# Assessment of animal and management based potential risk factor relation with claw health and lameness in dairy cows: A cross-sectional study

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## SUMMARY

Lameness is one of the most common problems modern dairy industries and it may originate as infectious or noninfectious. Lameness may also be related to housing and animal-based factors. In this regard, this study aimed to investigate the relationship between potential risk factors with lameness and claw lesions in dairy farms. Eleven dairy farms with 1685 cows were enrolled in this study. Relationships between lameness existence with hind limb conformation, claw conformation, days in milk (DIM), lactation number (LN), bedding type, claw trimming intervals, and relationships between infectious claw diseases (digital dermatitis-DD and heel erosion-HE) with LN, DIM, bedding type, footbath existence, footbath chemical, footbath changing frequency, and footbath solution volume per cow were investigated. A binary regression model was used to reveal relationships. There was no statistically significant difference in the relationship between cow breeds and lameness score, hind limb conformation, claw conformation, and claw diseases. A positive correlation between the existence of lameness with all risk factors was found. Cows with abnormal hind limb and claw conformation numbered 220 and were 2.3 times more prone to lameness ($P<0.001$), respectively. A positive correlation was found between infectious claw diseases with LN, DIM, bedding type, footbath chemical, and footbath changing frequency. However, a negative correlation was found between infectious claw diseases and footbath solution volume per cow. The relationship between the infectious claw disease existence with DIM and LN was found to be statistically significant ($P<0.001$). Also, an increase in LN and DIM were found to increase the risk of infectious claw lesion frequency by 3.3 and 2.2 times, respectively. Findings suggest that abnormal hind limb and claw conformations should be more closely monitored and investigated in terms of lameness. LN and DIM should also be monitored in terms of infectious claw diseases. The result of the study may help farmers to specify their potential animal and management-based risk factors related to lameness and infectious claw lesions in their farms.

## KEY WORDS

Dairy cow, footbath, claw conformation, hind limb conformation, claw diseases.

## INTRODUCTION

Lameness is one of the major causes of economic losses by reducing milk yield and reproductive performance in cows, increasing the culling rate and treatment costs in dairy farms[1-3]. Lameness also results in pain and welfare problems by adversely influencing the behavior of animals, including routine activities such as eating, drinking, and rest[4,5]. This situation is therefore considered in dairy farms as a herd health problem, not an individual one[1,5].

Lameness is known as a complex and multifactorial problem[3,6]. Lameness risk factors have been related to animal-based variables, and herd management practices have been reported to have an effect on their development[2,7,8]. Diet, genetic characteristics, breed, age, gender, days in milk (DIM) and lactation number (LN), limb and claw deformations may be considered as animal-based variables[1]. The alley dimensions, bedding used in paddocks and walking areas, and the presence of footbaths and, claw trimming interval, footbath chemicals, and its renewal frequency are factors that may be considered as herd management practices[3,6,9]. Claw lesions and lameness should be considered as a problem affected by potential risk factors[3]. Becker et al. (2014) argued that factors such as herd size, herd management practices, and housing systems may vary by location, so the relationship between claw lesions and lameness and risk factors should be separately disclosed in each geographical area[7]. The objective of the present study was to investigate relationships between animal-based potential risk factors (breed, hind limb conformation, claw conformation, DIM, LN), and management-based risk factors (bedding types, claw trimming intervals, footbath existence, footbath chemical, footbath changing frequency, and footbath solution volume per cow) with lameness and infectious claw lesions (DD and HE).

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## MATERIALS AND METHODS

### Farms and Animals

This study was carried out in districts of Tire, Odemis, and Kiraz in the east of the Kucuk Menderes Basin of Izmir, Turkey between September 2020 and December 2020. Farms that had free-stall housing systems with no access to pasture and a herd size of ≥ 50 lactating cows were selected to ensure that the participating farms were representative of the majority of farms in the Kucuk Menderes Basin of Izmir. Eleven farms agreed to be included in the study. Alleys were cleaned 2 times a day with automatic scrapers. A TMR was fed ad libitum and supplied twice daily at 09:00 and 19:00. The cows were milked twice daily at 08:30 and 18:30. Cow claws were trimmed routinely at dry-off. No clinical systemic disease symptoms were observed in the enrolled cows. Breed, LN, DIM, and claw trimming interval data were recorded based on-farm records. Lameness scores, hind limb conformation, claw conformation, presence of DD and HE, bedding type, and information about footbaths were recorded by observations during the visits.

### Lameness evaluation

Lameness evaluation was carried out using the 4-point scale, (10) impaired mobility scale of the UK Agriculture and Horticulture Development Board (i.e., walks with shortened strides, an arched back, and uneven weight balance on all feet), where 0= good mobility (i.e., walks with long strides and an even weight balance on all feet), 1= imperfect mobility (i.e., walks with shortened strides or uneven steps without an immediately identifiable affected limb), 2= impaired mobility (i.e., walks with uneven weight bearing on a limb that is immediately identifiable or walks with obviously shortened strides), and 3= severely impaired mobility (i.e., walks with shortened strides, an arched back, and uneven weight balance on all feet) when cows were standing and walking. All cows were observed for lameness when they moved from the milking parlor to the alley.

### Claw and hind limb evaluation

Claw conformations and claw lesions were recorded during the milking time. Claw lesions were recorded as the presence or absence of specific claw lesions in each claw: DD, and HE. Briefly, cows' feet were washed with water from a hose. The primary investigator (PI) examined claws for the existence of DD, and HE lesions. Simultaneously, claws were evaluated according to their conformations in terms of parameters such as normal, open claws, blunt claw, scissor claw, corkscrew claw, and big claws, and all data was transferred to an excel sheet. An external source of light was used in situations where the light source was inadequate during the examination. Assessment of hind limb conformations was performed by the PI who performed other examinations. The PI evaluated the hind limbs on feeding time in terms of criteria such as normal, open-limb, X, and bow-limbed, at a distance of about 5 meters, passing behind the cows without distracting them.

### Footbath evaluation

A questionnaire was conducted at each farm. The questions were either open-ended (e.g.,» What is the active ingredient used as a footbath?) or closed-ended (e.g.,» Are you using a footbath? response scale: yes or no). Specific information on the frequency of its use (times/weeks) and the changing frequency of footbaths was obtained from the questionnaire. The footbath's dimensions (length, width, and depth) were also measured to determine the volume of the footbath solution per cow ($cm^3$) in each farm. Footbath dimensions were used to calculate the footbath solution volume ($cm^3$) per cow by using the volume formula (lengthxwidthxdepth in cm).

### Statistical analysis

Explanatory variables such as animal-based information (breed, LN, DIM), claw and hind limb conformations, claw lesions, and management-based data (bedding type, claw trimming interval, footbath implementation, chemical, and changing frequency) were recorded in a spreadsheet program (Excel, Microsoft Corp., Redmond, WA, USA). For DIM data, cows were categorized into three groups based on the day in milk (DIM) according to the E-views equity test of means program: Group 1 (Early lactation): 0 ≤ DIM ≤ 45, group 2 (middle lactation): 46 ≤ DIM ≤75, and group 3 (late lactation): 76 ≤ DIM. Statistical analyses were carried out using SPSS 22 statistical package (IBM SPSS Statistics for Windows, Version 22.0, Armonk, NY, USA) program. Alpha values were set to <0.05 for statistical significance.

Relationships between breeds with the claw, hind limb conformations, lameness score, and claw diseases were investigated with the chi-square test. For achieving this, breeds (Simmental=0, Holstein=1), lameness (not exist=0, exist=1), claw and hind limb conformations (normal=0, abnormal=1), and claw lesions (healthy=0, lesion=1) were categorized to determine whether there is an association between categorical variables. In order to investigate the influence of hind limb and claw conformations, categorized DIM, bedding type, claw trimming interval, and LN on the event of lameness, a statistical model was conducted with binary logistic regression. For this aim, binary dummy variables for outcomes from the recorded data were coded as follows: Claw conformation (normal=0, abnormal=1), hind limb conformations (normal=0, abnormal=1), DIM (≤45 days=0, >45 days=1), bedding type (concrete+sand=0, sand=1), claw trimming interval (less than one year=0, more than one year=1), LN (1, and 2=0; 3, 4, and 5=1), and lameness (not exist=0, exist=1). The Hosmer-Lemeshow test was used to determine the goodness of fit of the logistic regression model.

Similarly, a binary logistic regression model was performed to observe the influence of categorized DIM, bedding type, footbath implementation, footbath solution volume ($cm^3$) per cow, footbath chemical, and footbath changing frequency on the event of claw diseases. For achieving this, dummy variables for covariates from the collected data were coded as follows: DIM (≤45 days=0, >45 days=1), LN (1, and 2=0; 3, 4, and 5=1), bedding type (concrete+sand=0, sand=1), footbath implementation (exist=0, not exist=1), footbath chemical ($CuSO_4$+formalin=0, $CuSO_4$=1), footbath changing frequency (everyday=0, every two days=1), footbath solution volume ($cm^3$) per cow (more than 1 liter=0, less than 1 liter=1), and claw lesions (healthy=0, lesion=1). The Hosmer-Lemeshow goodness-of-fit test was used to evaluate the model fit.

## RESULTS

### Descriptive statistics of cows

The average herd size was 187 lactating cows (range, 125 to 212). The enrolled breeds, LN, and DIM of cows were described in

**Table 1** - Descriptive statistics of cows used in this study by their DIM and LN (n, %).

| | | LN | | | | | |
|---|---|---|---|---|---|---|---|
| Breeds | DIM (day) | 1 (n, %) | 2 (n, %) | 3 (n, %) | 4 (n, %) | 5 (n, %) | Total |
| Simmental | 0-45 | 58 (36.5) | 46 (28.9) | 34 (21.4) | 17 (10.07) | 4 (2.5) | 159 (100) |
| | 46-75 | 32 (34.8) | 28 (30.4) | 13 (14.1) | 17 (18.5) | 2 (2.2) | 92 (100) |
| | 75< | 41 (36.6) | 24 (21.4) | 25 (22.3) | 16 (14.3) | 6 (5.4) | 112 (100) |
| | Total | 131 (36.09) | 98 (27) | 72 (19.83) | 50 (13.77) | 12 (3.31) | 363 (21.54) |
| Holstein | 0-45 | 188 (30.9) | 209 (34.4) | 103 (16.9) | 88 (14.5) | 20 (3.3) | 608 (100) |
| | 46-75 | 78 (25.7) | 113 (37.3) | 68 (22.4) | 35 (11.6) | 9 (3.0) | 303 (100) |
| | 75< | 111 (27) | 154 (37.5) | 73 (17.8) | 63 (15.3) | 10 (2.4) | 411 (100) |
| | Total | 377 (28.52) | 476 (36.01) | 244 (18.46) | 186 (14.07) | 39 (2.95) | 1322 (78.46) |

Table 1. Simmental breed cows (n=363, 21.54%) are less recorded than Holstein cows (n=1322, 78.46%), and no other breeds were encountered at farms used in this study. A total of 1685 dairy cows were enrolled in the study (Table 1). Second lactation (n=476, 36.01%) were the most common LN in Holstein breed cows and first lactation (n=131, 36.09%) was the most common LN in Simmental breed cows. The fifth lactation was the less encountered LN in both (n=39, 2.95% for Holstein and n=12, 3.31% for Simmental) breeds (Table 1). Early lactating (≤45 DIM) cows were the majority (608 Holstein and 159 Simmental) of the present study whereas mid-lactating cows (303 Holstein and 92 Simmental) were the less encountered cows in the study period (Table 1). There was no statistically significant difference between lactations within Simmental and Holstein breeds ($P$>0.05).

## Comparison of recorded traits by breeds

There was no statistically significant relationship between breeds (Holstein and Simmental) according to hind limb and claw conformation, lameness scores, and claw lesions ($P$>0.05, Table 2). In terms of lameness, 89.7% (n=1186) of Holstein cows and 88.2% (n=320) of Simmental cows were scored «as 0» (Table 2). The most encountered lameness score was a mild (score 1) in Holstein (n=71, 5.4%) and Simmental (n=24, 6.6%) cows (Table 2). Severe lameness (score 3) was less common in Holstein (n= 20, 1.5%) and Simmental (n=6, 1.7%) cows (Table 2). In terms of hind limb conformation, 1241 Holstein and 338 Simmental breed cows were recorded as normal. The highest and lowest number of abnormal hind limb conformation in both breeds were X and bow limbed, respectively (Table 2). On claw conformation evaluations, 1042 Holstein cows (78.8%) and 289 Simmental cows (79.6%) had normal claw shape. Corkscrew claws (28 [7.7%] Holstein and 105 [7.9%] Simmental cows) were the most common abnormal claw conformation in both breeds. Big claw had the lowest recorded number in Holstein [10, (0.8%)] and Simmental breeds [4, (1.1%)] (Table 2). On infectious claw disease evaluations, no lesions were found in 1178 (89.1%) Holstein and 320 (88.2%) Simmental cows. The most common lesion was DD with 5.3% in Holstein and 6.3% in Simmental cows. The least prevalent one was HE with 0.5% in Holstein breeds, and white line disease with 1.1% in Simmental cows (Table 2).

## Footbath Management

Footbath specifications of participating farms are presented in (Table 3). Footbaths had a median length of 202 cm (range, 175 to 225), width 81 cm (range, 70 to 100), and a

**Table 2** - The relationship between cow breeds and lameness score, hind limb conformation, claw conformation, and claw diseases (n, %).

| | | Breeds | | |
|---|---|---|---|---|
| | | Simmental (n, %) | Holstein (n, %) | P-value |
| Lameness score | 0- none-lame | 320 (88.1) | 1186 (89.7) | 0.821 |
| | 1- mild | 24 (6.6) | 71 (5.4) | |
| | 2- moderate | 13 (3.6) | 45 (3.4) | |
| | 3- severe | 6 (1.7) | 20 (1.5) | |
| Hind limb conformation | Normal | 338 (93.1) | 1241 (93.9) | 0.814 |
| | Open limb | 8 (2.2) | 29 (2.2) | |
| | Bow limbed | 5 (1.4) | 11 (0.8) | |
| | X limbed | 12 (3.3) | 41 (3.1) | |
| Claw conformation | Normal | 289 (79.6) | 1042 (78.8) | 0.869 |
| | Open claws | 10 (2.8) | 29 (2.2) | |
| | Blunt claw | 19 (5.2) | 72 (5.4) | |
| | Scissor claw | 13 (3.6) | 64 (4.8) | |
| | Corkscrew claw | 28 (7.7) | 105 (7.9) | |
| | Big claw | 4 (1.1) | 10 (0.7) | |
| Claw lesion | No-lesion | 320 (88.2) | 1178 (89.1) | 0.168 |
| | White line | 4 (1.1) | 14 (1.1) | |
| | DD | 23 (6.3) | 70 (5.3) | |
| | HE | 6 (1.7) | 7 (0.5) | |
| | Sole ulcer | 10 (2.8) | 53 (4) | |

**Table 3** - Characteristics of footbath practices for lactating cows in enrolled farms.

| Farm no | nLC (n) | Footbath chemical | Changing frequency | Dimensions (length x width x depth in cm) | Footbath solution volume per cow ($cm^3$) |
|---|---|---|---|---|---|
| 1 | 175 | Formalin+$CuSO_4$ | Everyday | 200x80x15 | 1371.42 |
| 2 | 146 | $CuSO_4$ | Everyday | 220x70x20 | 2109.58 |
| 3 | 145 | Formalin+$CuSO_4$ | Everyday | 200x75x25 | 2586.20 |
| 4 | 142 | Formalin+$CuSO_4$ | Every two days | 225x85x20 | 1346.83 |
| 5 | 203 | $CuSO_4$ | Everyday | 200x100x20 | 1970.76 |
| 6 | 130 | $CuSO_4$ | Every two days | 225x100x20 | 1730.76 |
| 7 | 212 | - | - | - | - |
| 8 | 136 | Formalin+$CuSO_4$ | Everyday | 180x70x15 | 1389.70 |
| 9 | 144 | $CuSO_4$ | Everyday | 200x80x20 | 2222.22 |
| 10 | 125 | - | - | - | - |
| 11 | 127 | Formalin+$CuSO_4$ | Every two days | 175x75x15 | 775.09 |

nLC: Number of lactating cows

mean depth of 18 cm (range, 15 to 25). Footbath design and footbath practices varied greatly among farms. Characteristics of footbath practices in enrolled cows are presented in (Table 3). There was no footbath implementation in the two farms. The combination of formalin+$CuSO_4$ was used by 5 farms, whereas 4 farms only used $CuSO_4$ as a footbath chemical. Six enrolled farms were changing their footbath solution every day, while 3 farms were renewing the footbath solution every two days (Table 3).

## Estimated relative risk factors of lameness

The data on the relationships between the hind limb and claw conformation, LN and DIM, bedding type, and claw trimming interval with the presence of lameness are presented in (Table 4). A positive correlation was found between all factors with the presence of lameness and this correlation was only statistically significant between the hind limb and claw conformations ($P<0.001$). Cows with abnormal hind limb and claw conformations were found to number 220 and were 2.3 times more prone to lameness, respectively (Table 4).

## Estimated relative risk factors of DD and HE

The data about the relationship between the presence of DD and HE with LN and DIM, bedding type, the footbath implementation, the footbath chemical, the footbath changing frequency, and the footbath solution volume per cow are presented in (Table 5). LN and DIM, the bedding type, the footbath chemical, and the footbath changing frequency were in positive correlation with DD and HE existence. However, footbath implementation and footbath solution volume per cow exhibited a negative correlation with DD and HE (Table 5). Only LN and DIM were found to have a statistically relevant relationship with the occurrence of DD and HE ($P<0.001$) and increasing LN and DIM raise the frequency of DD and HE by 3.39 and 2.20 times, respectively (Table 5).

# DISCUSSION

Lameness has a multifactorial, complex etiology and is characterized by pain, causes major economic losses by reducing

**Table 4** - Estimated relative risk factors (odds ratio) and 95% confidence interval (CI) on lameness.

| Variables | Numerical value of variables | b | SE | P-value | Estimated odds ratio | 95% CI for odds ratio |
|---|---|---|---|---|---|---|
| Hind limb conformation | 0=Normal, 1= Abnormal | 5.394 | 0.395 | 0.000 | 220.033 | 101.525-476.873 |
| Claw conformation | 0=Normal, 1= Abnormal | 0.852 | 0.244 | 0.000 | 2.344 | 1.454-3.781 |
| DIM | 0=Until 45 days, 1= Over 45 days | 0.252 | 0.229 | 0.272 | 1.286 | 0.821-2.014 |
| Bedding type | 0=Concrete + sand, 1= Sand | 0.089 | 0.321 | 0.782 | 1.093 | 0.582-2.052 |
| Claw trimming interval | 0=Less than one year, 1= More than one year | 0.454 | 0.302 | 0.132 | 1.575 | 0.871-2.846 |
| LN | 0=1 and 2, 1= 3, 4 and 5 | 0.139 | 0.231 | 0.548 | 1.149 | 0.731-1.806 |

b: Regression Coefficient, SE: Standard Error, CI: Confidence Interval

**Table 5** - Estimated relative risk (odds ratio) factors and 95% confidence interval (CI) on DD and HE.

| Variables | Numerical value of variables | b | SE | P-value | Estimated odds ratio | 95% CI for odds ratio |
|---|---|---|---|---|---|---|
| **LN** | 0=1 and 2, 1= 3, 4 and 5 | 1.221 | 0.160 | 0.000 | 3.392 | 2.476-4.645 |
| **DIM** | 0=Until 45 days, 1= Over 45 days | 0.789 | 0.132 | 0.000 | 2.202 | 1.700-2.853 |
| **Bedding type** | 0=Concrete + sand, 1= Sand | 0.215 | 0.164 | 0.190 | 1.240 | 0.899-1.710 |
| **Footbath application** | 0=Exist, 1= Non-exist | -0.24 | 0.210 | 0.253 | 0.786 | 0.521-1.187 |
| **Footbath solution volume per cow ($cm^3$)** | 0=More than 1 liter, 1= Less than 1 liter | -0.269 | 0.261 | 0.302 | 0.764 | 0.458-1.274 |
| **Footbath chemical** | 0=$CuSO_4$+ Formalin, 1= $CuSO_4$ | 0.136 | 0.135 | 0.313 | 1.145 | 0.880-1.491 |
| **Footbath changing frequency** | 0=Everyday, 1= Every two days | 0.120 | 0.164 | 0.462 | 1.128 | 0.818-1.555 |

b: Regression Coefficient, SE: Standard Error, CI: Confidence Interval

milk yield, lifespan, reproductive performance, and cow welfare[2,3,5]. When lameness is accompanied by infectious claw diseases, it becomes a herd issue, worsening existing losses; moreover, its prevalence and severity are often underestimated by farmers[11].

Therefore, many studies have been carried out in recent years to examine the relationship between lameness and infectious claw diseases, with possible risk factors that may influence the development and prevalence of these issues[1, 2, 5-8, 12].

Breed traits in dairy cows are considered as a potential risk factor for claw diseases, especially DD[7,13]. Becker et al. (2014) reported that Holstein cows were more prone to claw lesions than brown and red breeds[7]. Furthermore, the fact that Holstein cows' horn claw structures are more vulnerable to diseases has been linked to their vulnerability to metabolic diseases[13]. Contrary to these views, Bielfeldt et al. (2005) reported that there is no significant difference between Simmental, Swiss brown, and Holstein breeds in terms of factors such as claw lesions and lameness (14). In the present study, there was no statistically significant difference between Simmental and Holstein breeds in terms of claw and hind limb conformation, claw lesions, or lameness ($P$>0.05).

Abnormalities in cows' hind limb conformation and claw lesions may be related to claw diseases and lameness[15,16]. According to Toussaint Raven (1989), load variations on the paired claws can negatively affect hind limb conformation, potentially raising the risk of lameness[17]. Similarly, Olechnowicz et al. (2010) claimed that abnormal conformations may increase the risk of claw lesions and lameness[16]. It is also stated that abnormal claw conformations are a factor that increases the rate of both claw lesions and lameness[18]. Claw lesions were observed in 21%[19] and 42%[20] of cows with abnormal claw conformations, and these animals have a high risk for lameness. Abnormal claw conformation and claw lesions may have a reciprocal cause-and-effect relationship[21,23]. In the present study, cows with abnormal hind limb and claw conformations were found to be 220 and 2.3 times more likely to be lame than healthy cows, respectively (Table 4). These results support the hypothesis[16,21] that abnormal hind and claw conformations both raise the risk of lameness.

Studies that have investigated the relationship between other risk factors and lameness have reported different results[2-5, 7, 14, 24, 25]. The present study results showed that there was no statistically significant correlation between lameness and LN, DIM, bedding type, and claw trimming interval. Our findings are parallel to the results of the studies in which no relationship was found in terms of the factors mentioned[5, 14, 25], and hence they contradict the results of other studies[2,24]. As reported in Becker et al. (2014) differences in geography and management may result in changes[7]. However, scientific reports from different locations may provide key points to prevent lameness for others. Infectious claw diseases, especially DD and HE, have been the most common infectious causes of lameness, have a multifactorial etiology[12, 26, 27], and must be handled without causing major economic losses or herd welfare issues[3,14,28]. DD and HE have been linked to LN[14], DIM[29], bedding material[30], footbath implementation[12], chemical properties of the footbaths[27], and footbath change frequency[28]. Gomez et al. (2015)[29] and Bielfeldt et al. (2005)[14] reported that the 60-120 DIM cows and LN and DIM period increase the risk of HE, respectively. In agreement with other studies, we found a statistically significant positive relationship between the presence of DD and HE with LN and DIM, with changes in LN and DIM increasing the incidence of DD and HE by 3.39 and 2.20 times, respectively (Table 5). In extensive dairy farms, efficient and proper use of footbaths has become crucial in preventing infectious claw diseases[12,28,30]. A strong relationship between HE[3] and DD[12] with footbath usage has been stated. The association between footbath usage with the existence of DD and HE lesions was found to be statistically insignificant ($P$>0.05) in our findings. The chemicals, concentrations, and dimensions of footbaths used in the farms were evaluated as consistent with the literature[12, 26, 27, 28, 30]. The similarity of the management practices of footbath usage in study farms and the existence of only 2 of 11 farms (farm number: 7 and 10, 337/1685 cows) which have not been using footbaths may be thought to be the reason for this insignificant relationship.

## CONCLUSION

The present association between the infectious claw disease existence with DIM and LN and lameness with the hind limb conformation and claw conformation may be considered in dairy farms as a management practice of prevention of lameness and infectious claw diseases. The result of the study may help farmers to specify their potential animal and management-based risk factors related to lameness and infectious claw lesions in their farms. Dairy farmers may be able to prevent future losses by closely observing mid and late-lactating cows for lameness and infectious claw diseases.

## Statement of conflict of interest

Authors have declared no conflict of interest.

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