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RESEARCH ARTICLE

Investigating the effect of prophylactic claw trimming on the interval between calving and first observed elevated locomotion score in pasture-based dairy cows

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ABSTRACT

Aims: To evaluate, in a pasture-based dairy herd, the response to a three-time point hoof trimming regime on lameness incidence and time from calving to observation of an elevated locomotion score (LS).

Methods: This study was conducted on a 940-cow spring-calving herd in New Zealand's North Island between May 2018 and May 2019. Cows (n = 250) were randomly allocated to the hoof trimming group, with the remainder assigned to the non-trim cohort. One trained professional hoof trimmer used the five-step Dutch method to trim the hind feet of the trimming group. Throughout the subsequent production season, the whole herd was locomotion-scored fortnightly using the 4-point (0–3) Dairy NZ lameness score. Kaplan–Meier survival curves were used to assess the univariable effect of trimming on the interval between calving and first LS of ≥ 2 and first LS ≥ 1. A multivariable Cox proportional hazards regression was used to further evaluate the effect of trimming on time to elevated LS.

Results: Mean lameness (LS ≥ 2) prevalence was 2.6%, with 30% of cows having ≥ 4 observations during the study period when at least one LS was ≥ 2. For LS ≥ 1, mean prevalence was 40%, with 98.6% of cows having ≥ 4 observations during the study period when at least one LS was ≥ 1 during lactation. Hoof trimming had no apparent effect on the incidence of clinical lameness (LS ≥ 2) (trimmed *vs.* non-trimmed: 33.2% *vs.* 28.8%, respectively), but for LS ≥ 1, there was a small decrease in the incidence of LS ≥ 1 (trimmed *vs.* non-trimmed: 96.9% *vs.* 99.3%, respectively). The hazard of a cow having a first observed LS ≥ 2 in the control group was 0.87 (95% CI = 0.66–1.14) times that of the trimmed group; however, the hazard of a cow having a first LS ≥ 1 was 1.60 (95% CI = 1.37–1.88) times higher in the control than in the trimmed group.

Conclusion and clinical relevance: On this farm, prophylactic hoof trimming had no clinically relevant impact on the incidence of clinical lameness and was not associated with clinically beneficial reductions in time to first observed LS ≥ 2. This may be because claw horn imbalance was not pronounced on this farm, with 53% of cows needing no trim on either hind limb on the first trimming occasion. Further research on the response to prophylactic trimming in pasture-based dairy cattle is required.

Abbreviations: AHDB: Agriculture and Horticulture Development Board; CAT: Category; CHDL: Claw horn disruption lesion; LS: Locomotion score; MNT: Missed non-trim; MT: Missed trim; TNT: Total non-trim; TT: Total trim.

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Introduction

Lameness causes significant economic losses and welfare problems in dairy cattle worldwide. Multiple studies have reported impacts of lameness on milk production, fertility, and on-farm longevity (Archer *et al.* 2010; Machado *et al.* 2010; Somers *et al.* 2015), as well as significant impacts on animal welfare (Laven and Holmes 2008; Whay and Shearer 2017).

Lameness aetiologies can be divided into infectious and non-infectious (Potterton *et al.* 2012). Both are important (Potterton *et al.* 2012), but whereas infectious causes, especially digital dermatitis, can be controlled by effective biosecurity and improvements in farm hygiene (Laven and Hunt 2002; Speijers *et al.* 2010; Solano *et al.* 2017), non-infectious lameness (which is principally caused by claw horn disruption lesions (CHDL); Egger-Danner *et al.* 2014) is much more difficult to control. Claw horn diseases are thus considered to be the main challenge to reducing lameness in dairy cattle (Murray *et al.* 1996; Potterton *et al.* 2012; Shearer *et al.* 2015).

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Claw horn disruption lesions account for approximately 65% of lameness cases in housed cows (Murray *et al*. 1996; Bicalho and Oikonomou 2013). The numbers are similar in pasture-based systems. For example, in New Zealand, Chesterton *et al*. (2008) reported that CHDL accounted for 72.5% of diagnoses in lame cows treated by a veterinarian. Such lesions are associated with pressure load within the foot (Van der Tol *et al*. 2004). The lateral claw is larger than its medial counterpart (Nacambo *et al*. 2007), and the lateral claw carries more weight (Van der Tol *et al*. 2002, 2003). This situation worsens when the lateral claw becomes overgrown (Van der Tol *et al*. 2004) and is exacerbated when weight shifts from one limb to another (Nuss *et al*. 2019). Therefore, one area of significant focus is maintaining normal claw conformation to reduce the pressure imbalance within the foot, i.e. decreasing CHDL through preventative functional claw trimming (Toussaint Raven 1985; Shearer and van Amstel 2001).

Multiple studies have suggested that in housed dairy cows, preventative claw trimming can reduce the risk of lameness, prevent claw horn lesions, and improve performance (Manske *et al*. 2002; Fjeldaas *et al*. 2006; Hernandez *et al*. 2007). However, in their review of hoof trimming and lameness, Stoddard and Cramer (2017) stated that there were still large areas where there was insufficient knowledge of the impact of hoof trimming on lameness, particularly related to technique and frequency. The evidence for the benefit of preventive trimming is more limited in cows at pasture than in housed cows. Sadiq *et al*. (2021) reported that claw trimming increased the time to first lameness in both permanently housed cows and in cows allowed to graze. However, in that study grazing cattle only had access to grazing for 3–6 hours per day and were therefore housed for the majority of their day. As far as the authors are aware, the only published study of preventative claw trimming and lameness in cows that are permanently kept at pasture is that by Bryan *et al*. (2012), who studied the effect of trimming on three dairy farms in Canterbury in the South Island of New Zealand. They reported no effect of claw trimming on subsequent lameness incidence, but they found that the median days to lameness was lower in the control group than in the trimmed group (29 *vs.* 38 days), with the hazard for the control group of becoming lame being 1.56 (95% CI = 1.10–2.26) times that of the treatment group. However, in that study, hoof trimming was undertaken in November in cows that had calved between July and October, so it may have been too late to produce an optimal effect.

There is thus a need for more research on the impact of trimming on the risk of lameness in cattle based permanently at pasture. The principal objectives of the present study were to evaluate, in a pasture-based dairy herd in the North Island of New Zealand, the response to a three-time point regime of claw trimming (prior to dry-off, early lactation, and end of lactation) of lameness incidence and time to first observed increase in LS (≥ 2 and ≥ 1 on a 0–3 scale) after calving. A secondary objective was to assess how the degree of trimming needed by an individual cow varied between the two hind feet and over the three trimming occasions.

Materials and methods

Animals and farm location

The study was approved by Massey University Animal Ethics Committee (protocol number 18/22). The study was conducted on the 940 spring-calving cows on a dairy farm in the Manawatū-Whanganui region of New Zealand during the May 2018 to May 2019 production season. The majority of the cows were Friesian and Jersey crossbreds, with roughly 10% Friesian cows. Animal age ranged from 2–10 years (mean 4 years). The milking cows were managed as two groups that grazed separately. Both groups were milked twice daily through a 60-unit rotary milking parlour.

Routine lame cow management included identification of lame cows during regular operations by farm staff, followed by veterinary treatment of all lameness cases. Veterinary visits to treat lame cows occurred at least every 2 weeks (more frequently if required). Systematic locomotion scoring was not used by farm staff before or during the study. Once cows were identified as lame and treated, they were put into a lame-cow group until the farmer determined they were no longer lame. This group was kept in a paddock (confined grazing area) close to the milking parlour and milked once a day in the morning. The farm was selected for the study on the basis that the farmer was interested in the study, there was a close working relationship with the veterinary practice, and the farm did not have an identified lameness problem nor a problem with claw conformation. The leading causes of lameness on the farm were white line disease, sole injury, and foot rot (definitions as per Chesterton *et al*. 2008). Digital dermatitis had not been diagnosed at any time prior to the study's start.

Visit 1 (May 2018), prior to dry-off

Allocation of cows to treatment groups

The 940 spring-calving cows in the milking herd were mixed manually on the feed pad (covered concrete area where cows were fed supplementary feed). The gate was then opened, and approximately 20 cows were let out from the feed pad onto the collecting yard and lined up for claw trimming. Once these cows had been trimmed (see protocol below for cows allocated to trimming) and returned to pasture, the remaining cows on the feed pad were mixed again, and the process repeated until 250 cows had been assigned to the trimming group and had their first trim. This process took place over 3 consecutive days, with trimming being undertaken for 4 hours per day. All cows not assigned to trimming group (n = 690) were assigned to the non-trim cohort.

Protocol for cows not allocated to trimming

All non-trim animals except for 20 cows selected for a related study (Werema *et al*. 2023) were released directly to pasture from the collecting yard once trimming for all the selected cows had been completed for that day. In that study, the right hind foot of 20 cows in the non-trim group was scanned using ultrasound on the day of trimming. This necessitated those cows being brought in from pasture on the day of trimming (as were the cows in the trim group). Cows were managed according to farm protocol in their usual herd group, alongside the cows allocated to trimming, with no further manipulations.

Protocol for cows allocated to trimming

Trimming was performed by a single trained professional hoof trimmer (with > 25 years of experience) using a mobile hydraulic Wopa Pro + Cattle Crush (VeeHof Dairy Services Ltd, Ashburton, NZ) with accessories to restrain the cows. In this study, only hind limbs were appraised. Once the foot was lifted, the hoof trimmer (author FH) assigned each hindfoot to one of four categories: 0 = trim not required; 1 = light trim required (trim to remove slight difference between the claw height); 2 = moderate trim required (trim to correct marked claw height differential); and 3 = lesion trim (trim to correct claw height differential and therapeutic trimming for lesions, e.g. white line or sole lesions, where the hoof trimmer considered therapeutic trimming would be beneficial). The trim category for each foot was recorded alongside cow identification and the presence of any claw horn lesions directly into an Excel spreadsheet (Microsoft Corporation, 2018, Redmond, WA, USA). An angle grinder with a professional trimming disc (WOPA; Harreveld, the Netherlands) and Hauptner hoof trimming knives (Hauptner-Herberholz; Solingen, Germany) were then employed to trim the claws using the five-step Dutch method described by Toussaint Raven (1985). Briefly, this trimming procedure involves: 1) trimming the toe length of the medial claw to 75 mm, leaving 5–7 mm thickness in the tip of the toe and sparing the height of the heel, 2) making the lateral claw equal in length and weight-bearing surface to the medial (or as near as possible), 3) making a slope in the soles, 4) reducing the weight in the affected claw (if lesions present), and 5) removing loose horn and hard ridges.

Visit 2 (October 2018), in early lactation and Visit 3 (May 2019), prior to dry-off

Cows allocated to the trimming group retained this allocation throughout the whole study. At Visit 2 and 3, the farmer was sent the list of cows in the trim group; these cows were identified by the farm staff, separated from the main herd, restrained for a trim evaluation, and trimmed if necessary (recording as described for Visit 1). At all trimming occasions, cows in the trim group were returned to their original herd group alongside non-trimmed cows.

Locomotion scoring

Before the study began in May 2018, the first author, a veterinarian, was trained in locomotion scoring using the 4-point (0–3) scale Dairy NZ lameness score (Werema *et al*. 2022). In brief, the training consisted of observing training videos followed by supervised locomotion scoring of live cows with a trained observer until that trainer was satisfied that there was a sufficient agreement (kappa = 0.870; 95% CI = 0.771–0.926) between the trainer and the first author.

Starting in August 2018, cows were locomotion scored on a fortnightly basis. They were scored as they exited the parlour after afternoon milking on a flat concrete surface about 20 m in length. This walking distance was enough to assess cows' gait and posture attributes while exiting the milking parlour. The whole spring-calving herd, excluding the lame cow group, was locomotion scored throughout the production season (August 2018 to May 2019). A list of all cows that scored ≥ 2 (lame cows) during a scoring session was provided to the farmer to allow them to be drafted for examination and treatment at the next routine lameness visit if the farmer so desired. In addition to this identification process, farm staff continued to observe the herd for lameness throughout the production season.

Statistical analyses

All data were analysed using SPSS version 27 (IBM Corporation, Armonk, NY, USA). Descriptive statistics were created for the LS and claw trimming data sets. Data were analysed on an intention to treat basis, where subjects were analysed according to the groups they were initially allocated to. A repeated measures multinomial logistic regression model was used to assess the association between the trimming category and feet within cow and trimming category and trimming occasions. The outcome variable was trimming category, trimming occasion the independent variable and foot within cow the repeated measure.

The effect of trimming on the incidence of clinical lameness (LS ≥ 2 or treated for lameness) and the incidence of imperfect gait (LS ≥ 1 or treated for lameness) was assessed by categorising each cow based on its maximum recorded LS or if it was treated for lameness. The RR of being in each category was then calculated for cows in the trimming compared to the non-trimming group.

To evaluate the impact of claw trimming on the hazard of lameness, Kaplan–Meier survival curves were created to illustrate the univariable effect of claw trimming on the interval between calving and first LS of ≥ 2 and the interval between calving and first LS ≥ 1. For this analysis, if a cow was identified as lame by farm staff before it was observed as having an increased LS, its treatment date was recorded as the date when it had first had an elevated score, i.e. if all scores before lameness treatment were 0, a treated cow would be recorded as having their first score ≥ 1 and ≥ 2 on their treatment date. However, if they had previously had a score of 1, a treated cow would be recorded as having their first score ≥ 2 on their treatment date. Any cows that did not record a score of ≥ 1 or ≥ 2 were censored at their last LS.

A multivariable Cox proportional hazards regression was then used to further evaluate the effect of claw trimming on hazard of elevated LS. Two models were fitted: the first had days from calving to first observed LS ≥ 2 (clinical lameness) as the dependent variable, and the second had calving to first observed LS of ≥ 1 (imperfect gait). Cows treated for lameness before LS ≥ 2 or LS ≥ 1 were treated as described above for the Kaplan–Meier analysis. The treatment group (trim *vs*. non-trim) was the primary variable of interest in both models, with breed and age included as confounding variables. The breed was categorised as Friesian, Jersey, and Friesian x Jersey, while age was categorised as ≤ 4 years, 5–7 years, and ≥ 8 years. Only cows that had been in the lactating herd in the previous season were included in the analysis; heifers in their first lactation were thus not included.

Results are interpreted using the effect-size-related outcome and the CI for that outcome – i.e. OR for the association between foot or occasion and trimming category, HR for the Cox proportional hazards models of time to first observed increased LS, and RR for the effect of trimming on incidence. For these measures, CI were interpreted as compatibility intervals (as per Greenland in Gelman and Greenland 2019); i.e. the CI identify the range of effect sizes (HR, OR, and RR) compatible with our data. If the compatible range of effect sizes excludes 1, then our data show a clear effect of that independent variable on our outcome of interest. If the range of compatible effect sizes includes 1, then our data do not show a clear effect of that independent variable. This does not mean that there is no effect of that variable, simply that our data are compatible with both a positive and a negative effect as well as a null effect. If there is no clear effect of a variable, we then determine whether our data are compatible with clinically relevant effects (i.e. by assessing whether the lower or upper limits of the CI are compatible with clinically important effects). Clinical importance was determined by the authors based on experience and personal opinion.

Results

The age, breed and calving date of the two treatment groups are summarised in Table 1. Ten cows, five in the trim and five in the the non-trim group, were excluded from the analysis as they had less than four LS throughout the study duration.

Locomotion scores and lameness incidence

A total of 10,925 LS were recorded on 19 occasions between 15 August 2018 and 8 May 2019, with 3,013 (27.6%) scores from 223/250 (89.2%) cows in the trimmed group and 7,912 (72.4%) scores from 584/690 (84.6%) cows in the non-trimmed group.

In the non-trimmed group, the number of scores per cow ranged from 4 to 19, while in the trimmed group it ranged from 5 to 19. The median number of scores was 14 for both groups, and the IQR was

Table 1. Age, breed, and calving date of pasture-based dairy cows (n = 807) in a study investigating the effect of prophylactic claw trimming on the interval between calving and first observed elevated locomotion score, that were assigned to receive claw trimming (Trim) or not (Non-trim).

	Non-trim	Trim
Age (number (%))		
≤ 4 years	342 (58.6)	109 (48.9)
5–7 years	206 (35.3)	103 (46.2)
≥ 8 years	36 (6.2)	11 (4.9)
Breed (number of cows (%))		
Friesian	50 (8.6)	16 (7.2)
Jersey	5 (0.8)	2 (0.9)
Friesian x Jersey	529 (90.6)	205 (91.9)
Calving date		
Mean (95% CI)	21 Aug 2018 (20–23 Aug 2018)	24 Aug 2018 (22–26 Aug 2018)
Median (min, max)	18 Aug 2018 (4 July, 13 Oct 2018)	22 Aug 2018 (13 July, 12 Oct 2018)

Aug = August; Oct = October.

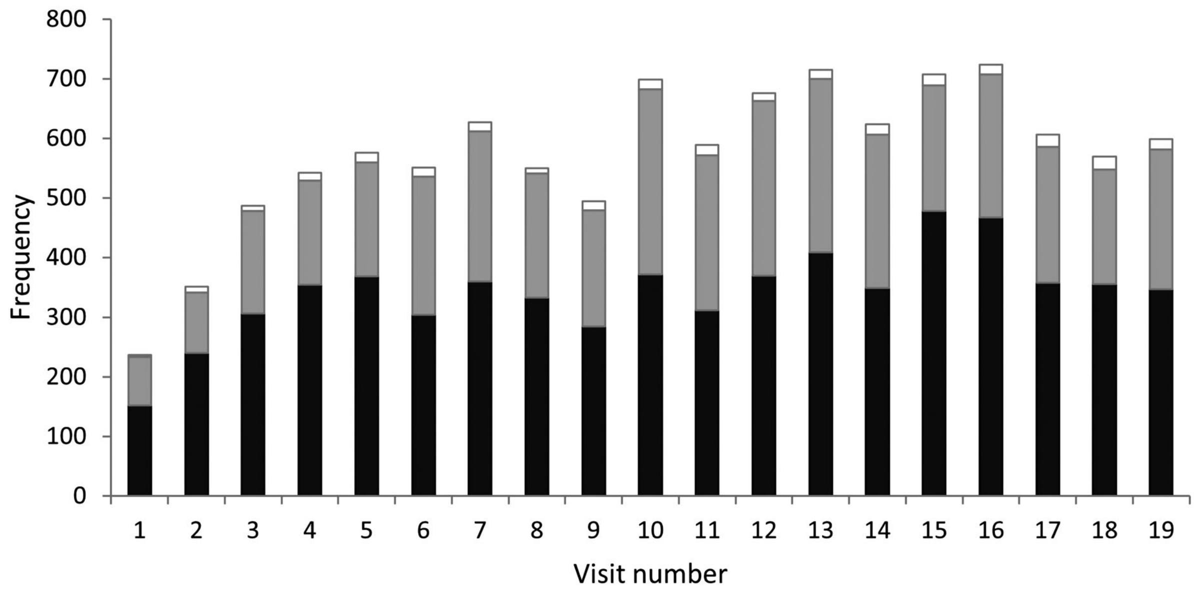

Figure 1. Frequency distribution of locomotion scores (LS; scored 0 = black; 1 = grey; ≥ 2 = white; n = 10,925) for 19 fortnightly farm visits from visit 1 in August 2018 to visit 19 in May 2019 and covering the 2018–2019 production season. Data are from a study investigating the effect of prophylactic claw trimming on the interval between calving and first observed elevated LS in pasture-based dairy cows. Note: fewer cows were scored early in the season as cows were only scored once they had calved (calving season is from late July to late October).

3. Over this period, three LS of 3 (three cows all non-trim) and 277 scores of 2 (239 cows; 68 (28.5% of trim cows), 171 (71.5% of non-trim cows)) were recorded. The frequency distribution of LS during the study period is summarised in Figure 1 and Supplementary Table 1. Mean prevalence of LS ≥ 2 was 280/10,925 = 2.6% (95% CI = 2.588–2.612) with 88/10,925 = 0.8% (95% CI = 0.787–0.813) of cows in the trim group and 192/10,925 = 1.8% (95% CI = 1.789–1.811) of cows in the non-trim group.

Over the whole of the study period, 35 cows were drafted by the farm staff for lameness treatment. Of those cows, 31 (88.6%) had been observed by the first author as having at least one LS ≥ 1 before treatment. Thus, four cows drafted for treatment by the farm staff had not been observed as having an elevated LS prior to drafting. Of the 31 cows drafted by the farm staff, which had been observed as having at least one LS ≥ 1, 18 had not been observed as having an LS > 1. Once cows treated for lameness were included, 11/ 807 (1.4%) cows never had a score > 0, 796 (98.6%) had at least one score of ≥ 1, and 242 (30%) had at least one score ≥ 2.

Claw trimming category

Two-hundred and fifty cows were trimmed during the first visit (dry-off), 221 cows during the second visit (early lactation), and 214 cows during the third trimming visit (end of lactation). The reason for the lower numbers at the later visits was not specifically recorded, but in most cases, the cow was still present on the farm, so the principal reason was that the cows were not presented by the farmer. Table 2 summarises the trim category by foot and trimming occasion. Due to the low number of cows requiring a lesion trim, data for lesion trim and moderate trim were combined for further analysis. The odds of

Table 2. Frequency at which claw trimming categories were assigned at each of three claw trimming occasions to the left and right hind limb of pasture-based dairy cows included in a study investigating the effect of prophylactic claw trimming on the interval between calving and first observed elevated locomotion score.

Trimming category	Left hind limb		Right hind limb	
	Frequency	Percentage (%)	Frequency	Percentage (%)
First trimming[a]				
No trim	120	48.0	143	57.2
Light trim	110	44.0	92	36.8
Moderate trim	17	6.8	14	5.6
Lesion trim	3	1.2	1	0.4
Sub-total	250	100.0	250	100.0
Second trimming[b]				
No trim	84	38.0	104	47.1
Light trim	126	57.0	102	46.1
Moderate trim	11	5.0	15	6.8
Lesion trim	0	0.0	0	0.0
Sub-total	221	100.0	221	100.0
Third trimming[c]				
No trim	83	38.8	99	46.3
Light trim	93	43.4	81	37.8
Moderate trim	38	17.8	31	14.5
Lesion trim	0	0.0	3	1.4
Sub-total	214	100.0	214	100.0
Overall				
No trim	287	42.0	346	50.5
Light trim	329	48.0	275	40.1
Moderate trim	66	9.6	60	8.8
Lesion trim	3	0.4	4	0.6
Grand total	685	100.0	685	100.0

[a]Conducted during dry-off (May/June 2018).
[b]Undertaken in early lactation (October 2018).
[c]Performed at the end of the lactation (May 2019).

Table 3. Category of trim applied on each of three trimming occasions to the left and right hind limbs of pasture-based dairy cows included in a study investigating the effect of prophylactic claw trimming.

	Right hind limb			
	No trim	Light trim	Moderate trim	Total
First trimming[a]				
Left hind limb				
No trim	107	13	0	120
Light trim	33	73	3	109
Moderate trim	3	6	8	17
Total	143	92	11	246
Second trimming[b]				
Left hind limb				
No trim	76	8	0	84
Light trim	28	93	5	126
Moderate trim	0	1	10	11
Total	104	102	15	221
Third trimming[c]				
Left hind limb				
No trim	68	15	0	83
Light trim	29	58	6	93
Moderate trim	2	8	25	35
Total	99	81	31	211
Total				
Left hind limb				
No trim	251	36	0	287
Light trim	90	224	15	329
Moderate trim	5	15	42	69
Total	346	275	57	668

[a]First trim occasion (28 May 2018) included four lesion trims.
[b]Second trim occasion (2 October 2018) included no lesion trims.
[c]Third trim occasion (10 May 2019) included three lesion trims.

being assigned a light trim rather than no trim were 1.5 (95% CI = 1.15–1.81) times higher for the left than the right foot, while for a moderate/lesion trim rather than no trim, the odds were 1.3 times higher (95% CI = 0.89–1.91). Trim occasion had no clear effect on the odds of having a light trim rather than no trim. Compared to the May 2019 trim, the OR were 0.8 (95% CI = 0.61–1.06) for the May 2018 trim and 1.27 (95% CI = 0.96–1.69) for the October 2018 trim. In contrast, trim occasion was associated with a change in the odds of having a moderate/lesion trim rather than no trim. Compared to the May 2019 trim, the OR were 0.34 (95% CI = 0.22–0.53) for the May 2018 trim and 0.35 (95% CI = 0.21–0.57) for the October 2018 trim. The effect of trim occasion and limb on trim category is illustrated in Table 3.

Claw lesions observed at trimming

The claw lesions observed at trimming included overgrown hoof, sole haemorrhage, sole ulcer and white line disease. The most common lesion type was white line disease, observed in 51/685 (7.4%) occasions from all cows examined over all three trimming visits, followed by sole haemorrhage in 43/685 (6.3%) occasions (see Table 4).

Incidence and survival analyses

In the non-trim group, 168/584 (28.8 (95% CI = 25.1–32.5)%) cows were recorded as having clinical

Table 4. Percentage (number) of cows that were observed to have claw lesions after claw trimming at each of three trimming occasions and overall, in a study investigating the effect of prophylactic claw trimming on the interval between calving and first observed elevated locomotion score in pasture-based dairy cows.

Lesion type	First trimming[a] (n = 250)	Second trimming[b] (n = 221)	Third trimming[c] (n = 214)	Overall (n = 685)[d]
None	84.8% (212)	77.4% (171)	90.2% (193)	84.1% (576)
OH	2.8% (7)	0.9% (2)	1.8% (4)	1.9% (13)
SH	3.2% (8)	11.3% (25)	4.7% (10)	6.3% (43)
SU	0.8% (2)	0.0% (0)	0.0% (0)	0.3% (2)
WLD	8.4% (21)	10.4% (23)	3.3% (7)	7.4% (51)

[a]Conducted during dry-off (May/June 2018).
[b]Undertaken in early lactation (October 2018).
[c]Performed at the end of the lactation (May 2019).
[d]Number of cow-trims over the three visits.
OH = overgrown hoof; SH = sole haemorrhage; SU = sole ulcer; WLD = white line disease.

lameness (at least one LS ≥ 2 or treated for lameness) *vs.* 74/223 (33.2 (95% CI = 27.0–39.4)%) of the trimmed group. The RR of clinical lameness in the non-trimmed *vs.* the trimmed cows was 0.87 (95% CI = 0.69–1.08). Thus, there was no clear effect of trimming on incidence of clinical lameness. Our data are compatible with no clinically relevant benefit of trimming as the upper limit of the 95% CI was only 1.08, which suggests that, at best, not trimming will produce only a small clinically unimportant 8% increase in the risk of becoming clinically lame. That is, on a farm where 30% of trimmed cows are observed as having clinical lameness, our data suggest that if the impact of not-trimming is as deleterious as is compatible with our data (RR = 1.08), non-trimmed cows will have an incidence of clinical lameness of 30.24%.

In the non-trim group, 580/584 (99.3%) cows were recorded as having at least one LS ≥ 1 *vs.* 216/223 (96.9%) of the trimmed group. The RR of LS ≥ 1 in the non-trimmed *vs.* the trimmed cows was 1.02 (95% CI = 1.0–1.05). Our data are thus not compatible with a negative effect of trimming on the incidence of LS ≥ 1, but they also suggest that any positive effect of trimming on the incidence of LS ≥ 1 is likely to be very small and probably clinically insignificant (maximum decrease of 5% in a herd where 100% of non-trimmed cows would be observed as having LS ≥ 1 at least once during a lactation).

Mean times to first observed LS ≥ 2 from the Kaplan–Meier survival model were 233 (95% CI = 221.8–245.1) and 255 (95% CI = 247.5–262.2) days for trimmed and non-trimmed cows, respectively (see Supplementary Figure 1). Median times to first observed LS ≥ 1 were 57 (95% CI = 49.7–64.3) and 35 (95% CI = 32.0–38.0) days for trimmed and non-trimmed cows, respectively (see Supplementary Figure 2).

The results of the Cox proportional hazards model on the hazard of being observed with an LS ≥ 1 or LS ≥ 2 for the first time are summarised in Table 5.

Table 5. The coefficients of the independent variables on the hazard of locomotion score (LS) ≥ 2 and LS ≥ 1 being observed for the first time (from Cox proportional hazards model[a]) in a study investigating the effect of prophylactic claw trimming on the interval between calving and first observed elevated LS in pasture-based dairy cows.

LS category	Model coefficient	HR	95% CI
For LS ≥ 2			
Trim group			
Trim	Ref		
Non-trim	−0.141	0.87	0.66–1.14
Breed			
Friesian	Ref		
Jersey	0.261	1.30	0.85–1.98
Friesian x Jersey	−0.129	0.88	0.22–3.54
Age			
≤ 4 years	Ref		
5–7 years	−0.577	0.56	0.34–0.92
≥ 8 years	−0.110	0.90	0.54–1.48
For LS ≥ 1			
Trim group			
Trim	Ref		
Non-trim	0.471	1.60	1.37–1.88
Breed			
Friesian	Ref		
Jersey	−0.106	0.90	0.70–1.16
Friesian x Jersey	−0.580	0.56	0.25–1.26
Age			
≤ 4 years	Ref		
5–7 years	−0.115	0.89	0.66–1.21
≥ 8 years	−0.137	0.87	0.64–1.19

[a]Breed and age included as confounder variables, so that the effect of non-trimming is the HR for the effect of not being trimmed on the hazard of being observed for the first time with a LS ≥ 2 or ≥ 1 at any given level of breed and age.

After accounting for age and breed, the hazard of a cow being observed for the first time with LS ≥ 2 in the control group was 0.87 (95% CI = 0.66–1.14) times that of the trimmed group (see Figure 2a). Thus, there was no clear effect of trimming on time to first observed LS ≥ 2 and our data are compatible with no clinically relevant benefit as the upper limit of the 95% CI was only 1.14, which suggests that, at best not trimming will produce only a small probably clinically unimportant 14% increase in the hazard of developing LS ≥ 2 for the first time. In contrast, after accounting for breed and age, the hazard of a cow having a first LS ≥ 1 was 1.60 (95% CI = 1.37–1.88) times higher in the control group than in the trimmed group (see Figure 2b). Thus, trimming had a clear effect on the hazard of being observed with a LS ≥ 1 for the first time. Calculation of 95% confidence bands that adequately take into account the correlation between serial time points is a non-trivial exercise for the predictions from a Cox model (Sachs *et al*. 2022). The HR indicates overall there is a greater hazard of a LS ≥ 1 for the control group compared to the trim group, with no evidence for a difference from trimming in the hazard of LS ≥ 2. In this study, we are more interested in an overall summary of the difference in the hazard of lameness, rather than a time-point by time-point comparison, and we do not believe that presentation of confidence bands will add to this interpretation.

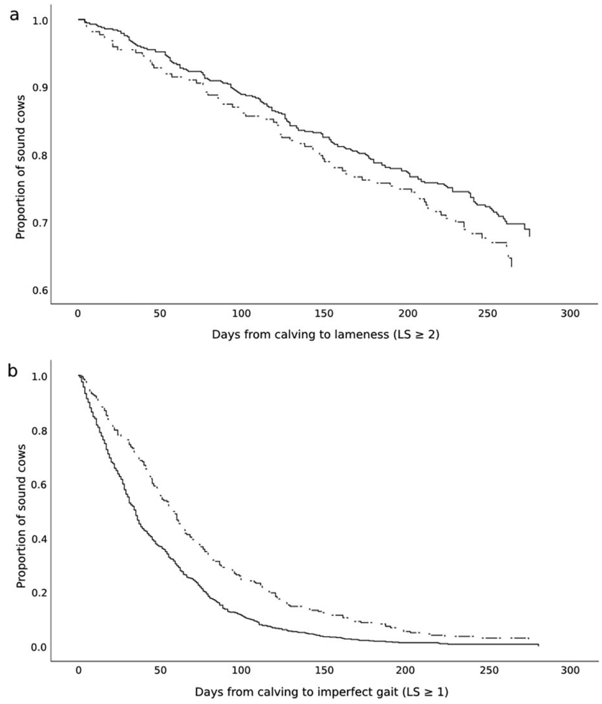

Figure 2. Results from the Cox proportional hazards regression model of the time from calving to (a) clinical lameness (lameness score (LS, scored 0–3) ≥ 2) and (b) imperfect gait (LS ≥ 1) for cows (n = 807) on one dairy farm in the 2018/2019 production season that did (dashed line; n = 223) or did not (solid line; n = 584) receive prophylactic claw trimming. Age and breed were included in the model as covariates. There was no clear effect of trimming on the time to first observed LS ≥ 2 (HR comparing non-trimmed with trimmed = 0.87 (95% CI = 0.66–1.14)). In contrast, trimming had a clear effect on the hazard of LS ≥ 1 (HR comparing non-trimmed with trimmed = 1.60 (95% CI = 1.37–1.88)).

Discussion

The present study evaluated a three-time point claw trimming regime on the incidence of clinical lameness and the time to first observed elevated LS (either LS ≥ 2 or LS ≥ 1) in dairy cows kept permanently at pasture. To the authors' knowledge, this is the only study other than that of Bryan *et al*. (2012) to have looked at claw trimming in such cattle. Bryan *et al*. (2012) reported that while trimming did not reduce overall lameness incidence throughout the lactation season, it did increase the time to lameness (as detected by farm staff) in the first 70 days after trimming. In contrast, we found no evidence of a clinically relevant benefit of trimming on time to first observed lameness (with our definition of lameness being a LS ≥ 2 or farmer request for lameness treatment). Our HR for a LS ≥ 2 was 0.87 (95% CI = 0.66–1.14) for non-trimmed *vs*. trimmed cows, whereas the equivalent HR for developing farm-staff detected lameness reported by Bryan *et al*. (2012) was 1.56 (95% CI = 1.10–2.26).

The key difference between these studies may have been the incidence of lameness. In our study farm, the incidence of cows treated for lameness during the study was 4.3% (35/807). In contrast, despite recording lameness over a shorter period (6 months), Bryan *et al.* (2012) reported an incidence of 14.5%. The level of lameness in the present study is relatively low compared to previous reports of lameness in New Zealand, which reported incidences of 15–20% (Alawneh *et al.* 2012; Mason *et al.* 2012) and lower than in previous years on the study farm (approximately 10%). The relatively low level of lameness on our study farm may be a key reason we found no effect of trimming, as it may reflect an absence of lameness risk factors which could be ameliorated by trimming. However, looking at our data, perhaps the most important factor is the lack of differences in claw height between medial and lateral claws in many of the cows, as this is a critical target of the trimming method used in this study (Toussaint Raven 1985).

Bryan *et al.* (2012) recorded claw height differential and showed that claw height was a risk factor for lameness incidence but not for time to first lameness case. In the current study, we did not record claw height differential; however, our categorisation of the amount of trimming required was based on the foot trimmer's estimate of claw height differential. So, our categories of "no", "light" and "moderate" trim are thus, respectively, approximately equivalent to the 0–2 mm, 3–4 mm, and > 4 mm claw height differential categories used by Bryan *et al.* (2012). Our lesion trim category has no direct comparator as that was based on the cow having a claw horn lesion that needed a therapeutic trim. At the first trim in this study, the percentage of cows needing no trim was 52.6%, and the percentage with at least one claw needing a moderate trim was 12.4% (see Table 2). In contrast, Bryan *et al.* (2012) reported that 18% of their cows had no height differential (0–2 mm) in either hind foot and that 25% had at least one hind foot with a claw height differential >4 mm. Thus, our study farm probably had much less claw imbalance than was observed on the farms in the study by Bryan *et al.* (2012), which may have resulted in us recording less benefit from trimming. More data is needed on the distribution of claw height differentials on more herds across New Zealand and on whether an increased proportion of cows with large claw height differentials is associated with increased lameness risk and the success of prophylactic hoof trimming.

Unlike Bryan *et al.* (2012), we did not measure claw height differential (or assess likely trim category) in our non-trimmed group. Thus, we could not include trimming category in our analysis of the effect of trimming on the incidence of lameness, or time to first observed increased LS. However, the effect of trimming on time to lameness reported by Bryan *et al.* (2012) was an effect of trimming alone, as, despite claw height differential being significant in an initial univariable model, it was excluded from their final model. So, it is unlikely that the exclusion of the trimming category in our model resulted in our failing to find an effect of trimming on time to lameness. Nevertheless, we believe that further research is required to establish better whether there is an interaction between the degree of trimming needed and the benefit of trimming in dairy cows kept permanently at pasture.

The aim of hoof trimming is to restore hoof conformation and balance the weight-bearing surface of the sole over the lateral and medial claws (Toussaint Raven 1985). However, there is only limited evidence as to how effective current trimming techniques are at achieving this goal, especially over the long term (Stoddard and Cramer 2017). In this study, we started with a population of cows which had never had prophylactic trimming (which is not routinely undertaken on most New Zealand farms). Thus, comparing trim categories across trimming sessions can provide information about the response to trimming in these cows. In this study population, the odds of a cow in the trimming group needing a moderate/lesion trim in May 2019 (after two trimming sessions) were 2.9 (95% CI = 1.89–4.55) times higher than in May 2018. This was principally driven by an increase in the proportion of moderate trims, 24/250 *vs.* 44/214 (see Table 3). Thus, at the end of the production season, more cows needed a moderate trim (trim to correct marked claw height differential) than they did at the start of the study (when hoof conformation reflected the balance of wear and growth from environment alone). As we did not have similar results from a control group that was not trimmed, we cannot be sure that this change was solely due to trimming, but it is clear that we need more data on the long-term impact of trimming on hoof conformation in cattle kept at pasture. These studies should record the degree of trimming needed at the individual cow level. Such records would also be valuable in studies of trimming in housed cows.

Despite finding no clinically relevant beneficial impact of trimming on time to lameness (LS $\geq$ 2 or farmer request for lameness treatment), we did find an association between trimming and the interval from calving to an observation of imperfect gait (i.e. LS $\geq$ 1), with trimmed cows having a median time to LS $\geq$ 1 that was 22 days longer than non-trimmed cows and a hazard of becoming unsound that was 62% of non-trimmed cows. It is unclear why we found this effect without also finding an effect of trimming on time to LS $\geq$ 2, but, consistent with other data from this study, it suggests that contrary to current wisdom (Sprecher *et al.* 1997; Hut *et al.* 2021) an increase in LS from 0 to 1 is not simply a step towards an inevitable increase to a score of 2 or more. In this study, 796/807 cows had at least one locomotion LS > 0, of which 242 had a LS $\geq$ 2 or were treated for lameness. Thus, 554/796 (approximately 70%) cows which had an elevated LS were neither treated for lameness nor had an LS > 1. Thus, at least in this population, most cows that had an elevated LS did not develop clinical lameness, suggesting that there are two populations of LS = 1 cows: those that are going to become clinically lame and those that are not, and that delaying the development of LS = 1 in the latter group does not impact the development of clinical lameness. Further research is required to better understand the evolution of LS in dairy cattle, especially at pasture, and to identify what differentiates a cow that has developed an LS = 1 that is not going to progress and a cow with an LS = 1 that is going to become clinically lame.

One interesting finding from this study was that not all cows identified by the farm staff as requiring lameness treatment were identified by locomotion scoring every 2 weeks. Of the 35 cows identified as lame by farm staff, four had no increase in LS, and 18 had a maximum score of 1 prior to their identification as needing lameness treatment. Locomotion scoring and identifying cows (using ear tags) while they are walking back to pasture after being milked is difficult (Ranjbar *et al*. 2016; Werema *et al*. 2022). So, attempting to score and identify individual cattle, irrespective of whether they were clinically lame, would have reduced the proportion of cattle we observed (Werema *et al*. 2021). However, in a study of lameness in heifers kept at pasture, where locomotion scoring was undertaken every 2 weeks, but identification was limited only to lame heifers (LS ≥ 2), approximately 50% of the heifers treated for lameness were identified by farm staff prior to having an LS ≥ 2 (Mason *et al*. 2022). This suggests that locomotion scoring every 2 weeks may not promptly identify all cases of lameness in cows at pasture. In contrast, in a study where locomotion scoring of cows at pasture was undertaken weekly (Alawneh *et al*. 2012), no cases of lameness were observed by farm staff before their LS was recorded as elevated by the independent locomotion scorer, although approximately 20% of cows which had a maximum LS of 2 (1–5 point scale; so approximately equivalent to LS = 1 in our system) were put forward for lameness treatment by farm staff. However, further research is required to establish the optimal regime for locomotion scoring in cows kept permanently at pasture.

The present study has a limitation in its use of LS for detecting lameness, which is subjective and prone to high within- and between-observer variation if training is insufficient (Van Nuffel *et al*. 2015; Schlageter-Tello *et al*. 2015a, 2015b). LS may not be sensitive enough to detect all lame cows, especially on large farms with pasture-based systems (Ranjbar *et al*. 2016; Werema *et al*. 2022). Despite not having a 100% sensitivity or specificity for lameness detection (O'Callaghan 2002; Flower and Weary 2006, 2009), LS remains the best lameness detection system currently available with trained observers. Our study did not find meaningful benefits of hoof trimming, but this was likely not due to the limitations of LS. This was evident by the low number of cows treated for lameness on the study farm, indicating a low incidence of lameness.

Conclusions

In this herd, where there was a low prevalence of lameness, and most cows needed only light or no trim, a regime of three preventative trims did not result in a clinically relevant decrease in lameness incidence or a clinically relevant increase in time to observed clinical lameness (LS ≥ 2). However, prophylactic trimming did increase the interval from calving to an observed change in gait (LS ≥ 1). This was a single farm study for a single lactation season. Further research is required on the impact of preventative trimming on the risk of lameness on more dairy farms across New Zealand for longer periods of time, with particular attention being paid to the degree of trimming needed and how this affects the response to trimming.

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No potential conflict of interest was reported by the author(s).

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