Prevalence of Lumpy Skin Disease in Cattle at Netrokona sadar in Bangladesh

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ABSTRACT

Cattle farming is a significant contributor to the socio-economic development of Bangladesh. However, infectious diseases continuously challenge cattle farming, causing tremendous losses to farmers. Among the diseases, Lumpy Skin Disease (LSD) has become a major burden in recent years. This study was conducted to reveal the prevalence of LSD in cattle in Netrokona Sadar Upazila. Data were collected directly from the cattle farmers at Upazila Veterinary Hospital (UVH), by visiting farms, and retrospectively from the register book of UVH from November 2022 to October 2023. Of the total of 2511 observed cattle, the prevalence of LSD was the second highest (16.97%). We further investigated the prevalence of LSD according to age, sex, breed, season, vaccination status, nutrition, hygiene, and deworming. LSD was more prevalent in young (17.67%), females (18.25%), cross-breed (23.96%), and non-vaccinated (17.28%) cattle. A higher prevalence was also found in the summer (38.77%) than in other seasons. Furthermore, we found more prevalence in cattle provided with traditional diets (18.22%), in unhygienic management (17.33%), and non-dewormed (18.63%) cattle. The findings illustrated that sex, immunization status, season of the year, and diet were significantly (p<0.01) associated with the prevalence of LSD. The study will aid stakeholders in evaluating the current state of LSD in the area and developing effective control strategies against it.

INTRODUCTION

The livestock sector is one of the most contributing sectors in Bangladesh, which ensures food security alongside agriculture. It contributes 1.80% to the gross domestic product (GDP), with a GDP growth rate of 3.23% (DLS 2023). However, every year, this sector is facing a continuous outbreak of different infectious diseases, leading to production loss as well as mortality in livestock. These diseases create financial burdens for farmers. Among these diseases, Lumpy Skin Disease (LSD) is one of the most significant emerging diseases in cattle and buffalo (El-Nahas et al., 2011). LSD virus is a double-stranded DNA (dsDNA) poxvirus belonging to the genus Capripoxvirus and spreads by arthropod bites and indirect contact (Nesterov et al., 2022; Sprygin et al., 2019). However, transmission through contaminated feed and water or direct contact was rarely reported (Ali et al., 2012). It is a transboundary viral disease of cattle and buffalo that originated in Africa, was first documented in Zambia in 1929 (MacDonald, 1931), and is endemic in several regions of the world, including Africa, Europe, the Middle East, and South Asia (Haig, 1957; Tuppurainen and Oura, 2014). Among South Asian countries, this disease has spread throughout the Indian subcontinent, including Bangladesh (Azeem et al., 2022). Since the first LSD case was reported on September 15, 2019 in Chattogram (Kayesh et al., 2020), it is now prevalent throughout the country.

Bangladesh has a widely distributed cattle population (24.86 million) and LSD is one of the most economically important emerging livestock diseases (DLS 2023). The disease affects animals' lymph nodes, causing them to enlarge and appear as 2–5 cm-diameter lumps. Warning signs include high temperature, milk supply drop, nasal and ocular discharge, salivation, appetite loss, depression, damaged hides, and emaciation. (Datten et al., 2023). The morbidity rate varies from 3 to 85% with a 1 to 3% mortality rate (Tuppurainen and Oura, 2012). The climatic conditions of Bangladesh are favorable for LSDV-transmitting vector propagation, which influences the rapid transmission of LSD in the cattle population (Kayesh et al., 2020). Eventually, farmers face widespread financial loss due to sharp decreases in milk production, long-term treatment costs, and post-infection reproductive difficulties.

LSD is highly prevalent in the neighboring areas of Netrokona Sadar Upazila (Chouhan et al., 2022). There have been documented LSD cases in the study area by the Upazilla Livestock Officer (ULO) and Veterinary Surgeon (VS) but have no research on this area yet. Given the preceding facts and the current situation, this study was designed to determine the prevalence of LSD in cattle in Netrokona Sadar Upazila, Bangladesh. This study will assist all stakeholders in assessing the current situation of LSD in the study area. Moreover, the findings of the study will help the stakeholders formulate effective control strategies against LSD.

MATERIALS AND METHODS

Study area and duration

The study was conducted in the Netrokona Sadar Upazila in Bangladesh (Figure 1). It is located between 24°47' and 24°58' north latitudes and between 90°38' and 90°50' east longitudes. (Banglapedia). This study was conducted from October 1st, 2022, to October 30th, 2023, a one-year duration.

Sample and sample size

During the study period, a total of 2511 cattle with different diseases were considered the sample size. Different variable data, including the cattle's age, sex, breed, vaccination status, season of the year, and management practices, were collected only for LSD-affected cattle. The data on vaccination with the goat pox vaccine was considered to determine the vaccination history.

Data Collection

Data were collected directly from the owner of the examined animal with consent from the Upazila Livestock Office and Veterinary Hospital, and the farms were visited directly through interviews and clinical examinations (Meher et al., 2017). In addition, information regarding LSD-affected cases was collected from earlier documentation in the UVH registration book.

Diagnosis by Clinical Examination

A close inspection was done carefully to observe the clinical signs (Meher et al., 2017), which included skin nodules, a typical fever for three days, and a marked decrease in milk production (in the case of lactating cattle). Moreover, other clinical signs, including nasal and ocular discharge, loss of appetite, emaciation, swollen lymph nodes, and skin and oral mucous membrane lesions, were common in LSD and considered for clinical diagnosis (El-Mandrawy and Alam, 2018).

Statistical Analysis

The R programming language and the software RStudio were utilized to perform statistical analysis. 'gtsummary,' 'gt,' and 'tidyverse' packages were used for data manipulation and table creation. The data were analyzed following Pearson's chi-square test. All p-values < 0.05 were considered statistically significant.

RESULTS

Prevalence of Diseases in the Surveyed Area

The present study was conducted to determine the prevalence of LSD in cattle in Netrokona Sadar Upazila. A total of 2511 disease cases were recorded during the study period, of which 426 were LSD cases (16.97% prevalence). The prevalence of naval illness, FMD, PPR, and other infectious diseases was 39.94%, 16.17%, 11.83%, and 15.09%, respectively (Figure 2).
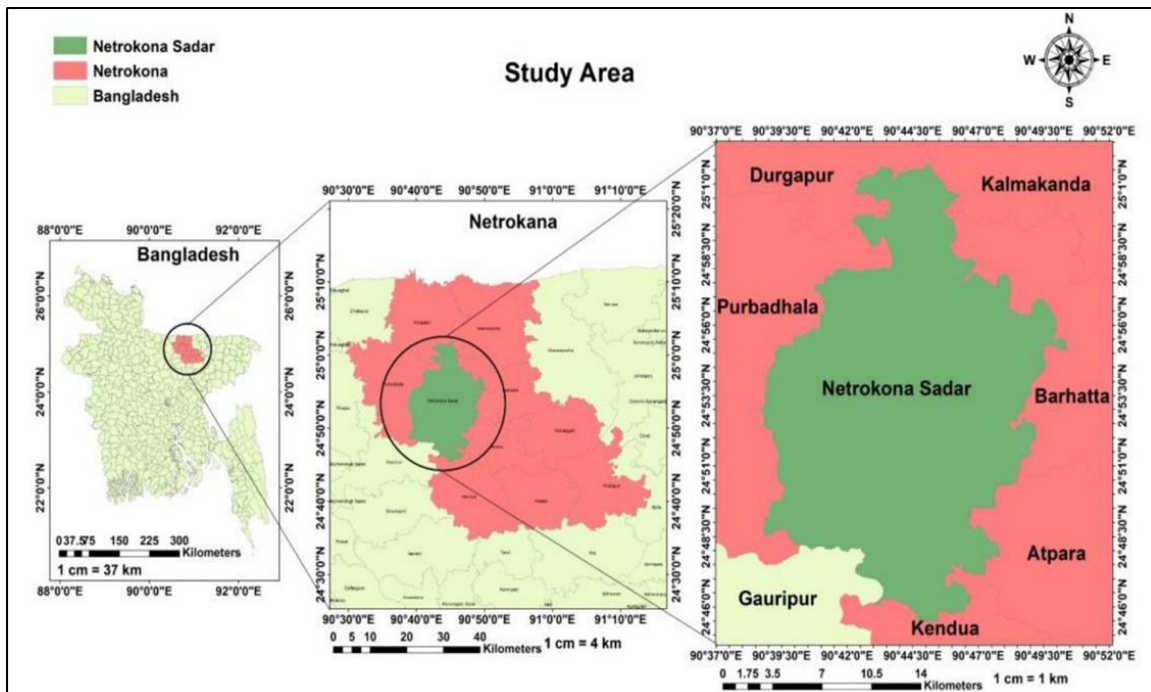

Figure 1. Map showing the study area (Netrokona Sadar Upazila, Bangladesh)
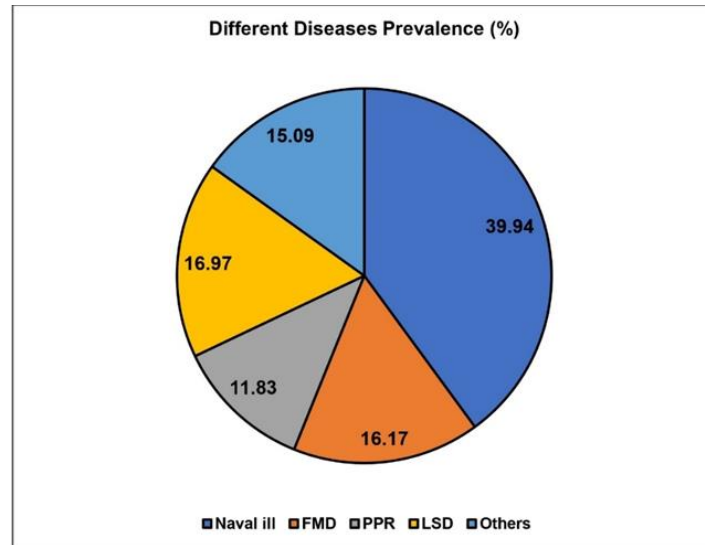
Figure 2. Prevalence of different diseases in the study area

Age-wise LSD prevalence

Based on age, we divided the cattle into two groups: young (0–12 months) and adult (greater than 12 months) (Figure 3). We found young cattle were affected more by LSD than adults. The percentage of diseased young cattle was lower than the percentage of LSD-infected young cattle, whereas the percentage of diseased adult cattle was greater than the percentage of LSD-infected adult cattle (Figure 3A). LSD prevalence was also higher in young cattle than in adults (Figure 3B). The age of cattle had no significant association with LSD prevalence ($p = 0.10$).
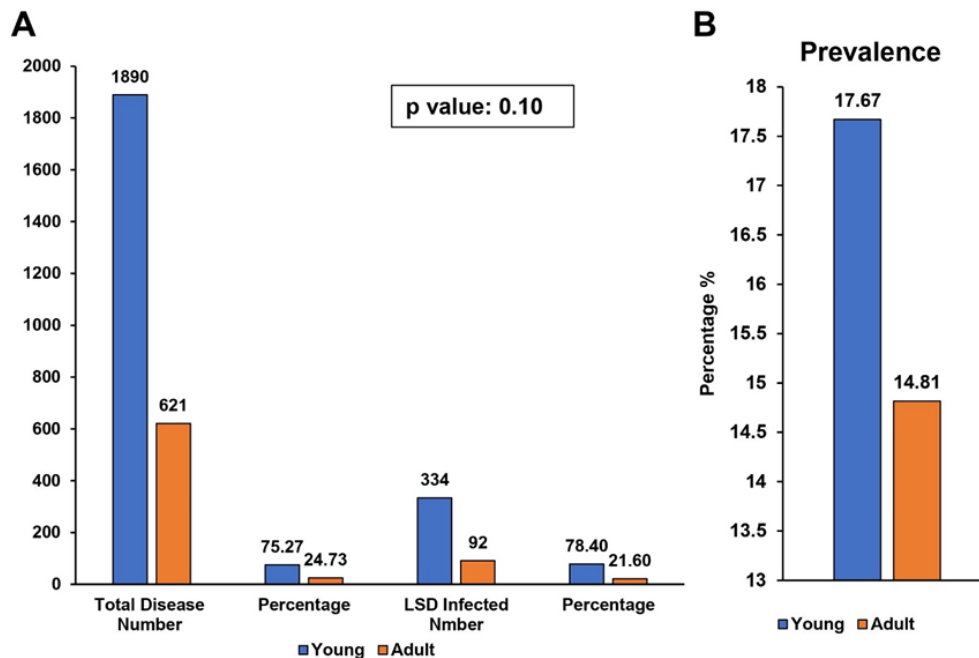

Figure 3. Prevalence of LSD in different age groups in the study area. A) Total cattle and infected cattle number with a percentage. B) Prevalence of LSD between young and adult cattle. p-value (<0.05) was considered statistically significant.

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Sex-wise LSD prevalence

The study identified that female cattle were affected by LSD in greater numbers than male cattle. The percentage of diseased female cattle was lower than that of LSD-infected female cattle, while the percentage of diseased male cattle was higher (Figure 4A). LSD prevalence was considerably higher in female cattle than males (Figure 3B). Cattle sex was significantly associated with LSD prevalence (p<0.01).

Figure 4. Prevalence of LSD between male and female cattle in the study area**.** A) Total cattle and infected cattle number with a percentage. B) Prevalence of LSD between male and female cattle. p-value (<0.05) was considered statistically significant.

Breed-wise LSD prevalence

The breed of cattle is one of the important factors in infectious disease. So, we studied the breed-wise LSD-infected number and prevalence. We found a higher LSD-infected number in the local cattle breed than the cross-breed. The percentage of diseased local cattle was lower than that of LSD-infected local breeds, while the percentage of diseased cross-breed cattle was higher (Figure 5A). However, cross-breeding had a higher prevalence than local breeds (Figure 5B).

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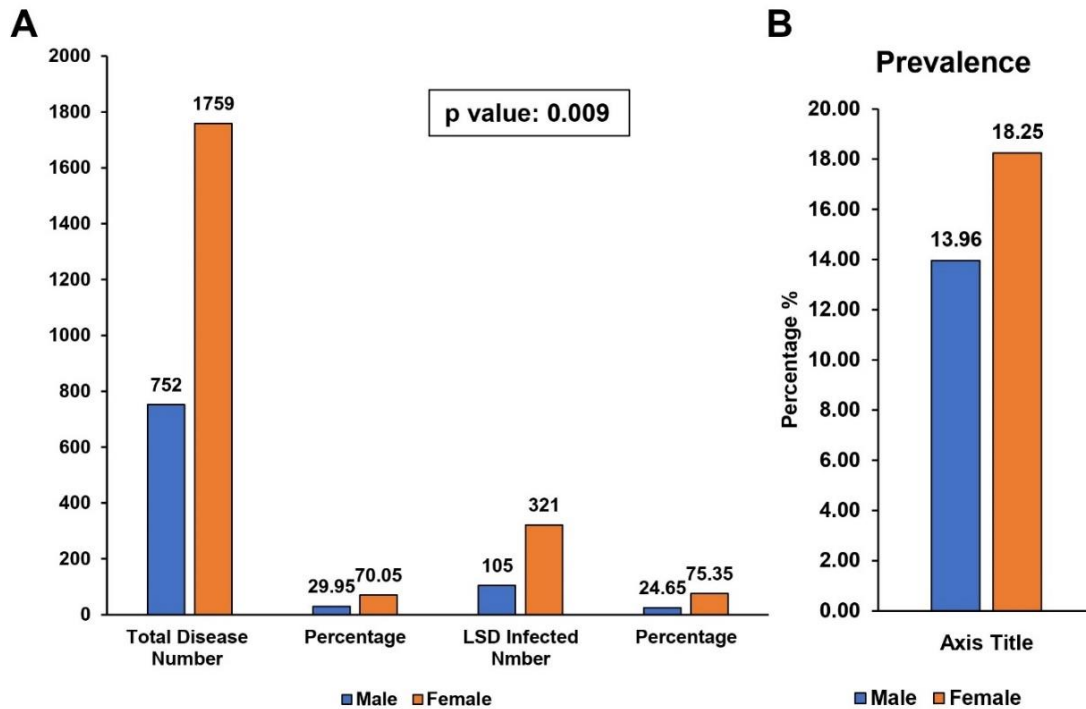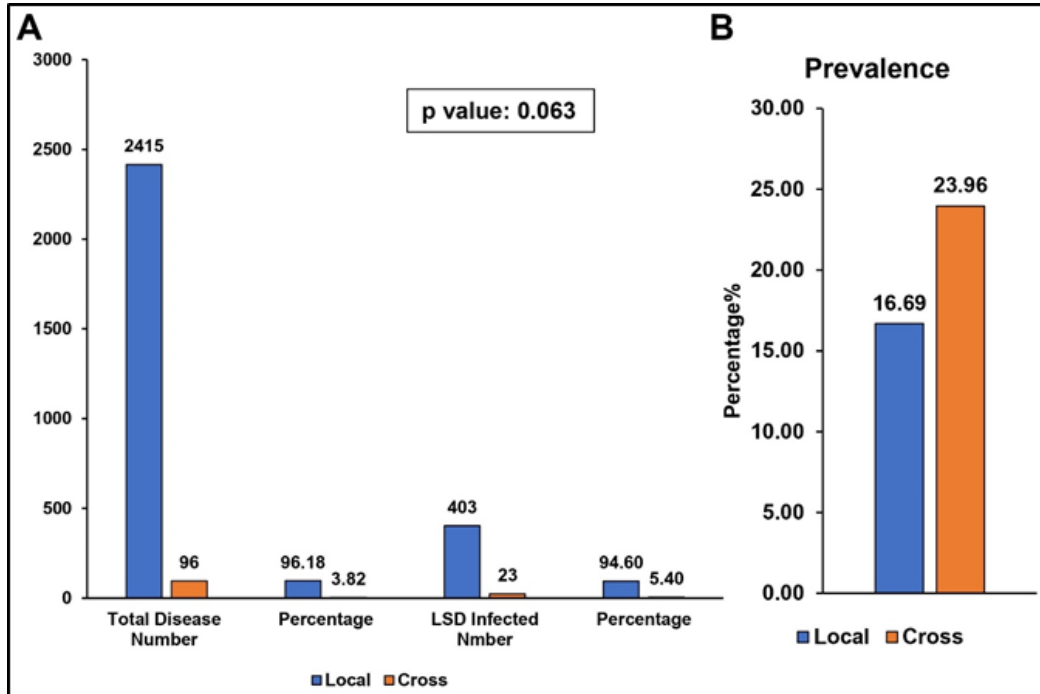
Figure 5. Prevalence of LSD between local and cross-breed cattle in the study area**.** A) Total cattle and infected cattle number with a percentage. B) Prevalence of LSD between local and cross breed. p-value (<0.05) was considered statistically significant.

Immunization-wise, LSD prevalence

As there were no licensed vaccines for preventing LSD in cattle, numerous farmers vaccinated their cattle with the goat pox vaccine to reduce the loss. We found a higher LSD-infected number in the non-vaccinated cattle than in the vaccinated cattle. The percentage of diseased vaccinated cattle was higher than that of LSD-infected local breeds, while the percentage of diseased non-vaccinated cattle was higher. Non-vaccinated cattle had a higher LSD prevalence than vaccinated ones. Importantly, immunization with the goat pox vaccine had a significant association ($p < 0.01$) with LSD prevalence (Table 1).

Table 1. Prevalence of LSD in cattle in the surveyed area based on immune status

Immunization status	Total Diseased Number	Percentage	No. of LSD Infected	Percentage	Prevalence (%)	*p*-value
Vaccinated	63	2.51	3	0.70	4.76	0.009
Non-vaccinated	2448	97.49	423	99.30	17.28	

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Prevalence based on season

This work categorized the study periods according to season and studied LSD prevalence in different seasons. In spring, the highest percentage of total disease cases was found, while the highest percentage of LSD cases was found in summer, with the highest LSD prevalence. In winter, we found no LSD cases with zero percentage prevalence (Table 2). LSD prevalence had a significant association with seasons (p<0.01).

Table 2. Prevalence of LSD in cattle in the surveyed area in different seasons

Season	Months	Total Disease Number	Percentage	No. of LSD Infected	Percentage	Prevalence	*p*-value
Summer	May- July	717	28.55	278	65.26	38.77	
Fall	August-October	666	26.52	125	29.34	18.77	
Winter	November-January	357	14.22	0	0	0	<0.001
Spring	February - April	771	30.70	23	5.40	2.98	

Prevalence based on Nutrition, Hygiene Practice, and Deworming Status

The present study found a lower LSD-infected percentage in cattle provided with balanced diets, maintained hygiene, and maintained deworming regularly compared to the total disease percentage. The same applied to the prevalence of LSD. Nutrition had a significant association with LSD prevalence (p<0.01), while hygiene and deworming had associations with LSD prevalence but not significantly (Table 3).

Table 3. Prevalence of LSD in cattle in the surveyed area based on different health related practices (Nutrition, Hygiene, Deworming)

Variable	Categories	Total Disease Number	Percentage	No. of LSD Infected	Percentage	Prevalence	*p*-value
Nutrition	Balanced diet	606	24.13	79	18.54	13.04	
	Traditional diet	1905	75.87	347	81.46	18.22	0.003
Hygiene	Maintained	318	12.66	46	10.80	14.47	
	Not maintained	2193	87.34	380	89.20	17.33	0.2
Deworming	Dewormed	1808	72.00	295	69.25	16.32	
	Non-dewormed	703	28.00	131	30.75	18.63	0.2

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DISCUSSION

Lumpy skin disease (LSDV) is a global threat to the cattle industry, with the first case reported in Bangladesh in 2019 (Kayesh et al., 2020). Despite confirmed incidences of LSD by ULO and VS in Netrokona Sadar Upazila, no study has been done to determine its prevalence. The current study was designed to investigate the prevalence of LSD in cattle in this area. The study revealed that LSD was the second most prevalent disease (16.97%) among the diseases found in the surveyed area (Figure 2). However, other authors reported a different prevalence of LSD in different regions of Bangladesh, such as Pory et al. (2021), who found 13.65% in Sylhet, Bangladesh; Hasib et al. (2021), 10% in Chattogram, Bangladesh; Sarkar et al. (2020), 41.06% in Dinajpur, Bangladesh; Haque and Gofur (2020), 49% in Naogaon, Bangladesh; Khalil et al. (2021), 21% in Barishal, Bangladesh; and Islam et al. (2023), 13.62% in Bagerhat, Bangladesh. The prevalence may differ from region to region due to sample size, methodology, and seasonal variation. Importantly, different climatic factors, including temperature, rainfall, and humidity, influence the availability of intermediate hosts and the ecology of the vectors and hosts (Caminade et al., 2019).

The prevalence of diseases also depends on several abiotic factors, including sex, age, nutrition, hygiene, immune status, and breed of animal (Biobaku and Amid, 2018). In our study, the LSD prevalence was higher in young animals than in adults (Figure 3). This finding was similar to the findings of the authors Abera et al. (2019) and Sarkar et al. (2020). This indicated that the very young cattle might have lower immunity to resist infectious disease progress (Vlasova and Saif, 2021). While the authors Elhaig et al. (2017) and Habiba and Aysha (2020) reported that LSD prevalence was higher in adult cattle, this might be due to a lack of vaccination applied to adult cattle and the presence of passive maternal immunity in calves.

As sex is one of the important criteria for disease prevalence, we studied LSD prevalence between the sexes. Importantly, we found higher LSD prevalence in females (Figure 4). Our finding was in line with the findings of Haque and Gofur (2020). Generally, males have much more physical soundness and immunity than females (Ruggieri et al., 2016), and this may be the possible cause of the lower prevalence of LSD in males. On the contrary, Badhy et al. (2021) reported that the prevalence of LSD was higher in males than females. It may be due to exposure to stress factors such as fatigue from heavy work (Abera et al., 2019). But Elhaig et al. (2017), Sameea Yousefi et al. (2017), and Sarkar et al. (2020) found no significant variation between the sexes in their studies. The prevalence of infectious disease varies from breed to breed (Biobaku and Amid, 2018). Our finding showed that crossbred cattle were more susceptible to LSD than indigenous cattle (Figure 5). This result was consistent with the findings of Hasib et al. (2021) and Kiplagat et al. (2020). The higher susceptibility of crossbred cattle might be due to their lower disease resistance capability in comparison to indigenous breeds (Tageldin et al., 2014).

In this study, the prevalence was significantly higher in non-vaccinated cattle (Table 1), which agreed with the findings of Sarkar et al. (2020). In fact, for controlling the LSD, sheep and goat pox virus vaccines have been widely used because the Capripox viruses have the trend to be host-specific yet offer cross-protection within the Capripox virus genus when vaccinations are administered (Tuppurainen and Oura, 2014). Infectious diseases, especially vector-borne, are greatly influenced by the environment and season (Caminade et al., 2019). So, we studied season-wise LSD prevalence, and this study showed a significant seasonal variation in LSD prevalence (Table 2). LSD was found in a higher percentage in the summer, having similarities with the findings of Islam et al. (2023). The authors stated that the outbreak of LSD mostly occurs in the summer season due to moist, warm conditions, which are favorable for the breeding of arthropod vectors. We found higher LSD prevalence among cross-breed (Figure 5) and non-vaccinated animals (Table 1). So, we further studied other health practices that might influence LSD prevalence. We found higher LSD prevalence among those cattle who followed the traditional diet and did not maintain proper hygiene (Table 3). Our findings were in line with the findings of Haque et al. (2021) and Khan et al. (2024). They reported that providing nutritious feed and maintaining hygiene reduced LSD prevalence significantly. Moreover, the cattle with no dewormed history had a higher prevalence (Table 1), and this result agreed with the results of Sarkar et al. (2020).

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CONCLUSION

The findings of the present study demonstrated that sex, immunization status, season of the year, and diet were related to the prevalence of LSD. All the stakeholders, including field veterinarians and policymakers, should consider these factors while formulating and implementing LSD control strategies. Further study should concentrate on the molecular characterization of the entire genome of the local strain of LSDV to produce a suitable vaccine candidate. Moreover, the public and private sectors should work together for the control and eradication of LSD in different parts of Bangladesh.

COMPETING INTEREST

The authors declare that they have no conflict of interest.

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REFERENCE

1. Abera Z, Kabeta T, Abera D, Ayana G, 2019. Survey on Distribution, Associated factors of Lumpy Skin Disease Occurrence and Its Vaccine Efficacy in selected Districts of East Wollega Zone, Western Oromiya. Biomedical Journal 1: 10.
2. Ali H, Ali A, Atta M, Cepica A, 2012. Common, emerging, vector-borne and infrequent abortogenic virus infections of cattle. Transboundary and emerging diseases 59: 11-25.
3. Azeem S, Sharma B, Shabir S, Akbar H, Venter E, 2022. Lumpy skin disease is expanding its geographic range: A challenge for Asian livestock management and food security. The Veterinary Journal, 279: 105785.
4. Badhy SC, Chowdhury MGA, Settypalli TBK, Cattoli G, Lamien CE, Fakir MAU, et al, 2021. Molecular characterization of lumpy skin disease virus (LSDV) emerged in Bangladesh reveals unique genetic features compared to contemporary field strains. BMC Veterinary Research,17: 1-11.
5. Banglapedia. https://en.banglapedia.org/index.php/Netrokona_Sadar_Upazila
6. Biobaku K, Amid S. Predisposing factors associated with diseases in animals in Nigeria and possible botanical immunostimulants and immunomodulators: a review. Bangladesh Journal of Veterinary Medicine 16:87-107
7. Caminade C, McIntyre KM, Jones AE, 2019. Impact of recent and future climate change on vector-borne diseases. Annals of the New York Academy of Sciences, 1436: 157-173.
8. Chouhan CS, Parvin MS, Ali MY, Sadekuzzaman M, Chowdhury MGA, Ehsan MA, Islam MT, 2022. Epidemiology and economic impact of lumpy skin disease of cattle in Mymensingh and Gaibandha districts of Bangladesh. Transboundary and Emerging Diseases, 69: 3405-3418.
9. Datten B, Chaudhary AA, Sharma S, Singh L, Rawat KD, Ashraf MS, Alneghery LM, Aladwani MO, Rudayni HA, Dayal D. 2023. An extensive examination of the warning signs, symptoms, diagnosis, available therapies, and prognosis for lumpy skin disease. Viruses 15: 604

10. DLS 2023, Livestock Economy at a Glance (2023-2024). Available at: https://dls.portal.gov.bd/sites/default/files/files/dls.portal.gov.bd/page/ee5f4621_fa3a_40ac_8bd9_898 fb8ee4700/2023-07-23-12-04-afbcccb96f8b27d4bab6501aa8c2c2ff.pdf. [Accessed 18 August 2024]

11. El-mandrawy SAM and RTM Alam, 2018. Hematological , biochemical and oxidative stress studies of lumpy skin disease virus infection in cattle. Journal of Applied Animal Research, 46: 1073–1077.

12. El-Nahas E, El-Habbaa A, El-Bagoury G and Radwan ME, 2011. Isolation and identification of lumpy skin disease virus from naturally infected buffaloes at Kaluobia, Egypt. Global Veterinaria, 7: 234-237.

13. Elhaig MM, Selim A and Mahmoud M, 2017. Lumpy skin disease in cattle: Frequency of occurrence in a dairy farm and a preliminary assessment of its possible impact on Egyptian buffaloes. Onderstepoort Journal of Veterinary Research, 84: 1-6.

14. Habiba UA, Aysha U. An epidemiological study on lumpy skin disease at Rangunia upazila of Chattogram district. Chattogram Veterinary and Animal Sciences University Chattogram-4225, Bangladesh, 2020.

15. Haig D. Lumpy skin disease. 1957.

16. Haque MH, Roy RK, Yeasmin F, Fakhruzzaman M, Yeasmin T, Sazib MRI, et al, 2021. Prevalence and management practices of lumpy skin disease (LSD) in cattle at Natore District of Bangladesh. European Journal of Agriculture and Food Sciences, 3: 76-81.

17. Haque MN and Gofur MR, 2020. Investigation of lumpy skin disease outbreak in cattle in Naogaon, Bangladesh. Bangladesh Journal of Agriculture and Life Science, 1: 89-93.

18. Hasib FMY, Islam MS, Das T, Rana EA, Uddin MH, Bayzid M, Nath C, Hossain MA, Masuduzzaman M, Das S. 2021. Lumpy skin disease outbreak in cattle population of Chattogram, Bangladesh. Veterinary Medicine and Science 7: 1616-24

19. Islam MA, Harun-Ur-Rashid S, Rahman MG, Azam MG. Prevalence Of Lumpy Skin Disease In Cattle At Kachua Area Of Bagerhat, Bangladesh. IOSR Journal of Agriculture and Veterinary Science 16: 21-26.

20. Kayesh MEH, Hussan MT, Hashem MA, Eliyas M, Anower AM. Lumpy skin disease virus infection: An emerging threat to cattle health in Bangladesh. Hosts and Viruses 2020; 7: 97.

21. Khalil MI, Sarker MFR, Hasib F and Chowdhury S, 2021. Outbreak investigation of lumpy skin disease in dairy farms at Barishal, Bangladesh. Turkish Journal of Agriculture-Food Science and Technology, 9: 205-209.

22. Khan MU, Polash MA-U-Z, Molla A-A, Romance M, Zahan N, Ali MS, Raihan J, Sarker S, Haque MH. 2024. Prevalence and Management Strategies for Lumpy Skin Disease (LSD) in Cattle: Emphasizing a Region-Based Scenario in Bangladesh. European Journal of Veterinary Medicine 4: 1-7

23. Kiplagat SK, Kitala PM, Onono JO, Beard PM and Lyons NA, 2020. Risk factors for outbreaks of lumpy skin disease and the economic impact in cattle farms of Nakuru County, Kenya. Frontiers in Veterinary Science, 7: 259.

24. MacDonald R, 1931. Pseudo-urticaria of cattle. Government of Northern Rhodesia: Department of Animal Health, 20-1.

25. Meher MM, A Hasan and M Afrin, 2018. Field Investigation on Sub-clinical Mastitis in Cows in Different areas of Barisal district in Bangladesh. Turkish Journal of Agriculture - Food Science and Technology, 6: 1159.

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26. Nesterov A, Mazloum A, Byadovskaya O, Shumilova I, Van Schalkwyk A, Krotova A, Kirpichenko V, Donnik I, Chvala I, Sprygin A. 2022. Experimentally controlled study indicates that the naturally occurring recombinant vaccine-like lumpy skin disease strain Udmurtiya/2019, detected during freezing winter in northern latitudes, is transmitted via indirect contact. Frontiers in Veterinary Science 9: 1001426

27. Pory FS, Lasker RM, Islam N and Siddiqui S, 2021. Prevalence of Lumpy Skin Disease at District Veterinary Hospital in Sylhet District of Bangladesh. International Journal of Research and Innovation in Applied Science, 6: 111-115.

28. Ruggieri A, Anticoli S, D'Ambrosio A, Giordani L, Viora M, 2016. The influence of sex and gender on immunity, infection and vaccination. Annali dell'Istituto Superiore di Sanita, 52: 198-204.

29. Sameea Yousefi P, Mardani K, Dalir-Naghadeh B, Jalilzadeh-Amin G, 2017. Epidemiological study of lumpy skin disease outbreaks in North-western Iran. Transboundary and Emerging Diseases, 64: 1782-1789.

30. Sarkar S, Meher MM, Parvez MMM, Akther M, 2020. Occurrences of lumpy skin disease (LSD) in cattle in Dinajpur sadar of Bangladesh. Research in Agriculture Livestock and Fisheries, 7: 445-455.

31. Sprygin A, Pestova Y, Wallace D, Tuppurainen E, Kononov A, 2019. Transmission of lumpy skin disease virus: A short review. Virus Research, 269: 197637.

32. Tageldin MH, Wallace DB, Gerdes GH, Putterill JF, Greyling RR, Phosiwa MN, et al, 2014. Lumpy skin disease of cattle: an emerging problem in the Sultanate of Oman. Tropical Animal Health and Production, 46: 241-246.

33. Tuppurainen ES and Oura CA, 2012. Review: lumpy skin disease: an emerging threat to Europe, the Middle East and Asia. Transboundary Emerging Diseases, 59: 40-8.

34. Tuppurainen E and Oura C, 2014. Lumpy skin disease: an African cattle disease getting closer to the EU. Veterinary Record,175: 300-301.

35. Vlasova AN, Saif LJ, 2021. Bovine Immunology: Implications for Dairy Cattle. Frontier Immunology, 12: 643206.

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