



SEASONAL EPIDEMIOLOGY AND VECTOR ECOLOGY OF  
LUMPY SKIN DISEASE IN SOUTH AND SOUTHEAST ASIA:  
A COMPREHENSIVE REVIEW OF KNOWLEDGE GAPS  
AND FUTURE PERSPECTIVES

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**Summary**

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Lumpy Skin Disease (LSD) is a viral infectious disease of cattle and buffalo caused by a *Capripoxvirus* and mainly spread by biting insects such as mosquitoes, flies, and ticks. First identified in Africa in 1929, it has now become a major transboundary threat in South and Southeast Asia. The disease shows a seasonal pattern, with outbreaks peaking during pre-Monsoon and Monsoon months when warm and humid conditions favor vector multiplication. Climatic factors including temperature, rainfall, and humidity play critical roles in vector abundance and virus transmission, while climate change is likely to expand risk zones further. Despite rising outbreaks, significant gaps remain in understanding LSD. Limited data exist on vector ecology, species-specific transmission roles, and seasonal activity under Asian conditions. Moreover, the absence of climate-integrated prediction models and inadequate information on field-level vaccine efficacy hinder effective control. LSD leads to severe socio-economic impacts such as reduced milk yield, poor animal health, skin damage, and trade restrictions, directly affecting rural farmers. This review emphasises the importance of future research in vector biology, region-specific surveillance, climate-based risk forecasting, and cross-border control measures. Addressing these gaps is vital for improving vaccination, strengthening vector management, and safeguarding livestock production in the region.

**Key words:** climate change, Lumpy Skin Disease (LSD), seasonal epidemiology, vector ecology

INTRODUCTION

Lumpy Skin Disease (LSD) is a vector-borne viral disease of cattle and water buffalo, caused by a *Capripoxvirus* of the *Poxviridae* family, and clinically characterised by fever, widespread skin nodules,

emaciation, reduced milk yield, and abortion (Davies, 1982; Woods, 1988). LSD is primarily transmitted through arthropod vectors, with mosquitoes (*Culex mirificens*, *Aedes natrionus*), biting flies (*Sto-*

*moxys calcitrans*, *Biomya fasciata*), and male ticks (*Rhipicephalus appendiculatus*, *Amblyomma hebraeum*) playing potential roles in its spread; however, their significance may vary by region based on vector density and feeding habits (WOAH, 2010).

LSD was first reported in Zambia in 1929 and later became endemic in most parts of Africa (Tuppurainen & Oura, 2014). It was then reported outside Africa for the first time in Israel in 1989, after which it spread to other countries in the Middle East (Tuppurainen & Oura, 2014). The disease reached Europe in 2015, with the first outbreaks recorded in Eastern Europe (EFSA, 2018). In South Asia, LSD appeared in 2019 and quickly spread across Southeast Asia in 2020 (Roche *et al.*, 2021).

LSD first emerged in South Asia with confirmed cases in Bangladesh in July 2019, followed by India in August 2019, and Sri Lanka later that same year (MALLI, 2019; Sudhakar *et al.*, 2020; DLS, 2021). Subsequent outbreaks were reported in Nepal in June 2020 (Pokharel Dhakal *et al.*, 2024), Bhutan in October 2020 (Rinchen, 2022), and Pakistan in November 2021 (Naveed, 2023). According to the European Food Safety Authority, the peak period for LSD outbreaks in general is during the summer and autumn seasons, typically from April to October (EFSA *et al.*, 2020). However, In South Asia, the highest risk period for LSD outbreaks aligns with the pre-Monsoon (March to May) and monsoon season (June to August) (Pory *et al.*, 2021), when heavy rainfall, elevated humidity, and warm temperatures create ideal environmental conditions for the proliferation of mechanical vectors and virus transmission (Abbasi, 2025). These vectors significantly facilitate the transmission of

Lumpy Skin Disease virus (LSDV) in the region. As a result, LSD prevalence peaks in May-June (Badhy *et al.*, 2021), declines significantly in post-Monsoon (September to November), and remains moderate during the winter (December to February) periods (Syed & Amin, 2016; Pory *et al.*, 2021).

Despite growing awareness, there remains a critical gap in understanding the seasonal epidemiology and vector ecology of LSD in South Asia. Most existing studies focus on clinical management or molecular diagnostics (WOAH, 2010), with limited attention to how seasonal changes and vector dynamics influence disease transmission and outbreak patterns. Moreover, data on vector species distribution, abundance, and behavior in different agro-ecological zones of South and Southeast Asia are insufficient or outdated.

This review, therefore, aims to critically assess the current understanding of the seasonal patterns and vector ecology of LSD in South and Southeast Asia, identify key research gaps, and propose future directions for effective disease surveillance, vector control, and risk forecasting strategies. By addressing these aspects, this study hopes to contribute to the development of region-specific, evidence-based control measures to mitigate the impact of LSD on livestock health and rural livelihoods.

## VIROLOGY AND PATHOGENESIS OF LSD

The LSDV, which causes LSD, is a double-stranded DNA virus belonging to the *Capripoxvirus* genus. This genus includes three viruses: Lumpy Skin Disease Virus (LSDV), Sheep Pox Virus (SPPV), and Goat Pox Virus (GTPV). LSDV is very

similar to the other two, sharing about 97% of its genetic material with them (Tulman *et al.*, 2001). The virus is oval-shaped, possessing large lateral bodies, and approximately 320×260 nm in size. Its genome consists of about 151 kilobase pairs (kb) of double-stranded DNA and encodes nearly 156 open reading frames (Biswas *et al.*, 2020).

After infection, the LSDV multiplies in the body, enters the blood, causes fever, moves to the skin, and forms lumps or nodules (Constable *et al.*, 2017). In experimental studies, several changes were observed after injecting the LSDV under the skin. Within 4 to 7 days post-infection (DPI), swelling appears at the injection site in the form of small lumps or raised patches, typically 1–3 cm in size. From 6 to 18 DPI, the virus enters the bloodstream (a condition known as viraemia) and was shed through saliva and nasal discharge. Between 7 to 19 DPI, the animals develop swelling in the adjacent lymph nodes and skin lumps begin to appear all over the body. Interestingly, around 42 days after the onset of fever, the virus is also detected in the semen (Coetzer, 2004).

In cases of natural infections, immunity usually becomes detectable about 2 weeks after infection. The strongest immunity is seen between 3 to 4 weeks after infection and can last for up to 5 months (EFSA, 2018). Most LSD viruses live inside the cells, so humoral immunity alone is not sufficient to stop the virus from multiplying. Therefore, cell-mediated immunity is very important for controlling the infection effectively. After vaccination, the humoral immune response can last more than 7 months and helps prevent the disease (Milovanović *et al.*, 2019). However, since the exact duration of humoral and cellular immunity is

not fully known, in areas where the disease is common it is recommended that animals get a booster vaccine every year.

The virus multiplies inside fibroblasts, macrophages, pericytes, and endothelial cells, resulting in inflammation of blood vessels (vasculitis) and lymph vessels (lymphangitis) in the affected tissues (Coetzer, 2004). These pathological changes result in vascular damage, leading to skin necrosis, oedema, and nodule formation. In some severe cases, thrombosis and infarction of skin tissues are observed, contributing to the development of characteristic skin lesions of LSD.

#### GLOBAL OVERVIEW OF LSD AND OUTBREAK TRENDS

LSD was first reported in Zambia in 1929, after which it spread throughout South Africa, causing sporadic outbreaks in various regions (Davies, 1991). Over time, the disease became endemic across the African continent. LSD later expanded beyond Africa, with its presence recorded in Asia during 1988–1989, followed by outbreaks in the Middle East and Europe in 1990 (Abdulqa *et al.*, 2016). In Southeast Asia, LSD was reported in Vietnam in October 2020 (WOAH, 2020), and subsequently in Myanmar in November 2020 (Seerintra *et al.*, 2022), Thailand in March 2021 (WOAH, 2022), Laos PDR in May 2021 (TNWHC, 2024), Malaysia: May 2021 (WOAH, 2022), Cambodia: September 2021 (Porco *et al.*, 2023), Indonesia: February 2022 (WOAH, 2022), and finally in Singapore: March 2022 (WOAH, 2022) (Table 1).

In recent years, LSD has emerged as a significant transboundary disease in South Asia. The first confirmed cases in South Asia were reported in Bangladesh in July 2019, India in August 2019, and Sri

**Table 1.** Timeline of first LSD outbreaks in Southeast Asia

Country	Year of first confirmed case	Reference
Philippines	None Known	Bucad (2021)
Vietnam	October 2020	WOAH (2020)
Myanmar	November 2020	Seerintra <i>et al.</i> (2022)
Thailand	March 2021	WOAH (2022)
Laos PDR	May 2021	Thailand-NWHC (2024)
Malaysia	May 2021	WOAH (2022)
Singapore	March 2022	WOAH (2022)
Indonesia	February 2022	WOAH (2022)
Cambodia	September 2021	Porco <i>et al.</i> (2023)
Brunei Darussalam	None Known	MPRT (2023)
East Timor	None Known	WOAH (2022)

Lanka in 2019 (MALLI, 2019; Sudhakar *et al.*, 2020; DLS, 2021), followed by outbreaks in Nepal – June 2020 (Pokharel Dhakal *et al.*, 2024), Bhutan – October 2020 (Rinchen, 2022), and then the disease appeared in Pakistan in November 2021 (Naveed, 2023) (Table 2). LSD spread rapidly throughout Southeast Asia during 2020, marking a new phase in its geographical expansion (Roche *et al.*, 2021). Climatic factors such as temperature, humidity, and rainfall, along with increased animal movement and informal trade, have contributed significantly to the regional and cross-border spread of LSD in South Asia (Roche *et al.*, 2021). Recent studies have revealed possible genetic mutations in LSDV strains, indicating potential changes in virulence and transmission patterns. Whole genome sequencing of LSDV from India identified two distinct variant groups: one group, with fewer mutations, closely related to the 2019 LSDV strain from Ranchi, and the other clustering with strains from earlier Russian outbreaks in 2015 (Yadav *et al.*, 2024). These developments highlight the urgent need for continued surveillance, regional cooperation, and updated control

strategies to effectively manage and contain the spread of LSD across Asia.

#### SEASONAL EPIDEMIOLOGY OF LSD IN SOUTH ASIA

In South Asia, LSD demonstrates a clear seasonal trend, largely governed by climatic conditions that influence vector ecology. The disease shows highest prevalence during the pre-Monsoon (March–May) and Monsoon (June–August) seasons, when warm and humid environments promote the growth and activity of arthropod vectors. Data from Bangladesh illustrate this trend, with prevalence sharply rising in April (18.71%), peaking in May (46.99%) and June (48.69%) (Pory *et al.*, 2021). These months recorded cumulative rates of 70.84% (Pre-Monsoon) and 62.72% (Monsoon), with respective monthly averages of 23.61% and 20.91% (Table 3).

Environmental risk factors further reinforce this seasonal pattern. According to Podshibyakin *et al.*, (2024), LSD transmission risk increases when cattle density exceeds 10–20 heads/10 km<sup>2</sup>, particularly in winter and autumn. Water body density,

**Table 2.** Timeline of first LSD outbreaks in South Asia

Country	Year of first confirmed case	Reference
Bangladesh	July 2019	DLS (2021)
India	August 2019	Sudhakar <i>et al.</i> (2020)
Bhutan	October 2020	Rinchen (2022)
Nepal	June 2020	Pokharel Dhakal <i>et al.</i> (2024)
Sri Lanka	2019	MALLI (2019)
Pakistan	November 2021	Naveed (2023)
Maldives	None Known	WOAH (2022)

**Table 3.** Seasonal distribution of LSD prevalence in South Asia (Pory *et al.*, 2021)

Season Name	Winter	Pre-Monsoon	Monsoon	Post-Monsoon
Duration	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
Cumulative prevalence (%)	15.80	70.84	62.72	1.94
Average prevalence (%)	5.27	23.61	20.91	0.65

especially 13–23.5 m<sup>2</sup>/km<sup>2</sup> in spring and over 14.5 m<sup>2</sup>/km<sup>2</sup> in summer, and specific rainfall levels (105–185 mm/month in winter and over 50 mm/month in autumn) were identified as key drivers of outbreaks. These thresholds correspond with seasonal peaks, supporting the idea that environmental factors intensify vector populations and enhance LSDV transmission.

In contrast, disease incidence declines significantly during the Post-Monsoon (September–November) and Winter (December–February) seasons, with cumulative rates of just 1.94% and 15.80%, respectively (Pory *et al.*, 2021) (Table 3). Cooler temperatures and reduced humidity likely limit vector activity, reducing viral transmission. In the same Bangladeshi study, clinical cases dropped sharply from July (12.24%) onward, with minimal presence in August (1.79%) through October (0.52%) and complete disappearance in November and December (0%). This decline suggests that unfavourable

climatic conditions act as a natural suppressor of LSD outbreaks.

Understanding this temporal distribution is essential for effective disease control. Since temperature and precipitation directly influence vector-borne disease dynamics by affecting vector survival, reproduction, and virus replication, recognising these seasonal risks is vital. Higher temperatures facilitate vector activity and viral replication, whereas cooler, drier conditions reduce biting rates and pathogen development (Fouque, 2020). Therefore, timely implementation of vaccination and vector control programmes – particularly before high-risk periods – can significantly reduce LSD burden in endemic areas.

#### VECTOR ECOLOGY AND ITS ROLE IN LSD TRANSMISSION

Vectors, being ectothermic, are pivotal in the mechanical transmission of LSDV among susceptible animals. Climatic fac-

tors such as temperature, rainfall, and humidity profoundly affect their reproduction, survival, distribution, and disease transmission potential (de Souza & Weaver, 2024; Khafagi *et al.*, 2024). The transmissibility of vector-borne viruses is influenced by both extrinsic factors – such as climate change, temperature, and urbanisation – and intrinsic factors like genetics, lifespan, and host immunity (Samuel *et al.*, 2016). The LSD spreads more rapidly in hot and humid conditions, especially during the rainy summer and autumn seasons, and in low-lying marshy areas where the environment becomes ideal for the proliferation of vectors responsible for its transmission (Mulatu & Feyisa, 2018; Akther *et al.*, 2023). These vectors are considered to play significant roles in the transmission of LSDV. Hard ticks have demonstrated transstadial and transovarial persistence of LSDV in *Amblyomma hebraeum*, *Rhipicephalus appendiculatus* and mechanical or intrastadial transmission by *Rhipicephalus appendiculatus* and *Amblyomma hebraeum* (Tuppurainen *et al.*, 2011; Lubinga *et al.*, 2013). Female *Aedes aegypti* mosquitoes have been shown to mechanically transmit the LSDV from infected to susceptible cattle (Chihota *et al.*, 2001). The virus has also been found in *Stomoxys*, *Biomya*, *Musca*, *Culicoides*, and *Glossina* species, all of which feed aggressively on domestic cattle and may potentially spread LSD (Weiss, 1968; Carn & Kitching, 1995). LSDV was also found in *Anopheles stephensi*, *Culex quinquefasciatus*, *Stomoxys calcitrans*, and *Culicoides nubeculosus*, but these insects were not successful in mechanically transmitting the virus. However, *Culicoides punctatus* may have played a role in spreading the LSDV outbreak in Turkey (Chihota *et al.*, 2003;

Şevik & Doğan, 2017). In South Asia, *Stomoxys*, *Haematobia*, *Rhipicephalus*, and *Musca* are considered important vectors for LSD transmission due to their high abundance and widespread presence (Manjunatha Reddy *et al.*, 2025). A major research gap is the near absence of entomological studies in South Asia, impeding comprehensive understanding of vector ecology and transmission dynamics.

#### INTERPLAY OF SEASONALITY, VECTOR DYNAMICS AND DISEASE MANAGEMENT

LSD in South Asia exhibits a marked seasonal trend, with the highest prevalence observed during the hot and humid months from April to July. Epidemiological data indicate that the disease begins to intensify in April, peaks during May and June, and gradually declines from July onwards. By November and December, clinical cases nearly disappear, suggesting that cooler and drier conditions significantly reduce transmission. This seasonal pattern strongly correlates with climatic factors that influence the ecology of disease vectors (Pory *et al.*, 2021).

Several arthropod vectors play a role in LSDV transmission, including *Stomoxys*, *Haematobia*, *Rhipicephalus*, and *Musca* in South Asia (Manjunatha Reddy *et al.*, 2025). Their abundance and activity are influenced by environmental conditions such as rainfall, temperature, and humidity. Warm and wet seasons provide ideal breeding conditions, contributing to higher disease transmission (Pory *et al.*, 2021). However, scientific evidence on vector ecology in South Asia remains limited and fragmented.

This knowledge gap presents a challenge for developing precise vector control strategies. Inadequate entomological

surveillance impairs our ability to predict outbreaks or implement effective control measures. Strengthening research on local vector populations, their seasonal dynamics, and their role in LSDV transmission is critical. Understanding vector ecology will inform targeted interventions, particularly in endemic and high-risk areas.

To reduce LSD outbreaks, an integrated approach is essential. This includes strategic vaccination before the monsoon, ongoing vector surveillance, and climate-informed early warning systems. Public awareness campaigns and coordinated government responses can further enhance preparedness. Sustainable control of LSD in South Asia depends on aligning disease management with seasonal and environmental realities.

#### CLIMATE CHANGE AND FUTURE LSD RISK PROJECTIONS

Climate change is now considered one of the major threats to sustainable livestock production (Kalaighazhal *et al.*, 2025). Rising temperatures, shifting rainfall patterns, and increased humidity are expected to expand the habitat range of arthropod vectors, enabling LSD spread into previously unaffected or high-altitude regions (Fouque, 2020).

Warmer and more humid environments promote vector activity and viral replication, while cooler and drier conditions tend to suppress biting rates and pathogen development (Fouque, 2020). Pory *et al.* (2021) reported that LSD is most common in the pre-Monsoon (March–May) and Monsoon (June–August) seasons, as the weather during these periods is most suitable for vector growth.

Extreme weather events such as floods can further intensify outbreak risks by displacing livestock and creating ideal

breeding grounds for vectors (Fouque, 2020). Since arthropod vectors are ectothermic, their reproduction, survival, geographic distribution, and ability to transmit diseases are all influenced by temperature, rainfall, and humidity (de Souza & Weaver, 2024).

Despite these clear associations between climate and disease dynamics, very few studies have integrated climate projections into LSD forecasting or control strategies. There is an urgent need for climate-responsive risk assessment tools to support early warning systems and proactive interventions.

#### SOCIO-ECONOMIC IMPACT OF LSD IN SOUTH AND SOUTHEAST ASIA

LSD imposes a significant economic burden on both individual farmers and the broader livestock industry. Recent estimates suggest that the total economic cost of LSD in South, East, and Southeast Asia may reach as high as USD 1.45 billion (Roche *et al.*, 2021). The direct economic losses primarily stem from decreased milk production, reduced quality of meat and hides, and impaired reproductive performance in infected cattle. In addition, expenses related to veterinary care, treatment, and the management of infected animals further escalate the financial burden on livestock producers.

On the other hand, indirect economic impacts include trade restrictions, quarantine measures, and the cost of implementing disease control programs (Gari *et al.*, 2011; Tuppurainen & Oura, 2012; Limon *et al.*, 2020). LSD outbreaks often necessitate substantial costs related to vaccination campaigns and vector control strategies (WOAH, 2022), increasing the pressure on already strained veterinary and agricultural resources.

Beyond direct losses, LSD adversely affects animal welfare and long-term productivity, resulting in sustained economic repercussions. In livestock-dependent communities, its impact extends beyond farms, threatening local economies and food security. Thus, mitigating LSD's economic burden demands a comprehensive strategy integrating prevention, timely diagnosis, and effective control to safeguard cattle production and livestock-based livelihoods.

#### RESEARCH GAPS AND FUTURE DIRECTIONS

Despite increasing LSD outbreaks in South and Southeast Asia, key knowledge gaps hinder effective control. Notably, entomological data on vector species, their abundance, seasonal activity, and vectorial competence remain scarce. This limits our ability to design targeted vector control strategies suited to regional ecosystems.

Epidemiological models largely overlook dynamic climatic variables and fail to forecast outbreaks with sufficient precision. Similarly, data on long-term vaccine efficacy, immunity duration, and post-vaccination surveillance are lacking. Spatial risk assessments integrating livestock density, vector habitat, and climate data are virtually absent. To bridge these gaps, priority areas include:

- Region-specific vector surveillance and ecology studies;
- Climate-integrated outbreak modeling and risk mapping;
- Longitudinal assessment of vaccine-induced immunity;
- Socio-economic impact evaluations to inform policy.

A coordinated, cross-border research and surveillance framework is essential to build a regional LSD early warning system and guide context-specific interventions.

#### CONCLUSION

Lumpy Skin Disease (LSD) presents a growing transboundary threat in Asia, driven by climate-sensitive vector dynamics and increased livestock movement. While its virology and pathology are well-characterised, insufficient understanding of vector ecology and seasonal transmission limits timely and effective response. A shift towards proactive, evidence-based control is urgently needed: anchored in robust surveillance, strategic vaccination, and climate-informed risk forecasting. Regional collaboration, coupled with targeted research investments, will be of key importance in reducing LSD burden and protecting livestock-dependent livelihoods.

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