Veterinary World, EISSN: 2231-0916
Available at www.veterinaryworld.org/Vol.15/December-2022/2.pdf

REVIEW ARTICLE
Open Access

Lumpy skin disease: A newly emerging disease in Southeast Asia

Kanokwan Ratyotha[1], Suksanti Prakobwong[2], and Supawadee Piratae[1,3]

1. Faculty of Veterinary Sciences, Mahasarakham University, Maha Sarakham 44000, Thailand; 2. Department of Biology, The Parasitology, Geoinformatics, Environment and Health Science Research Group, Faculty of Science, Udon Thani Rajabhat University, Udon Thani 41000, Thailand; 3. One Health Research Unit, Faculty of Veterinary Sciences, Mahasarakham University, Maha Sarakham 44000, Thailand.

Corresponding author: Supawadee Piratae, e-mail: supawadee.p@msu.ac.th
Co-authors: KR: kanokwan.ryth@gmail.com, SukP: suksanti.pr@udru.ac.th
Received: 29-06-2022, **Accepted:** 01-11-2022, **Published online:** 05-12-2022

doi: www.doi.org/10.14202/vetworld.2022.2764-2771 **How to cite this article:** Ratyotha K, Prakobwong S, and Piratae S (2022) Lumpy skin disease: A newly emerging disease in Southeast Asia, *Veterinary World*, 15(12): 2764–2771.

Abstract

Lumpy skin disease (LSD) is caused by LSD virus (LSDV). This virus has been classified in the genus *Capripoxvirus*, family Poxviridae which generally affects large ruminants, especially cattle and domestic water buffalo. The first outbreak of LSD was found in 1929 in Zambia, then spreading throughout Africa and with an ongoing expanding distribution to Asia and Europe. In 2020, LSD was found from Southeast Asia in Vietnam and Myanmar before reaching Thailand and Laos in 2021. Therefore, LSD is a newly emerging disease that occurs in Southeast Asia and needs more research about pathology, transmission, diagnosis, distribution, prevention, and control. The results from this review show the nature of LSD, distribution, and epidemic maps which are helpful for further information on the control and prevention of LSD.

Keywords: *Capripoxvirus*, distribution, lumpy skin disease, newly emerging disease, Southeast Asia.

Introduction

Lumpy skin disease (LSD) is caused by LSD virus (LSDV), a virus in the family Poxvirus, genus *Capripoxvirus* as well as sheep pox virus (SPPV) and goat pox virus (GTPV) [1]. This virus can cause infection mainly in cattle (*Bos* spp.) and buffaloes (*Bubalus* spp.); there are also reports in other wild ruminant species, such as giraffes, bulls, and springboks [2]. This arbovirus is probably transmitted by mechanical transmission through blood–sucking arthropods, including mosquitoes, ticks, and flies [3]. This virus can also be transmitted to susceptible animals through direct contact with the secretions of other infected animals and indirect contact from contaminants of the owner of the animals and objects (vehicle, equipment, etc.) [1, 4]. Infected animals may present variations of clinical signs ranging from subclinical to high morbidity and mortality. The clinical signs are fever (40.0°C–41.5°C), lacrimation, nasal discharge, hypersalivation, lethargy, anorexia, and weakness, followed by the development of nodular lesions in the skin and mucous membranes of the whole body. In addition, these lesions may develop into the muscular layer [3, 4]. The resulting wound lesions can develop necrotic tissue and scarring, which may occur with secondary infection with other types of complications such as bacteria, viruses, or myiasis and cause severe clinical symptoms [5]. In general, prevalence of LSD ranges from 1%–2% to 80%–90% in different situations in the endemic region [2]. Mostly LSD can cause low mortality and the differences in the mortality rate may be explained by differing susceptibility of hosts (strain, age, and host immune response).

The first reported case of LSD occurred in 1929 in Zambia and after that, it spread throughout South Africa with sporadic outbreaks in some areas [5]. At present, this disease is an endemic disease in Africa. Lumpy skin disease has recently spread in Asia during 1988–1989 following outbreaks in Europe and the Middle East in 1990 [6]. The disease emerged in South Asia in 2019 and then rapidly spread throughout Southeast Asia in 2020 [1]. Infection with LSDV could affect not only the health status of ruminants, but furthermore, might impact the economic activity of ruminants, especially cattle.

Here, we review the general information about LSD and show where research is needed for a better understanding of the biology, pathology, transmission, diagnosis, distribution, prevention, and control of this newly emerging disease in Southeast Asia.

Virus and Classification

Lumpy skin disease virus (LSDV) is a virus in the family Poxviridae, subfamily Chordopoxviridae, genus *Capripoxvirus*. The genus *Capripoxvirus* comprises three viruses; SPPV, GTPV, and LSDV. Lumpy skin disease virus is large–sized (230–260 nm) enclosed in a lipid enveloped with a genome of approximately 150 kilobase pairs (kbp) and shared 97% identity in the nucleotide sequences with SPPV and GTPV genome (Figure-1). The LSDV genome included at least 146 putative genes, which displayed proteins that play roles in virion structure, DNA replication, transcription and metabolism, protein

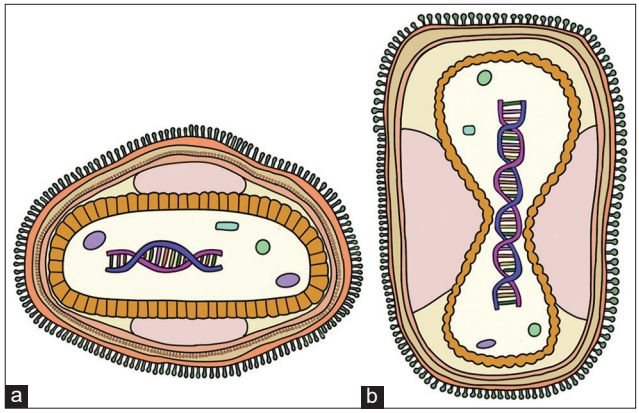

Figure-1: Schematic diagram of the poxvirus structure. (a) cross-section; (b) longitudinal section. (Figure prepared by Kanokwan Ratyotha).

processing and assembly, virus stability, and evading host immune response [7]. Lumpy skin disease virus can cause infection mainly in large ruminants; specifically in cattle, buffaloes, and other wild ruminant species. However, the disease is not contagious from animals to humans. Signs and symptoms of LSDV vary widely and depend on many factors, such as status of the host's immune response, strain of the virus, and the environment. Severe clinical signs of disease may occur in young animals, lactating animals, or animals with lower immunity than healthy animals. European beef cattle strains (*Bos taurus*) are more susceptible to LSD than tropical or Indian beef cattle strains (*Bos indicus*). Moreover, domestic buffalo (*Bubalus bubalis*) have a lower incidence rate than cattle [1, 4, 8]. The LSDV genome can be detected in nodules, ulceration, blood, secretions, and semen in both vertebrate (ruminant) (Table-1) [1, 2, 4] and invertebrate animals (arthropods) (Table-2) [9–19].

Table-1: Vertebrate hosts susceptible to LSDV infection.

Vertebrate hosts	Countries/ Regions	References
Giraffe		
Giraffa camelopardalis	South Africa	[1, 4]
Impala		
Aepyceros melampus	South Africa	[1, 4]
Eland		
Taurotragus oryx	South Africa	[1]
Wildebeest		
Connochaetes gnou	South Africa	[1]
Thomson's Gazelle		
Eudorcas thomsonii	South Africa	[1]
Oryx		
Oryx leucoryx	South Africa, Saudi Arabia	[1, 2, 4]
Oryx gazelle	South Africa, Saudi Arabia	[1, 2]
Springbox		
Antidorcas marsupialis	Namibia	[1, 2, 4]
African wild buffalo		
Syncerus caffer	Kenya	[1, 2]

LSDV=Lumpy skin disease virus

Table-2: LSDV genome detected in vertebrate animals.

Invertebrate hosts	Countries/ Regions	References
Ticks		
Rhipicephalus appendiculatus	South Africa	[9–12]
Amblyomma hebraeum	South Africa	[9–11, 13–15]
Rhipicephalus decoloratus	South Africa	[13, 15]
Glimpses		
Haematopota spp.	South Africa	[16]
Flies		
Stomoxys calcitrans	Belgium, Egypt	[16, 17]
Mosquitoes		
Aedes aegypti	Egypt	[18]
Anopheles stephensi	Egypt	[17]
Culex quinquefasciatus	Egypt	[17]
Culicoides nubeculosus	Egypt	[19]

LSDV=Lumpy skin disease virus

transmission, Spread, and Virus Stability

Lumpy skin disease is a vector-borne disease transmitted by mosquitoes (*Aedes aegypti, Anopheles stephensi, Culex quinquefasciatus,* and *Culicoides nubeculosus*), ticks (*Rhipicephalus appendiculatus, Rhipicephalus decoloratus,* and *Amblyomma hebraeum*), and Diptera (*Haematopota* spp. and *Stomoxys calcitrans*). The LSDV can survive in skin nodules for 1 month and at least 3 weeks in air–dried hides. The virus is excreted in the blood, nasal secretions, saliva, ear notches, semen, and milk and can be transmitted to suckling calves [20–22]. In general, vectors enhance the distribution of LSDV by mechanical and biological transmissions. Many studies have reported that after blood-sucking vectors (mosquitoes, ticks, glimpse, and flies) take a blood meal from infected cattle (viremia stage), the virus can propagate and shed in the salivary glands, head, body, and feces of insects. This allows the infected insects to become a reservoir for further transmission [15]. The infectivity of LSDV has been studied in both egg and juvenile of ticks (*R. decoloratus*) in which it was found that the disease can be transmitted by transovarial transmission [14]. In addition, the mechanical contact of flies is also a way they can be carriers of disease. Direct contact between cattle in a cage has been commonly found in endemic areas. However, the viral transmission was also accomplished by the contamination of veterinary equipment and vehicles as well as stockholders from a farm translocating to distant areas [1, 23]. Most LSD infections have been found in the summer when vectors are active; it may designate the blood–feeding insects and the virus spread. The enhancement of risk factors was associated with a warm and humid climate that supported the reproduction of vector populations. The introduction of new animals to a herd is one of the risk factors.

Lumpy skin disease virus is well tolerated in the environment in the pH range of 6.3–8.3 and it can survive in dry scabs on the skin for up to 3 months [1]. Lumpy skin disease virus can grow in cell cultures at

4°C for up to 6 months, in phosphate buffer saline at 28°C for up to 35 days, in skin nodule lesions collected from frozen at –80°C for up to 10 years. However, it can be destroyed by ultraviolet heat for an exact time, for example, 55°C for 2 h, 60°C for 1 h, and 65°C for 30 min. Moreover, this virus is sensitive to excess acid or base and therefore, it can be destroyed by common disinfectants [9].

Pathogenesis and Clinical Signs

In some outbreaks that occurred in Africa and middle Asia countries, the mortality rate was generally low (1%–3%) but may reach 40% in some regions. After infection, the incubation period ranges from 4 to 7 days, as determined experimentally, but for naturally occurring infections, the incubation period is 28 days or is prolonged to 35 days [1, 4]. Lumpy skin disease virus infection by intradermal replication in fibroblasts, macrophage, pericytes, and endothelial cells leads to viremia causing vacuities and lymphangitis in affected areas [2]. After cattle recover from infection, they acquire antibodies for about 6 months [6]. Lumpy skin disease is an economically impact disease in an outbreak because the severity in cows peaks during lactation and causes a decreased milk harvest during the high fever caused by the viral infection and bacterial mastitis. Clinical signs after the incubation period can be classified into 4 phases.

Phase 1 (acute phase) after the incubation period, animals have fever as high as 41°C for about 7 days sometimes prolonged to 10 days with anoxia, depression, lacrimation, increased nasal discharge, saliva secretions, lack of milk, found multinodular lesions around skin, and mucous membrane. Some cases are non–febrile.

Phase 2 subscapular and precrural lymph nodes develop noticeable enlargement 3–5 times of their normal, and there are increased multi nodules, mostly on the head, neck, limbs, genitalia, udder, mucous membrane, nasal and oral cavities, or plaques at the site of inoculation. The diameter of the nodule lesion is 0.5–5 cm, apparent in varying numbers and sizes, from only a few to multiple lesions covering the entire animal (Figure-2a). After 1–2 days, nodules rupture, also shedding virus depending on the concentration of virus. Sometimes found edema of limbs is caused by lymphangitis and vasculitis.

Phase 3, after 2–3 weeks, nodules lesions into ulceration and become necrotic. Also, beaded serum exudes, especially from limbs and causes lameness, pain, and lack of movement. In severe cases, an ulcerative lesion appears in the mucous membranes at various points, such as the eye and nasal cavities; there is excessive salivation, lachrymation, and nasal discharge. The secretions from animals may contain LSDV [19].

Phase 4, after at least 1 month, there is complete healing of ulcerations and also thickening of the skin and hyperpigmentation of the lesion (Figure-2b).

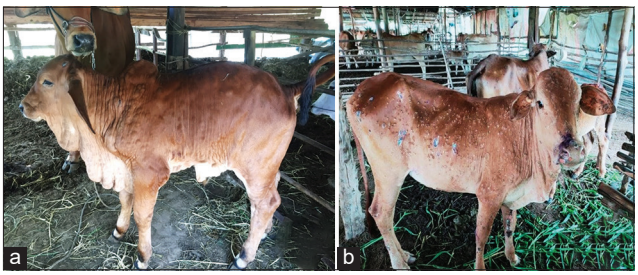

Figure-2: The clinical sign of lumpy skin disease in cattle in Thailand. (a) The lymph nodes develop noticeably enlarged 3–5 times of its normal; (b) the nodule lesions' transformation into ulceration and necrosis.

Bacterial and virus infections can occur in lesions, and these pathogens are able to be inhaled by the host, causing a sequence of complications. These complications include keratitis, mastitis, pneumonia, and myiasis and can increase mortality. Other clinical signs of complications are abortion, decreased lactation, anestrus, infertility, and subclinical sign may be present. Post-mortal LSDV infected cattle have been found with nodule formation and ulceration in the trachea, lung, and gallbladder [6, 19, 24]. Differential diagnosis include pseudo LSD/bovine *Herpes* mammillitis by bovine *Herpes* virus type 2, pseudocowpox and bovine papular stomatitis by *Parapoxvirus,* insect biting, urticaria, and demodicosis [4]. In outbreaks of the disease, the morbidity rate varies widely depending on the immune status of the hosts and the abundance of mechanical arthropod vectors.

Lumpy skin disease virus affects large ruminants, especially cattle and domestic water buffalo; however, this virus has also been reported in wildlife due to these animals belonging to the suborder Ruminantia, as well as cattle and buffaloes. Clinical signs of LSDV infection in wildlife are difficult to monitor and may range from asymptomatic to severe clinical signs [24]. Although reports of disease in wildlife are low incidence, it is still a concern whether the disease spreads from pets to wildlife [25]. It is difficult to prevent and control the disease due to the inability to control livestock and make preventive vaccines for wildlife as well as livestock. There are also many species of ruminant wildlife that are not known how to transmit disease, which can affect their natural population.

Humoral and Cellular Immunity

In cases of natural infection, the immunity caused by infection can be detected approximately 2 weeks after infection. From experimental infection, antibodies are detectable from 6 to 8 day post-infection. The highest immunity can be detected during 3–4 weeks after infection and remain detectable for up to 5 months [26]. Although antibodies are able to limit the spread of extracellular organisms, most LSDV are predominantly intracellular. Humoral immunity cannot be enough to eliminate the proliferation of viruses inside cells. Therefore, cell-mediated immunity is essential for the effective control of infection in animals. Once

an animal has been vaccinated, the humoral immune response can last longer than 7 months which is capable of preventing disease [27]. However, animals in endemic regions are recommended to receive an annual vaccination booster due to the duration of humoral and cellular immunity is still unknown.

Diagnosis

Diagnosis of LSDV is based on characteristic clinical signs combined with various laboratory approaches. Virus isolation and electron microscopy can be done but are rather expensive, labor and time–consuming, and cannot differentiate between poxvirus virions. The immunological–based techniques such as enzyme-linked immunosorbent assay have been developed to detect antibodies for LSDV infection; however, false detection caused by non-specific binding can occur between *Parapoxvirus* and *Capripoxvirus* [28]. In the laboratory, DNA–based detection methods by polymerase chain reaction (PCR) or real-time-PCR (RT-PCR) is used to detect viral DNA in specimens, including nodules, secretion, semen, and blood of suspected animals [29]. Target genes for PCR or RT-PCR detection are often used for the gene–specific viral attachment proteins such as P32, RPO30, and GPCR [30, 31]. For diagnosis, LSDV, sheep and goat poxviruses can be distinguished by real-time PCR technique [32]. The differentiation among natural genotypic targets of either vaccine or field strain genomes was developed by using a universal TaqMan probe to cover the field, vaccine, and recombinant strains of LSD [33]. The virulent LSDV from the vaccine strain was established by the restriction fragment length polymorphism [34].

Necropsy and Histopathological Finding

Infection with LSDV classically causes an acute disease with fever, depression, and appearance of nodules and lesions in the skin. The clinical signs of LSD are lymph nodes to form a skin blister about 2–5 cm in diameter on the skin, such as head, neck, legs, breast, and genitals. The necrotic nodules were ulcerated and formed deep scabs [35]. Larger vesicles may become necrotic and scarred for several months, while smaller vesicles heal faster. Blisters or ruptures of the cyst can be found. The mucus in the mouth, gastrointestinal tract, trachea, and lungs may be seen with edema. For asymptomatic infection, lesions are found in the subcutaneous or muscular layer. After the postmortem, lesions are often found in the respiratory organs, gastrointestinal tract, breast, lungs, bladder, kidneys, uterus, or testicles [36]. Histopathological examination of nodular skin biopsies showed edema, hyperemia, acanthosis, hydropic degeneration, and hyperkeratosis in epidermis [37].

Epidemiology (Susceptibility Hosts, Prevalence in Other Countries)

Lumpy skin disease virus was first investigated in Zambia in 1929 and was endemic in Africa during 1988–1989. However, the disease had been transmitted to middle Asian countries, including Saudi Arabia, Iran, Israel, and Iraq, by 1990 [6]. The incidence of LSD worldwide in 2016–2020 included African and Asian countries, and the epidemiology dynamically changed between the years. The prevalence and incidence of LSD detected by RT-PCR were reviewed during 2016–2020 (Figure-3). In 2016, the prevalence of LSD in the countries was 4.66% in Iraq [38], 4.77% in Uganda [39], 5.00% in Nigeria [40], 6.00% in Saudi Arabia [23], 7.22%–18.0% in Ethiopia [41, 42], and 12.9%–22.00% in Kazakhstan [43, 44]. In 2017, the prevalence of LSD in countries was 24.00% in Egypt [45] and 5.67% in Ethiopia [46]. In 2018, the prevalence of LSD was 29.00% in Russia [47] and 31.20%–88.80% in Egypt [48–50]. In 2019, the prevalence of LSD was 10.00% in Bangladesh [51], 19.50% in China [52], 22.28%–27.50% in Egypt [36, 53], and 37.66% in India [54]. In 2020, the prevalence of LSD was 3.00%–6.00% in Myanmar [55], 4.85% and 53.20% in Nepal [56, 57], 13.93% in India [58], and 78.00% in Bangladesh [59]. In 2021–2022, the prevalence of LSD was 70% in Egypt [60], 4.17% in Thailand [61], 5.9% in Mongolia [62], and 36.2% in Ethiopia [63].

Prevalence of LSD in Southeast Asia

Lumpy skin disease was shown to be distributed to South Asia through Southeast Asia (SEA) in 2019–2020 [1]. The first detection was found in the upper part of Vietnam in 2020 by the World Organization for Animal Health or Office International des Epizooties; OIE. The virus was isolated, identified, and investigated. The virus was similar to that endemic in Russia in 2017 and in China in 2019, indicating the disease was introduced from China–Vietnam border, and became distributed through 27 provinces in the country [64, 65]. Thereafter, LSD was transmitted to other countries in SEA, such as Laos, Cambodia, Thailand, and Myanmar [55, 66, 67]. In Malaysia, the disease has been reported but some cases have not been confirmed as LSD [68]. In Indonesia and the Philippines, LSD has not been found and critical notification in the prevention and control of LSD were concerned [69, 70]. In Thailand, at least 65 of 76 Provinces had reported infected animals to OIE by April, 2021. The Thai government produced strategies for prevention and controls, such as non–transfer of the animals from endemic areas, and vaccination in cattle and buffalo [71], which resulted in a sharp drop in morbidity rate in cattle in Thailand in 2022. Our experiences are agreeable with the encounter of LSD in Turkey in 2013 where uncontrolled animal movement is an important risk factor for spreading LSD to the neighboring countries, including Balkan, Caucasus, Iran, and Asia. Therefore, when any case occurs, isolation, quarantine, and vector control are necessary and have to be applied immediately [72].

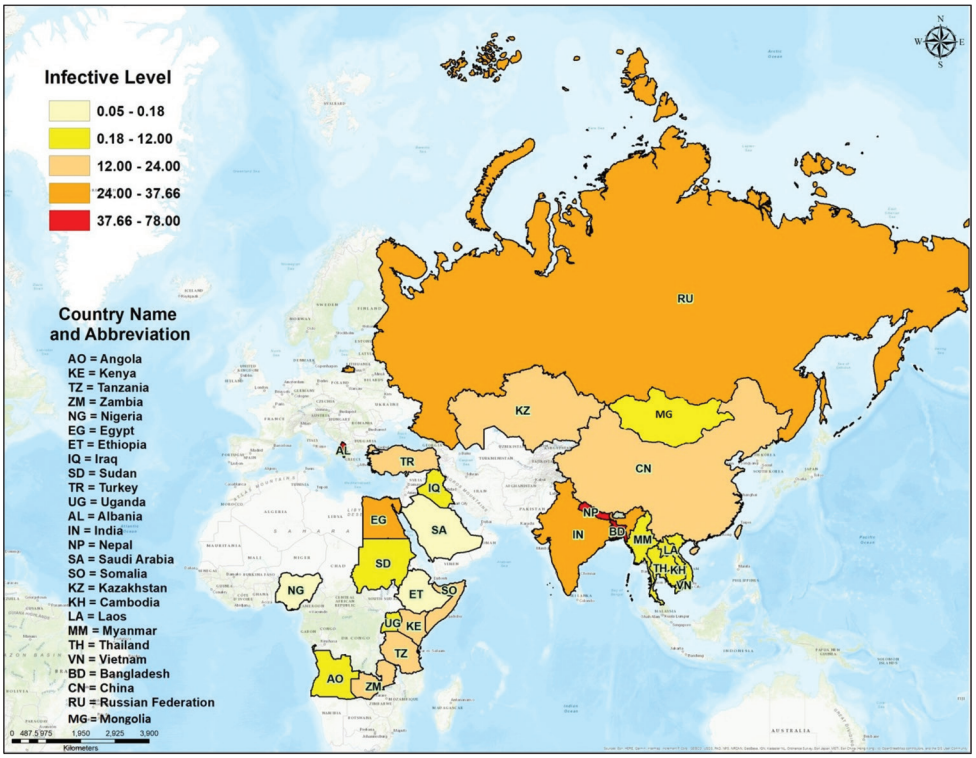

Figure-3: Prevalence of lumpy skin disease positively detected by polymerase chain reaction assay during 2016–2022. [Source: base map from the public Geo-Informatics and Space Technology Development Agency (GISTDA) using ArcGIS software (ESRI Inc., Redlands, CA, USA)].

Prevention Control and Eradication (Risk Factors, Regulations, Actions, and Vaccinations)

The stability of viruses in ambient conditions for a long period has certainly been established. It can persist in desiccated lesions on skin for 25–50 days and persist for many months in the dark environment in animal sheds. Veterinary education is needed for livestock workers to enable the performance of timely diagnoses of the disease to diminish the spread of the disease. Effective treatment against LSD has not been recognized. Symptomatic treatment for anti–inflammatory symptoms and antibiotics for preventing secondary microbial infection was used. Supportive therapy such as the Vitamin B–complex, Vitamin AD3E to retain the feeding capacity, and reproductive maintenance was frequently used (Table-3) [73–75].

Disease spreading can occur by infected animals or contaminated equipment or vectors. Early outbreaks can be controlled if the animal population is quarantined, sanitation on equipment or locality and biosafety. Controlling the movement or quarantine of newly imported animals for at least 3–4 weeks before being imported to the farm is one of the practices during the epidemic period [26]. Blood–sucking insects are the main vectors that cause the rapid spread of the disease; therefore, destroying breeding grounds, removing manure and cleaning with pesticides to disinfect and eliminate vectors regularly are recommended. Moreover, vaccination is an important preventive measure to reduce the spread and severity of the disease.

Table-3: Therapeutic agents for LSD treatment.

Therapeutic agents	Pharmacological effects	References
Enrofloxacin	Antibiotic	[73, 74]
Oxytetracycline		[73, 75]
Penicillin		[75]
Cephalosporin		[75]
Tetracycline		[75]
Fluoroquinolone		[75]
Chlorpheniramine maleate	Antihistamine	[73, 74]
Meloxicam	Nonsteroidal anti–inflammatory	[73, 74]
Dexamethasone suspension	Steroidal anti–inflammatory	[75]

LSD=Lumpy skin disease

To prevent and control strategies, including the assortment of risks and affected animals, movement restrictions, and compulsory and consistent vaccination are recommended, including the following:

Restriction of animal movement

The movement of animals infected with LSDV and/or effects of LSD must be exactingly prohibited to prevent the distribution of the disease to other areas and crossover to non-infected farms. The prevention of transboundary movements and the restriction of animal movement should be strict. Animals with skin lesions should be investigated and should be isolated for assessment.

Control the distribution of vectors

The distribution of arthropod vectors' movement and spread is risk factors for LSD transmission. Insecticides and traps are frequently used in livestock to prevent the disease.

Vaccination

The immunization of LSD by live attenuated vaccines has been effectively used in endemic areas. Antigenic homology of *Carpipoxvirus,* including SPPV, GTPV, and LSDV, cross-protection of immune response was beneficial [1, 4, 24, 76]. A live attenuated vaccine is commercially available for LSD eradication. Sheep pox vaccine from SPPV and GTPV is used for control in countries with high LSD outbreaks. Types of LSD vaccines are as follows: (1) Attenuated LSDV vaccines (Neethling vaccines) are the currently effective vaccine to prevent LSD in cattle. The effective control success possibility is 80% in the livestock, (2) Attenuated SPPV vaccines are suitable for the areas that SPPV and LSDV outbreak and (3) Attenuated Gorgan GTPV vaccine is suitable for the areas where outbreaks are a combination of SPPV and LSDV [1]. The live attenuated LSDV vaccine (Neethling vaccines), which is used in livestock worldwide, is the only ubiquitous LSDV vaccine. After vaccination, the immunity is raised within 10–30 days. This vaccine is recommended at any age unless contemporaries showing signs of infection have already occurred.

Conclusion

Lumpy skin disease is an infectious disease in large ruminants, cattle, and domestic water buffalo. This disease regularly occurs in Africa, Europe, and some regions of Asia and spread to Southeast Asia in 2020. The clinical signs range from subclinical to high fever, lymph node enlargement, and apparent nodules over the entire body, followed by developing necrotic tissue and scarring. Although LSD has a low mortality rate, the development of lesions can cause complications and has no specific treatment. Successful prevention of LSD is vaccination together with vector control, controlling animals, especially from endemic regions, and monitoring the situations of LSD outbreaks continuously by disease surveillance.

Authors' Contributions

KR: Performed literature search and drafted the manuscript. SukP: Reviewed and edited the manuscript. SP: Conceived the study, reviewed and edited the manuscript, and performed final manuscript revision. All authors have read and approved the final manuscript.

Acknowledgments

The authors are thankful to the One Health Research Unit and the Veterinary Infectious Disease Research Unit, Mahasarakham University, Thailand, for supporting the study. The authors did not receive any funds for this study.

Competing Interests

The authors declare that they have no competing interests.

Publisher's Note

Veterinary World remains neutral with regard to jurisdictional claims in published map and institutional affiliation.

References

1. Roche, X., Rozstalnyy, A., TagoPacheco, D., Pittiglio, C., Kamata, A., Alcrudo, D.B., Bisht, K., Karki, S., Kayamori, J., Larfaoui, F. and Raizman, E. (2020) Introduction and Spread of Lumpy Skin Disease in South, East and Southeast Asia: Qualitative risk Assessment and Management. Food and Agriculture Organization, Rome.
2. Spickler, A.R. (2008) Lumpy Skin Disease. Available from: https://www.cfsph.iastate.edu/diseaseinfo/factsheets.php. Retrieved on 17-01-2022
3. Beard, P.M. (2016) Lumpy skin disease: A direct threat to Europe. *Vet. Rec*., 178(22): 557–558.
4. Tuppurainen, E., Alexandrov, T. and Beltrán-Alcrudo, D. (2017) Lumpy skin disease-a manual for veterinarians. *FAO Anim. Prod. Health Manual.*, 20: 7–46.
5. Davies, F.G. (1991) Lumpy skin disease, an African capripox virus disease of cattle. *Br. Vet. J*., 147(6): 489–503.
6. Abdulqa, H.Y., Rahman, H.S., Dyary, H.O. and Othman, H.H. (2016) Lumpy skin disease. *Reprod. Immunol. Open Acces*., 1(4): 2476–1974.
7. Tulman, E.R., Afonso, C.L., Lu, Z., Zsak, L., Kutish, G.F. and Rock, D.L. (2001) Genome of lumpy skin disease virus. *J. Virol*., 75(15): 7122–7130.
8. Davies F.G. (1991) Lumpy skin disease of cattle: A growing problem in Africa and the Near East. *World Anim. Rev*., 68(3): 37–42.
9. Tuppurainen E.S.M., Venter E.H., Coetzer J.A.W. and Bell-Sakyi L. (2015) Lumpy skin disease: Attempted propagation in tick cell lines and presence of viral DNA in field ticks collected from naturally-infected cattle. *Ticks Tick Borne Dis*., 6(2): 134–140.
10. Lubinga, J.C., Tuppurainen, E.S.M., Stoltsz, W.H., Ebersohn, K., Coetzer, J.A.W. and Venter, E.H. (2013) Detection of lumpy skin disease virus in saliva of ticks fed on lumpy skin disease virus-infected cattle. *Exp. Appl. Acarol*., 61(1): 129–138.
11. Tuppurainen, E.S., Stoltsz, W.H., Troskie, M., Wallace, D.B., Oura, C.A.L., Mellor, P.S., Coetzer, J.A. and Venter, E.H. (2011) A potential role for ixodid (hard) tick vectors in the transmission of lumpy skin disease virus in cattle. *Transbound. Emerg. Dis*., 58(2): 93–104.
12. Tuppurainen E.S.M., Lubinga J.C., Stoltsz W.H., Troskie M., Carpenter S.T., Coetzer, J.A.W., Venter, E.H. and Oura, C.A.L. (2013) Mechanical transmission of lumpy skin disease virus by *Rhipicephalus appendiculatus* male ticks. *Epidemiol. Infect*., 141(2): 425–430.
13. Lubinga, J.C., Tuppurainen, E.S., Coetzer, J.A., Stoltsz, W.H. and Venter, E.H. (2014) Evidence of lumpy skin disease virus over-wintering by transstadial persistence in *Amblyomma hebraeum* and transovarial persistence in *Rhipicephalus decoloratus* ticks. *Exp. Appl. Acarol*., 62(1): 77–90.
14. Lubinga, J.C., Tuppurainen, E.S.M., Mahlare, R., Coetzer, J.A.W., Stoltsz, W.H. and Venter, E.H. (2015) Evidence of transstadial and mechanical transmission of lumpy skin disease virus by *Amblyomma hebraeum* Ticks. *Transbound. Emerg. Dis*., 62(2): 174–182.
15. Tuppurainen E.S., Lubinga J.C., Stoltsz W.H., Troskie M., Carpenter S.T., Coetzer J.A., Venter H.E. and Oura, C.A. (2013) Evidence of vertical transmission of lumpy skin

disease virus in *Rhipicephalus decoloratus* ticks. *Ticks Tick Borne Dis*., 4(4): 329–333.
16. Sohier, C., Haegeman, A., Mostin, L., De Leeuw, I., Van Campe, W., De Vleeschauwer, A., Tuppurainen, E.S.M., van den Berg, T., De Regge, N. and De Clercq, K. (2019) Experimental evidence of mechanical lumpy skin disease virus transmission by *Stomoxys calcitrans* biting flies and *Haematopota* spp. horseflies. *Sci. Rep*., 9(1): 20076.
17. Chihota, C.M., Rennie, L.F., Kitching, R.P. and Mellor, P.S. (2003) Attempted mechanical transmission of lumpy skin disease virus by biting insects. *Med. Vet. Entomol*., 17(3): 294–300.
18. Chihota, C.M., Rennie, L.F., Kitching, R.P. and Mellor, P.S. (2001) Mechanical transmission of lumpy skin disease virus by *Aedes aegypti* (*Diptera*: *Culicidae*). *Epidemiol. Infect*., 126(2): 317–321.
19. Al-Salihi, K. (2014) Lumpy skin disease: Review of literature. *Mirror Res. Vet. Sci. Anim*., 3(3): 6–23.
20. Aerts, L., Haegeman, A., De Leeuw, I., Philips, W., Van Campe, W., Behaeghel, I., Mostin, L. and De Clercq, K. (2021) Detection of clinical and subclinical lumpy skin disease using ear notch testing and skin biopsies. *Microorganisms*, 9(10): 2171.
21. Bedeković, T., Šimić, I., Krešić, N. and Lojkić, I. (2018) Detection of lumpy skin disease virus in skin lesions, blood, nasal swabs and milk following preventive vaccination. *Transbound. Emerg. Dis*., 65(2)*:* 491–496.
22. Irons, P.C., Tuppurainen, E.S.M. and Venter, E.H. (2005) Excretion of lumpy skin disease virus in bull semen. *Theriogenology*, 63(5): 1290–1297.
23. Kasem, S., Saleh, M., Qasim, I., Hashim, O., Alkarar, A., Abu-Obeida, A., Gaafer, A., Hussien, R., AL-Sahaf, A., Al-Doweriej, A. and Bayoumi, F. (2018) Outbreak investigation and molecular diagnosis of Lumpy skin disease among livestock in Saudi Arabia 2016. *Transbound. Emerg. Dis*., 65(2): 494–500.
24. Namazi, F. and Tafti, A.K. (2021) Lumpy skin disease, an emerging transboundary viral disease: A review. *Vet. Med. Sci*., 7(3): 888–896.
25. Tuppurainen, E.S., Venter, E.H., Shisler, J.L., Gari, G., Mekonnen, G.A., Juleff, N., Lyons, N.A., De Clercq, K., Upton, C., Bowden, T.R., Babiuk, S. and Babiuk, L.A. (2017) Review: Capripoxvirus diseases: Current status and opportunities for control. *Transbound. Emerg. Dis*., 64(3): 729–745.
26. European Food Safety Authority (EFSA), Calistri, P., DeClercq, K., De Vleeschauwer, A., Gubbins, S., Klement, E., Stegeman, A., Abrahantes, J.C., Antoniou, S.E., Broglia, A. and Gogin, A. (2018) Lumpy skin disease: Scientific and technical assistance on control and surveillance activities. *EFSA J.*, 16(10): e05452.
27. Milovanović, M., Dietze, K., Milićević, V., Radojičić, S., Valčić, M., Moritz, T. and Hoffmann, B. (2019) Humoral immune response to repeated lumpy skin disease virus vaccination and performance of serological tests. *BMC Vet. Res.*, 15(1): 80.
28. Tian, H., Chen, Y., Wu, J., Shang, Y. and Liu, X. (2010) Serodiagnosis of sheeppox and goatpox using an indirect ELISA based on synthetic peptide targeting for the major antigen P32. *Virol. J.*, 7(1): 245.
29. Tuppurainen, E.S., Venter, E.H. and Coetzer, J.A.W. (2005) The detection of lumpy skin disease virus in samples of experimentally infected cattle using different diagnostic techniques. *Onderstepoort. J. Vet. Res.*, 72(2): 153–164.
30. Zhou, T., Jia, H., Chen, G., He, X., Fang, Y., Wang, X., Guan, Q., Zeng, S., Cui, Q. and Jing, Z. (2012) Phylogenetic analysis of Chinese sheeppox and goatpox virus isolates. *Virol. J.*, 9(1): 25.
31. Ochwo, S., VanderWaal, K., Ndekezi, C., Nkamwesiga, J., Munsey, A., Witto, S.G., Nantima, N., Mayanja, F., Okurut, A.R.A., Atuhaire, D.K. and Mwiine, F.N. (2020) Molecular detection and phylogenetic analysis of lumpy skin disease virus from outbreaks in Uganda 2017–2018. *BMC Vet. Res.*, 16(1): 66.
32. Lamien, C.E., Le Goff, C., Silber, R., Wallace, D.B., Gulyaz, V., Tuppurainen, E., Madani, H., Caufour, P., Adam, T., El Harrak, M. and Luckins, A.G. (2011) Use of the Capripoxvirus homologue of Vaccinia virus 30 kDa RNA polymerase subunit (RPO30) gene as a novel diagnostic and genotyping target: Development of a classical PCR method to differentiate Goat poxvirus from Sheep poxvirus. *Vet. Microbiol*., 149(1–2): 30–39.
33. Alexander, S., Olga, B., Svetlana, K., Valeriy, Z., Yana, P., Pavel, P. and Aleksandr, K. (2019) A real-time PCR screening assay for the universal detection of lumpy skin disease virus DNA. *BMC Res. Notes*, 12(1): 371.
34. Menasherow, S., Rubinstein-Giuni, M., Kovtunenko, A., Eyngor, Y., Fridgut, O., Rotenberg, D., Khinich, Y. and Stram, Y. (2014) Development of an assay to differentiate between virulent and vaccine strains of lumpy skin disease virus (LSDV). *J. Virol. Methods*., 199: 95–101.
35. Badhy, S.C., Chowdhury, M.G.A., Settypalli, T.B.K., Cattoli, G., Lamien, C.E., Fakir, M.A.U., Akter, S., Osmani, M.G., Talukdar, F., Begum, N., Khan, I.A., Rashid, M.B. and Sadekuzzaman, M. (2021) Molecular characterization of lumpy skin disease virus (LSDV) emerged in Bangladesh reveals unique genetic features compared to contemporary field strains. *BMC Vet. Res.*, 17(1): 61.
36. Ali, A.A., Neamat-Allah, A.N., Sheire, H.A.E.M. and Mohamed, R.I. (2021) Prevalence, intensity, and impacts of non–cutaneous lesions of lumpy skin disease among some infected cattle flocks in Nile Delta governorates, Egypt. *Comp. Clin. Path*., 30(4): 693–700.
37. Gharban, H.A., Al-Shaeli, S.J., Al-Fattli, H.H. and Altaee, M.N. (2019) Molecular and histopathological confirmation of clinically diagnosed lumpy skin disease in cattle, Baghdad Province of Iraq. *Vet. World*., 12(11): 1826–1832.
38. Fayad, A.N. (2017) A study of Lumpy skin disease outbreak in Thi Qar Province. *UTJ Sci*., 6(3): 12–18.
39. Ochwo, S., VanderWaal, K., Munsey, A., Ndekezi, C., Mwebe, R., Okurut, A.R.A., Nantima, N. and Mwiine, F.N. (2018) Spatial and temporal distribution of lumpy skin disease outbreaks in Uganda (2002–2016). *BMC Vet. Res*., 14(1): 174.
40. Adedeji, A.J., Akanbi, O.B., Adole, J.A., Chima, N.C. and Baje, M. (2018) Outbreak of lumpy skin disease in a dairy farm in Keffi, Nasarawa State, Nigeria. *Sokoto J. Vet. Sci.*, 16(3): 80–86.
41. Leliso S.A., Dawo F. and Chibsa T.R. (2021) Molecular characterization of lumpy skin disease virus isolates from outbreak cases in cattle from Sawena District of Bale Zone, Oromia, Ethiopia. *Vet. Med. Int*., 2021: 8862183.
42. Mohammed, Y., Tefera, Y. and Bayissa, B. (2017) Isolation of lumpy skin disease virus from cattle in and around Kombolcha and Dessie, northeastern Ethiopia. *Bull. Anim. Health. Prod. Afr*., 65(3): 491–499.
43. Issimov, A., Rametov, N., Zhugunissov, K., Kutumbetov, L., Zhanabayev, A., Kazhgaliyev, N., Nurgaliyev, B., Shalmenov, M., Absatirov, G., Dushayeva, L. and Akhmetaliyeva, A. (2020) Emergence of the first lumpy skin disease outbreak among livestock in the Republic of Kazakhstan in 2016. *Preprints*., 2020: 1–14.
44. Orynbayev, M.B., Nissanova, R.K., Khairullin, B.M., Issimov, A., Zakarya, K.D., Sultankulova, K.T., Kutumbetov, L.B., Tulendibayev, A.B., Myrzakhmetova, B.S., Burashev, E.D., Nurabayev, S.S., Chervyakova O.V., Nakhanov A.K. and Kock R.A. (2021) Lumpy skin disease in Kazakhstan. *Trop. Anim. Health. Prod*., 53(1): 166.
45. Abd Elmohsen, M., Selim, A. and Abd Elmoneim, A.E. (2019) Prevalence and molecular characterization of lumpy skin disease in cattle during period 2016–2017. *Benha Vet. Med. J*., 37(1): 172–175.
46. Tassew, A., Assefa, A., Gelaye, E., Bayisa, B. and Ftiwi, M. (2018) Identification and molecular characterization of

lumpy skin disease virus in East Hararghe and East Shewa Zone, Oromia Regional State. *ARC J. Anim. Vet. Med*., 4(3): 1–16.
47. Aleksandr, K., Pavel, P., Olga, B., Svetlana, K., Vladimir, R., Yana, P. and Alexander, S. (2020) Emergence of a new lumpy skin disease virus variant in Kurgan Oblast, Russia, in 2018. *Arch. Virol*., 165(6): 1343–1356.
48. Elhaig, M.M., Almeer, R. and Abdel-Daim, M.M. (2021) Lumpy skin disease in cattle in Sharkia, Egypt: Epidemiological and genetic characterization of the virus. *Trop. Anim. Health. Prod*., 53(2): 287.
49. Faris, D.N., El-Bayoumi, K., El-Tarabany, M. and Kamel, E.R. (2021) Prevalence and risk factors for lumpy skin disease in cattle and buffalo under subtropical environmental conditions. *Adv. Anim. Vet. Sci*., 9(9): 1311–1316.
50. Hodhod, A., Elgendy, E., El-Moniem, M.I.A. and Ibrahim, M.S. (2018) Isolation and molecular characterization of lumpy skin disease virus in Egypt during 2017–2018. *Eur. J. Pharm. Med. Res*., 7(1): 96–103.
51. Hasib, F.M.Y., Islam, M.S., Das, T., Rana, E.A., Uddin, M.H., Bayzid, M., Nath, C., Hossain, M.A., Masuduzzaman, M., Alim, M.A., Das, S. and Alim, M.A. (2021) Lumpy skin disease outbreak in cattle population of Chattogram, Bangladesh. *Vet Med Sci*., 7(5): 1616–1624.
52. Lu, G., Xie, J., Luo, J., Shao, R., Jia, K. and Li, S. (2021) Lumpy skin disease outbreaks in China. *Transbound. Emerg. Dis*., 68(2): 216–219.
53. Keshta, H.G., Allam, A.M., Fadl, S.E. and El Beskawy, M. (2020) Detection of lumpy skin disease during an outbreak in summer 2019 in Menoufia governorate, Egypt using Clinical, biochemical and molecular diagnosis. *Zagazig Vet. J*., 48(4): 378–389.
54. Sudhakar, S.B., Mishra, N., Kalaiyarasu, S., Jhade, S.K., Hemadri, D., Sood, R., Bal, G.C., Nayak, M.K., Pradhan, S.K. and Singh, V.P. (2020) Lumpy skin disease (LSD) outbreaks in cattle in Odisha state, India in August 2019: Epidemiological features and molecular studies. *Transbound. Emerg. Dis*., 67(6): 2408–2422.
55. Maw, M.T. An update on the Lumpy Skin Disease (LSD) Outbreak Situation Country Name: Myanmar. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/04_myanmar_mtm.pdf. Retrieved on 17-01-2022.
56. Ganesh, K.C., Karki, S., Koirala, P., Upadhyaya, D., Regmi, B. and Pande, K. (2020) First report of Lumpy skin disease outbreak in cattle and buffaloes of Gandaki Province, Nepalm, Authorea. p1–8.
57. Pandey, G., Pathak, C.R., Sadaula, A., Bastakoti, R., Hamal, P., Khanal, P., Sapkota, P., Pandeya, Y.R. and Paudel, S. (2021) Molecular and Serological Detection of Lumpy Skin Disease in Cattle of Western Chitwan, Nepal. In: Proceedings of 12th National Workshop on Livestock and Fisheries Research in Nepal on 3-4 March. p57–61.
58. Sethi, R.K., Senapati, S.K., Selim, A.M., Acharya, A.P., Mishra, C., Das, M., Das, M., Hegazy, Y.M. and Biswal, S.S. (2021) Molecular epidemiology of first lumpy skin disease outbreak in Odisha, India. *Vet. Res. Commun*., 46(3): 711–717.
59. Giasuddin, M., Yousuf, M.A., Hasan, M., Rahman, M.H., Hassan, M.Z. and Ali, M.Z. (2019) Isolation and molecular identification of lumpy skin disease (LSD) virus from infected cattle in Bangladesh. *Bangladesh J. Livest. Res*., 26(1–2): 15–20.
60. Selim, A., Manaa, E. and Khater, H. (2021) Molecular characterization and phylogenetic analysis of lumpy skin disease in Egypt. *Comp. Immunol. Microbiol. Infect*., 79: 101699.
61. Seerintra, T., Saraphol, B., Wankaew, S. and Piratae, S. (2021) Molecular identification and characterization of Lumpy skin disease virus emergence from cattle in the northeastern part of Thailand. *J. Vet. Sci*., 23(5): e73.
62. Odonchimeg, M., Erdenechimeg, D., Tuvshinbayar, A., Tsogtgerel, M., Bazarragchaa, E., Ulaankhuu, A., Selenge, T., Munkhgerel, D., Munkhtsetseg, A., Altanchimeg, A., Odbileg, R., Soyolmaa, G., Enkhmandakh, Y, Batmagnai, E., Sugar, S., Kimura, T., Sugimoto, C., Isoda, N., Batsukh, B. and Sakoda, Y. (2022) Molecular identification and risk factor analysis of the first Lumpy skin disease outbreak in cattle in Mongolia. *J. Vet. Med. Sci.*, 84(9): 1244–1252.
63. Mathewos, M., Dulo, F., Tanga, Z. and Sombo, M. (2022) Clinicopathological and molecular studies on cattle naturally infected with lumpy skin diseases in selected districts of Wolaita Zone, Southern Ethiopia. *BMC Vet. Res.*, 18(1): 297.
64. Long, P.T. (2021) An update on the Lumpy Skin Disease (LSD) Outbreak Situation Country Name: Vietnam. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/06_vietnam_long.pdf. Retrieved on 17-01-2022.
65. Tran H.T.T., Truong A.D., Dang A.K., Ly D.V., Nguyen, C.T., Chu, N.T., Hoang T.V., Nguyen H.T., Nguyen V.T. and Dang, H.V. (2021) Lumpy skin disease outbreaks in vietnam, 2020. *Transbound. Emerg. Dis*., 68(3): 977–980.
66. Sothyra, T. (2021) An update on the Lumpy skin disease (LSD) Outbreak situation Country name: Cambodia. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/01_cambodia_tum.pdf. Retrieved on 17-01-2022.
67. Souriya, V.S. (2021) Lumpy Skin Disease (LSD) Outbreak Situation in Lao PDR. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/02_laos_souriya.pdf. Retrieved on 17-01-2022.
68. Abdullah S.D. (2021) Preparedness by the Country at the Risk of Lumpy Skin Disease (LSD) Incursion Country Name: Malaysia. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/03_malaysia_abdullah.pdf. Retrieved on 17-01-2022.
69. Bucad A.C. (2021) Preparedness by the Country at the Risk of Lumpy Skin Disease (LSD) Incursion. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/08_philippines_bucad.pdf. Retrieved on 17-01-2022.
70. Hidayat M.M. (2021) Preparedness by the Country at the Risk of Lumpy Skin Disease (LSD) Incursion Country Name: Indonesia. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/07_indonesia_lsd_preparedness_risk_of_incursion.pdf. Retrieved on 17-01-2022.
71. Premashthira, S. (2021) An update on the Lumpy Skin Disease (LSD) Outbreak Situation Country Name: Thailand. Available from: https://www.rr-asia.oie.int/wp-content/uploads/2021/06/05_thailand_premashthira.pdf. Retrieved on 17-01-2022.
72. Turan, N., Yilmaz, A., Tekelioglu, B.K. and Yilmaz, H. (2017) Lumpy skin disease: Global and Turkish perspectives. *Appro. Poult. Dairy Vet. Sci*., 1(1): 1–5.
73. Anil, T.S.V. and Durga, A.K. (2021) Antibiotic versus no antibiotic approach in the management of lumpy skin disease (LSD) in cattle. *J. Entomo. Zool. Stud*., 9(1): 1612–1614.
74. Islam S.J., Deka, C. and Sonowal, P.J. (2021) Treatment and management of lumpy skin disease in cow: A case report. *Int. J. Vet. Sci. Anim. Husb*., 6(2): 26–27.
75. Feyisa, A.F. (2018) A case report on clinical management of lumpy skin disease in bull. *J. Vet. Sci. Technol*., 9(3): 538.
76. Kitching, P. (1983) Progress towards sheep and goat pox vaccines. *Vaccine*, 1(1): 4–9.

****