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The Effects of Several Cow and Herd Level Factors on Lameness in Holstein Cows Reared in Izmir Province of Turkey

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Abstract: This study was carried out to determine the prevalence of lameness and risk factors for lameness. Data of 1078 Holstein cows from 34 farms in Izmir province of Turkey were evaluated. Lameness was determined by using a Lameness Score (LS) scale with 5 levels. Mean prevalence of lameness ($LS\geq 3$) was 28.3%. The percent of the cows with LS 1-5 were found to be 37.9, 33.8, 20.9, 5.8 and 1.6%, respectively. Cow-level variables were parity, days in milk, body condition score and hygiene score of lower rear legs. There were 18 herd level variables used to explain the variation in the prevalence of lameness among the herds. LS data were analysed using individual and multifactorial binary logistic regression. About 12 of the 22 potential risk factors investigated in the study were found to be significant ($p<0.10$) in the individual logistic regression analysis. However, only 9 of the 12 factors remained in the final multifactorial logistic regression model. These significant 9 factors on lameness were parity, body condition score, herd size, animal keeper, total area per cow, soil area per cow, frequency of scraping, ratio of concentrate feed to total feed intake and consulting a feeding expert. Lameness risk was increased with increasing parity, herd size and ratio of concentrate feed to total feed intake and it was increased with decreasing in body condition score, total area per cow and soil area per cow and the risk was also increased if a feeding expert was not available or animal keeper was the stockman ($p<0.10$). Frequency of scraping was found a significant ($p = 0.031$) risk factor for lameness. Minimum prevalence of lameness was determined in the herds scraped once in 6-10 days.

Key words: Lameness, risk factors, Holstein cows, Turkey, prevalence

INTRODUCTION

Lameness in dairy cows is one of the most important diseases in terms of economics and animal welfare. Most economic losses related to lameness are reduced milk yield, discarded milk, increased cost of labour and veterinary treatment, early culling, longer calving interval and reduced reproductive performance (Kossaibati and Esslemont, 1997; Enting *et al*., 1997; Sprecher *et al*., 1997; Juarez *et al*., 2003). Lameness is the third most important disease after mastitis and fertility problems in dairy cattle (Enting *et al*., 1997). Lameness cost per case was estimated between $327 and $346 (USDA, 2002). Lameness is usually associated with substantial pain and discomfort (Whay *et al*., 1998). Pain negatively changed the individual and social behaviour of affected animals. For example, affected cows reduced their total activity as returning late from milking parlor and spending less time for feeding and longer total lying times (Galindo and Broom, 2002; Juarez *et al*., 2003; Bach *et al*., 2007).

Lameness Score (LS) should be considered to increase dairy profitability. Lameness can be assessed using direct observations of cow's gait and back posture (Sprecher *et al*., 1997) and it is the most reliable sign to diagnose leg disorders (Gorgul, 2004). Lameness scoring helps us to identify affected cows at earlier stages of lameness and bring about faster recovery and decreased therapy costs (Espejo and Endres, 2007). Knowing the risk factors for leg disorders may be used to reduce the prevalence of lameness.

Therefore, several studies (Alban, 1995; Clarkson *et al*., 1996; Sprecher *et al*., 1997; Manske *et al*., 2002; Bielfeldt *et al*., 2005; Sogstad *et al*., 2005; Espejo *et al*., 2006; Espejo and Endres, 2007) were conducted to determine the prevalence of lameness and risk factors for lameness in many countries. The differences among animals for lameness are connected to the animal itself and its herds. Herd level risk factors are environmental and management factors such as housing system, herd type, herd size, barn floor, scraping method, foot bathing, trimming and nutrition (Nocek, 1997; Bielfeldt *et al*., 2005; Amory *et al*., 2006; Barker *et al*., 2007). Cow level risk factors are breed, parity, lactation period, body weight, Body Condition score (BCS) and milk yield (Wells *et al*., 1993; Green *et al*., 2002; Manske *et al*., 2002; Espejo *et al*., 2006).

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In Turkey, various studies (Kocak and Ekiz, 2006; Cecen and Gorgul, 2007) have been made on lameness in dairy cows but lameness scoring was not used in these studies. Lameness scoring is a practical and fast way of assessing lameness in dairy cows. Knowledge of herd and cow level risk factors for lameness might be used to reduce the prevalence of lameness.

This study was conducted to determine the prevalence of lameness using lameness scoring system and the risk factors for lameness in Izmir province of Turkey.

MATERIALS AND METHODS

Study field and animal material: The prevalence of lameness and risk factors for lameness in Holstein cows were studied in the towns of Odemis (33 farms) and Menemen (1 farm) of Izmir, the western part of Turkey. The study was carried out in 34 farms. The province of Izmir and especially the town of Odemis is an important centre for dairy cattle breeding and Odemis is called the little Netherlands in view of dairy cattle production. In Odemis there are nearly 2300 members of Cattle Breeders' Association and 41000 Holstein cows with 674 tons of mean milk production per day. Mean 305 days milk yield per Holstein cow in Odemis was found to be 6966 kg (Yaylak, 2003).

Total number of dairy cows in this study was 1078. Data were collected between June 2006 and September 2007. In all herds cows were housed in loose housing system (with or without free stalls).

Scoring animal and data collected: All farms were visited once during the study period. All cows were scored for lameness, body condition and hygiene of lower rear legs by the same researcher. Lameness scoring was done using a 1-5 scoring system developed by Sprecher *et al.* (1997). According to this scoring system, score 1 is given to normal cows and score 5 to severely lamed cows. Body condition scoring was performed according to the method developed by Edmonson *et al.* (1989). In this system, cows were scored with the points 1-5 with intervals of 0.25. The cow with BCS of 1 was considered as very thin and the cow that had BCS of 5 was considered as very fat. Hygiene Score of cows' Lower rear legs (HSL) was given according to Cook's Hygiene Scoring Card (Cook, 2002) with a scale of 4 points (1 = clean, 2 = slightly dirty, 3 = moderately dirty, 4 = extremely dirty). Individual cow information such as parity and Days In Milk (DIM) were obtained from computer records of the Cattle Breeders' Association of Izmir. Detailed information about housing characteristics, feeding strategy and management facilities were obtained by interviews with herd owners. Seasons were categorized into two groups according to total rainfall in the month of the herd visit (Table 1).

Statistical analysis: Two types of variables were collected in this study. The first one is cow-level variables which were parity, DIM, BCS and HSL (Table 1). Other variables are herd level variables which were used to explain the variation in prevalence of lameness among the herds. The herd level variables considered in this study were shown in Table 1. Sub-groups of cow and herd level variables were also shown in Table 1. The dependent variable in this study was LS. Lameness scoring with five levels was converted into binary definition as 0 for healthy cows (cows with LS 1 or 2) and 1 for lame cows (cows with LS 3, 4 or 5).

Table 1: Risk factors for lameness in cows and their levels investigated in this study

Risk factors	Sub-groups
Cow levels risk factors	Parity (1; 2; 3; 4; 5;≥6)
	Days in milk (1:1-30; 2: 31-60; 3:61-90; 4:91-150; 5:151-240; 6:241+)
	Body condition score (1: ≤2.50; 2:2.75-3.50; 3: ≥3.75)
	Hygiene score of cows' lower rear legs (1; 2; 3; 4)
Herd levels risk factors	Herd size (cow) (1:≤29; 2:30-50; 3: ≥51)
	Animal keeper (1: owner; 2: stockmen)
	Education status of farm owner (1: unschooled; 2: primary school; 3: middle school; 4: high school; 5: university)
	Dairy farmer's experience, year (1:1-9; 2:10-19; 3:≥20)
	Closeness status of barn (1: full close; 2: partially close)
	Season (1: April-September; 2: October-March)
	Total area per cow (m^2) (1:≤20; 2:21-30;3:≥31)
	Soil area per cow (m^2) (1:0-10; 2:11-20; 3:21-30; 4:31-40; 5:41-50)
	Concrete floor area per cow (m^2) (1:≤4; 2:5-9; 3:≥10)
	Frequency of scraping (once in 1: 1-5; 2: 6-10; 3: ≥11 days)
	Ratio of concentrate feed to total feed intake (on DM basis) (1:0.20-0.29; 2:0.30-0.39; 3:0.40-0.49; 4:0.50-0.59)
	Forage and concentrate feeding method (1: mixed, 2: separate)
	Forming feeding groups (1: yes; 2: no)
	Concentrate feeding prepartum (1: yes; 2: no)
	Consulting feeding expert (1: yes; 2: no)
	Metabolic energy class of concentrate feed (1:2.50-2.65; 2:2.70; 3:2.75-2.80 Mcal kg^{-1})
	Foot bath (1: yes; 2: no)
	Claw trimming (1: if cow is lame; 2: when nails lengthen; 3: one or two times in a year)

Lameness data were analysed using binary logistic regression. Logistic regression is useful for situations in which you want to be able to predict the presence or absence of a binary characteristic such as lameness based on values of a set of predictor variables. It is similar to a linear regression model but it is suited to models where the dependent variable is dichotomous. Logistic regression analysis was carried out in two steps. Firstly, the individual effect of 22 potential risk factors for lameness was separately analysed using binary logistic regression. From these individual analyses, significant ($p<0.10$) factors on lameness were determined. Secondly, the significant factors from the individual analyses were all included in the multifactorial model. The multifactorial model was analysed under forward stepwise method using likelihood ratio statistics. Stepwise selection method with entry testing was based on the significance of the score statistics and removal testing was based on the probability of likelihood ratio statistics which was based on the maximum partial likelihood estimates. Forward methods start with a model that includes only intercept initially.

At each step, the predictor that contributes the highest is added to the model, until all of the predictors in the model are significant ($p<0.10$). Logistic regression coefficients (B) can be used to estimate odds ratios (Exp B) for each of the independent variables in the model. The Odds Ratio (OR) represents the ratio-change in the odds of the lameness for a one-unit change in the predictor factor. All the analyses were carried out using SPSS (2003).

RESULTS AND DISCUSSION

Mean number of cows, mean parity and daily milk yield in the farms were 45 head, 2.5 lactations and 24 kg, respectively. The percent of the cows with LS 1-5 were found to be 37.9, 33.8, 20.9, 5.8 and 1.6%, respectively. In the study, cows with LS≥3 were considered as clinical lame as in the study of Espejo and Endres (2007). Prevalence of lameness (LS≥3) averaged 28.3%. The mean prevalence of lameness in other studies changed from 2.0-65.2% (Clarkson *et al*., 1996; Sprecher *et al*., 1997; Bielfeldt *et al*., 2005; Espejo *et al*., 2006; Bach *et al*., 2007).

On the other hand, the differences, both regionally and nationally in the reported prevalences may be due to the definitions of lameness with different scoring systems and observers (Amory *et al*., 2006).

Of the 22 potential risk factors, 12 factors were found significant in the individual logistic regression analysis (Table 2). Ten effects (stage of lactation, dairy farmer's experience, closeness status of barn, concrete floor area per cow, forage and concentrate feeding method, forming feeding groups, concentrate feeding prepartum, metabolic energy class of concentrate feed, foot bath and claw trimming) were not significant. However, only 9 of 12 remained in the multifactorial logistic regression analysis (Table 2). The significant 9 factors on lameness were parity, body condition score, herd size, animal keeper, total area per cow, soil area per cow, frequency of scraping, ratio of concentrate feed to total feed intake and consulting a feeding expert. Effects of hygiene score of cows' lower rear legs, education status of farm owner and season found significant in individual analysis were not included in the final logistic model. In the following sections, the factors found significant in multifactorial analysis were discussed in detail.

Table 2: Significance levels of the risk factors for lameness in cows

Risk factors	Significance in individual logistic regression	Significance in multifactorial logistic regression
Cow level risk factors		
Parity	0.000*	0.000*
Days in milk	0.594NS	-
Body condition score	0.001*	0.000*
Hygiene score of cows' lower rear legs	0.002*	0.894NS
Herd level risk factors		
Herd size (cow)	0.070*	0.053*
Animal keeper	0.014*	0.081*
Education status of farm owner	0.000*	0.842NS
Dairy farmer's experience (year)	0.167NS	-
Closeness status of barn	0.205NS	-
Season	0.000*	0.759NS
Total area per cow (m^2)	0.000*	0.002*
Soil area per cow (m^2)	0.000*	0.000*
Concrete floor area per cow (m^2)	0.865NS	-
Frequency of scraping	0.001*	0.031*
Ratio of concentrate feed to total feed intake	0.002*	0.010*
Forage and concentrate feeding method	0.945NS	-
Forming feeding groups	0.239NS	-
Concentrate feeding prepartum	0.126NS	-
Consulting feeding expert	0.001*	0.000*
Metabolic energy class of concentrate feed	0.488NS	-
Foot bath	0.466NS	-
Claw trimming	0.880NS	-

*$p<0.10$; NS: Not Significant ($p>0.10$)

Parity: In this study, parity was used as an indicator of cow's age. Susceptibility to lameness increased significantly ($p<0.001$) with lactation number (Table 2 and 3). The prevalences of lameness (LS≥3) for parities 1 to 6 were 19.3, 29.0, 26.8, 38.2, 38.8 and 48.0%, respectively (Table 3). According to binary logistic regression analysis, cows with parity 2-5 and ≥6 were 1.9, 1.8, 3.5, 3.8 and 5.5 times more likely to be lame than cows with first parity. The results indicated an obvious tendency towards a higher possibility of lameness in older cows. Similar results were reported from several studies (Rowlands, 1985; Wells *et al*., 1993; Boelling and Pollott, 1998; Hirst *et al*., 2002; Manske *et al*., 2002; Sogstad *et al*., 2005; Espejo *et al*., 2006).

Table 3: Results from multifactorial model analysis on risk factors for lameness in cows

Risk factors	Number of cows	Lameness prevalence (LS≥3), %	B	SE	Wald	df	Sig.	Odds ratio (Exp B)	90.0% C.I. for Exp B Lower level	Upper level
Parity	-	-	-	-	52.364	5	0.000	-	Reference level	
1	383	19.3	-	-	-	-	-	1.000	-	-
2	276	29.0	0.638	0.203	9.854	1	0.002	1.893	1.355	2.645
3	149	26.8	0.612	0.241	6.463	1	0.011	1.844	1.241	2.741
4	110	38.2	1.251	0.258	23.439	1	0.000	3.495	2.285	5.344
5	85	38.8	1.334	0.278	23.018	1	0.000	3.795	2.402	5.996
≥6	75	48.0	1.703	0.289	34.699	1	0.000	5.491	3.413	8.835
Body condition score	-	-	-	-	21.520	2	0.000	-	-	-
≤2.50	509	33.6	-	-	-	-	-	1.000	-	-
2.75-3.50	493	24.1	-0.629	0.155	16.453	1	0.000	0.533	0.413	0.688
≥3.75	76	19.7	-1.044	0.326	10.257	1	0.001	0.352	0.206	0.602
Herd size (cow number)	-	-	-	-	5.868	2	0.053	-	-	-
≤29	190 (12)*	25.8	-	-	-	-	-	1.000	-	-
30-50	428 (14)	25.5	0.497	0.324	2.350	1	0.125	1.643	0.964	2.800
≥51	460 (8)	32.0	0.769	0.329	5.476	1	0.019	2.158	1.257	3.707
Animal keeper (owner)	264 (12)	22.3	-	-	-	-	-	1.000	-	-
Animal keeper (stockmen)	814 (22)	30.2	0.449	0.257	3.045	1	0.091	1.566	1.026	2.391
Total area per cow (m^2)	-	-	-	-	12.278	2	0.002	-	-	-
≤20	218 (9)	29.4	-	-	-	-	-	1.000	-	-
21-30	431 (13)	35.5	-0.464	0.310	2.236	1	0.135	0.629	0.377	1.048
≥31	429 (12)	20.5	-1.271	0.365	12.149	1	0.000	0.281	0.154	0.511
Soil area per cow (m^2)	-	-	-	-	23.956	4	0.000	-	-	-
0-10	56 (3)	41.1	-	-	-	-	-	1.000	-	-
11-20	357 (11)	34.2	-0.892	0.449	3.943	1	0.047	0.410	0.196	0.858
21-30	272 (8)	29.4	-1.937	0.510	14.414	1	0.000	0.144	0.062	0.334
31-40	297 (9)	21.2	-0.505	0.522	0.934	1	0.334	0.604	0.256	1.425
41-50	96 (3)	17.7	-0.662	0.560	1.398	1	0.237	0.516	0.205	1.296
Frequency of scraping	-	-	-	-	6.943	2	0.031	-	-	-
once in 1-5 days	535 (16)	33.5	-	-	-	-	-	1.000	-	-
once in 6-10 days	397 (12)	21.9	-0.560	0.217	6.657	1	0.010	0.571	0.399	0.816
once in≥11 days	146 (6)	26.7	-0.180	0.318	0.321	1	0.571	0.835	0.495	1.409
Ratio of concentrate feed to total feed	-	-	-	-	11.431	3	0.010	-	-	-
0.20-0.29	102 (6)	18.6	-	-	-	-	-	1.000	-	-
0.30-0.39	369 (11)	24.1	0.087	0.436	0.040	1	0.841	1.091	0.533	2.235
0.40-0.49	460 (12)	30.9	0.228	0.432	0.277	1	0.599	1.255	0.617	2.556
0.50-0.59	147 (5)	37.4	1.056	0.455	5.380	1	0.020	2.874	1.359	6.075
Feeding expert, available	662 (19)	24.6	-	-	-	-	-	1.000	-	-
Feeding expert, none	416 (15)	34.1	0.666	0.175	14.537	1	0.000	1.947	1.460	2.594
Constant	-	-	-0.739	0.164	20.356	1	0.000	0.478	-	-

*Figures in paranthesis are the numbers of herds

Rowlands (1985) have shown that older cows (10 years old) were over four times more likely to develop lameness than younger cows (3 years old). Hirst *et al.* (2002) estimated that cows which are lame in the first lactation had a much higher risk of becoming lame again. Espejo *et al.* (2006) determined that the prevalence of lameness (LS ≥3) in the first lactation animals was 12.8% and prevalence increased on average at a rate of 8% per lactation. In this study, average increment of lameness percentage for per one unit increase in parity was found to be 5.3% from the simple regression analysis (R^2 = 92%). The reasons of increment of lameness with rising age would be cumulative damages in claw tissue as a result of previous pathological changes, foot lesions, arthritis and ligament break and less agility of cows (Nocek, 1997; Hirst *et al.*, 2002; Bielfeldt *et al.*, 2005; Sogstad *et al.*, 2005). As parity increases, secretion tissue of udder and milk production increases. As the udder secretion tissue increases, the udder enlarges. Abnormally large udder leads to unnatural gait, damage to the hind feet and increased lameness (Boelling and Pollott, 1998). Cows with high milk production tend to be at high risk of lameness (Green *et al.*, 2002; Kocak and Ekiz, 2006). On the other hand, the observations in the field showed that farmers do not desire to cull cows with high milk yield even if feet problems exist. Boelling and Pollott (1998) also stated that lameness plays an increasingly important role in later lactations of cows.

Body condition score: BCS was significant ($p<0.001$) effect on lameness of cows (Table 2). Prevalence of lameness was 33.6, 24.1 and 19.7% for BCS sub groups of ≤2.50, 2.75-3.50 and ≥3.75, respectively (Table 3). As similar to the results, Espejo *et al.* (2006) found that BCS was associated with the prevalence of lameness (42.57, 22.05 and 19.69% for the same BCS sub-groups, respectively). Risk of lameness is higher for cows having lower BCS. Indeed, cows with BCS of 2.75-3.50 and ≥3.75 have lower odds of lameness (OR = 0.5 and 0.4, respectively) than the cows with BCS≤2.50. Boettcher and van Dorp (1999) stated that cows with BCS 1 were about seven times more likely to be lame than the cows with BCS = 2.5. Van Dorp *et al.* (2004) estimated negative phenotypic and genetic correlations between BCS and LS. They declared that cows with higher BCS had better locomotion. Boettcher and van Dorp (1999) put forward two different ideas for relationship between BCS and lameness. The first one is simply cause-result relationship between them as lame cows have trouble walking. The second idea is that neither lameness causes lower BCS nor low BCS causes lameness; in fact, both might be a result of rumen acidosis. Wells *et al.* (1993) found a strong relationship between body condition and clinical lameness and reported that body weight loss might be a result of lameness. Juarez *et al.* (2003) suggested that lame cows have a tendency to arrive later to the feed bunk offering less feed quantity and quality due to sorting by early arriving cows. Espejo *et al.* (2006) stated that cows with high milk yield are not capable of meeting the nutritional requirement and eventually they lose condition. Body condition loss occours in early lactation due to negative energy balance. In this period, cows cannot consume sufficient DM to meet the requirement of high milk yield and deficiency of nutrients appears. In this case, farmers want to compensate for this deficiency and they generally use more concentrates including high amount of easily digestible carbohydrates to increase energy contents of the diet (Collard *et al.*, 2000). Diets with high amounts of concentrates or insufficient forage, or both of them, are followed by acidosis in the rumen (Nocek, 1997). Laminitis is more common for cows suffering from acidosis. For this reason, laminitis is assumed to be a disease related to negative energy balance and it is higher for cows with lower BCS (Collard *et al.*, 2000). On the other hand, cows with higher BCS are expected to be heavier and also heavier cows have more foot and leg problems than smaller cows (Dechow *et al.*, 2003). The cows selected for larger body size were more often culled due to leg and foot problems than the cows that were selected for small body size (Hansen *et al.*, 1999).

Herd size: With increasing herd size, it is significantly (p<0.10) more likely for a cow to be lame (Table 2). Lameness prevalence was 25.8, 25.5 and 32.0% for herds having ≤29, 30-50 and ≥51 cows, respectively (Table 3). Risk for lameness was 1.6 and 2.2 times higher for herds having 30-50 and ≥51 cows, respectively as compared to herds having ≤29 cows. There were some studies reporting that herd size is related to lameness (Alban, 1995; Katsoulos and Christodoulopoulos, 2009) while others determined no relationships between herd size and lameness (Sogstad *et al.*, 2005; Amory *et al.*, 2006; Espejo and Endres, 2007). Alban (1995) obtained that lameness risk for herds having >124 cows was 4 times higher than that for herds having 20-30 cows. Similarly, Katsoulos and Christodoulopoulos (2009) reported that risk for herds having >50 cows was 4 times higher than that for herds having <50 cows. On the other hand, Espejo and Endres (2007) found that herd size was not a significant factor in their study on freestall herds having >150 cows. Sogstad *et al.* (2005) researched on relatively small herds and no significant difference in the prevalence of lameness among herds was found. They stated that the space allowance per cow may be more important than herd size. Individual observation and care for cows are more difficult in large herds than smaller ones. Alban (1995) thought that more works were done using mechanization in a large herd and high degree of mechanization may reduce the time of farmers for each cow. This may increase lower detection possibility of lame cows (Alban, 1995). Especially infectious lameness could increase in larger herds. Rushen (2001) stated that larger herds would increase the risk for infectious diseases, due to increased contact among larger numbers of animals.

Animal keeper: Effect of animal keeper (owner or stockmen) was a significant (p = 0.081) risk factor for lameness in the multifactorial logistic regression model (Table 2). If the animal keeper was the farm owner, the percentage of lame cows was 22.3% while it was 30.2% if the animal keeper was the stockmen in the herd (OR = 1.6). This may arise from the fact that the farm owner pays more attention than the stockmen. Indeed, the level of lameness was closely related to the stockmen's level of knowledge about lameness, their impatient characters, awareness, recognition and dealing with lameness problems (Vermunt, 2004). For example when the stockmen were impatient, the rate of lameness became higher. Ward (1994) reported that farmers who knew more about lameness and foot lesions had a lower prevalence of lameness in their herd. Farmers with more training in lameness and claw trimming had also lower prevalence of lameness in their herd.

Total area per cow: Prevalence of lameness for herds having ≤20, 21-30, or ≥31 square meters area per cow were 29.4, 35.5 and 20.5%, respectively (Table 3). Risk of lameness for herds having ≥31 m^2 per cow was significantly lower (OR = 0.3) than the risk for herds having ≤20 m^2 per cow. Increasing total area per cow decreases the disturbance of cows each other and decreases manure accumulation on the floor and therefore the floor remains dry.

Soil area per cow: Soil area per cow had a significant effect (p = 0.000) on lameness risk (Table 2). For soil area sub-groups of ≤10, 11-20, 21-30, 31-40 and ≥41 m^2 per cow, the prevalence of lameness was 41.1, 34.2, 29.4, 21.2 and 17.7%, respectively (Table 3). Compared to reference level (≤10 square meters per cow), odds ratios for the other sub-groups were 0.4, 0.1, 0.6 and 0.5, respectively. Average decrease of lameness percentage per one square meter increment in soil area was found to be 0.6% from the simple regression analysis (R^2 = 99%). Cattle is a land animal and they prefer to stand, walk and lie on soft floors such as soil and straw. Soft barn surface (straw yard system) was largely beneficial to claw health (Somers *et al*., 2003). Soft soil floor decreased the mechanical stress to hoof. Although increasing soil area per cow is more desirable in this study, it could be difficult to allow more area due to high land prices in Odemis town. According to our results, at least a 10 m^2 soil area per cow could be advised. However, this area should not be stony since stony places increase the risk of lameness in cows (Harris *et al*., 1988; Ramos, 2006).

Frequency of scraping: Floors were scraped with a tractor (32 herds) or with automatic scrapers (2 herds) in herds investigated in this study. Herds were classified into three sub-groups according to frequency of scraping (once in 1:1-5 days; 2:6-10 days; 3: ≥11 days). Prevalence of lameness in these sub-groups was 33.5, 21.9 and 26.7%, respectively. Frequency of scraping was found to be a significant (p = 0.031) risk factor for lameness (Table 2). Minimum prevalence of lameness was found in the herds scraped once in 6-10 days.

The floor hygiene is an important factor, especially in large herds with intensive production. Overstocking may produce more manure being deposited and make worse the existing problem (Cook, 2002). Cook (2002) recommends scraping three times a day as minimum frequency to control infectious foot disease. Frequent scraping can help to reduce wet and unhygienic circumstances on the floor and to prevent the claw horn from contacting manure. Despite this advantage of frequent scraping, it also makes concrete floors slippery. The contacting of claw horn to hard concrete floor can damage the surface of the horn. For this reason, breeders prefer to leave some manure (called horn manure) on the concrete floor where cows walk around especially during summer season. Watery manure on the concrete floor dries due to high temperatures during summer season. Cows prefer soft floors. However, Rushen and de Passille (2006) stated that covering the walking surface with a thin layer of slurry increased frequency of slipping and number of strides of dairy cows. More standing in slurry increases claw horn moisture and this result in soft horn and easier damaging conditions and also less viscous slurry may penetrate the horn more easily (Leach *et al*., 2005). In addition, the manure may include harmful chemicals damaging the claw horn and manure is a good place for microorganisms that can infect the skin (Bergsten, 2004).

Concentrate Feed Ratio (CFR): Four CFR sub-groups (20-29, 30-39, 40-49 and 50-59%) were created according to ratio of concentrate feed to total feed intake on dry matter basis. Prevalences of lameness in these groups were 18.6, 24.1, 30.9 and 37.4%, respectively (Table 3). With increasing concentrate feed ratio in the diet, the possibility of becoming lame is increased significantly (p = 0.010). Risk of lameness for herds with CFR of 30-39, 40-49 and 50-59% were 1.1, 1.3 and 2.9 times higher, respectively than that for herds with CFR of 20-29%. Cows fed diets with high CFR had more lameness. Similarly, Manson and Leaver (1989) compared two groups of cows offered a diet in which concentrate: silage ratio was 60:40 or 40:60. The 60:40 diet increased lameness scores, increased number and duration of clinical lameness and decreased hoof hardness.

Nutrition is one of the factors contributing to the occurrence of laminitis which leads to poor quality horn in dairy cattle. Effects of nutrition to laminitis occur in different ways. One of them is acidosis. Acidosis which occurs in the presence of large amounts of lactic acid in rumen is closely related to functional fiber ratio, amount and type of grain, grain processing, rates of fermentation, fermentable carbohydrate, forage type and quality and ratio of forage to grain in diets (Nocek, 1997; Tomlinson *et al*., 2007). When ruminal pH decreases, vasoactive substances (histamine and endotoxins) are absorbed into the blood stream. These substances lead to vessel wall damage in the hoof, internal haemorrhage, swelling of the laminae and papillae and severe pain (Nocek, 1997). The other effect of rumen acidosis is on the biotin synthesis. Biotin which has a significant role on integrity of the hoof wall is normally synthesized by related microorganisms in the rumen but if acidosis exists, biotin synthesis is depressed (Bergsten, 2003). The number of researches on the effect of nutrition for claw health is limited (Tomlinson *et al*., 2007). However, not only the effect of diet composition on lameness risk but also how the diet is prepared and how much of this diet is consumed by cows and feeding behaviour of cows are considerable (Bergsten, 2003). Based on the observations in Odemis town, improper feeding management was common. Thus, acidosis or Subacute Rumen Acidosis (SARA) may be higher. Cecen and Gorgul (2007) reported that lameness was 35.8% in a herd where diarrhea and acidosis were also high due to improper feeding regimes in Bursa province of Turkey. Similarly, SARA is a widespread health and production problem in the US dairy herds (Nordlund, 2002). Vermunt (2004) stated that the risk of SARA is less when the concentrate: forage ratio of the diet is kept under 60:40.

Feeding expert: Consulting a feeding expert decreased the possibility of becoming lame significantly ($p<0.001$). Lameness prevalence for herds having a feeding expert and those not having one were 24.6 and 34.1%, respectively (OR = 1.95). Decreasing lameness due to consulting a feeding expert could be interpreted as feeding being arranged according to physiological requirements of cows.

CONCLUSION

It is clear that lameness in dairy cattle is a multifactorial problem and many processes may lead to lameness but preventative treatments are the most effective ways to reduce the risks. Nine factors among 22 potential risk factors were found to be significant in multifactorial logistic regression model. Significant factors on lameness in this study were parity and BCS as cow-level factors and herd size, animal keeper, total area per cow, soil area per cow, frequency of scraping, ratio of concentrate feed to total feed intake and consulting a feeding expert as herd-level factors. Most of the cow-level and herd-level factors could be managed to reduce lameness prevalence in dairy farms. Some of these factors are also related to each other. For example, factors such as nutrition and herd size are related to lameness and lameness can be reduced with proper housing and management (Bergsten, 2003; Sogstad *et al*., 2005; Barker *et al*., 2007). Reducing the existing lameness problem often entails a multidisciplinary approach with the involvement of a nutritionist and farm-building engineer (Vermunt, 2004). Prevention and early identification of lameness will be crucial to improve and maintain the welfare and profitability of dairy cows.

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