Review Article

Lumpy Skin Disease Virus Infection: An Emerging Threat to Cattle Health in Bangladesh

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Abstract | Lumpy skin disease (LSD) is a highly infectious and economically important transboundary disease of cattle caused by LSD virus (LSDV). LSD is characterized by fever and the appearance of nodular lesions in the skin covering all parts of the body. LSD is currently endemic in many African countries and causing significant economic losses. LSD has recently spread out of Africa into the Middle East region, and still continuing to spread other territories of the world. In September 15, 2019 the first occurrence of LSD outbreak in Bangladesh has been reported to the OIE (World Organization for Animal Health). LSD is a vector-borne disease, and climatic conditions of Bangladesh are favorable for the propagation of vectors, which should influence the rapid transmission of LSD in the cattle population of Bangladesh. Therefore, LSD may appear as a big challenge to cattle health in Bangladesh in the near future. Consequently, it is very important to take strategic plans and immediate control measures for LSD outbreak control and prevention in Bangladesh. In this review article, we will focus on epidemiology and modes of LSDV transmission, and its effective control and preventive measures to reduce or eradicate the LSDV infection from a recently infected country like Bangladesh. In addition, we will highlight on impacts of LSD outbreaks in cattle industry of Bangladesh, and necessity of farmers' awareness building and telemedicine service during the Coronavirus disease 2019 (COVID-19) outbreaks in controlling LSD.

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Introduction

Lumpy skin disease (LSD), an economically important transboundary disease of cattle, is transmitted by arthropod vectors (Woods, 1988). It was first described as "pseudo-urticaria" in Zambia (formerly Northern Rhodesia) in 1929 (MacDonald, 1931). Later, in the 1940s it was identified as an infectious viral disease caused by lumpy skin disease virus (LSDV) (Von-Backström, 1945). LSD is characterized by nodular lesions development in the skin covering the whole body (Tageldin et al.,

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2014). LSD may cause systemic effects such as fever, anorexia, dysgalactia and pneumonia, and lesions in the mouth and upper respiratory tract (Davies, 1991a). LSDV, a double stranded DNA virus has a genome of approximately 151 kbp with a central coding region of 156 putative genes (Tulman et al., 2001). Similar to other poxviruses, the central coding region of the LSDV genome is bounded by two identical inverted terminal repeat regions of about 2.4 kbp at both termini (Tulman et al., 2001). LSDV belongs to the genus Capripoxvirus in the family Poxviridae (Tulman et al., 2001). The genus Capripoxvirus comprised of three closely related important animal virus species, such as sheeppox virus (SPV), goatpox virus (GPV), and LSDV, affecting sheep, goats, and cattle, respectively (Babiuk et al., 2008; Kitching, 2003). These viruses cause significant economic damages to the sheep, goat, and cattle industry in Africa and Asia (Fenner, 1996). Sheep pox was originally reported in the first century AD, and goatpox was notified in Southern Europe and Northern Africa in the 1880s (Diallo and Viljoen, 2007), suggesting LSD as an old disease but recently identified, and the true evolutionary history and spread of the Capripoxviruses (CaPVs) still remain to be resolved. Generally, CaPV infections are host-specific, and the geographic distribution patterns of sheeppox, goatpox, and LSD are different (Carn, 1993). All three CaPVs only can produce disease in ruminants, and zoonoses are not reported (Limon et al., 2020). Moreover, LSD has not been observed in sheep and goats even when they are kept in a close contact with infected cattle (Davies, 1991b). Despite the fact the origin of LSD is obscure but until recently it was believed to be a disease confined to Africa, where it is endemic in most countries (Coetzer, 2004). LSD is now considered as a rapidly emerging disease of major consequence, and its recent spreading to many Asian countries becoming a big threat to cattle population (EFSA, 2015, 2018). LSD is listed as a World Organization for Animal Health (OIE)-notifiable disease for rapid spreading and great economic impacts. In 2019, for the first time LSD outbreak was reported in Bangladesh (OIE World Animal Health Information Database, 2019; EFSA, 2020). LSD outbreaks in 2019 caused infections in a large number of cattle populations countrywide, and appearing as an emerging threat to cattle health in Bangladesh. Again, in 2020 the LSD outbreaks are being reported in different areas of the country, where LSD is rapidly spreading in thousands of cattle with at least 50 deaths in the northern and north-eastern districts of Bangladesh (Dhaka Tribune, 2020b). During this global pandemic of COVID-19, Bangladesh is also being badly attacked, as of 6 July 2020, there are 165618 confirmed COVID-9 cases in Bangladesh, including 2096 related deaths (WHO, 2020). Due to the Coronavirus disease 2019 (COVID-19) outbreaks, it is speculated that the smooth veterinary health services are subject to interruption, which may negatively impact the outcome of the LSD (Gortázar and de la Fuente, 2020). Therefore, it is important to ascertain the health service by enhancing telemedicine during this COVID-19 health emergency. The origin and spread of the virus in the cattle of Bangladesh remain to be investigated. Therefore, investigation to detect the origin of the disease and its modes of transmission is paramount to reduce/eradicate its further spread in Bangladesh, as LSD has a high impact on production efficiency and profitability which may result in substantial economic losses to cattle industry of the country. In this study, we aimed to focus on epidemiology and modes of transmission of LSD, as well as measures to be taken for the effective control and prevention of LSD. Furthermore, we will discuss the economic impacts of LSD on the cattle farming in Bangladesh. In addition, we will discuss the importance of active surveillance and early detection of the LSD to limit the re-emergence and future spread of LSD, the neglected tropical disease of cattle.

Epidemiology

Cattle are the natural hosts for LSDV (Tuppurainen et al., 2015; Şevik et al., 2016). Asian water buffaloes can also be naturally infected with LSDV (El-Nahas et al., 2011). LSDV is highly host-restricted, while SPV and GPV can cause infection in both sheep and goat (Limon et al., 2020). Although LSDV-specific antibodies have been reported in some wild ruminants like eland, blue wildebeest, giraffe, greater kudu and impala, but their role in the LSD epidemiology is not well documented (Barnard, 1997). The incubation period for LSD in natural infections is about 1-4 weeks (Coetzer, 2004). The morbidity rate can greatly vary, ranging from 3 to 85% (Thomas and Maré, 1945). Although mortality rate of LSD is usually low (1 to 3%), but in some cases it may reach 40% (Babiuk et al., 2008; Coetzer, 2004). LSDV has a lower mortality rate compared to SPV and GPV infection (Limon et al., 2020). A recent study reported no significant variations were found in prevalence of LSD in cattle regarding age and sex (Elhaig et al., 2017), whereas the disease severity considerably varies depending on the breed of cattle (Davies, 1991a). Crossbred cattle are more susceptible to LSDV infection compared to zebu cattle (Gari et al., 2011; Kiplagat et al., 2020). Also, disease severity in young animals and cows in the peak of lactation is more pronounced causing severe loss to production (Al-Salihi, 2014). Since 2012, the disease has been spreading outside the African continent with outbreaks in many Middle East countries such as Israel, Jordan and Lebanon in 2012-2013, and continued spreading into and through Turkey in 2013, and it is now endemic (EFSA, 2015, 2018). In 2014, LSD outbreak was reported in Azerbaijan (Zeynalova et al., 2016). In 2015, LSDV spread to Greece, the Caucasus and Russia. In 2016, the virus further spread east into the Balkan region, north towards Moscow, and west into Kazakhstan (Sprygin et al., 2018a; Tasioudi et al., 2016). According to the OIE, LSD outbreak has also been notified in many other countries, including Kuwait (1991), Lebanon (1993), Yemen (1995), United Arab Emirates (2000), Bahrain (2003), Israel (2006-2007), and Oman (2010) (Shimshony and Economides, 2006). LSD was first reported in Bangladesh in September, 2019, but the outbreak was started in July, 2019 and confirmed in August, 2019 (Figure 1) (OIE World Animal Health Information Database, 2019). In 2019, LSD was also reported in China and India for the first time (EFSA, 2020). The overall prevalence of 2019 LSD outbreak in cattle of Bangladesh was 2.19%, and the highest prevalence was 8.26%, observed in Chattogram (Table 1) (Food Security Cluster. Situation Report: Lumpy Skin Disease in Bangladesh, 2019). The lowest prevalence (0.01%) was observed in the cattle of Sylhet and Mymensingh division, Bangladesh (Table 1), which may indicate the influence of geographic distribution on LSD outbreak due to vectors prevalence involved in LSDV transmission. The seasonal pattern influencing LSD outbreaks is an important factor from epidemiological point of view to consider, indicating its relationships with vector prevalence (EFSA, 2019). In Bangladesh during monsoon season (May–August) the vector activity is increased and that will influence the outbreaks of LSD. In 2020, the outbreaks of LSD are ongoing which causing thousands of new infections with 1-2% mortality (Dhaka Tribune, 2020b). During no or minimal vector activity where LSDV resides is not well characterized (Tuppurainen et al., 2017a). Although there is no report indicating a carrier state for LSDV infected animals (Tuppurainen et al., 2017a), but a recent study in an experimental infection demonstrated the presence of live LSDV in lymph nodes and testicles of clinically and sub-clinically infected animals, suggestive for the reservoirs of live LSDV (Kononov et al., 2019).

Table 1: *Prevalence of LSD in cattle population in different divisions of Bangladesh (Food Security Cluster. Situation Report: Lumpy Skin Disease in Bangladesh, 2019).*

Division	Cattle population	LSD cases	Prevalence (%)	95% CI	P value
Dhaka	3906043	17300	0.44	0.43-0.45	P<0.0001
Chattogram	3145717	259765	8.26	8.23-8.29	
Rajshahi	4276463	13854	0.32	0.31-0.33	
Khulna	3610506	235633	6.53	6.5-6.56	
Sylhet	1572944	182	0.01	0.01-0.01	
Barisal	1770563	22232	1.26	1.24-1.28	
Rangpur	4608034	4256	0.09	0.09-0.09	
Mymensingh	2437626	306	0.01	0.01-0.01	

95% CI: 95%-confidence interval.

Figure 1: *LSD in a calf (image was taken during an outbreak of LSD in 2019 at Pekua, Cox's Bazar, Bangladesh). The entire body was covered with multiple nodular skin lesions.*

Modes of transmission of LSDV

The transmission modes of LSDV between animals and from herd to herd are incompletely understood. Direct transmission of LSDV between animals may occur but its relative importance compared to vector transmission yet to confirm. Several studies suggest that LSDV can be mechanically transmitted by different blood-feeding vectors (Sprygin et al., 2019). LSDV is mainly transmitted by arthropod vectors like biting flies, ticks such as *Rhipicephalus appendiculatus*, *Rhipicephalus decoloratus* and *Amblyomma hebraeum*, and mosquitoes (*Aedes aegypti*) (Chihota et al., 2001; Lubinga et al., 2014). The virus can be transmitted through contaminated mouth parts of vectors without real replication of the virus inside arthropod cells or tissues (Sprygin et al., 2019). Chihota et al. (2001) demonstrated the mechanical transmission of LSDV in the mosquito *Aedes aegypti*, which is prevalent in Bangladesh (Paul et al., 2018), and may act as mechanical vector for LSDV transmission. Tuppurainen et al. showed the association of male *Rhipicephalus appendiculatus* ticks in LSDV transmission (Tuppurainen et al., 2013). Kamal et al. (1996) reported the prevalence of *Rhipicephalus appendiculatus* ticks in 65.45% cattle of Chittagong hilly area in Bangladesh, and it is noteworthy to mention that the first outbreak of LSDV infection was reported in Chittagong area of Bangladesh (OIE World Animal Health Information Database, 2019). *Stomoxys calcitrans* (Stable fly) was reported as the most important vector for LSDV transmission during LSD outbreaks in Israel (Yeruham et al., 1995; Kahana-Sutin et al., 2017). A recent study demonstrated *Stomoxys calcitrans* as the most efficient vector for LSDV transmission, where *Aedes aegypti* was found as an efficient vector, but *Culicoides nubeculosus*, *Anopheles stephensi*, and *Culex quinquefasciatus* were inefficient for LSDV transmission (Gubbins, 2019). Sohier et al. (2019) showed that both *Stomoxys calcitrans* and *Haematopota* spp. can support mechanical transmission of LSDV. Chihota et al. (2003) reported the failure of LSDV transmission by *Culicoides nubeculosus*. In a recent study, Sprygin et al. (2018b) demonstrated that the common housefly (*Musca domestica*) could be involved in the LSD transmission. Although further work is required to confirm the role of *M. domestica* in the transmission of LSDV (Sprygin et al., 2018b), but it is speculated that houseflies may play an important role in the seasonal transmission of LSD in Bangladesh.

The sharing of feed or water troughs contaminated by discharges from infected animals may act as an indirect route of LSDV transmission (Ali et al., 2012). LSDV can be transmitted by intrauterine transmission (Rouby and Aboulsoud, 2016), as well as from mother to calf through skin lesions on the mother's udder and teats or through contaminated milk (Tuppurainen et al., 2017b). Prevalence of arthropod vectors may vary between regions due to variations in climate, season, temperature, humidity and vegetation, therefore, vectors in different areas are required to be investigated for the involvement in LSDV transmission depending on their abundance and feeding behaviour. Indirect vector transmission is predominant at small distances, but movement of infected animals may play the vital role in long-distance spreading of the disease (Sprygin et al., 2019; Saegerman et al., 2018). Extremes of weather and natural disasters may influence the spreading of vector-borne infectious disease, suggesting an association of climate change with these events (Jones et al., 2008). A recent study indicated that precipitation and temperature are positively associated with the risks for LSDV, while negatively affected by wind (Machado et al., 2019). Therefore, understanding the cause of a disease emergence is very critical to its prevention.

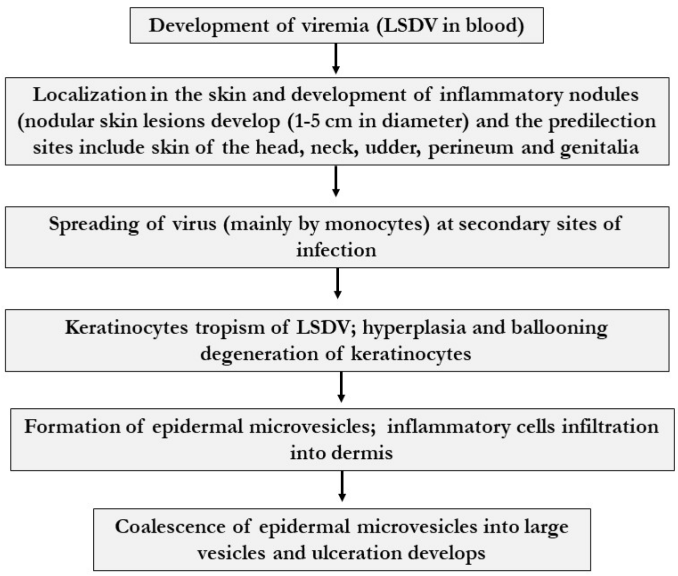

Figure 2: *A schematic diagram of LSD pathogenesis.*

Pathogenesis

A schematic representation of LSD pathogenesis has been indicated in Figure 2. Briefly, LSD is a systemic disease of cattle, characterized by fever, followed by the development of nodular lesions in the skin that can cover the entire body (Tuppurainen et al., 2017b; Constable et al., 2017). Then virus spread to the secondary sites of replication, primarily by monocytes. LSDV has a tropism of keratinocytes, and it causes hyperplasia and ballooning degeneration of keratinocytes (Coetzer, 2004). Then, there is the formation of epidermal microvesicles, and inflammatory cells enter into dermis. Finally,

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epidermal microvesicles coalesce into large vesicles, and ulceration develops (Mulatu and Feyisa, 2018).

The economic impacts of LSD in the world and Bangladesh

LSD is one of the economically significant diseases causing severe production loss. The impacts of disease are usually easy to identify but difficult to quantify. When the disease outbreaks are broad a long-term effect on livestock leads to the great impacts on the economy of the country. The cost of animal disease depends on the losses related to animal illness, death, reduced production and losses in trade and other revenues (Rushton, 2009). LSD renders decreased milk and beef production, loss of draft power, mortality, increased treatment and vaccination costs, embargo on trades, and thus LSD may affect overall economy of the farmers as well as of the country (Gari et al., 2011). LSD also has socio-economic impacts (Tuppurainen and Oura, 2012). The economic impact of the disease relates to the prolonged convalescence, and in this respect, LSD is similar to another transboundary disease of cloven-hoofed animals, foot-and-mouth disease. The OIE categorizes LSD as a notifiable disease because of the major economic impact caused by the outbreak. LSD occurrence in dairy herd causes sharp decrease in the milk production. In addition, LSD occurrence results loss of weight gain, increased abortion rates, and damage to hides (Tuppurainen et al., 2012). A recent study in Ethiopia showed LSD as an economically devastating viral disease causing financial problems in livestock industries due to significant milk production loss, infertility, abortion, trade embargo and sometimes death (Gumbe, 2018). Another recent study demonstrated how LSD can cause significant economic losses, and it was found that the economic losses were related to death of the LSDV-infected animals, selling of the infected animals at low price, slaughtering of the animals, treatment cost, and production loss of milk and meat (Limon et al., 2020).

The livestock sector in Bangladesh is an integral component of agriculture, which accounts for 1.54% of total gross domestic product (GDP) in Bangladesh (Livestock Economy at a Glance, 2018). Cattle are one of the main components of the livestock sector in Bangladesh. LSD may substantially impact on the livelihoods of small-scale farmers and poor rural communities, which make up the majority of cattle owners in Bangladesh. The cost for providing supportive treatment for 2-3 months during the recovery period from LSD is unrealistic for many of these low-income farmers (Food Security Cluster. Situation Report: Lumpy Skin Disease in Bangladesh, 2019).

Control and prevention of LSD

So far, there is no effective antiviral against LSDV infection. Different approaches are in use for the prevention and control of LSD outbreaks. Using a single approach, it is difficult to effectively control and prevent LSDV infection. Therefore, multiple approaches are required for control and prevention of the LSDV infection, including restricted movements, screening, quarantine, and disinfection of the infected animals, control of vectors, vaccinations and treatment of affected animals to prevent secondary bacterial infections (Tuppurainen et al., 2017b).

Vaccines and vaccination

Despite some limitations such as adverse reactions, longer waiting period after last outbreak to achieve disease free status, limited clinical surveillance for the disease in subpopulation, etc., vaccination has been proved as best tool for quick and effective control of LSD, as it reduces the total number of susceptible animals within the population, and prevent entry and spread of the disease (EFSA, 2019). Moreover, vaccination is easier to implement than other approaches such as vector control and stamping out of the affected cattle or unaffected cattle in the affected herds. Also, vaccination protects the animals from the clinical manifestation of the disease and thus direct and indirect economic losses are prevented. Notably, different countries have shown the success in controlling LSD outbreak by vaccination campaign. For example, vaccination campaign of cattle population in Balkan region with LSD homologous vaccine strain reduced the outbreaks from 7483 cases in 2016 to 385 cases in 2017, and in 2018 there was no reports of outbreaks, confirming the effectiveness of LSD homologous vaccine strain (EFSA, 2019). Genomic analysis revealed the closeness of the CaPVs, where 98% sequence similarity exists between all three species (Tulman et al., 2002; Gershon and Black, 1988; Black et al., 1986), and Capripoxviruses cannot be distinguished serologically from each other (Carn, 1993). Due to the antigenic homology these viruses can provide cross-protection (Capstick and Coackley, 1961). Therefore, it might be possible to use a single vaccine strain to protect cattle, sheep and goats (Kitching, 2003). Despite effectivity of a heterogenous vaccine sometimes recurrence of disease after vaccination becomes a limitation to its use. An incomplete protection has been reported in cattle vaccinated with SPV vaccines against LSD (Brenner et al., 2009; Ayelet et al., 2013). Notably, in Turkey, despite continued vaccination with heterologous vaccines since 2014 still there is LSD outbreak reports, indicating an insufficient protection of heterologous vaccine (EFSA, 2019, 2020). In addition, Abdallah et al. (2018) reported the infection of LSDV in cattle previously vaccinated with Romanian SPPV vaccine, which requires further evaluation of vaccine efficacy under field conditions. Moreover, in an efficacy study, Kenyan sheep pox virus strain vaccine (KS1 O-180) showed poor efficacy in protecting cattle populations against LSD infection under field conditions (Molla et al., 2017). However, a recent study demonstrated that Goatpox virus (G20-LKV) vaccine strain elicits a strong protective response and showed full protection in cattle against LSD (Zhugunissov et al., 2020).

In another field study in Israel, Ben-Gera et al. showed that Neethling vaccines provide good protection in cattle, and is superior to attenuated SPV vaccine in preventing LSD morbidity (Ben-Gera et al., 2015). In 2019, no LSD outbreak was reported in South-Eastern Europe, where a mass vaccination programme with homologous LSD vaccine was conducted (EFSA, 2020). There are different vaccines for LSD, including LSDV Neethling vaccine, Kenyan sheep and goat pox (KSGP) O-180 strain vaccines and Gorgan goat pox vaccine, with different trade names. Therefore, selection of a right vaccine candidate against LSD is crucial for its effective control and prevention. According to Officials of DLS-Bangladesh, a heterogenous goatpox vaccine was administered to 34,000 heads of cattle in Chattogram, Bangladesh, and the vaccine was found to be effective against LSD (Dhaka Tribune, 2020). Until recently, there is no LSDV vaccine developed in Bangladesh for vaccinating cattle against LSD (personal communication). An effective homogenous LSDV vaccine is essential for successful control and elimination of the LSD (EFSA, 2020). In particular, achieving the highest vaccination coverage in the shortest period of time is cornerstone to rapidly control of LSD outbreaks, along with good clinical surveillance for immediate notification of suspected clinical cases that should be confirmed in the laboratory to differentiate LSD field virus from the vaccine strain. Also, any country lifting its vaccination program is expected to demonstrate that it is disease-free by setting up a surveillance scheme along the lines indicated by the OIE. Although stamping out strategy is implemented in some countries as an efficient method despite high cost for preventing the spread of an infectious disease like LSD, but this strategy seems to be not that much feasible in the context of the economy of Bangladesh, as the majority of cattle farmers in this country are poor or very poor. In case of stamping out policy implementation the affected farmers should be sufficiently compensated.

Vector control

Vector-borne transmission of LSD is a big threat towards LSD control and prevention. An effective vector control or vector elimination program is crucial to limit the transmission of LSDV. Information on how long the insect vectors remain infective for LSDV transmission and the capability of spreading the disease is important to control LSD. It is important to detect which insect acts as a major vector for LSDV transmission in a certain geographic region. Also, better LSD control and prevention strategies are important for the prevention of the re-emergence of disease in an area where outbreak already occurred. Effective vector control is imperative as it is thought that it will reduce the impact of the disease in endemic areas and also inhibit further spread of the disease into new areas. Design and implementation of effective and economically viable vector control plans are important to make the vector control program successful and to reduce the expense of the vector control program. It has been evident that LSD is endemic in many countries in Africa and has never been eradicated once it has entered a new region, indicating effective vector control is crucial for the prevention of the re-emergence of the disease. In Bangladesh the climatic conditions are favorable for vectors propagation, which may make difficult of the successful vector control program and thus LSD control. So the possibility of resurge of infection in the coming years cannot be ruled out. Notably, in Russia the first LSD outbreak was reported in 2015, but most devastating year for Russia was 2016 (Kononov et al., 2017). The risk in farms with outdoor access is six times higher than in farms where animals are kept indoors, independent of vaccination status, possibly because of higher exposure to vectors bite (EFSA, 2018). A proper epidemiological investigation to assess the risk factors associated with the ever first LSD outbreaks in Bangladesh is needed to develop a context-appropriate intervention for preventing infections and limiting the spread of LSDV in cattle population.

Awareness building

Considering the consequence of LSD outbreaks in cattle industry in Bangladesh, DLS-Bangladesh should take different steps to tackle the spread of the disease, including active monitoring and surveillance of the cattle farms, holding of the awareness increasing events for the farmers, cattle traders, and personnel related to cattle industry, and technicians, strategic plans about vaccinations, etc. Furthermore, to reduce the LSD spread implementation of all the possible approaches should be ascertained, including restricted or total banned of cattle movement in affected areas, awareness building of the farmers, instructions on separation of the affected cattle and avoidance of communal grazing, and frequent treatment of cattle with insect repellents to minimize the risk of vector transmission of the disease. Furthermore, the farmers should be introduced about the telemedicine veterinary services, which is very important particularly to reduce the LSD spread and avoid fatal outcome of LSD during this COVID-19 health emergency.

Active surveillance and early detection

To limit the spread of LSDV infection, active surveillance and early detection are very important. Particularly, active monitoring and surveillance is highly essential as many farmers are not aware of LSDV infection and its impacts on animal health. Many farmers also lack of knowledge of transmission patterns of LSD. Furthermore, there are some farmers those are even not aware of this cattle disease in Bangladesh. Both active and passive monitoring and surveillance should be enforced for limiting the spread of the infection, and effective vector control program and adopting vaccination strategy may finally remove LSDV infection from Bangladesh and restore the LSD-free status in the country. Also, free-ranging herds that are not monitored daily outbreaks may remain undetected for weeks, may help in further spreading. Active surveillance is very much essential for early detection of the disease (EFSA, 2020). If vaccinations are done, post-vaccination monitoring and evaluation of vaccination program is also important. The outbreaks in India (EFSA, 2020) represent a threat for the neighboring Bangladesh, which can be at risk of new incursion. Due to religious value in India maybe no stamping out policy will be implemented, so the affected cattle may remain as the source for further infection. Therefore, a continued active monitoring will be necessary for controlling LSDV infection in Bangladesh.

Early detection of the disease is paramount in limiting the spread of any disease, particularly LSD. Any lacking in laboratory capacity may compromise the early detection of LSD, which may facilitate the spreading of the disease. Therefore, an improved laboratory facilities towards early detection of LSDV infection is also required. It is also of importance to establish the reference laboratory for LSDV detection and molecular characterization, and monitoring of the affected animals/herds. Moreover, continuous monitoring and surveillance are important for screening and early detection of LSD. Moreover, the majority of the small-scale cattle farmers in Bangladesh lack knowledge of LSDV infection, therefore, it is also necessary to train the farmers. Prophylactic vaccination of the entire cattle population may control and prevent the outbreaks, if vaccination is done well in advance in at-risk areas. In economic context, slaughtering of all LSDV-infected and in-contact animals is not feasible in majority of the cattle rearing farmers in Bangladesh, which may further complicate the control and eradication of LSDV, because of the transmission of the virus via arthropod vectors from asymptomatic viraemic animals (Tuppurainen et al., 2017b). The knowledge in the context of cattle rearing practices, vaccination approaches, managing sick/dead animals should be made available to the farmers, which will help toward control and prevention of the disease. Moreover, molecular epidemiologic study is necessary to detect the isolates and origin of the isolates causing LSD outbreaks in the cattle population of Bangladesh, which is also needed for proper control planning and its implementation.

Conclusion

LSD is economically important due to its significant effects on the livelihoods of small-scale farmers. LSD may be considered as an emerging animal disease of substantial importance as climatic changes favoring arthropod vectors propagation that involved in LSDV transmission. Once LSD has occurred in a country virtually it is impossible to eradicate. An effective vaccination campaign is required to greatly reduce the morbidity and economic effects of an epizootic. It is important to set a nationwide control plan for early detection by active surveillance to take immediate action if any outbreak/infection is reported. Moreover, it is important to investigate and detect the risk factors for LSD in the context of Bangladesh. The information on LSDV local isolates and their phylogenetic analysis is of importance to understand LSDV molecular epidemiology and to develop vaccine with local isolates for effective control and prevention of the disease.

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Authors Contribution

All authors contributed equally to this study.

Conflict of interest

The authors have declared no conflict of interest.

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