Herd-level risk factors for seven different foot lesions in Ontario Holstein cattle housed in tie stalls or free stalls

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ABSTRACT

Worldwide, there is considerable between-herd variation within individual foot lesion prevalence studies. This variation suggests that herd-level risk factors are important from a prevention perspective. The objective was to determine the effect of selected risk factors on the prevalence of 7 foot lesions in both tie-stall and free-stall housing systems. As part of a cross-sectional foot lesion study 5 hoof trimmers recorded lesions for all cows that were foot trimmed in a herd. In addition, they completed a risk factor questionnaire for each herd. The impact of specific risk factors was evaluated using separate multi-variable models for both free-stall and tie-stall herds. The lesions evaluated were digital dermatitis, sole ulcer, sole hemorrhage, heel horn erosion, white line separations, white line abscess, and interdigital fibroma. Model types were selected based on herd-level lesion distribution. Detrimental risk factors identified in free-stall housing included increased alley scraping frequency (2.2- to 2.4-fold for sole ulcers) and trimming in summer or fall (−0.2-fold vs. spring and winter for digital dermatitis). Protective risk factors in free stalls included intermediate bedding depth (0.4-fold for 2.5 to 7.5 cm vs. more or less bedding for interdigital fibroma) and trimming heifers before calving (0.1-fold for white line abscess). In tie-stall herds no protective risk factors were identified. Detrimental risk factors for lesions in tie stalls included year-round access to outside areas (2.1-fold increase in digital dermatitis, 3.5-fold for white line separation, and 7.0-fold for interdigital fibroma vs. no or only seasonal exercise access), routine spraying of feet (2.0-fold increase in digital dermatitis), larger herds (3.0-fold increase in interdigital fibroma vs. <41 cow herds), and the use of wood bedding material (6.5-fold vs. straw bedding for interdigital fibroma). The risk factors identified need further evaluation to determine the temporal relation-

ships, as well as whether the relationships with foot lesions are causal.

Key words: foot lesion, risk factor, tie stall, free stall

INTRODUCTION

In the past 15 to 20 yr, very little progress has been made in reducing the prevalence of lameness in North America (Wells et al., 1993; Cook, 2003). The most recent estimates of lameness prevalence are 20 to 22% and 23 to 27% in North American tie-stall and free-stall barns, respectively (Cook, 2003; Zurbrigg et al., 2005). These prevalence estimates are based on locomotion scores and should be considered an indicator of clinical disease. The prevalence of subclinical disease such as foot lesions identified at routine hoof trimming is likely higher (Manske et al., 2002).

Currently, there is a paucity of North American foot lesion data collected from multiple tie-stall or free-stall herds. Estimates from Europe indicate that prevalence of foot lesions is approximately 50% in tie-stall housing systems (Sogstad et al., 2005) and 70 to 80% in free-stall housing (Somers et al., 2003; Sogstad et al., 2005). In these and other European studies, there is considerable between-herd variation in lesion prevalence. Furthermore, herd-level variance makes a large contribution to the total variance for most lesions (Manske et al., 2002; Sogstad et al., 2005; Holzhauer et al., 2006a). This large between-herd variation suggests that herd-level risk factors may be important determinants of lesions and lameness in dairy cattle.

The importance of herd-level risk factors in the control of lameness and foot lesions was reviewed by Bergsten (2001). Yet, at that time, there were very few multi-variable herd-level epidemiological techniques and studies on which to base management recommendations (Hirst et al., 2002). Historically, the majority of studies that identified potential risk factors for the control of lameness were based on producer-recorded lameness data (Rowlands et al., 1983; Faye and Le-scourret, 1989). Still, recent studies have used either locomotion scoring (Amory et al., 2006) or foot lesions

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found at routine hoof trimmings (Sogstad et al., 2005; Somers et al., 2005a; Holzhauser et al., 2006b) to identify potential risk factors. The use of foot lesion or locomotion data decreased the underestimation problems that commonly occur with producer-recorded lameness data (Whay et al., 2002), but can still be affected by misclassification bias on the part of the hoof trimmer(s) (**HT**; Holzhauser et al., 2006a).

A variety of lameness risk factors have been identified. Unfortunately, there are considerable differences in breeds, housing, nutrition, and management between these predominantly European studies and typical dairy farms in Ontario and the rest of North America. One difference is that most of the European studies focused mainly on herds using free-stall housing systems. Because most farms in Ontario still use tie stalls for housing milking cows (Zurbrigg et al., 2005), there is a need to identify important risk factors in typical Ontario and other North American conditions. Knowledge of such factors could be used to design hoof health management programs to reduce the prevalence of lameness and foot lesions in both tie-stall and free-stall housing systems.

The objective was to evaluate relationships between selected herd-level risk factors and foot lesion prevalence in Ontario tie-stall and free-stall dairy herds.

MATERIALS AND METHODS

Five professional HT were recruited to enroll herds for participation. From March 2004 to May 2005, HT recorded the presence of foot lesions on all cows trimmed in participating herds. Details of lesion recording methods and HT recruitment and training are described elsewhere (Cramer et al., 2008). Briefly, participants were recruited via a mailing to HT that advertised in dairy industry magazines or were listed in a provincial database. Hoof trimmers that responded were trained in lesion identification at the onset of the project using digital images of common lesions. At the conclusion of the project, HT were evaluated to ensure lesion identification remained consistent. Recording forms were provided that contained lesion codes based on the recommendations of the American Association of Bovine Practitioner's lameness committee (Shearer et al., 2004).

As well as recording lesions, HT administered a 3-page questionnaire that captured descriptive herd management data from each of the participating farms. The questionnaire included items pertaining to farm characteristics (breed, herd size, milk production, housing, flooring, bedding management, and pasture access), hoof health management (trimming routine, foot disinfection), and nutrition (feeding management,

additive use). Farms with missing or deficient data on the questionnaires were contacted in an attempt to fill out missing data. For herds using a DHI milk recording service, production and herd size data were taken from DHI records; otherwise, they were calculated from questionnaire data.

Data Management and Statistical Analysis

Both questionnaire and lesion data were entered into a database (MySQL 4.1, MySQL AB, Uppsala, Sweden) via the Internet. Data management and descriptive analyses were done using Microsoft Excel (Redmond, WA) and a commercially available statistical program (Stata 9.2, Stata Corp., College Station, TX). Individual cows with duplicate, unreadable, or missing cow identification were removed from the data set.

For each herd, lesion-specific prevalence was calculated in the following manner: the number of affected cows was divided by the number of cows examined during the particular hoof trimming visit. For each cow, foot lesion data were recorded on all 4 limbs and these data were collapsed into a single record for each cow. A cow was considered affected with a particular lesion if at least 1 foot had the lesion present. Cows with multiple lesions were considered affected for all lesions present on the feet. Several herds had multiple hoof-trimming dates, but only the data from the visit at which the questionnaire was administered were included in the analysis.

Because of differences in risk factors between free stall and tie stalls, all analyses were performed separately for tie-stall and free-stall herds. Multivariable models were created for each specific lesion, including digital dermatitis (**DD**), heel horn erosion (**HHE**), sole ulcer, white line disease abscess (**WLA**), white line disease separation (**WLS**), hemorrhage (**HEM**), and interdigital fibroma.

Multivariable models were built in multiple stages, the first of which was to determine the type of model to be used. This determination was made by graphically assessing the distribution of herd prevalence for each lesion. If the distribution appeared close to a normal distribution, linear regression was used. When the distribution was not close to a normal distribution and less than 40% of the herds had a prevalence of zero, a negative binomial regression model was selected. If more than 40% of the herds had zero prevalence, herds were classified as affected or unaffected with each specific lesion and logistic regression was used. Logistic regression was used instead of zero-inflated negative binomial regression because of a large number of herds with zero counts and the lack of variability between affected herds.

Table 1. Descriptive statistics of herd-level prevalence of foot lesions diagnosed at hoof trimming in 134 tie-stall herds and 38 free-stalls herds in Ontario Holstein herds

Lesion	Percentile			Proportion of zero prevalence herds	
	25th	50th	75th	n	%
Free-stall housing					
Digital dermatitis	9.4	18.0	38.9	3	7.9
Sole ulcer	4.4	9.0	16.8	4	10.5
Hemorrhage	3.5	8.3	18.5	7	18.4
Heel horn erosion	0.0	2.9	14.1	12	31.6
White line separations	0.0	3.8	9.7	12	31.6
Interdigital fibroma	0.0	2.9	7.0	10	26.3
White line abscess	0.0	0.0	3.8	20	52.6
Tie-stall housing					
Digital dermatitis	0.0	4.8	15.0	40	29.9
Sole ulcer	0.0	3.8	7.3	46	34.3
Hemorrhage	0.0	5.3	12.2	37	27.6
Heel horn erosion	0.0	3.8	14.6	46	34.3
White line separations	0.0	0.0	0.0	104	77.6
Interdigital fibroma	0.0	0.0	0.2	101	75.4
White line abscess	0.0	0.0	0.0	106	79.1

In the second stage of model building, variables of interest were screened for unconditional associations with each foot lesion. From this screening process variables with $P < 0.20$ were selected for inclusion in the final step of model building. Before the final step, the correlation between significant variables was assessed. If the Pearson correlation coefficient between 2 variables was >0.5 , one of the variables was removed based on its P -value in the unconditional model and the hypothesized casual model for the lesion of interest (Dohoo et al., 2003).

In the final model-building step, manual backward elimination was used to eliminate variables with a $P < 0.05$. If the removal of a variable changed the parameter estimate of any of the remaining covariates by $>25\%$ or the likelihood ratio test was significant, the eliminated variable was retained as a confounder (Dohoo et al., 2003). In this final modeling step, HT was forced into the model as a fixed effect for all models. All final models were assessed for proper fit by the assessment of residuals, model assumptions, and appropriate goodness of fit tests according to the methods described for each particular modeling approach by Dohoo et al. (2003).

RESULTS

A total of 2,603 cows in 38 free-stall herds and 5,582 cows in 134 tie-stall herds were included. Median, 25th, and 75th percentiles for herd-level foot lesion prevalence are in Table 1 for both tie-stall and free-stall farms. Average daily milk production was 28.8 kg [95% confidence interval (CI): 27.2 to 30.5 kg] and 30.0 kg (CI: 29.3 to 30.7 kg) in free-stall and tie-stall barns,

respectively. Median herd size was 75 (CI: 58 to 85) in free stalls and 42 (CI: 38 to 44) in tie stalls. In tie-stall herds, only 4 HT were included, with 1 HT trimming 40% of the herds, whereas the other 3 HT each trimmed around 20% of the herds. In free-stalls herds, 1 HT trimmed 38% of the herds, whereas the other 4 HT trimmed 24, 18, 13, and 8% of the herds, respectively. Descriptive statistics for potential risk factors for foot lesions in tie-stall and free-stall housing systems are in Table 2. Additional descriptive statistics for risk factors evaluated in free-stall herds are in Table 3.

Tie Stalls

In the DD, WLS, and interdigital fibroma models, year-round access to pasture was associated with higher lesion prevalence (Tables 4 and 5). Other variables associated with increased lesion prevalence were wood bedding material (WLA) and routine spraying of feet (DD). No protective risk factors were identified. In all 5 models, HT was included in the final models as a non-significant effect. For the 2 remaining foot lesions (HHE and HEM), HT was a significant variable throughout model development; therefore, results are not presented here.

Free Stalls

Increasing the frequency of alley scraping had a significant association with increased prevalence in the models for DD and sole ulcer (Tables 6 and 7). Other variables associated with increased lesion prevalence were trimming in fall or summer (DD; Table 6) and medium bedding depth (interdigital fibroma; Table 7).

Table 2. Distribution of descriptive risk factors evaluated for relationships with herd level prevalence of foot lesions in Ontario dairy farms

Cluster and variable	Category	Tie stall		Free stall	
		n	%	n	%
Farm characteristics					
Daily milk production (kg/cow per day)	<28	36	27.5	11	30.6
	28–31	36	27.5	14	38.8
	>31	59	45.0	11	30.6
Proportion of cows trimmed at visit (%)	<50	12	8.9	8	21.0
	>50 <100	47	35.1	15	39.5
	>99	75	56.0	15	39.5
Access to outside exercise area	Never	31	23.1	25	65.8
	Seasonally	73	55.5	9	23.7
	Year-round	30	22.4	4	10.5
Housing characteristics					
Bedding material	Straw	133	94.0	15	39.5
	Wood	6	4.5	17	44.7
	Sand or other	2	1.5	6	15.8
Bedding depth (cm)	<2.5	18	13.5	18	47.4
	2.5 to 7.5	62	46.6	12	31.6
	>7.5	53	39.9	8	21
Surface under bedding	Sand			7	15.8
	Rubber-filled mattress	65	48.5	25	65.8
	Rubber mat	27	20.1	6	18.4
	Cement	40	29.9		
	Other	2	1.5		
Hoof health management					
Times a year cow trimmed, n	1	61	45.5	10	26.3
	>1	73	54.5	28	73.7
Heifers trimmed before calving?	No	65	50.0	24	63.2
	Yes	65	50.0	14	36.8
Routinely spray feet?	No	98	78.4	28	75.7
	Yes	27	21.6	9	24.3
Trimming season	Spring	66	49.3	20	52.6
	Summer	32	23.9	8	21.1
	Fall	11	8.1	1	2.6
	Winter	25	18.7	9	23.7

The only variable associated with decreased lesion prevalence was trimming of heifers before calving (WLA; Table 8). For the remaining 3 lesions (WLS, HHE and HEM), HT was a significant confounder throughout the modeling process; therefore, results from these models are not presented here.

DISCUSSION

This study used foot lesion data collected at the individual cow level to evaluate relationships between herd-level prevalence and lesion status with herd-level risk factors. Unlike other studies (Somers et al., 2005b; Holzhauer et al., 2006b), no cow-level risk factors were evaluated because descriptive cow-level data were not available for all trimmed cows. Furthermore, the majority of cow-level variables usually identified by cow level studies such as age, DIM, and breed are not factors easily manipulated in a lameness prevention or control program. Considering these factors, an analysis that focused solely on herd-level risk factors was considered more appropriate.

The risk factors identified in the present study were associated with specific lesions. Still, the relationships were not necessarily causal in nature, because this was a cross-sectional observational study. The major limitation of this cross-sectional study design was that exposure and disease were measured at the same time. Thus, the temporal relationship between exposure and

Table 3. Distribution of free-stall-specific variables used to evaluate relationships with herd-level foot lesions prevalence in Ontario free-stall herds

Variable	Category	n	%
Three-row barn?	No	18	47.4
	Yes	20	52.6
Flooring	Slats	8	21.1
	Smooth	4	10.5
	Rubber	9	23.7
	Grooved	20	52.6
Daily frequency of alley scraping	<3	15	39.5
	3 to 7	10	26.3
	>7	13	34.2
Use footbath?	No	11	29.0
	Yes	27	71.0

Table 4. Final significant variables for tie-stall housing from negative binomial models with herd-level prevalence of digital dermatitis and sole ulcers as the outcome

Outcome ¹ and explanatory variable	Category	Prevalence ratio ²	P-value	95% CI	
				Lower	Upper
Digital dermatitis (n = 125)					
Access to outside exercise area	Seasonally	1.4	0.27	0.8	2.5
	Year-round	2.1	0.04	1.0	4.1
	Never		Referent		
Routinely spray feet ³		2.0	0.02	1.1	3.3
Sole ulcer (n = 134)					
Proportion of cows trimmed (%)	<50	2.0	0.04	1.0	3.8
	50 to 100	1.1	0.74	0.7	1.6
	>100		Referent		

¹Model includes hoof trimmer as a nonsignificant fixed effect.

²Prevalence ratios are interpreted as odds ratios.

³Interpretation example: In herds that routinely sprayed cows' feet, the prevalence of cows with digital dermatitis was 2.0 times higher than in herds that did not routinely spray cows' feet.

disease is unclear for certain risk factors (Dohoo et al., 2003).

Hoof Trimmers

The use of multiple HT inherently created some problems because of the potential for misclassification bias of foot lesions. For this reason, HT was included in all models as a fixed effect. For WLS, HEM, and HHE, HT was a significant variable in the final model. These models were not presented here because the significance of HT in the model makes interpreting the other risk factors in the model dependent on HT, and inference to the target population becomes difficult.

Other studies found a significant effect of HT for HEM and HHE (Holzhauer et al., 2006a) and WLS (Sogstad et al., 2005). Although the diagnosis of all foot lesions involves some degree of subjectivity, it appeared that accurate and consistent recording of lesions such

as HEM, HHE, and WLS was even more difficult. In an attempt to address this problem of misclassification bias, future studies of bovine foot lesion frequency that use multiple HT should create a more objective definition of these lesions by including a minimum affected area requirement and include training on live cows. Alternatively, the number of lesions or the number of people involved in scoring could be reduced. However, this would reduce the ability to make inferences to the broad target population.

Tie Stalls

Year-round access to a pasture or outside exercise area had a significantly negative association (2.0- to 7.0-fold) with WLS, DD, and interdigital fibroma in tie stalls (Tables 4 and 5). In contrast, a benefit was recorded when there was opportunity for exercise for cows that are normally tied (Loberg et al., 2004).

Table 5. Final significant variables for tie-stall housing from logistic regression models with herd-level absence or presence of white line abscess, white line separation, and interdigital fibroma as the outcome

Outcome ¹ and explanatory variable	Category	Odds ratio	P-value	95% CI	
				Lower	Upper
White line separation (n = 134)					
Access to outside exercise area	Never		Referent		
	Seasonally	0.9	0.83	0.3	2.8
	Year-round	3.5	0.05	1.0	11.9
White line abscess (n = 133)					
Bedding material	Straw		Referent		
	Wood	6.5	0.03	1.2	33.7
Interdigital fibroma (n = 133)					
Access to outside exercise area	Never		Referent		
	Seasonally	2.2	0.18	0.7	7.1
	Year-round	7.0	0.01	1.7	28.4
Large herd, no. of cows	>41	3.0	0.02	1.1	8.0

¹Model includes hoof trimmer as a nonsignificant fixed effect.

Table 6. Final significant variables for free-stall housing from a linear regression model with herd-level prevalence of digital dermatitis as the outcome

Explanatory variable ¹	Category	Coefficient	P-value	95% CI	
				Lower	Upper
Daily frequency of alley scraping	<3		Referent		
	3–7	0.1	0.15	–0.0	0.2
	>7	0.2	<0.01	0.1	0.3
Season of trimming	Spring		Referent		
	Summer and fall	–0.2	<0.01	–0.4	–0.1
	Winter	–0.1	0.55	–0.2	0.1

¹Model includes hoof trimmer as a nonsignificant fixed effect and n = 38 herds.

Therefore, it is likely that the characteristics of the exercise or housing area during the late fall and winter months were responsible for the associations observed in the current study. These characteristics were not recorded in the current study. Nonetheless, it is likely that at times the exercise area would be wet, slippery, and rough, all factors that have been associated with an increased prevalence of lameness (Bergsten, 2001).

Even though the use of various spraying solutions was efficacious (Hernandez et al., 1999), the routine spraying of cows' feet was associated with an increased prevalence of DD (Table 4). The efficacy of spraying was dependent on product (Hernandez et al. 1999), frequency, duration, and concentration. Only product used was recorded in this study; therefore, it is unclear if the duration, frequency, or concentration used were appropriate. Moreover, it is currently unclear what proper durations are, because the efficacy of spraying has only been assessed in the short-term (Hernandez et al., 1999).

The relationship between the use of wood products for bedding and WLA in tie stalls (Table 5) is unlikely a direct causal relationship. The association should be interpreted with caution because of the low number of herds using wood bedding material (Table 2).

Free Stall

Season of foot trimming had a pronounced effect only on DD in free stalls (Table 6), with herds being trimmed in the summer or fall having a lower prevalence than herds trimmed in the spring. It is surprising that no other lesion had a significant association with season, because Cook et al. (2004) suggested that there were seasonal effects for hoof horn lesions due to heat stress. Although heat stress is uncommon for extended periods in Ontario, it does occur. It is possible that there was not enough power in the present study to determine the association between season and other lesions. Additionally, the timing of hoof trimming was at the discretion

Table 7. Final significant and confounding variables in free stall housing from negative binomial models with prevalence of sole ulcers and interdigital fibroma as the outcome

Outcome ¹ and explanatory variable	Category	Prevalence ratio ²	<i>P</i> -value	95% CI	
				Lower	Upper
Sole ulcers					
Daily frequency of alley scraping	<3		Referent		
	3 to 7 ³	2.2	0.02	1.1	4.4
	>7	2.4	0.01	1.2	4.8
Interdigital fibroma					
Bedding depth (cm)	<2.5		Referent		
	2.5 to 7.5	0.4	0.03	0.2	0.9
	>7.5	1.1	0.81	0.5	2.6
Access to outside exercise area ⁴	Never		Referent		
	Seasonally	1.1	0.79	0.5	2.4
	Year-round	0.3	0.09	0.1	1.2

¹Model includes hoof trimmer as a non significant fixed effect and n = 38 herds.

²Prevalence ratios are interpreted as odds ratios.

³Interpretation example: In herds that scraped the alleys in their barns between 3 and 7 times daily the prevalence of cows with sole ulcers was 2.2 times higher than herds that scraped the alleys less than 3 times a day.

⁴Confounding variable.

Table 8. Final significant and confounding variables in free-stall housing from logistic regression model with herd-level presence of white line abscess as the outcome

Explanatory variable ¹	Category	Odds ratio	P-value	95% CI	
				Lower	Upper
Heifers trimmed before calving		0.1	0.02	0.01	0.7
Daily frequency of alley scraping ²	<3		Referent		
	3–7	0.5	0.43	0.1	3.2
	>7	3.9	0.18	0.5	28.3

¹Model includes hoof trimmer as a nonsignificant fixed effect and n = 38 herds.

²Confounding variable.

of the producer and occurred only once a year for several herds. With once-yearly hoof trimming, seasonal effects on lesion prevalence would be difficult to detect. Possible explanations for the reduced prevalence of DD associated with trimming in the warmer months of the year are barns having a drier environment due to lower humidity or more frequent foot bathing due to less risk of freezing.

As a means to control both infectious and hoof horn lesions, improvements in cleanliness (Berry, 2001) and drier environments (Borderas et al., 2004) have been recommended. In theory, increasing the frequency of cleaning alleys through the use of automatic alley scrapers should result in cleaner and drier floors. Contradicting that theory, the present study found that an increased frequency of alley scraping was associated with a higher prevalence of ulcers and DD (Table 6). Two other studies (Bell, 2004; Barker et al., 2007) described an association with the presence of alley scrapers and a higher prevalence of severe hoof horn lesions or lameness. In contrast, cows housed on slatted floors with alley scrapers had lower odds of both DD (Somers et al., 2005a) and HHE (Somers et al., 2005b), compared with cows on solid floors with alley scrapers or slatted floors without alley scrapers.

Combining these results, it could be hypothesized that for infectious lesions, alleys scrapers are only beneficial on slatted floors. It is possible that on solid floors too much manure builds up in front of the scrapers, and more of the foot is exposed to more manure, thereby increasing the risk of infectious lesion development.

Similarly, it could be hypothesized that for hoof horn lesions such as sole ulcers (Table 7), the constant movement of alley scrapers creates other potentially negative factors. Examples of these risk factors include scraper design features, increased aggressive social interactions, decreased lying time, or resulting floor properties. These negative factors could have a role in the development process of hoof horn lesions by potentially increasing the strain a cow places on the suspensory apparatus of the third phalanx (Lischer et al., 2002; Cook

et al., 2004). Finally, it is possible that alley scraping frequency is an intervening variable and that another unmeasured variable is responsible for the association (Dohoo et al., 2003).

In the current study, keeping a medium amount of bedding in free stalls was significantly associated with a reduced prevalence of interdigital fibroma (Table 7). The pathogenesis of interdigital fibroma is not completely understood. Nevertheless, it is thought that chronic irritation by manure, moisture, conformation, flooring (Berry, 2001), and normal gait biomechanics (Meyer et al., 2007) lead to proliferation of the interdigital skin and, thus, play a role in lesion development. Bedding depth could have a protective effect on interdigital fibroma if bedding increases the cleanliness of the hoof and interdigital area. Yet, if bedding was truly protective it would be expected that the highest level of bedding depth would have a positive relationship. Therefore, it is likely that medium bedding depth is an intervening variable for another unknown factor.

Although the current study identified a positive relationship between trimming heifers and WLA prevalence (Table 8), it is difficult to draw inferences to the hoof health of first-lactation cows. This difficulty arises because only 1 cow out of all the cows trimmed had to be affected to identify a herd as WLA positive. Therefore, this association likely indicated that herds that hoof trimmed their heifers before calving have a higher management level with respect to hoof care and have fewer cows with severe lesions such as WLA present. Nonetheless, other than a small study in Prince Edward Island (Scharko and Davidson, 1998), there is a paucity of data on the benefit of hoof trimming heifers before calving.

CONCLUSIONS

Contradicting some commonly made recommendations, this study found associations between increased lesion prevalence and increased frequency of alley scraping, spraying of feet, and year-round opportu-

nity for exercise. Before their incorporation into foot health programs, these findings need further evaluation at both the cow and herd levels to determine if their relationships are causal in nature. These future studies should be prospective to allow for determining the temporal relationship between risk factors and lesions. The current study confirmed the significant effect HT can have on the recording of hoof lesions, especially HEM, HHE, and WLS.

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