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Review

Lumpy skin disease (LSD): a risk to farmers and livestock worldwide

ANJU BALA[1], UMESH KUMAR JAISWAL[1], ANJU POONIA[2*], ANAMIKA[3], ANIKA MALIK[1] and RACHNA[4]

[1]Department of Veterinary and Animal Husbandry Extension Education
[2]Department of Veterinary Surgery and Radiology, [3]Department of Animal Genetics and Breeding
[4]Department of Dairy Business Management
College of Veterinary Sciences, Lala Lajpat Rai University of Veterinary and Animal Sciences
Hisar 125004 Haryana, India
*Email for correspondence: anjupooniavs@gmail.com

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ABSTRACT

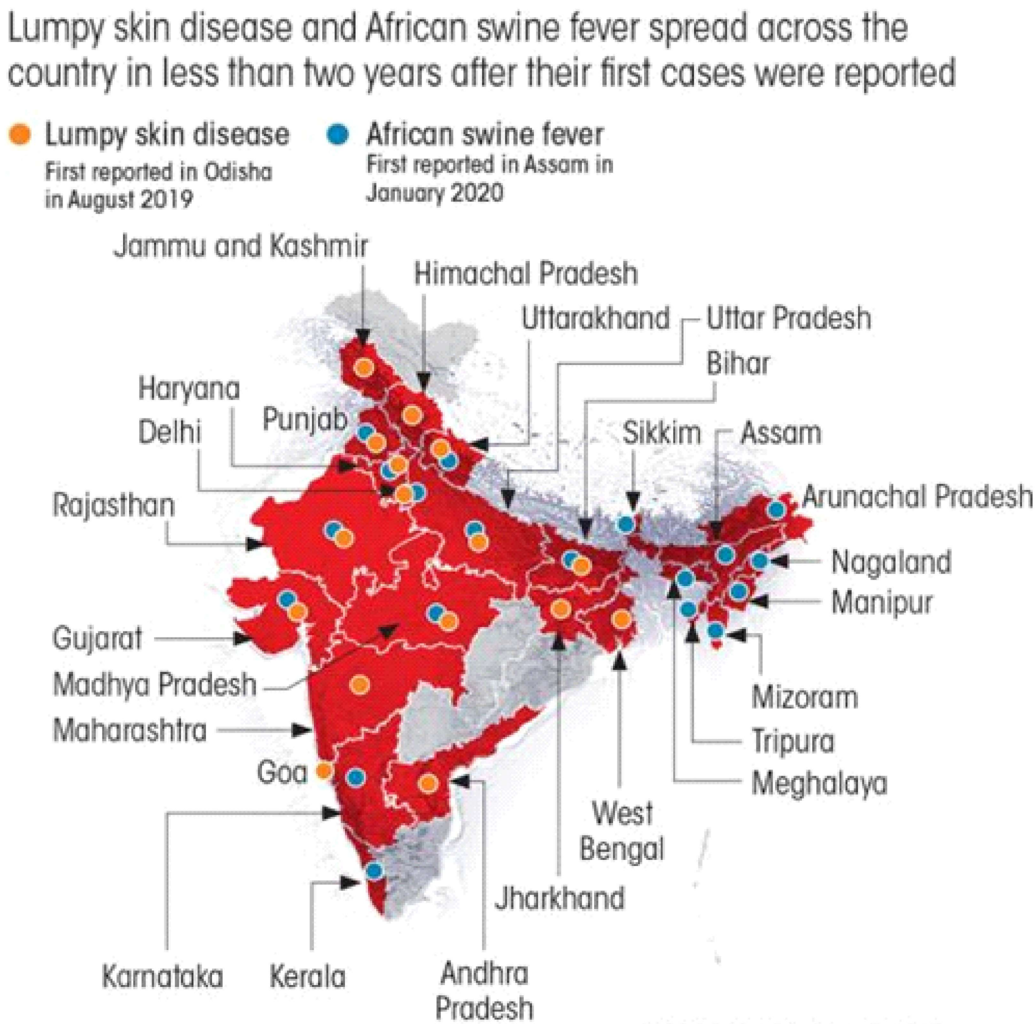
Lumpy skin disease is an emerging bovine viral disease which is endemic in most African countries and some Middle East ones and the elevated risk of the spread of disease into the rest of Asia and Europe should be considered. Understanding the restrictions and channels of distribution is crucial given the recent rapid spread of disease in nations that are currently disease-free. *Capripoxvirus*, the responsible agent, can also cause goatpox and sheeppox. Given that they pose a threat to worldwide trade and could be exploited as tools of economic bio-terrorism, the economic impact of these diseases is a major worry. Due to poor conditions in farming communities and limited availability to efficient immunizations, the dissemination of *Capripoxvirus* appears to be spreading.This is mostly caused by the economic consequences of the Covid-19 pandemic, the enforcement of debilitating sanctions in endemic areas, a growth in the trading in live animals and animal products, both legally and illegally, as well as the repercussions of global climate change. The goal of the current review is to offer current knowledge on the different facets of the illness, including its clinicpathology, transmission, epidemiology, diagnostics, preventative and control strategies and the probable contribution of wildlife to the disease's spread.

Keywords: Capripox; disease; epidemiology; lumpy skin disease; livestock

INTRODUCTION

Lumpy skin disease (LSD) is an infectious viral disease of cattle and buffaloes caused by the *Capripoxvirus* of family Poxviridae. LSD, a major threat to stockbreeding, can cause acute or sub-acute disease in cattle and water buffalo (Givens 2018). All ages and breeds of cattle are affected; especially the young and cattle in the peak of lactation (Tuppurainen et al 2011). The reason why the World Organization for Animal Health (WOAH) has placed this transboundary disease on the notifiable disease list is due to its significant economic losses and the potential for rapid spread (Tuppurainen and Oura 2012). The recent spread of the disease in disease-free countries indicates the importance of its transmission as well as control and eradication (Sprygin et al 2019). It is transmitted by arthropod vectors such as mosquitoes, biting flies and ticks. In India, the disease was first reported during the year 2019. The disease is characterized by mild fever for 2-3 days followed by development of stiff, round cutaneous nodules (2-5 cm in diameter) on the skin all over the body. These nodules are circumscribed, firm, round, raised and involve the skin, subcutaneous tissue and sometimes muscles. Symptoms may include lesions in mouth, pharynx and respiratory tract, emaciation, enlarged lymph nodes, oedema of limbs, reduction in milk production, abortion, infertility and sometimes, death. The morbidity rate is around 10-20 per cent and mortality rate is around 1-5 per cent (Arjkumpa et al 2022).

Causative agent: LSD is caused by the lumpy skin disease virus (LSDV) (Seerintra et al 2022), a member of the genus *Capripoxvirus* (CaPV) of the family Poxviridae. Capripoxviruses (CaPVs) represent one of the eight genera within the chordopoxvirus (ChPV) sub-family of the Poxviridae.



Source: African swine fever (ASF) situation update in Asia and Pacific, UN Food and Agriculture Organization, Media Reports

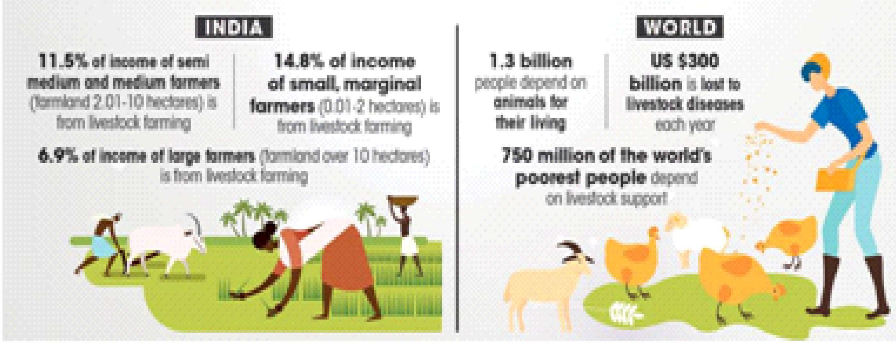
The *Capripoxvirus* genus currently comprises sheeppox virus (SPPV), goatpox virus (GTPV) and lumpy skin disease virus (LSDV), causing disease in sheep, goats or cattle respectively (Tulman et al 2002).

Transmission of lumpy skin disease: Long distance dispersal of LSDV seems to occur via the movement of infected animals, but distinct seasonal patterns indicate that arthropod-borne transmission is most likely responsible for the swift and aggressive short-distance spread of the disease. The mode of vector-borne transmission of the disease is most likely mechanical, but there is no clear-cut evidence to confirm or disprove this assumption. To date, the most likely vectors for LSDV transmission are blood-sucking arthropods such as stable flies (*Stomoxys calcitrans*), mosquitoes (*Aedes aegypti*) and hard ticks (*Rhipicephalus* and *Amblyomma* species). New evidence suggests that the ubiquitous, synanthropic house fly, *Musca domestica* may also play a role in LSDV transmission, but this has not yet been tested in a clinical setting (Sprygin et al 2019). Infected bulls can excrete the virus in the semen, however, transmission of LSD via infected semen has not been demonstrated. It is not known if transmission can occur via fomites, for example ingestion of feed and water contaminated with infected saliva. Animals can be experimentally infected by being injected with blood or material from cutaneous nodules.

Clinical symptoms: Lumpy skin disease can occur in acute, sub-acute and chronic forms (Rouby et al 2021). The disease is characterized by mild fever for 2-3 days followed by development of stiff, round cutaneous nodules (2- 5 cm in diameter) on the skin all over the body. These nodules are circumscribed, firm, round, raised and involve the skin, sub-cutaneous tissue and sometimes muscles (Hendrick 2017). The clinical

Endemic and Persistent

Diseases	Pathogens	Livestock	Zoonosis	Cases from 2017-2021
Anthrax	*Bacillus anthracis bacteria*	Multispecies	Yes	935
Babesiosis	*Babesia parasite*	Cattle	Yes*	16,185
Black Quarter	*Clostridium chauvoei bacteria*	Cattle and sheep	No	782
Bluetongue	Bluetongue virus	Ruminants, mainly sheep	No	3,349
Enterotoxaemia	*Clostridium perfringens bacteria*	Sheep and goat	No	2,012
Fasciolosis	*Fasciola hepatica parasite*	Cattle and sheep	Yes	15,292
Foot and mouth disease	Aphthovirus	Cattle, swine, sheep, goat	No	1,48,197
Hemorrhagic septicemia	*Pasteurella multocida bacteria*	Cattle and buffalo	No	5,122
Peste des petits ruminants	Morbilivirus	Goat and sheep	No	6,923
Sheep and Goat Pox	Sheep pox virus and goat pox virus	Sheep and goat	No	6,656
Swine fever	Pestivirus	Pigs	No	1,943
Theileriosis	*Theileria annulata parasite*	Cattle	No	2,719
Trypanosomosis	*Trypanosoma parasite*	Multispecies	Yes	6,556



Source: National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI): Land and Livestock Holdings of Households and Situation Assessment of Agricultural Households, 2019, Food and Agriculture Organization

features of the disease include fever, inappetence, nasal discharge, salivation and lacrymation, enlarged lymph nodes, a considerable reduction in milk production, loss of body weight and sometimes death (Tasioudi et al 2016). Some marks of crust are seen after bursting of the nodules on whole body. Symptoms may include lesions in mouth, pharynx and respiratory tract, emaciation, enlarged lymph nodes, edema in legs, dewlap and brisket region, reduction in milk production, abortion, infertility and sometimes death.

Postmortem findings: Due to lumpy skin disease, pox lesions can be seen all over the digestive and respiratory systems as well as on nearly any internal organs' surface. After the animal is skinned, sub-cutaneous lesions are easily discernible. There are hemorrhages in the lungs, spleen and rumen. Distinctive skin nodules are also found. It includes ulcerative lesions in the respiratory and digestive tract mucosa; reddish, hemorrhagic to whitish lesions in the lungs, edoema (interlobular) and nodules in the lungs, heart lesions (endocardium) and skin vascular thrombosis followed by cutaneous infarction and sloughing (Singh 2022).

Diagnosis: Despite a primary clinical diagnosis of LSD, the diagnosis is confirmed by using conventional PCR (Zheng et al 2007) or real time PCR techniques (Bowden et al 2008). A real time PCR technique differentiates among LSDV, sheep and goat poxviruses (Lamien et al 2011). To differentiate virulent LSDV and vaccine strain, restriction fragment length polymorphism (RFLP) has been used (Menasherow et al 2014). Stubbs et al (2012) stated that molecular methods are more precise, reliable and rapid compared to other methods. Among serological techniques, the virus neutralization test, though slow and costly with a high specificity and low sensitivity, is the only currently validated/valid test (Beard 2016).

Treatment: LSD being a viral illness, there is currently no specific treatment. LSD treatment is only symptomatic, with antibiotic medication which is used to prevent subsequent bacterial problems (Namazi and Tafti 2021).Antibiotics such as penicillins, cephalosporins, tetracyclines and fluroquinolones are prescribed for 5 to 7 days depending on the severity of the illness.

Salib and Osman (2011) conducted treatment studies for reducing LSD consequences. They were effective, utilizing a mix of medications that fight bacteria and inflammation, provide comfort and treat infections (Kumar et al 2022). They also recommended anti-histaminic and non-steroidal anti-inflammatory medications. An anti-pyretic medication, such as paracetamol, was given to reduce fever.

Abutarbush et al (2015) advised regular multivitamins and liver-supporting medications for anorexia recovery. Treating LSD and its effects is costly and does not always result in a full recovery; therefore, avoidance is more effective for minimizing large financial losses, milk loss from mastitis and losses of food products from death, miscarriage, fever and myiasis.

Economic impact: Cattle and buffalo play an important role in the socio-economic fabric of Asia. They are not only a source of income and food but also represent an accessible means to deposit savings and as a source of draught power. Such services help smallholders to overcome poverty hurdles, especially in poor settings where financial services and agricultural mechanization have not yet penetrated. Some communities value cattle and buffaloes highly for their role in social, cultural and religious traditions.

Knowing the economic impact of a disease can help decide on the most cost-effective disease control approach. Economically, Asia accounts for 31 and 98 per cent of global cow and buffalo milk production respectively and 29 per cent of the cattle slaughtered globally for meat production (Roche et al 2020). LSD can inflict substantial direct losses through mortality, reduced milk production, damaged hides, poor growth, reduced draught power capacity and reproductive problems associated with abortions, infertility and lack of semen for artificial insemination. Vaccination costs, trade and other indirect revenue losses are directly proportional to the extent of LSD spread. LSD has led to serious economic losses in affected countries. The disease causes a considerable reduction in milk yield (from 10 to 85%) due to high fever and secondary mastitis (Namazi and Tafti 2021).

Other consequences of the disease include damaged hides, decline of the growth rate in beef cattle, temporary or permanent infertility, abortion, treatment and vaccination costs and death of infected animals (Sevik and Dogan 2017).

Limon et al (2020) in a study in northeast Nigeria, reported that lumpy skin disease (LSD), sheeppox (SP) and goatpox (GP) are contagious viral infections, affecting cattle (LSD), sheep and goats (SP and GP) with highly characteristic clinical signs affecting multiple body systems. All three diseases are widely reported to reduce meat, milk, wool and cashmere production although few studies have formally evaluated their economic impact on affected farms. The median incidence risk and fatality rate were 33 and 0 per cent in cattle, 53 and 34 per cent in sheep; 50 and 33 per cent in goats respectively, with young stock having higher incidence risk and fatality rates than adults. Almost all farmers (94%) treated affected animals with antibiotics, spending a median of USD 1.96 (min USD 0.19, max USD 27.5) per herd per day. Slaughtering or selling affected animals at low prices were common coping strategies. Milk production dropped 65 per cent when cows were clinically affected and 35 per cent after they recovered. Cattle lost a median of 10 per cent of their live weight and sheep and goats lost 15 per cent. Overall economic losses at farm level ranged from USD 9.6 to 6,340 depending on species affected and production system.

Chouhan et al (2022) determined the attack rate and risk factors along with economic losses of the LSD outbreaks in Bangladesh's Mymensingh and Gaibandha districts and reported that lumpy skin disease (LSD) is an emerging viral disease of cattle that negatively impacts livestock by reducing animals' production and increasing management costs. The average economic loss per case was USD 110.40.

Kiplagat et al (2020), in a study in case-control study of cattle farms in Nakuru, Kenya, compared the economic impact between farms keeping purely indigenous or exotic breeds of cattle which indicated mean farm-level losses of USD 123 and 755 respectively. The mean farm-level losses from reduction in milk yield and mortality were estimated at USD 97 and 31 for farms keeping indigenous breeds whilst for farms keeping exotic breeds the equivalent losses were USD 266 and 431 respectively.

Klement (2018) reported that the incidence of LSD is the first factor which determines its direct economic impact. This depends on the abundance of vectors, the susceptibility of the host and the use of preventive measures (Gari et al 2011). It can reach even 85 per cent in an affected herd if no preventive measures are applied (Tuppurainen and Oura 2012). Case fatality is also an important factor, influencing the economic impact of a disease. However, accurate estimation of case fatality is very difficult to provide as in most of the developed countries, sick animals are culled and in developing countries, the exact pathological reason for natural animal death is not always provided.

Prevention and control: The treatment of LSD is only symptomatic and targeted at preventing secondary bacterial complications using a combination of anti-microbials, anti-inflammatory, supportive therapy and antiseptic solutions (Salib and Osman 2011). Vaccination is the only effective method to control the disease in endemic areas along with movement restrictions and the removal of affected animals (Sevik and Dogan 2017). The culling of affected animals, movement restrictions and compulsory and consistent vaccination have been recommended as control strategies (Beard 2016). Moreover, risk factors should be considered in control activities (Sevik and Dogan 2017).

Educating veterinarians and livestock workers would enable them to perform timely diagnoses of clinical cases, helping to slow the spread of disease (Beard 2016). However, regarding the role of arthropod vectors, elimination of the disease is likely to be difficult and any delays in the removal of infected animals increase the risk of LSD transmission (Tuppurainen et al 2017).

Furthermore, the rapid confirmation of a clinical diagnosis is essential so that eradication measures, such as quarantine, slaughter out of affected and in contact animals, proper disposal of carcasses, cleaning and disinfection of the premises and insect control can be implemented as soon as possible during the eruption (Constable et al 2016). Moreover, rigorous import restrictions on livestock, carcasses, hides and semen from endemic areas must be in place in disease free areas (Sevik and Dogan 2017).

Vaccination of cattle using a vaccine with demonstrated efficacy is the best option for controlling the spread of LSD, especially if pre-emptive ie applied before the virus enters a region or country at risk. However, preventive vaccination against LSD leads to trade restrictions on the export of live cattle and their products, which may deter disease-free exporting countries from implementing pre-emptive vaccination in high-risk regions. Pre-emptive vaccination is highly recommended when LSD is detected across borders in neighbouring countries. It may take the form of zone or buffer vaccination, taking into account geographical barriers, transport access routes and host population densities (Anon 2017). The commercially accessible vaccines against LSD are live attenuated vaccines.

Vaccine and vaccination: Vaccination is the only effective method of control the disease in the endemic area along with movement restrictions and removal of affected animals. Bazid et al (2022) conducted a study to evaluate the safety and efficacy of a new live attenuated LSD vaccine produced by Middle East for vaccines (MEVAC®) based on the Neethling strain. In the field, around 2 per cent (80/4301) of the animals showed hyper-reactivity and 0.6 per cent (24/4301) showed small skin swellings that disappeared within few hours PV. Abortion was recorded in three animals (0.3%, 3/867).

In LSD free countries that use the sheep pox vaccine to protect sheep against sheep pox, it was recommended to use the same vaccine during LSD outbreaks because of potential safety issues associated with the live attenuated LSDV vaccine use (Tuppurainen and Oura 2012). Live vaccines produce a strong and long lasting immune response and are efficient in the control of disease spread (Tuppurainen et al 2020). However, live vaccines can cause local inflammation and a mild disease with skin lesions (Bedekovic et al 2017). Inactivated vaccines could be applied in the final stage of disease eradication as a part of the strategy that uses live vaccines first (Hamdi et al 2020).

As there is a chance of recombination between the wild field strain and the live vaccine, the risk of coinfection should be considered with the use of live vaccines and natural infection is probably made worse by the vaccination of infected animals (Sprygin et al 2019).

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The ten-fold dose of attenuated SPPV vaccines is recommended for immunization of bovines against LSD. Nevertheless, compared to the Neethling vaccine its efficacy is significantly lower (Ben-Gera et al 2015). Currently, most commercially available vaccines against LSD are live attenuated vaccines based on a LSDV strain, sheeppox virus (SPPV), or goatpox virus (GTPV) (Tuppurainen et al 2021). Gorgan GTPV vaccine is a good, cost-effective alternative in those countries where GTP and LSD overlap. Recent data from Kazakhstan also enhance the understanding of the potential use of GTPV where the goatpox vaccine strain for LSD elicited a strong protective immune response in cattle (Zhugunissov et al 2020). In India the GTPV Uttarkashi strain is being evaluated for level of protection against LSD as compared to the LSDV vaccine and is already used for emergency vaccination. In Bangladesh, GTPV vaccine was used in Chattogram and found to be effective against LSD (Kayesh et al 2020). There are also several studies of the GTPV vaccine based on the Gorgan strain with successful results (Zhugunissov et al 2020).

Self-observed future strategies to control lumpy disease in livestock: Controlling lumpy disease in animals requires a comprehensive approach that includes preventive measures, early detection and appropriate management strategies. As of last knowledge update in September 2021, there was no specific information available on a disease called lumpy disease in animals. However, assuming to a hypothetical condition or a specific disease that may emerge in the future, here are some general strategies that can be applied to control and manage infectious diseases in animals:

- Vaccination programmes
- Quarantine and biosecurity
- Surveillance and early detection
- Rapid response and containment
- Education and awareness
- Research and development
- Collaboration and coordination

It is important to note that specific strategies for controlling a particular disease may vary depending on its characteristics, including the mode of transmission, affected animal species, geographical location and available resources. Therefore, it is crucial to consult veterinary experts and authorities to tailor the control measures to the specific disease.

CONCLUSION

The recent spread of the disease into disease free areas indicates its epidemiological and economic significance. Considering the extensive boundaries of Middle East countries, animal movements among these countries should be attentively controlled by veterinary authorities. Furthermore, paying close attention to the different aspects of the disease, such as transmission and epidemiology and the implementation of effective preventive measures such as vaccination, could result in better disease control. Therefore, accurate and timely diagnosis in endemic areas, vaccination with the homologous strain of the LSDV, vector control, animal movement restriction and LSDV testing of bulls used for breeding are highly recommended as tools to control further spread.

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