following treatment, to maximize recovery and limit the welfare impacts of this painful and self-perpetuating disease.

CONFLICT OF INTEREST STATEMENT

None of the authors has any financial or personal relationship that could inappropriately influence or bias the content of the paper.

ACKNOWLEDGMENT

This study was support, in part, by University of Nottingham International Excellence Scholarship and by the Agriculture and Horticulture Development Board (AHDB) Dairy Division, a levy board, not for profit organisation working on behalf of British Dairy Farmers. The authors wish to thank the collaborating farmers and Nikki Bollard for her technical assistance.

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Table 1 Classification and description of claw horn lesions used in a study to investigate the effect of claw horn lesion type at the time of treatment on recovery.

Type of lesion	Classification	Description
No Lesion		No claw horn lesion or any other lesion identified on the foot.
Sole Ulcer	Mild	Small penetration of sole surface, corium not expose or granulation tissue not observed.
	Severe	Penetration of sole surface with exposure of corium and/or granulation tissue present.
Sole Haemorrhage	Mild	Presence of diffuse light pink and/or yellow coloration at any location on the sole.
	Moderate	Presence of dark pink coloration at any location on the sole.
	Severe	Presence of very dark red or purple coloration at any location on the sole.
White Line Haemorrhage	Mild	Presence of diffuse light pink and/or yellow coloration at any location on the white line.
	Moderate	Presence of dark pink coloration at any location on the white line.
	Severe	Presence of very dark red or purple coloration at any locations on the white line.
White Line Separation	Mild	Dark coloured marks in the white line at any location.
	Moderate	Deep fissures and/or impacted areas in the white line at any location.
	Severe	Very deep or profound fissure, with the corium involved and/or purulent exudate, necrosis, granulation tissue and /or separation of wall and sole at any location.

Table 2 Distribution of claw horn lesion type by severity across 112 cows in a study investigating lesion type at the time of treatment on recovery. Percentages of lesions by severity and by type are in parentheses.

Lesion Type	Classification (Severity)	Lateral Claw	Medial Claw	Total by severity	Total by Lesion
Sole Ulcer					
	Mild	25 (67.6)	12 (32.4)	37 (78.7)	47 (100.0)
	Severe	8 (80.0)	2 (20.0)	10 (21.3)	
Haemorrhage					
	Mild	87 (68.5)	40 (31.5)	127 (60.5)	210 (100.0)
	Moderate	36 (63.2)	21 (36.8)	57 (27.1)	
	Severe	18 (69.2)	8 (30.8)	26 (12.4)	
White Line Haemorrhage					
	Mild	47 (54.7)	39 (45.3)	86 (64.6)	133 (100.0)
	Moderate	22 (64.7)	12 (35.3)	34 (25.6)	
	Severe	10 (76.9)	3 (23.1)	13 (9.8)	
White Line Separation					
	Mild	18 (47.4)	20 (52.6)	38 (65.5)	58 (100.0)
	Moderate	9 (52.9)	8 (47.1)	17 (29.3)	
	Severe	3 (100.0)	0	3 (5.2)	
Heel horn erosion		32 (46.4)	37 (53.6)		69 (100.0)
Under run		10 (40.0)	15 (60.0)		25 (100.0)

Table 3 Multilevel logistic regression analysis of the likelihood of recovery from lameness caused by claw horn lesions 2 weeks after therapeutic trimming

Model term	Freq[1]	Coef[2]	SE	OR	z	Confidence Interval		P-value
						2.5%	97.5%	
Intercept		2.13						
Farm								
Farm 1	48	Reference						
Farm 2	38	0.29	0.65	1.33	0.19	0.37	4.78	0.66
Farm 3	6	-0.47	1.15	0.62	0.17	0.07	5.91	0.68
Farm 4	58	0.73	0.61	2.08	1.45	0.63	6.89	0.23
Farm 5	88	0.38	0.59	1.46	0.41	0.46	4.61	0.52
Mobility score at treatment								
MS 2	228	Reference						
MS 3	10	-1.93	0.91	0.15	4.49	0.02	0.9	0.03
Cow with one claw affected								
No	182	Reference						
Yes	56	-1.00	0.47	0.37	4.50	0.15	0.93	0.03
Operator								
Operator 1	216	Reference						
Operator 2	22	-1.68	0.61	0.19	7.57	0.06	0.62	0.01
Sole Ulcer								
Area (mm2)	238	-0.006	0.004	0.99	2.25	0.99	1.00	0.13
Presence								
No	194	Reference						
Yes	44	0.96	0.85	2.61	1.28	0.50	13.70	0.26
Sole Haemorrhage								
Area (mm2)	238	0.001	0.001	1.00	1.00	1.00	1.00	0.32
Presence								
No	92	Reference						
Yes	146	-0.09	0.46	0.92	0.04	0.37	2.26	0.85
White line haemorrhage								
Length (mm)	238	0.05	0.02	1.05	4.80	1.00	1.09	0.03
Presence								
No	137	Reference						
Yes	101	-2.20	0.68	0.11	10.45	0.03	0.42	0.001
White line separation								
Length (mm)	238	-0.03	0.03	0.98	0.69	0.92	1.03	0.40
Presence								
No	188	Reference						
Yes	50	0.54	0.89	1.71	0.36	0.30	9.84	0.55
Heel horn erosion								
No	169	Reference						
Yes	69	-0.44	0.56	0.65	0.62	0.22	1.93	0.43
Double sole								
No	213	Reference						
Yes	25	-0.04	0.68	0.96	0.00	0.25	3.61	0.95

[1]Frequency of observations; [2]Coefficient

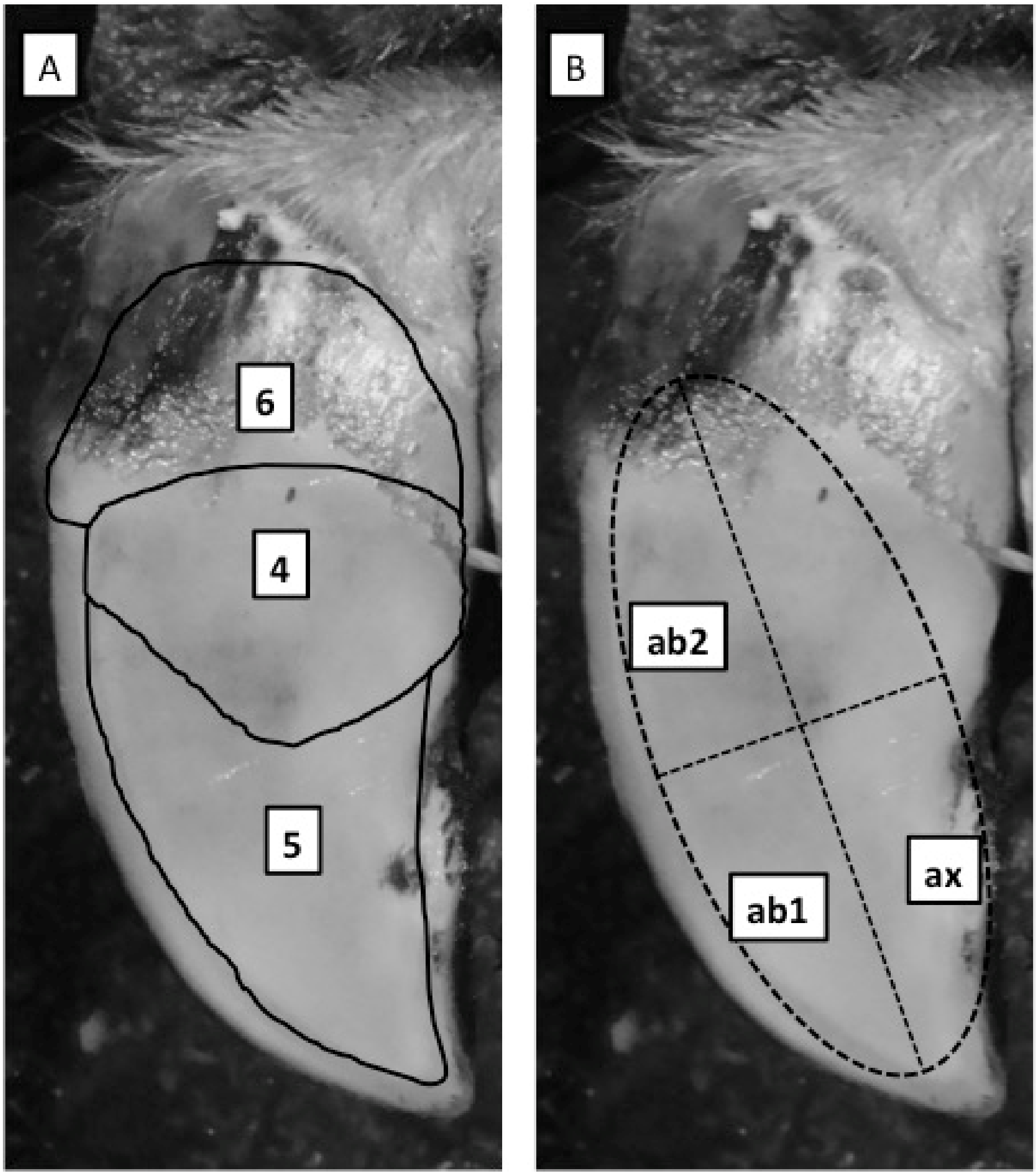

Figure 1 Zones of the distal surface of the claw used to describe location of claw horn lesions observed in a study investigating the effect of lesion type at the time of treatment on recovery. Figure 1-A shows zones for sole ulcers and haemorrhage 4= sole, 5= toe, 6= heel.Figure 1-B shows zones for white line lesions ab1= abaxial wall zone 1, ab2= abaxial wall zone 2, and ax= axial wall (Modified from Leach et al., 1998). White line zones were defined using anatomical features as follows: an ellipse was drawn on the sole area of each picture, the limits of the main long ellipse axis where the outer edge of the white line at the corner of the toe and the caudal extremity of the white line at the heel. Then, the abaxial border of the ellipse was extended to meet the abaxial white line. This gave three areas: abaxial 1, abaxial 2 and axial that allowed for consistency between pictures.

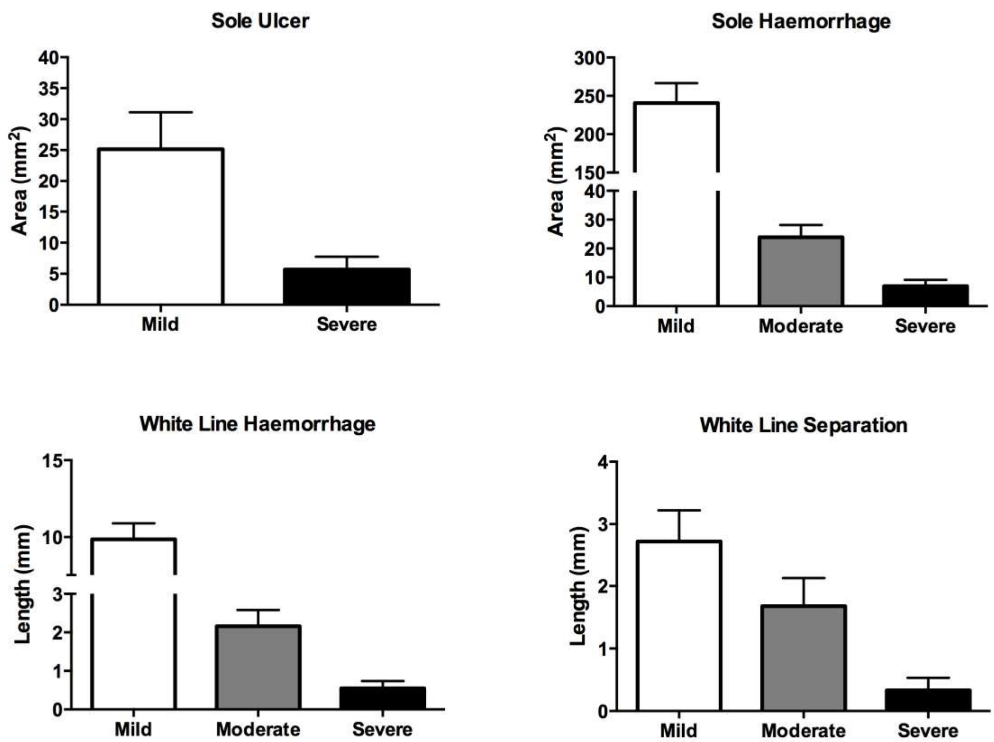

Figure 2 Distribution of area/length and standard error of each claw horn lesion type measured on pictures by severity scored on a categorical scale in a study investigating lesion type at the time of treatment on recovery.