



Prevalence and Associated Risk Factors of Lameness in Cows at Commercial Dairy Herds in Punjab, Pakistan

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ABSTRACT

Lameness is one of the biggest insults to the well-being and productivity of dairy cows, which results in colossal economic losses for dairy producers. Nevertheless, it is overlooked and least studied dairy problem in Pakistan. The objective of this study was to determine the prevalence and associated risk factors of lameness at commercial dairy herds in Punjab, Pakistan. The sample size was 2,555 cows from 15 dairy herds assessed using a 5-point locomotion rating scale. A cow with a locomotion score of 3 or higher was considered to be lame. Lame cows were investigated for hoof and claw disorders based on clinical assessment. The prevalence of lameness at the herd-level ranged from 3.08% to 33.08% (overall = 14.20%). The prevalence based on severity showed that on all farms, the majority of cows were mildly lame (7.71%) followed in order by moderately lame (4.61%) and severely lame (1.88%). Prevalence of lameness was significantly higher ($P < 0.05$) in cows with a low body condition score (≤ 2.75) than in cows with a higher body condition score. In addition, cows fed commercial concentrate were 1.6 times more likely to be lame than cows fed TMR. Cows on farms with an annual hoof trimming frequency had 1.7 times higher odds to be lame than cows with twice-a-year hoof trimming. Similarly, cows in environmentally controlled sheds had a 2.6 times higher probability of lameness than cows kept in open sheds. Moreover, prevalence of lameness was significantly associated ($P < 0.05$) with the seasons of the year; highest in wet summer while lowest in spring. Among the hoof and claw lesions, sole ulcer was significantly ($P < 0.05$) more prevalent than white line disease, sole hemorrhage or inter-digital dermatitis. It was concluded that lameness and hoof lesions are important health problems in studied commercial dairy herds. The occurrence of lameness could be reduced in dairy herds if producers become aware of the associated risk factors, and improve management practices related to cows, environment and facility design.

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Authors' Contribution

SA, MA and AZD conceived the research idea and designed the study. SA, SJ and MA visited the dairy farms and collected the data. SH and IA performed data analysis. MA, KA and JAK wrote the paper.

Key words

Lameness, Dairy cattle, Hoof lesion

INTRODUCTION

Lameness is the most common welfare issue of dairy cattle (Rutherford *et al.*, 2009) associated with pain to cow (Why *et al.*, 1997), reduced milk yield (Amory *et al.*, 2008), decreased fertility (Walker *et al.*, 2008) and increased culling rate (Booth *et al.*, 2004). Lameness is also considered one of the principal health problems that significantly affect the economics of dairy industry (Kossaibati and Esslemont, 1997) after mastitis and reproductive failure.

The high incidence, severity and economic significance of lameness accounts for its importance. Herd- and cow-level prevalence of lameness varies between regions and countries as cow level prevalence of lameness was 19.1% in Malaysia (Sadiq *et al.*, 2017) and 36% in New Zealand (Fabian *et al.*, 2014). In India, prevalence of lameness was reported as 17.52% (Chakrabarti and Kumar, 2016). The incidence of lameness in New York State, ranged from 27% to 54% in lactating cows and 14% in dry cows (Foditsch *et al.*, 2016). Cook (2003) reported an incidence of lameness of 21% in summer and 24% in winter in Wisconsin dairy herds. Likewise, in the UK the prevalence of lameness varied over period of time as 25% (Why *et al.*, 2003) and 36% (Leach *et al.*, 2010). However, occurrence of lameness in tropics may vary due to diverse

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management practices influencing the predominance of associated risk factors (Sadiq *et al.*, 2017).

The factors involved in lameness occurrence are many including infectious agents, laminitis, conformational lesions but hoof and claw lesions by far are the most important. However, the cause of hoof and claw lesions is not completely understood but number of risk factors affects their development (Kumar *et al.*, 2019). According to Tadich *et al.* (2010) hoof lesions were also reported in non-lame cows in subclinical form, and cause reduced milk production (Green *et al.*, 2014).

Dairy producers in many countries did not consider lameness as a problem and usually underestimate, and only present severe cases of lameness for treatment (Horseman *et al.*, 2014; Kalyuzhny *et al.*, 2019). The need is to educate the farmers to evaluate the risk of lameness in a much better way and to educate staff on farms to understand the impact and losses of lameness.

Limited information on the lameness in dairy cattle is available in Pakistan where dairy industry is an emerging trend, and thousands of dairy cows are being imported from Australia, Europe and USA every year. Keeping in view the cow welfare and economic significance of lameness to the dairy industry, this study was carried out to determine the prevalence and associated risk factors of lameness in cows at commercial dairy herds in Punjab, Pakistan.

MATERIALS AND METHODS

Study animals

This study was carried out on 15 commercial dairy herds of ≥ 50 animals for a period of one year (April 2018 – March 2019) in Punjab, Pakistan. The farms were selected which were having exotic cattle breeds (Holstein-Friesian/Crossbred). These dairy farms were selected at random in different regions of Punjab, and each dairy farm was visited separately. At the time of visit, a comprehensively designed data capture form on presumed risk factors was completed with the help of farm veterinarian or manager. Entries in data capture form included were farm description (name and address, total cows, lame cows), description of individual cow (Lactation number, body condition score, type of hoof lesion, number of lame hooves), management practices (floor cleaning routine, foot-dip practices, type of feed), facility design (type of shed, floor grooves pattern, type of bunker's bedding) and the environment (seasons).

Diagnosis and scoring of lameness

The farm environment was assessed and all cows on the farm were evaluated for the presence or absence of lameness. Lameness was assessed using a 5-point locomotion scoring system ranged from score 1 to 5 as

described by (Lischer *et al.*, 2000). Brief description of locomotion scoring is given as: 1, normal, stand and walk normally with a leveled back and made long confident strides; 2, uneven gait, gait slightly abnormal; 3, mildly lame, stand with flat back, but arched when walked; 4, moderately lame, stand and walked with an arched back and short strides. Slight sinking of dew-claws in limb opposite to the affected limb; 5, severely lame, pronounced arching of back, reluctant to move, shifted weight completely off the affected limb. Lameness assessment was made by moving the cows on a flat surface that provided good footing. The posture and gait of each cow in the herd were carefully observed. The cows having locomotion score of 3 or higher were considered to be lame. The lame cows were further evaluated for hoof disorders like sole ulcer (SU), white line disease (WLD), sole hemorrhage (SH), and interdigital dermatitis (IDD).

Prevalence calculation

Herd-level and cow-level prevalence of lameness was computed using formula as described by (Thrusfield, 2005).

Statistical analysis

Data on prevalence and risk factors were recorded in Microsoft Excel 2010 and then entered in SPSS version 22 for statistical analysis. After basic descriptive statistical analysis, the chi-square test values and odd ratio were calculated to determine the association between several risk factors for lameness. A probability level ($P < 0.05$) was considered to be statistically significant.

RESULTS

Herd-level prevalence

Out of 2,555 cows assessed at 15 dairy herds, 363 were lame giving rise 14.20% overall prevalence based on 5 point lameness scoring system. Statistically, significant difference ($P < 0.05$) in prevalence of lameness was observed among all the dairy herds. The prevalence of lameness at the herd-level ranged from 3.08% to 33.08%. The highest prevalence (33.08%) was at farm 15 followed in order by 30.49% at farm 4, 20% at farm 5, 19.41% at farm 14, 18.18% at farm 8 and 16.36% at farm 12. On the other hand, the lowest prevalence (3.08%) was observed at farm 3 followed in order by 7.78% at farm 6, 8.24% at farm 1 and 8.44% at farm 11. The prevalence at farms 7, 9, 10, 12 and 13 was 21%, 14.71%, 14.67%, 16.36% and 15.56%, respectively (Fig. 1A). Locomotion scoring or severity based distribution of lameness is given in Table I. Prevalence of locomotion score-3 (mild lameness) was

higher (7.71%) compared to 4.61% of score-4 (moderate lameness) and 1.88% of score-5 (severe lameness). Statistical analysis revealed significant difference ($P<0.05$) in severity of lameness. When compared severity of lameness at individual dairy herds, highest prevalence of locomotion-score 3 was 18.29% and lowest was 1.54%. Similarly, maximum prevalence of locomotion-score 4 was 15.38% while 1.54% was the lowest. Likewise, peak prevalence of locomotion score 5 was 10%. Statistical analysis showed a significant difference ($P<0.05$) in prevalence of locomotion scores 3, 4 and 5 among different dairy herds (Fig. 1B).

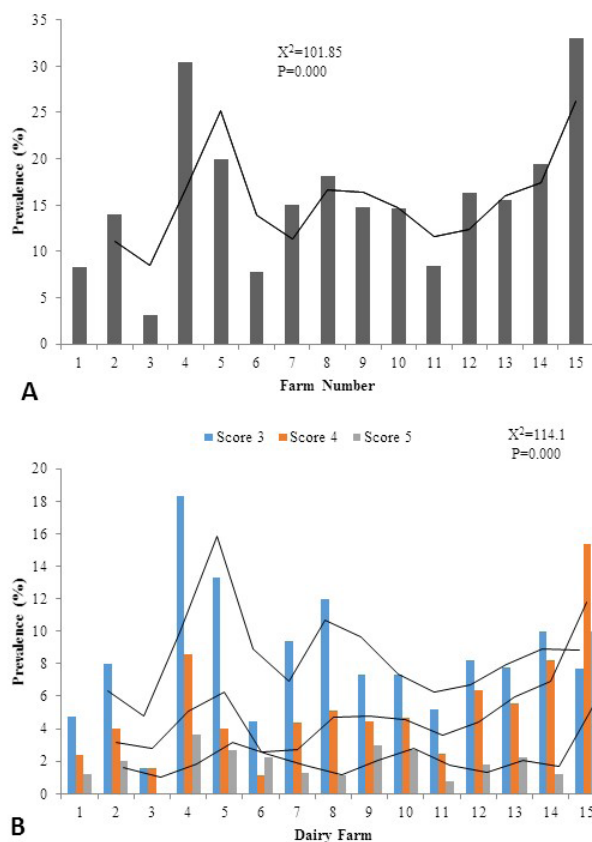


Fig. 1. Distribution of prevalence of lameness (A) and Locomotion score based prevalence of lameness (B) in cows at different commercial dairy herds in Punjab.

Cow-level variables

Prevalence was higher in cows involving single hoof (5.87%) and two hooves (5.36%) compared to cows with three hooves (2.19%) and four hooves (0.78%) affected, which is statistically significantly different ($P<0.05$). Similarly, a significantly higher ($P<0.05$) lameness prevalence was observed in rear hooves (51.79% in left rear; 33.05% in right rear) than front hooves (10.47% in left front; 4.69% in right front). Although, lameness

prevalence was greater in cows of 2nd lactation (4.58%) and 3rd lactation (4.11%) than 1st lactation (2.81%), 4th lactation (1.68%) and 5th lactation (1.02%) but statistically difference was non-significant ($P>0.05$) (Table 1). Body condition score (BCS) was also considered as risk factor of lameness. Prevalence in cows of BCS 2.25, 2.5 and 2.75 was higher (28.93%, 26.17%, and 18.46%, respectively) compared to BCS 3, 3.25, 3.5 and 4 (13.22%, 8.54%, 2.2%, and 2.48%, respectively). Prevalence of lameness was significantly higher ($P<0.05$) in cows with a low body condition score (≤ 2.75) than in cows with a higher body condition score (Fig. 4). Among the hoof and claw lesions, sole ulcer (9%) was significantly ($P<0.05$) more prevalent than white line disease (1.80%), sole hemorrhage (1.53%) or inter-digital dermatitis (1.88%) (Fig. 3).

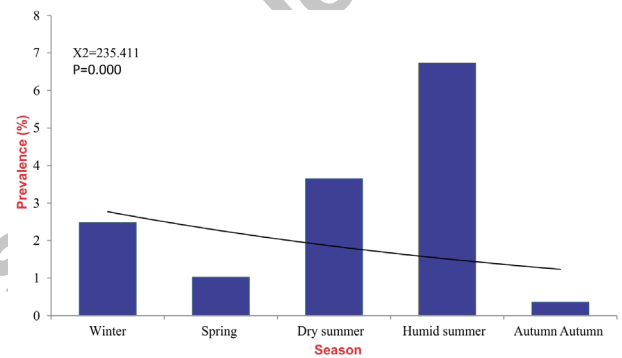


Fig. 2. Seasonal distribution of prevalence of lameness in cows at commercial dairy herds of Punjab. Winter, Nov 15 to Feb 15; Spring, Feb 16 to Apr 30; Dry summer, May 01 to Jun 30; Humid summer, Jul 01 to Sep 15; Autumn, Sep 16 to Nov 14.

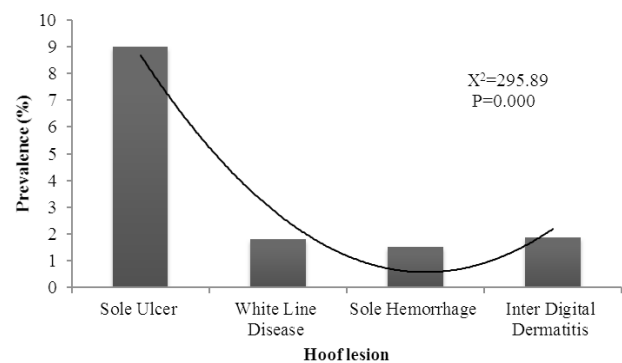


Fig. 3. Prevalence of different types of hoof lesion in cows at commercial dairy herds in Punjab.

Management and environment variables

Hoof trimming frequency also affected the occurrence of lameness. Prevalence in cows at dairy herds with annual hoof trimming was higher (15.41%) than cows at herds

with twice-a-year hoof trimming frequency (12%), which is statistically significantly different ($P < 0.05$). Cows on farms with an annual hoof trimming frequency had 1.7 times higher odds to be lame than cows with twice-a-year hoof trimming. Although, dairy herds having once-a-day floor washing routine had increased prevalence of lameness (15.33%) compared to herds having twice-a-day floor washings routine (10.18%) but the difference was non-significant ($P > 0.05$). Similarly, prevalence in cows at farms having no foot dipping routine was higher (15.30%) than cows at herds having routine practice of foot dipping (13.28%) but the difference was non-significant ($P > 0.05$). Use of commercial concentrate was significantly associated ($P < 0.05$) with lameness compared to total mixed ration (TMR). Dairy cows fed on commercial concentrate had increased prevalence of lameness (16.74%) than cows fed on TMR based diets (11.29%). Cows fed commercial concentrate were 1.6 times more likely to be lame than cows fed TMR (Table II). Prevalence of lameness in cows was observed high in humid summer (6.73%) followed in order by dry summer (3.64%), winter (2.47%), autumn (1.02%), and spring (0.35%) and was statistically significant ($P < 0.05$) (Fig. 2).

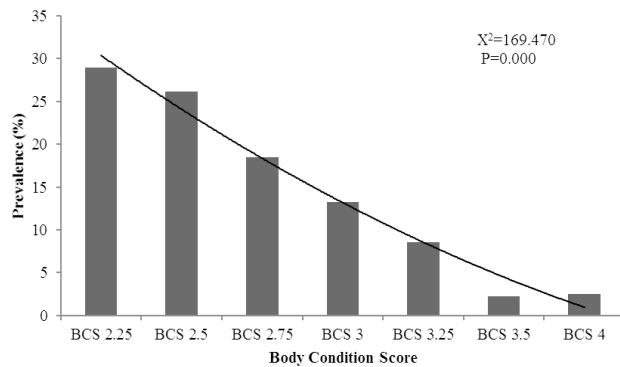


Fig. 4. Distribution of prevalence of lameness in relation to body condition score of cows at commercial dairy herds of Punjab.

Housing variables

Data showed a higher prevalence of lameness (28.29%) in cows at environmentally controlled sheds compared to open sheds (12.98%), which is statistically significantly different ($P < 0.05$). Cows in environmentally controlled sheds had a 2.6 times higher probability of lameness than cows kept in open sheds. Floor type pattern at dairy herds was divided into two categories viz. horizontal grooves and vertical grooves. Cows kept on floor type with vertical grooves have high prevalence of lameness (19.76%) than cows on floor with horizontal grooves (12.55%), and is significantly different ($P < 0.05$).

Furthermore, results indicated an increased prevalence of lameness (28.29%) in cows kept on rubber mattress compared to cows kept in sand bunkers (12.98%), and the difference was statistically significant ($P < 0.05$) (Table II).

Table I. Cow related risk factors associated with lameness at different dairy herds in Punjab.

Risk factor	Category	Number examined	Number positive (%)	X ² (P)
Severity	Mild	2555	197 (7.71)	96.417 (P=0.000)
	Moderate		118(4.61)	
	Severe		48(1.88)	
No. of hooves affected	1	2555	150(5.87)	135.533 (P=0.000)
	2		137(5.36)	
	3		56(2.19)	
	4		20(0.78)	
Hoof-wise	Right front	363	17(4.69)	272.32 (P=0.000)
	Right rear		120(33.05)	
	Left front		38(10.47)	
	Left rear		188(51.79)	
Lactation	1st	2555	72(2.81)	4.303 (P=0.367)
	2 nd		117(4.58)	
	3 rd		105(4.11)	
	4 th		43(1.68)	
	5 th		26(1.02)	

DISCUSSION

Lameness is one of the biggest insults to the well-being and productivity of dairy cows, which results in colossal economic losses for dairy producers. Nevertheless, it is overlooked and least studied dairy problem in Pakistan. This was the very first study of lameness in cows in commercial dairy herds in Punjab, Pakistan. This study included 2,555 cows from 15 commercial dairy herds and this sample size was selected based on convenient sampling technique. The prevalence of lameness at the herd level ranged from 3.08% to 33.08% (overall = 14.20%) was similar to the prevalence described by (Sadiq *et al.*, 2017) who reported an average prevalence of 19.1% (ranging from 10.0 to 33.3%) in cows. (Dippel *et al.*, 2009) reported a prevalence of 31% in Australian dairy herds in Simmental and 34% (0 to 81%) in Holstein-Friesian and Fleckvieh cows. A prevalence of clinical lameness of approximately 30% in British Columbia and California, and approximately 55% in the northeastern United States has been observed by (von Keyserlingk *et al.*, 2012).

Table II. Housing and management related risk factors associated with lameness in cows at different dairy herds in Punjab.

Risk factor	Category	Number of animals examined	Number (%) positive animals	X ² (P)
Hoof-trimming frequency	Annual trimming	1655	255(15.41)	5.555 (P=0.018) OR=1.336
	Twice-a year trimming	900	108(12.0)	
Foot dipping routine	Regular	1385	184(13.28)	2.110 (P=0.146) OR=0.848
	Occasional	1170	179(15.30)	
Floor washings frequency	Once-a-day	672	103(15.33)	0.938 (P= 0.333) OR=1.130
	Twice-a-day	1883	260(10.18)	
Feed type	Commercial concentrate	1368	229(16.74)	15.492(P= 0.000) OR=1.6
	TMR	1187	134(11.29)	
Shed type	Environmentally controlled	205	(28.29)	36.278(P=0.000) OR=2.645
	Open shed	2350	(12.98)	
Floor grooves pattern	Horizontal grooves	1968	247(12.55)	19.287(P=0.000) OR=0.583
	Vertical grooves	587	116(19.76)	
Bunker type	Sand bunkers	2350	305(12.98)	36.278(P=0.000) OR=0.378
	Rubber mattress	205	58(28.29)	

Similar assessments have been reported from studies in China (Chapinal *et al.*, 2014) and the United Kingdom (Barker *et al.*, 2010). In the present study, the prevalence of lameness was higher in cows with a lower body condition score (≤ 2.75) than in cows with a higher body condition score was similar to the results of (Dippel *et al.*, 2009) who reported low body condition scores of 1.25-2.5 for Holstein-Friesian cows were at high stakes for becoming lame. (Green *et al.*, 2014) reported the highest average prevalence of 45% in BCS 2.5.

The prevalence of lameness was higher in 2nd and 3rd lactation cows was also consistent with (Sanders *et al.*, 2009) who found that lameness increases as parity increases and incidence is lower at the start of lactation and increases as lactation progresses. Similarly, an increased incidence of hoof damage has been reported in cows and buffaloes above 2nd and 3rd lactation, respectively (Bagate *et al.*, 2012). As the parity increases, the animals undergo more phases of transition in their life, which has an impact on the health of the hooves and also on the process of keratinization. This indicates that parity has a significant effect on hoof disorders.

Sole ulcer (SU), sole hemorrhage (SH), white line disease (WLD) and interdigital dermatitis (IDD) were the causes of lameness involving hooves. Likewise, Green *et al.* (2014) reported that the most common causes of lameness were SU (39%), SH (13%), DD (10%) and WLD (8%). Similarly, Bielfeldt *et al.* (2005) reported sole

disorders (15.7%), WLD (6.1%), heel erosion (13.6%) and skin disorders (5.3%), while Hernandez *et al.* (2002) observed claw lesions (60%), papillomatous DD (31%) and interdigital phlegmon (9%). Claw horn disruption, SU and WLD were the most common causes associated with lameness and involved in significant economic loss (Bicalho and Oikonomou, 2013).

In this study, cows on farms with an annual hoof trimming frequency had 1.7 times higher odds to be lame than cows with twice-a-year hoof trimming. The American Angus Association has indicated that good foot structure is essential to the longevity of animals and that the problem with the claw can affect the structural strength of the hoof. As indicated herein, previous studies (Solano *et al.*, 2015) have also shown the relationship between the overgrown claw and occurrence of lameness. Hygiene and cleanliness on the farm are also associated with the appearance of lameness. According to Relun *et al.* (2013), the prevalence of claw lesions was associated with dirty leg hygiene and an overgrown claw. Poor leg hygiene increases the development of infectious lesions or claw horns by exposing the feet to manure and moisture, which affects the health of the claws. Cows housed on wet litter were 2.5 times more likely to be lame than those housed on dry litter (Jewell *et al.*, 2019). According to experiments conducted by Gregory (2004) and Gregory *et al.* (2006), exposure of cow's hooves to urine and fecal contamination causes the hoof to swell and soften.

Moreover, prevalence of lameness was significantly associated with the seasons of the year; highest in wet summer while lowest in spring was in agreement with Sanders *et al.* (2009) who reported overall prevalence of 49.1%, with highest prevalence in summer season. The reason for the high prevalence during the summer season could be attributed to excessive use of showers, which makes the ground wet and the hooves soften, and more prone to lameness.

An increase in the prevalence of lameness in cows in environment-controlled barns has been reported compared to open barns. This high prevalence in cows in controlled housing could be due to the reason of poor ventilation, increased humidity and an increased drainage problem, resulting in wetter floor than open sheds. In addition, an increased prevalence of lameness was observed in cows kept on a rubber mattress rather than in sand bunkers. Soft bedding provides enough rest time for cows and minimizes the risk of lameness (Cook and Nordlund, 2009). Although healthy cows benefit from additional comfort on soft rubber bedding, but for lame cows, rubber mattress become a significant risk factor for increased severity of lameness due to time spent by cows standing rather than sitting on rubber mattress. In this case, the provision of soft bedding such as sand bunkers provides adequate soft bedding for cows to rest and, therefore, reduces the severity of lameness (Cook and Nordlund, 2009). Our results are also in agreement with others (Chapinal *et al.*, 2013; Solano *et al.*, 2015; Cook *et al.*, 2016) who reported that cows housed in sand bunkers were less prone to lameness than those kept on mattresses.

CONCLUSION

This is apparently the very first study to determine the prevalence and associated risk factors for lameness in commercial dairy herds in Punjab, Pakistan. Study finds lameness and hoof disorders to be significant health concerns in commercial dairy herds and exploit a wide range of risk factors of lameness related to cow, management, environment and facility design. Dairy producers need to improve the body condition score and cow management during the first two lactations. In addition, lameness and hoof disorders could be reduced through enhanced farm hygiene, foot dipping routine, feeding practices, hoof trimming frequency and better facility design. The knowledge and information generated should be disseminated to farmers and veterinary practitioners for better implementation. Further studies are suggested to investigate herd-cow-level lameness prevalence and risk factors on corporate and smallholder dairy farms, including native breeds.

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Statement of conflict of interest

The authors have declared no conflicting interest.

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