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Prevalence and Risk Factors of Lameness and Its Underlying Causes in Lactating Dairy Cows in Bangladesh

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Title: Prevalence and Risk Factors of Lameness and Its Underlying Causes in Lactating Dairy Cows in Bangladesh

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Abstract

Lameness is one of the most significant health, welfare, and productivity challenges in dairy cattle; however, structured epidemiological data from Bangladesh remains scarce. This cross-sectional study estimated the prevalence of lameness, identified associated cow- and management-level risk factors, and documented its underlying causes in lactating dairy cows managed under tie-stall systems. The study was conducted between July 2023 and June 2024 in Shahjadpur Upazila, Sirajganj District, a major milk-producing region of Bangladesh. A total of 643 crossbred (Holstein-Friesian × indigenous zebu) lactating cows from 60 MilkVita-affiliated farms were evaluated using a standardized 5-point locomotion scoring system. The overall cow-level prevalence of lameness was 21.69% (95% CI: 18.6–24.9%). Hind limbs were significantly more affected than forelimbs ($p = 0.005$). Farmers consistently underestimated lameness prevalence compared with veterinary assessment (median: 14.25% vs. 21.82%). Multivariable logistic regression identified higher parity (>4) (OR = 2.31), active milking status (OR = 1.87), increased

milking frequency (>2 times/day) (OR = 2.14), low body condition score (<2.5) (OR = 3.76), and concentrate-plus-roughage feeding system (OR = 2.02) as independent risk factors ($p < 0.05$). Claw horn lesions, particularly sole ulcers and white line disease, were the predominant underlying causes. These findings indicate that lameness remains moderately prevalent in smallholder dairy systems in Bangladesh and is strongly influenced by metabolic stress and management practices. Targeted nutritional management, body condition monitoring, and improved farmer awareness are essential to reduce lameness burden and enhance dairy cow welfare and productivity.

Keywords: Lameness; Dairy cattle; Prevalence; Risk factors; Animal welfare; Bangladesh

1. Introduction

Lameness is one of the most important health, welfare, and economic challenges affecting dairy cattle worldwide. It is a multifactorial condition characterized by abnormal gait resulting from pain or dysfunction of the locomotor system, most commonly associated with claw horn lesions and infectious hoof disorders [1,2]. In intensive dairy systems, cow-level prevalence typically ranges from 10% to 35%, with herd-level averages around 20–25% [2,3]. Lameness severely compromises animal welfare by causing persistent pain and restricted mobility and is associated with reduced milk yield, impaired reproductive performance, increased treatment costs, and premature culling [4,5]

Although lameness has been extensively studied in Europe and North America, epidemiological data from developing countries remain comparatively limited. In tropical and subtropical dairy systems, reported prevalence commonly ranges between 12% and 25%, though considerable variation exists due to differences in housing systems, nutrition, breed composition, and diagnostic criteria [6,7]. Across these systems, claw horn lesions particularly sole ulcers and white line disease—are consistently identified as the predominant underlying causes [1]. Furthermore, farmer under-recognition of mild and moderate lameness is widely documented, leading to delayed detection and progression to chronic lesions [8].

Bangladesh represents a rapidly transforming dairy sector within South Asia. Dairy production is predominantly smallholder-based, accounting for more than 80% of total milk production, with farms typically maintaining 2–15 crossbred cows under semi-intensive or confined tie-stall systems [9,10]. Cooperative networks such as MilkVita have expanded milk marketing

63 infrastructure and encouraged the adoption of high-yielding Holstein-Friesian × indigenous zebu
64 crossbreds to meet growing urban demand [9]. While these crossbreds enhance milk production
65 potential, they are more susceptible to metabolic imbalance and claw horn disruption when
66 managed under nutritionally and structurally constrained conditions.
67 Tie-stall housing systems, commonly used in Bangladesh, typically feature concrete flooring,
68 limited exercise, and prolonged standing. Such conditions increase mechanical loading on the
69 claws and predispose cows to claw horn lesions. Biomechanical studies demonstrate that the hind
70 limbs bear greater weight during standing and locomotion, explaining the predominance of hind-
71 limb lameness in confined systems [11]. Field-based welfare assessments in Sirajganj district, one
72 of the country's major milk-producing regions, have highlighted deficiencies in stall design,
73 bedding, drainage, and hygiene, all recognized risk factors for lameness development [12]
74 Metabolic and nutritional factors further increase the risk of lameness in crossbred lactating cows.
75 High-producing animals frequently experience negative energy balance during early lactation.
76 Reduced body condition score (BCS) has been linked to decreased digital cushion thickness,
77 reduced shock-absorption capacity, and increased susceptibility to claw horn lesions [13,14]. In
78 Bangladeshi smallholder systems, concentrate-plus-roughage feeding regimens are common, and
79 inconsistent fiber balance may predispose cows to subclinical ruminal acidosis, a recognized
80 precursor of laminitis and claw horn disruption [1]. Higher parity further increases risk due to
81 cumulative mechanical trauma and degenerative claw changes across successive lactations.
82 Despite these established risk pathways, structured herd-level epidemiological studies on lameness
83 prevalence, associated risk factors, and underlying causes in Bangladesh remain scarce. Existing
84 national reports largely emphasize milk production trends rather than animal health and welfare
85 indicators [10]. Moreover, farmer awareness and perception of lameness burden in Bangladeshi
86 dairy systems have not been systematically quantified, although evidence from other regions
87 indicates substantial underestimation by producers [8].
88 Given the rapid intensification of dairy farming in Bangladesh and the increasing reliance on high-
89 yielding crossbred cows managed under confined tie-stall conditions, a comprehensive field-based
90 epidemiological assessment is essential. Therefore, the present study aimed to (1) estimate the
91 cow-level prevalence of lameness in lactating dairy cows in a major milk-producing region of
92 Bangladesh, (2) identify associated cow- and management-level risk factors using multivariable

logistic regression analysis, and (3) characterize the predominant underlying causes of lameness under smallholder production conditions.

2. Materials and Methods

2.1 Study design and study area

A cross-sectional study was conducted between July 2023 and June 2024 in Shahjadpur Upazila, Sirajganj district, Bangladesh, one of the country's largest milk-producing regions. The cross-sectional design was selected to estimate the point prevalence of lameness and to evaluate associated cow-level and management-related risk factors under field conditions. Cross-sectional studies are widely used in veterinary epidemiology to measure disease burden and explore associations between outcomes and exposures at a defined time point [15,16]. The study area is characterized by a high density of small- to medium-scale dairy farms operating predominantly under tie-stall housing systems, with crossbred (Holstein-Friesian × indigenous zebu) lactating cows managed under semi-intensive feeding and confined housing conditions.

2.2 Study population and sampling

The study population consisted of lactating dairy cows from MilkVita-affiliated farms within the selected upazila. A total of 60 dairy farms were included in the survey. Herd sizes ranged between 8 and 15 animals, reflecting the typical smallholder production structure of the region. All lactating cows present on each farm during the visit were examined, resulting in a total of 643 crossbred lactating cows included in the study. Farms were selected based on accessibility, active milk supply to MilkVita, and the owner's willingness to participate. Within each selected farm, a census approach was used, in which all eligible lactating cows were assessed to avoid within-herd sampling bias. Only cows free from severe systemic illness unrelated to locomotor disorders were included in the evaluation.

2.3 Sample size determination

The minimum required sample size for estimating lameness prevalence was calculated using the standard formula for cross-sectional studies:

$$n = \frac{Z^2 \times P_{exp} \times (1 - P_{exp})}{d^2}$$

where:

n = required sample size

Z = Z statistic for 95% confidence level (1.96)

P_{exp} = expected prevalence

d = desired absolute precision

The expected prevalence (P_{exp}) was assumed to be 20%, based on previous international and Asian prevalence estimates ranging between 15% and 25% [1,6]. A precision level (d) of 5% and a 95% confidence level were applied.

$$n = \frac{(1.96)^2 \times 0.20 \times (1 - 0.20)}{(0.05)^2}$$

$$n = \frac{3.84 \times 0.16}{0.0025}$$

$$n = \frac{0.6144}{0.0025} = 246$$

Thus, the minimum required sample size was approximately 246 cows. However, to increase statistical power, account for clustering at the farm level, and improve the precision of risk factor analysis, a substantially larger sample (n=643 cows) was included in the study. A larger sample size enhances the reliability of prevalence estimates and strengthens the robustness of multivariable modeling [17].

2.4 Lameness Assessment

Lameness was assessed using the standardized 5-point locomotion scoring system developed by Sprecher et al. [18], which is widely accepted for dairy cattle and validated for epidemiological applications [1,2]. Cows were observed while standing and walking on a flat concrete surface within the farm premises. Scores ranged from 1 (normal gait) to 5 (severely lame). Cows scoring ≥2 was classified as lame for prevalence analysis, consistent with herd-level lameness studies [2].

Two trained veterinarians independently performed locomotion scoring. Prior to data collection, calibration sessions were conducted to harmonize the interpretation of locomotion scores and minimize inter-observer variability. Any discrepancies were resolved through consensus evaluation. For cows classified as lame, detailed clinical examination of affected limbs was conducted to identify probable underlying causes, including sole ulcers, white line disease, digital dermatitis, interdigital lesions, and traumatic injuries.

2.5 Body Condition Scoring

Body Condition Score (BCS) was assessed using a standardized 1-5 scoring scale with 0.25 increments, as described by Edmonson *et al.* (1989). For statistical analysis, BCS was categorized into two groups: <2.5 (low body condition) and ≥2.5 (adequate body condition). The cut-off of 2.5 was selected based on evidence linking reduced BCS to decreased digital cushion thickness and increased risk of claw horn lesions [13,14]

2.6 Data Collection

Data were collected through structured questionnaires and direct farm observations. Face-to-face interviews were conducted with farm owners or managers to obtain information on cow-level and management-related variables. Cow-level variables included age, parity, pregnancy status, milking status, milking frequency, and BCS. Management-level variables included herd size, feeding system (concentrate with roughage vs total mixed ration), use of rubber mats in stalls, and foot-dipping routine. Additionally, farmers were asked to estimate the number of lame cows in their herd to compare producers' perceptions with veterinary assessments.

2.7 Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version XX (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to calculate overall lameness prevalence and limb distribution. Univariable associations between lameness and categorical explanatory variables were evaluated using the Chi-square (χ^2) test. Variables with $p < 0.20$ in univariable screening were considered eligible for multivariable logistic regression modeling [15].

A multivariable logistic regression model was constructed to identify independent risk factors for lameness. Lameness status (0 = non-lame, 1 = lame) was used as the dependent variable. Adjusted

odds ratios (OR) with 95% confidence intervals (CI) were calculated. Backward stepwise elimination was used to derive the final model, retaining variables with $p < 0.05$. Statistical significance was set at $p < 0.05$.

2.8 Ethical Considerations

Farm owners provided informed verbal consent prior to participation. Ethical approval was obtained from the Animal Welfare and Experimentation Ethical Committee (AWEEC), Bangladesh Agricultural University (Approval No. AWEEC/BAU/2023(2)/48(A); approved on 05/02/2023).

3. Results

3.1 Overall Prevalence of Lameness

Among the 643 lactating dairy cows examined, 137 were classified as lame (locomotion score ≥2), resulting in an overall cow-level prevalence of 21.69% (95% CI: 18.6–24.9%). The remaining 506 cows (78.31%) were classified as non-lame (Table 1).

Table 1. Overall prevalence of lameness in lactating dairy cows (n = 643).

Lameness Grade	No. examined	Proportion (%)
Normal (not lame)	506	78.31
Lame	137	21.69

3.2 Severity Distribution of Lameness

The distribution of locomotion scores among the 137 lame cows is presented in Figure 1. Mild and moderate lameness constituted the majority of cases, whereas severe lameness represented a smaller proportion of affected animals.

3.3 Farmers versus Veterinary Assessment

Herd-level prevalence estimates differed between veterinary assessment and farmer perception (Table 2). Veterinary examination identified a median lameness prevalence of 21.82%, with a range of 5–32.76% across farms. In contrast, farmers reported a lower median prevalence of 14.25%, ranging from 0% to 23.54%.

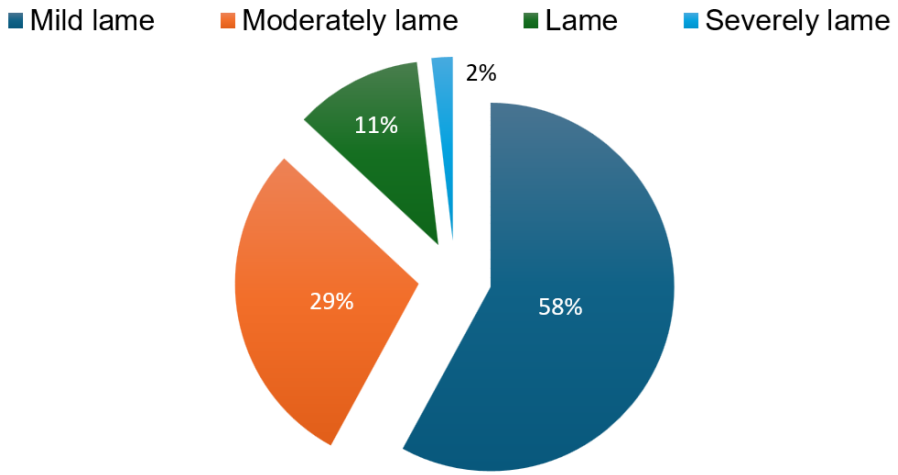


Figure 1. Distribution of lameness severity among affected cows (n = 137).

Table 2. Estimated by farmers and examined by Veterinarians.

Cows	Observer	Ranged prevalence	Median lameness
643	Veterinarians	5 – 32.76	21.82%
	Farmers	0 – 23.54	14.25%

3.4 Limb Distribution

Lameness was significantly more frequent in the hind limbs compared to the forelimbs ($\chi^2 = 5.320$; $p = 0.005$). Hind limb involvement accounted for 13.05% of affected cows, whereas forelimb involvement accounted for 3.57% (Table 3). The left hind limb (6.99%) was the most commonly affected, followed by the right hind limb (6.06%).

Table 3. Limb distribution of lameness among affected cows.

Affected limbs	Number (%) of positive animal	Total positive	X^2 P-value
Right forelimb	8 (1.24)	3.57	X = 5.320 P=0.005
Left forelimb	15 (2.33)		
Right hind limb	39 (6.06)	13.05	
Left hind limb	45 (6.99)		

3.5 Cow-Level Risk Factors

3.5.1 Univariable Analysis

The results of the univariable analysis are presented in Table 4. Significant associations with lameness were identified for parity ($p = 0.036$), milking status ($p = 0.047$), milking frequency ($p = 0.034$), and body condition score ($p = 0.002$). Cows in higher parity categories (>4) showed a greater proportion of lameness compared with first- and second-parity cows. Actively milking cows had a higher prevalence of lameness compared with non-milking cows. Similarly, cows milked more than twice daily had a higher prevalence than those milked twice daily. A low body condition score (<2.5) was strongly associated with lameness. Age and herd size were not significantly associated ($p > 0.05$), while pregnancy status demonstrated a borderline association ($p = 0.068$).

3.5.2 Multivariable Logistic Regression

After adjusting for potential confounders, the following variables remained independently associated with lameness. Variables with $p < 0.20$ in univariable screening were included in the multivariable logistic regression model. After adjusting for potential confounders, five variables remained independently associated with lameness (Table 5). Cows with parity >4 had significantly higher odds of lameness compared with cows in parity 1–2 (Adjusted OR = 2.31; 95% CI: 1.28–4.18; $p = 0.005$). Actively milking cows were 1.87 times more likely to be lame compared with non-milking cows (95% CI: 1.04–3.35; $p = 0.037$). Increased milking frequency (>2 times/day) was associated with higher odds of lameness (OR = 2.14; 95% CI: 1.18–3.87; $p = 0.012$). Low body condition score (<2.5) showed the strongest association, with affected cows having nearly 4 times the odds of lameness compared with cows with BCS ≥2.5 (OR = 3.76; 95% CI: 1.89–7.48; $p < 0.001$). The feeding system was also independently associated with cows fed concentrate plus roughage, showing higher odds of lameness compared to those fed total mixed ration (OR = 2.02; 95% CI: 1.14–3.59; $p = 0.016$).

3.6 Management-Related Risk Factors

Management-level associations are summarized in Table 6. The feeding system was significantly associated with lameness ($p = 0.005$). Cows receiving concentrate with roughage exhibited a higher prevalence compared with cows fed a total mixed ration (TMR). In contrast, use of rubber mats ($p = 0.37$) and foot-dipping routine ($p = 0.145$) were not significantly associated with lameness in univariable analysis.

Table 4. Cow-level risk factors associated with lameness (n=137).

Risk factors	**Category**	**Prevalence**	**X^2**	p-value
Age	< 2 years	2.95	1.380	0.368
	>/=2 years	13.66		
Herd size	10 to 20	2.49	1.576	0.623
	21 to 30	7.93		
	>30	6.22		
Pregnancy	Pregnant	12.28	3.108	0.068
	None pregnant	4.36		
Parity	1-2	1.24	3.879	(P=0.036)
	3-4	5.60		
	>4	9.80		
Milking status	Milking	11.20	2.724	0.047
	Non milking	5.44		
Milking frequency	2 / day	10.28	4.51	0.034
	>2 / day	96		
BCS	<2.5	72	12.08	0.002
	>2.5	35		

Table 5. Multivariable logistic regression analysis of risk factors associated with lameness.

Variable	**Adjusted OR**	**95% CI**	**p-value**
Parity (>4 vs 1–2)	2.31	1.28–4.18	0.005
Milking status (Milking vs Non-milking)	1.87	1.04–3.35	0.037
Milking frequency (>2/day vs 2/day)	2.14	1.18–3.87	0.012
BCS (<2.5 vs ≥2.5)	3.76	1.89–7.48	<0.001
Feed type (Concentrate+roughage vs TMR)	2.02	1.14–3.59	0.016

Table 6. Management-related risk factors associated with lameness in cow (n=137).

Risk factors	Category	Prevalence (%)	X^2	P-value
Feed types	Concentrate with roughage	78 (12.13)	0.983	0.005
	TMR	29 (4.51)		
Use rubber mat	Yes	34 (5.29)	1.967	0.37
	No	73 (11.35)		
Foot dipping routine	Occasional	46 (7.15)	2.132	0.145
	No	61 (9.49)		

Feed type was significantly associated with lameness (p = 0.005). Rubber mat use (p = 0.37) and foot-dipping routine (p = 0.145) were not significantly associated.

3.7 Underlying causes of lameness

The distribution of underlying causes of lameness is presented in Figure 2. Claw horn lesions, including sole ulcers and white line disease, constituted the majority of cases, followed by infectious conditions such as digital dermatitis. Traumatic injuries represented a smaller proportion of identified causes.

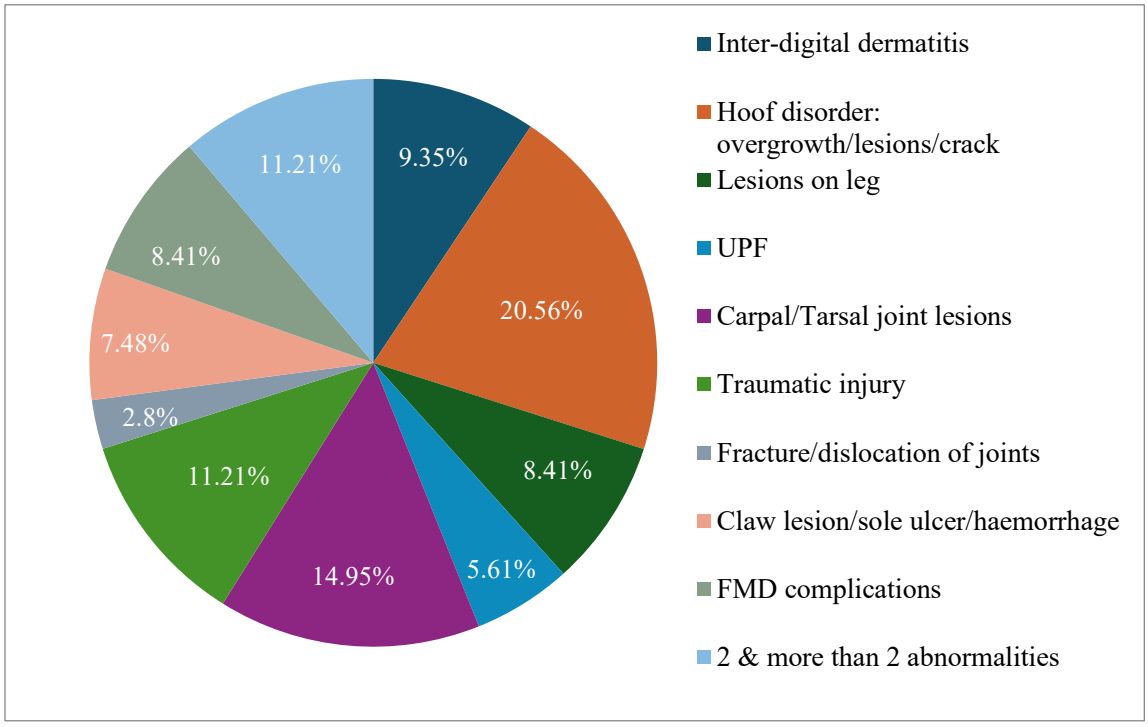


Figure 2. Causes underlying lameness of dairy cows in Bangladesh.

4. Discussion

The present study demonstrates that lameness affects approximately 1 in 5 lactating cows in tie-stall dairy systems in Bangladesh. The observed prevalence (21.69%) aligns with global reports on confined housing systems, where lameness prevalence typically ranges from 15% to 30% [1,2]. The magnitude suggests that lameness represents a substantial welfare and productivity concern in smallholder dairy farms.

The predominance of mild-to-moderate lameness cases indicates that locomotor impairment often persists at early stages. Similar patterns have been reported in herd-level surveys where mild cases dominate but frequently progress without intervention [4,2]. Early detection is therefore critical for preventing chronic claw damage.

Farmers' consistent underestimation of lameness prevalence confirms findings from previous studies showing producers' poor recognition of mild lameness [19]. Failure to detect early-stage lameness delays treatment and exacerbates economic losses. The significantly higher prevalence in hind limbs is consistent with biomechanical evidence that rear claws bear greater weight and experience higher loading forces, particularly in confined housing systems [11,20]. Prolonged standing on concrete flooring further increases shear stress on posterior claws.

Parity emerged as an independent risk factor, with cows in higher parities showing over twice the odds of lameness. This supports the cumulative trauma hypothesis, whereby repeated lactations lead to progressive claw horn damage [5]. Milking status and increased milking frequency were also independently associated with lameness. Increased standing time during milking has been linked to elevated claw horn disruption and laminitic changes [21]. Lactation itself imposes metabolic demands that may predispose cows to hoof lesions.

The strongest association was observed with low BCS. Cows with BCS <2.5 had nearly four times higher odds of lameness. Reduced body condition is associated with decreased digital cushion thickness, reduced shock-absorption capacity, and increased susceptibility to claw horn lesions [13,14]. This finding underscores the importance of maintaining adequate energy balance in lactating cows. Feed type was independently associated with lameness, suggesting nutritional management plays a significant role. Diets not properly balanced for fiber and energy may predispose cows to subclinical ruminal acidosis, a known risk factor for laminitis and claw horn disruption [1].

The lack of association with rubber mats and foot-dipping may reflect inconsistent application or inadequate quality rather than true ineffectiveness. Properly implemented flooring improvements and hoof hygiene programs have been shown to reduce lameness in other production systems [22]. The predominance of claw-horn lesions as underlying causes confirms that mechanical and metabolic stressors are primary drivers of lameness in tie-stall systems. Similar lesion patterns have been reported in confined dairy systems worldwide [23].

5. Conclusion and recommendation

This study demonstrates that lameness is a moderately prevalent condition affecting approximately one in five lactating dairy cows managed under tie-stall housing systems in Bangladesh. Hind limbs were significantly more affected than forelimbs, reflecting the biomechanical and management-related pressures characteristic of confined production systems. Independent risk factors identified in this study included higher parity, active milking status, increased milking frequency, low body condition score, and feeding system, highlighting the combined influence of physiological stress and management practices on lameness occurrence. Furthermore, the consistent underestimation of lameness prevalence by farmers suggests gaps in early recognition, particularly for mild and moderate cases, which may delay timely intervention and increase the risk of chronic claw damage.

To reduce the burden of lameness in smallholder dairy systems, targeted preventive strategies are required. These should include improved nutritional management to maintain optimal body condition, balanced feeding practices to minimize metabolic stress, routine locomotion scoring to detect early, and strengthened farmer awareness and training programs. Implementation of structured hoof health management and evidence-based extension support through cooperative networks could substantially improve dairy cow welfare, productivity, and longevity in Bangladesh.

6. Conflict of interest

There is no conflict of research interest.

7. Acknowledgements

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8. Funding sources

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9. Data availability

The datasets generated during the current study are available from the corresponding author on reasonable request

10. Author's contribution

S. Akter Shanta and M. Ariful Islam contributed to the conception and design of the study. Data collection was conducted by S. Akter Shanta, Mst. Tahomina Akter, Md. Siam Ahmed, and M. Aktaruzzaman. Data analysis performed by A. K. M. Anisur Rahman and S. Akter Shanta. The first draft was prepared by S. Akter Shanta, M. Ariful Islam, and A.K.M. Anisur Rahman. Review and editing were performed by M. Ariful Islam, S. Akter Shanta, and A. K. M. Anisur Rahman. All authors read and approved the final manuscript

11. Consent to publish declaration

Not applicable

12. References

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