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LUMPY SKIN DISEASE VIRUS: EMERGING THREAT TO INDIAN CATTLE HEALTH AND ECONOMY

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Lumpy Skin Disease Virus: Emerging Threat to Indian Cattle Health and Economy

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Abstract

Lumpy skin disease (LSD), caused by the lumpy skin disease virus (LSDV), is an economically significant and rapidly emerging transboundary disease affecting cattle and buffalo. LSDV belongs to the genus *Capripoxvirus* within the family *Poxviridae* and is genetically related to the sheep pox and goat pox viruses. Since its first detection in Zambia in 1920, the disease has expanded from Africa to the Middle East, Europe, Central Asia, and South and Southeast Asia, reaching India and several neighboring countries in recent years. LSDV is a large, double-stranded DNA virus that replicates in the cytoplasm and shows a strong tropism for epidermal cells, producing characteristic skin nodules, systemic illness, and substantial production losses. Transmission occurs mainly through arthropod vectors, though direct and indirect routes, including vertical transmission, are also reported. The disease causes significant economic losses from reduced milk yield, mortality, treatment costs, and trade restrictions. Laboratory diagnosis relies on PCR, serology, histopathology, and electron microscopy. Control strategies include vector management, movement restrictions, and prophylactic vaccination using live attenuated vaccines, with recent advances such as DIVA-compatible vaccines and improved diagnostics. Ongoing global spread underscores the necessity for strengthened surveillance, coordinated control programs, and continued research on pathogenesis, transmission, and vaccine development.

Keywords: Lumpy skin disease (LSD), *Capripoxvirus*, Arthropod-Borne Transmission, Economic Impact, Vaccination and Diagnostics.

1. Introduction

Only cattle (Bos taurus and Bos indicus) and water buffalo (Bubalus bubalis) are susceptible to lumpy skin disease, which is very host-specific and has also been observed in certain wild ruminants. The LSD virus is a member of the genus Capripoxvirus, subfamily Chordopoxviridae, and family Poxviridae [1]. lumpy skin disease (LSD), an infectious illness that is becoming more common in cattle and buffalo, was thought to be a neglected condition. It was initially discovered in Zambia in 1920, and after spreading to other African nations, it became endemic in the majority of sub-Saharan regions. Until Egypt reported its first case in 1988, the illness was only seen in this region. Then, in 1989, epidemics occurred in Israel. The Arabic Peninsula nations of Kuwait (1991), Lebanon (1993),

Yemen (1995), the United Arab Emirates (2000), Bahrain (2003), Israel (with recurrent outbreaks in 2006 and 2007), and Oman (2010) were among those that reported cases between the 1990s and 2010. Another outbreak struck Israel in 2012, and the illness spread to Jordan and Iraq, Turkey came next in 2013. Azerbaijan and Iran reported the first cases in 2014, followed by Armenia, Greece, and Russia a year later. Turkey is a crucial crossroads between Asia and Europe. In 2016, outbreaks or cases were recorded in Georgia, Kazakhstan, Albania, Bulgaria, Montenegro, North Macedonia, and Serbia as the expansion progressed towards Europe. During the 2017–2018 era, no other nations reported LSD cases, and epidemics were limited in a few countries, particularly European Member States. Central Asia saw the emergence of LSD in 2019; China, Bangladesh, After Bhutan and Nepal reported their first cases in 2020, it proceeded to spread throughout central Asia. It also shifted towards South-East Asia that year, including Vietnam, Hong Kong, Myanmar, and Sri Lanka. As Cambodia, Thailand, and Malaysia reported their first instances, LSD continued to expand towards South-East Asia in 2021 and continued to be recorded in additional Asian nations, such as Mongolia, Pakistan, and Taiwan. Ultimately, the first instances were reported by Indonesia and Afghanistan in 2022. and Viruses 2023, This year, India reported its first instances [2]. Similar to other capri poxviruses, such as the sheep pox (SPPV) and goat pox (GTPV) viruses, LSDV is a double-stranded DNA (dsDNA) poxvirus virus that is spread by indirect contact and bites from arthropods Current research has already identified a number of knowledge gaps, such as the creation of safer, more affordable, and more effective vaccines that can distinguish between infected and vaccinated animals (DIVA); the effectiveness of vaccines and their immunological protection (including immunogenic epitopes for a protective response); the role of various arthropod vectors and the direct and indirect transmission of capri poxviruses; and the creation of better diagnostic tests (such as pen-side or CRISPR/Cas assays) [3].

1.1 Morphology of poxvirus

Poxviruses have huge genomes of double-stranded DNA and are shaped like bricks or ovals. Light microscopy may be used to see the poxviruses, which are the biggest of all animal viruses. According to electron microscopy, the poxviruses are oval or brick-shaped, 200–400 nm in size. Double-stranded DNA, which is encased in a membrane, is found inside the nucleosome. The virion's distinctive textured look is caused by randomly distributed surface tubules on the lipoprotein bilayer's outer surface. The membrane's lipid content differs from that of the host cell membrane. Although the virus frequently obtains an envelope, the nucleoprotein core, lateral bodies, and membrane are infectious when combined Among the most intricate viruses that are known to exist are pythons. The linear, double-stranded DNA genomes of poxviruses vary greatly, ranging from 130 to 230 kbp across species [4].

2. Taxonomy and virology

2.2 Classification

Lumpy skin disease virus, genus Capri poxvirus, order Cividale's, class Pokkesviricetes, phylum Nucleocytoviricota, family Poxviridae, subfamily Chordopoxvirinae, and realm Varidnaviria [5] The genus Capripoxvirus, which belongs to the family Poxviridae, is closely related to sheep and goat pox and cannot be distinguished by serology [6].

Figure 1: **Infected Cow from Lumpy virus.**
Michel Bellaiche (Kimron Veterinary Institute)

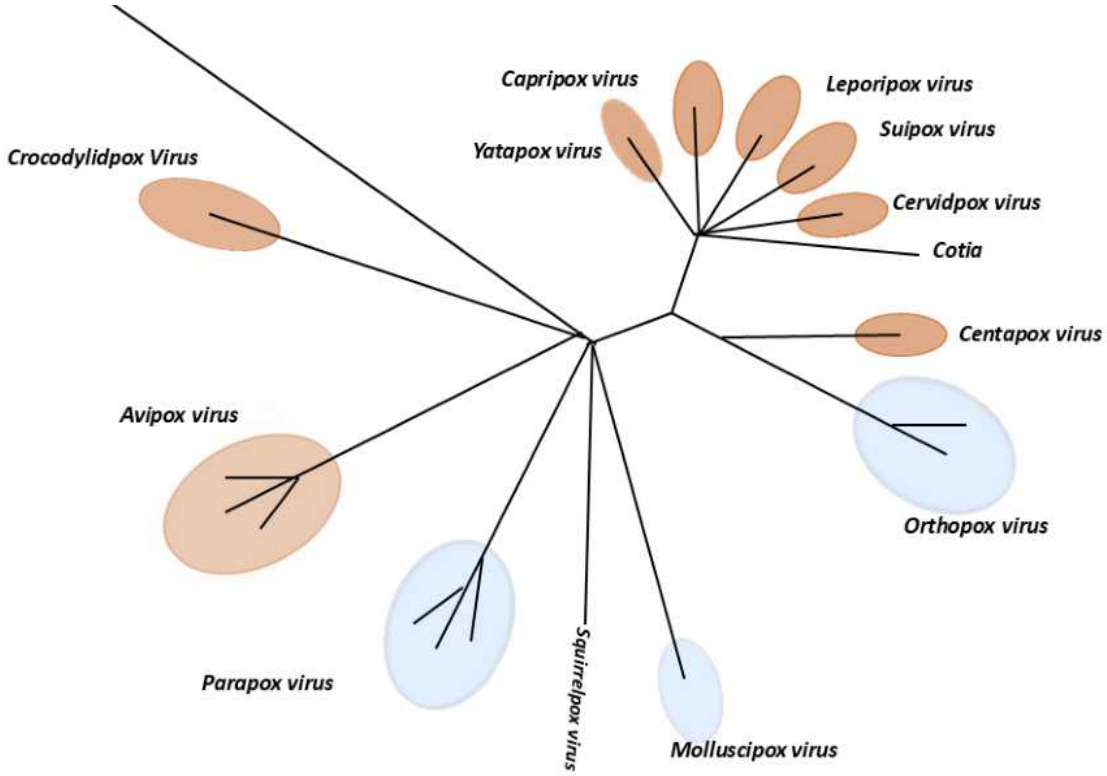

Figure 2: Species chart of Lumpy skin diseases.

3. Genetic features (dsdna genome, relatedness to sheep pox & goat pox)

Cattle are the main host of lumpy skin disease (LSD), a viral illness brought on by the virus responsible for lumpy skin disease (LSDV). Sheep pox virus (SPPV) and goat pox virus (GTPV) are also members of the capri poxvirus

(CAPV) genus, which contains LSDV. At 97% nucleotide identity, the genomes of SPPV and GTPV are very comparable to those of LSDV1. Although these viruses usually cause clinical infections in a variety of animal species, LSDV has historically shown a restricted host range, affecting cattle and buffalos mostly [2]. However, some research has shown that it may infect other ruminant species, such as gazelles5, camels4, giraffes3, and yaks2. Similar to the majority of poxviruses, LSDV is a virus that prefers to infect epidermal cells. Infected animals usually develop skin lesions and nodules as a result of LSDV infection [7]**.** Although the genus Capripoxvirus, which includes the sheep pox virus (SPPV) and goat pox virus (GTPV), is closely linked to the lumpy skin disease virus (LSDV), they differ in some nucleotides, indicating that they are phylogenetically separate. It is difficult to name isolates of capripoxviruses since their taxonomy and nomenclature are mostly reliant on the host species that is afflicted. Although many strains of GTPV and SPPV only infect sheep or goats, there are instances where these strains may infect both species [8].

3.1 Structure and replication cycle of LSDV

The virus is a member of the Capripoxvirus genus, subfamily Chordopoxvirniae, family Poxviridae, and has a large, 151 kb linear double-stranded DNA genome The physical traits of viruses in the Poxviridae family are quite similar Since the LSDV particle pattern diagram has not yet been resolved by the researchers, we use the poxvirus pattern diagram as a guide to create the LSDV structural pattern prediction diagram. SPPV, GTPV, and LSDV are members of the Capripoxvirus genus[11]. The virus's genome is 151 kb long, with a 2.4 kb inverted terminal repeat sequence on each wing and a central coding region. The scientific prediction is that there are 156 potential genes in LSDV [9].

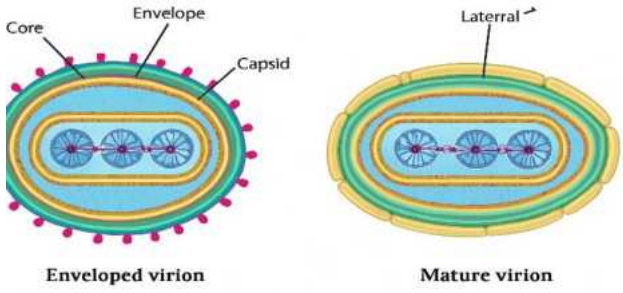

Figure 3: Morphology of Lumpy virus.

Compared to the other two viruses in the genus, it possesses nine more genes. It has envelopes and is around 350 nanometres long and 300 nanometres wide, resembling a poxvirus in appearance but lacking clotting function. Sheep embryonic kidney and lung cells, chicken embryo fibroblasts, and lamb and calf kidney or testicular cells are among the major cells in which this virus may multiply. Although the pathogenic alterations are gradual, it can also proliferate in Madin-Darby bovine kidney cells and baby hamster kidney cells (BHK-21) [10]

4. Transmission dynamics

LSD is a host-specific illness that is mechanically spread by arthropod vectors, similar to several other poxviruses. Bovine animals, such as cows and buffaloes, are the infective host or hosts (Fig. 3) [3]. Remarkably, there is currently no traceable history or proof of human infection for LSD, making it a non-zoonotic illness. According to recent research, LSDV can spread through direct or indirect contact. Infected cattle might potentially contract the virus vertically through the intrauterine pathway [11].

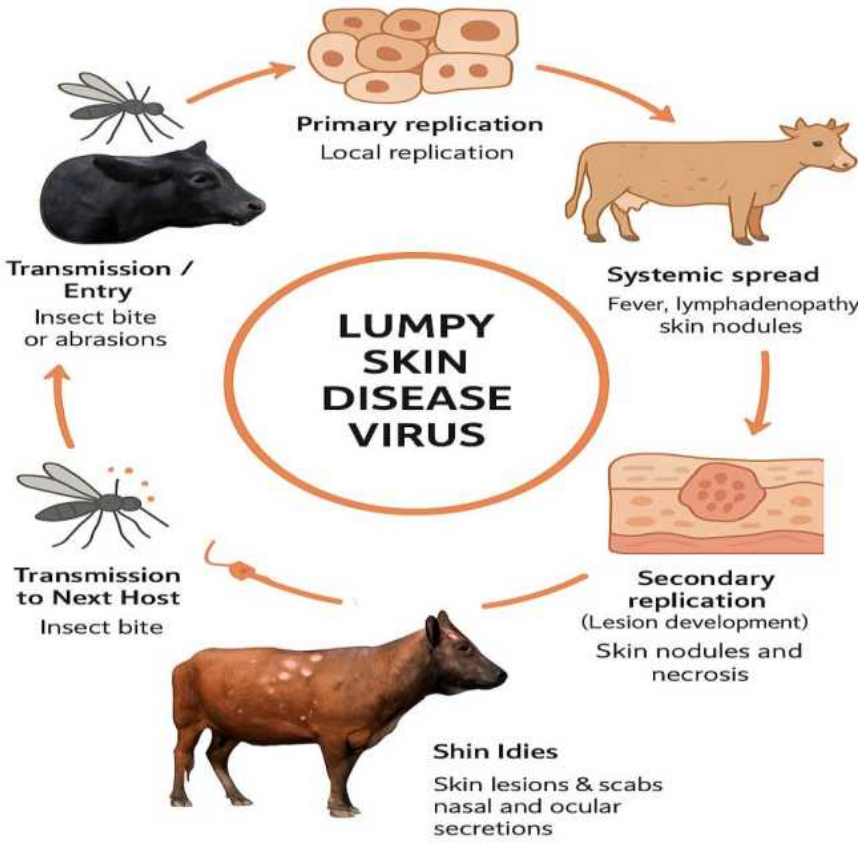

Figure 4: Lifecycle of the lumpy Virus.

4.1 Direct and indirect modes of transmission, non-vectored

Although there is little real scientific data, physical touch has generally been demonstrated to be an ineffectual method of LSDV transmission. LSDV transmission by direct touch is likely to occur, albeit at low rates and efficiency, according to early experimental studies and field observations conducted in South Africa Weiss [12] Observations of LSD outbreaks taking place outside of the window of ideal insect activity temperatures lend credence to this [13].

4.2 Insect transmission

A number of poxviruses, including swinepox viruses, myxoma viruses and fowlpox viruses (Brody, 1936), have been documented to be mechanically transmitted by arthropod vectors. Mosquitoes, fleas, and other biting arthropods can easily mechanically spread the rabbit (Shope) fibroma virus. The viruses were linked to the arthropod's head and mouthparts in each of these instances, but not to its body [14].

4.3 Tick transmission

Sterilised tubes were used to keep ticks alive. No later than three days following tick collection, the ticks were used in subsequent trials. A tentative categorisation based on morphological characteristics was conducted [15]

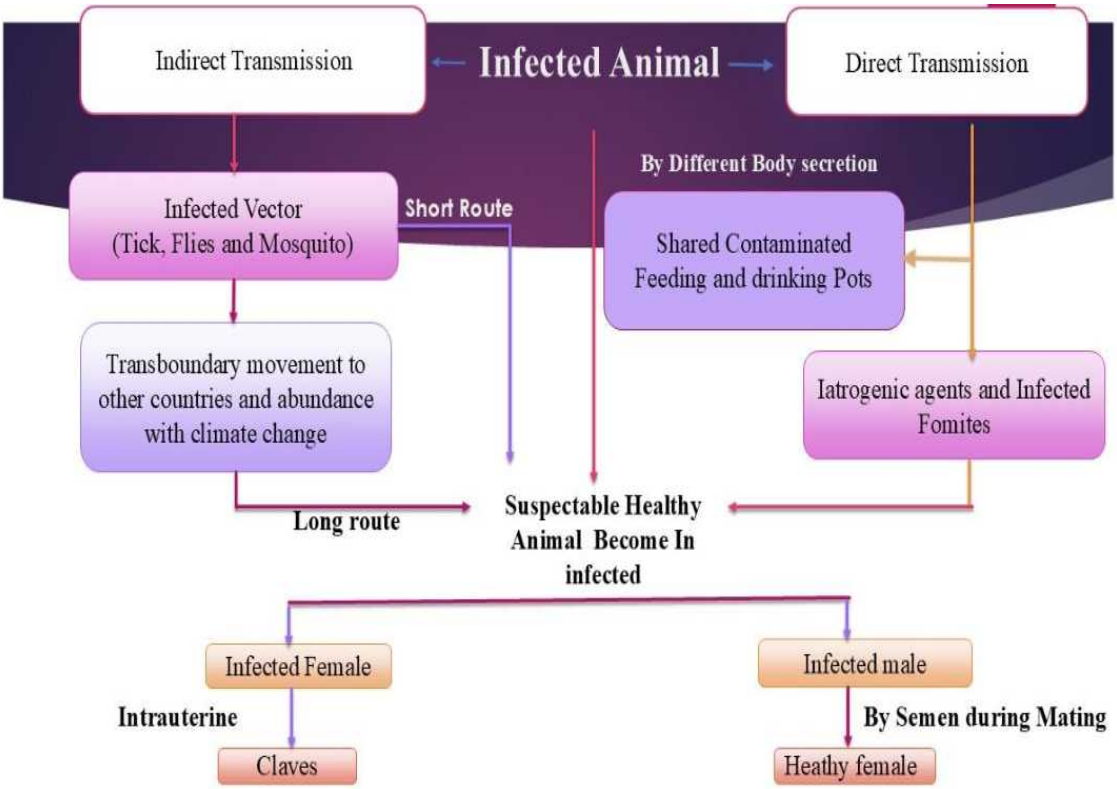

Figure 5: Transmission of lumpy virus.

5. Pathogenesis and clinical features

A systemic condition known as lumpy skin disease first appears as cell-associated viremia and severe lymphadenopathy before lesions appear. According to Young, Basson, and Weiss (1970), blood monocytes most likely have a major part in the spread of viruses to secondary infection sites [15]. Most of the capri pox viruses and other members of the Chordopoxviridae subfamily have a particular predilection for keratinocytes. Proliferation and ballooning degeneration of stratum spinosum keratinocytes, the formation of epidermal macrovesicles, and the infiltration of inflammatory cells into the dermis are characteristics of skin lesions. There are well-described gross lesions associated with LSD [14]. Although most skin nodules are raised, firm, and

spherical, some may combine to create massive, irregular plaques with distinct borders. The sub-cutis layer is oedematous and has a reddish-grey surface when the nodule is cut [16]. Deep skin nodules that puncture into surrounding muscles and subcutaneous tissues are giving rise to widespread postmortem lesions that result in vacuities, necrosis, oedema, congestion, and bleeding. As the disease deteriorated, the nodules eventually formed a thick scab and were necrotic [17]. A few nodules were seen intermittently on the head and neck in a small number of the individuals that were examined; later, these nodules spread throughout the body [18]. When LSDV infects areas such as the head, neck, and limbs, nodules form on the skin that covers the majority of the body [19]

The lesions have an impact on dairy operations and lower milk output. Lethargy, decreased appetite, fever, respiratory issues, oedema, and secondary infections are some of its distinguishing characteristics [4]. A cough or discharge from the nose might be caused by lesions. Swelling can exacerbate limb discomfort and cause the surrounding nodules to expand. Systemic oedema is the phrase used to describe widespread swelling that affects different parts of the body. Abscesses and a host of additional issues arise as a result of secondary infection. Due to the possibility of the disease spreading through normal breeding, skin lesions may result in testicular enlargement or other reproductive issues [20].

Table 1: Infected, Death and Vaccination Cattel by Lumpy virus.

Year	Infected / Cases (cattle)	Deaths (cattle)	Vaccinations (number of cattle vaccinated)
2019	First report of LSD in *Odisha* in September 2019. Number of infected cases not clearly available.	~67,000 cattle deaths **since onset** by ~Sep 2022 *including* 2019-22 period. But death in 2019 alone not separated.	No clear vaccination numbers for 2019. GIS/government not reporting per year in many sources.
2022	~2,945,863 cattle reported affected.	~155,366 cattle died in 2022.	~62,884,366 (≈ 6.28 crore) vaccinations done in 2022.
2023	Data for active / new cases in certain states; exact national total not found. For example, Maharashtra outbreak with ~98,230 affected in certain districts.	339 cattle died in Maharashtra districts in 2025, but 2023 "over 8,000 cattle died in India" in some reports.	Many vaccination campaigns: total doses / animals vaccinated yearly are reported in parts, but a consolidated national number for 2023 was not clearly found.

2025	Maharashtra districts had ~98,230 affected in recent outbreak.	In that outbreak, 339 died in those districts.	"Over 28 crore animals have also been vaccinated against LSD since 2022" (cumulative).

6. Diagnosis of lSDV

LSD is frequently diagnosed in the field using the disease's distinctive clinical symptoms. To confirm the diagnosis, quick and accurate laboratory testing is necessary for mild and subclinical types [21]. The most widely used techniques for diagnosing LSD include the use of the polymerase chain reaction (PCR) to identify viral DNA. Serology-based diagnostic tests or other molecular assays are also the recommended diagnostic methods for identifying antibodies to the LSD virus. In both endemic and non-endemic nations, effective management and eradication of LSD depend on prompt diagnostic confirmation of the tentative field diagnosis [22]. Identification of the agent, standard histopathological investigation, and immune histological staining can also be used to perform a laboratory test for LSD. Direct immunofluorescent labelling, viral neutralisation, or ELISA can all be used for antigen testing. Transmission electron microscopy of biopsy samples or dried crusts can reveal typical capri pox (genus) virions [23].

7. Economic impact

The economic cost of LSD on nations is both direct (related to mortality) and indirect (related to the disease's effects on animal health and productivity), with the latter outweighing the former. While the morbidity rate of LSD ranges from 3% to 85% globally, the fatality rate is modest and often regarded as 1-3 percent [24]. The milk output of dairy cows afflicted with LSD is significantly reduced. According to Table 9, in around 35% of the farms, the LSD epidemic resulted in a daily milk output loss of 0 to 3 litres per animal. It was determined that each impacted animal's daily milk output has decreased by an average of 5.45 litres. Since the cost of a litre of cow milk was determined to be INR 35.61, the daily loss per cow as a result of lower milk output was projected to be INR 194.07 [25] In 12 dairy farms, just one buffalo displayed LSD symptoms. Five litres less milk was produced by the buffalo that tested positive for LSD. The daily loss in terms of milk production per buffalo was estimated to be INR 302.85, as the average selling price of buffalo milk in the research region was determined to be INR 60.57. Buffaloes were found to be impacted for an average of 10 days, and it required an additional 15 days for their milk outputs to return to normal. As a result, the economic effect of the loss in buffalo milk production was estimated to be INR 7571.25 [26].

8. Prevention and control strategies

Prophylactic vaccination of the whole cow herd, done well in advance in at-risk locations, provides the best protection. Cattle movements both domestically and internationally ought to be tightly regulated or outright

prohibited [27]. A veterinarian certificate that includes all information about the animals' origins and assurances of animal health should be sent with authorised cattle transfers. Cattle herds in impacted communities should, if at all feasible, be maintained apart from other herds by avoiding communal grazing to protect animal welfare [2]. The viability of separating, however, must be assessed on an individual basis since in many instances, the entire hamlet constitutes a single epidemiological unit. Advice from the appropriate authorities and veterinarians should be obtained because different countries have different national management strategies. Antibiotics (topical +/- injectable) and nonsteroidal anti-inflammatory medications (NSAIDs) can be used to treat infections. Examples of these include. Methylene blue antiviral therapy. Non-steroidal anti-inflammatory medications are used to treat the inflammatory disease. When a temperature is high, paracetamol is used. The use of antibiotics to combat recurrent illnesses [16]

9. Advances in research

The development of a vaccine to prevent Lumpy Skin Disease (LSD), which is brought on by the Lumpy Skin Disease virus (LSDV), has advanced significantly at the Indian Veterinary Research Institute (IVRI) in Muktsar [16]. The live attenuated variant of the vaccine has demonstrated encouraging outcomes in generating protective immunity in cattle. It is an essential tool for managing this economically significant illness in livestock as field tests have shown how well it works to lower the frequency and intensity of LSD outbreaks. Current diagnostic testing for LSD have developed in tandem with vaccination campaigns, and methods like enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR) are essential [22]. These tests make it possible to identify LSDV quickly and accurately, which allows for prompt intervention and control measures to stop the disease's spread [24].

10. Global challenges and future perspectives

LSD is a major animal health hazard because to its ongoing development and reemergence in several nations. Since LSD is a transboundary disease, countries that do not use it are becoming increasingly concerned about the potential threat of intrusion as a result of the increased demand for animal products and services [28]. Due to their shared borders with nations experiencing outbreaks, countries like Australia, New Zealand, the United Kingdom (UK), the United States, France, Italy, Belgium, Hungary, Spain, Portugal, Slovenia, Slovakia, Croatia, Bosnia, and Ukraine that have no history of LSD infection are at high risk of contracting the disease [23]. Recurrent emergence is a risk that should be controlled in nations where outbreaks have been controlled and preventative measures be used less strictly. The resurgence of LSD with detrimental effects on animal health and the economy has recently affected Kenya, Romania, Russia, Moldova, Georgia, Armenia, Azerbaijan, Tajikistan, Mongolia, Turkey, Israel, Iraq, Syria, Jordan, Afghanistan, Pakistan, India, Nepal, Bangladesh, Sri Lanka, Myanmar, Thailand, Malaysia, Singapore, China, and Indonesia [2]

Conclusion

One of the most important transboundary animal illnesses affecting cattle is Lumpy Skin Disease Virus (LSDV), which poses a major risk to the health of cattle, food security, and the world economy. Its quick transcontinental expansion demonstrates how epidemics are fuelled by vector ecology, increased animal commerce, and climate change. Despite improvements in disease management brought about by advancements in molecular diagnosis and vaccine development, there are still gaps in monitoring, efficient vector control, and consistent immunisation methods. The financial strain brought on by decreased milk production, hide damage, infertility, and trade restrictions highlights the critical need for concerted global action. To control LSDV and stop its potential worldwide spread, a robust One Health strategy that incorporates veterinary treatments, epidemiological modelling, farmer education, and governmental assistance is essential. To protect cattle health and ensure livelihoods globally, it will be essential to bolster research, surveillance systems, and sustainable control methods.

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