A Review of Global Epidemiology of Lumpy Skin Disease, its Economic Impact, and Control Strategies

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Summary

Lumpy skin disease (LSD) is an emerging viral disease, particularly of cattle and water buffalo. The disease is caused by lumpy skin disease virus (LSDV), a member of the genus Capripoxvirus of family Poxviridae which is manifested by characteristic skin nodules, pyrexia, lachrymation, nasal discharge, and swelling of superficial lymph nodes. Lumpy skin disease causes huge economic losses to the livestock farmers due to significant milk loss, damage of the hides, and reproductive problems such as abortion and infertility in affected animals. Initially, LSD was confined to Africa but later spread to Asia and Europe, particularly after 2012. This article describes the spatial and temporal patterns of LSD outbreaks that occurred from 2005-Mid-September, 2020 using the publicly available outbreak data from the World Animal Health Information System (WAHIS) of the World Organization for Animal Health (OIE). There were

3118 LSD outbreaks reported in the last 15 years with 2265 (72.6%) from Europe, 462 from Asia (14.8%), and 391(12.5%) outbreaks from Africa. 3070 (98.46%) of the total outbreaks during the study period occurred since 2012, with the highest month-wise outbreaks observed in July (778) and seasonally in the summer season (1873) which corresponds with the vector season. Since 2012, around 3 (2.78) new countries per year are being affected by LSD. The current situation of LSD spread demands for globally coordinated efforts to control this transboundary disease. Effective surveillance for early detection, vector control measures, vaccination, and regulation of animal movement is necessary to curb down the further spread of LSD.

Key words: Emerging animal disease, Outbreaks, Asia, Europe, Africa, Transboundary animal disease

Introduction

Lumpy skin disease (LSD) is a viral disease caused by lumpy skin disease virus (LSDV), a *Capripoxvirus* belonging to the family *Poxviridae* (Buller et al., 2005; Sprygin et al., 2020). Lumpy skin disease is primarily a disease of cattle and water buffaloes (El-Tholoth & El-Kenawy, 2016; Tuppurainen et al., 2017) but can also infect some wild ruminants such as Arabian oryx, springbok, impala, and giraffe (Sudhakar et al., 2020; Tuppurainen et al., 2017; Greta et al., 1992). The disease is characterized by pyrexia, lachrymation, nasal discharge, swelling of the superficial lymph nodes, and the presence of highly characteristic firm flat-topped papules and nodules of size 5-50 mm all over the body particularly in the head, neck, genitalia, udder, buccal mucosa and limbs (Babiuk et al., 2008; Tageldin et al., 2014; Tuppurainen et al., 2017). Morbidity from LSD is variable ranging from 2-45% while mortality generally lies below 10% (Tuppurainen et al., 2017).

In the late 1920s, LSD was first identified in a southern African country called Zambia (Beard, 2019; Morris, 1931). For several decades, the disease was restricted to Southern Africa (Sprygin et al., 2020) but thereafter spread to other African countries and reached the Middle East by the late 1980s (Beard, 2019; Davies, 1982). To date, LSD has spread beyond Africa and has reached several countries across Europe and Asia and is continuing to spread further (Alkhamis & VanderWaal, 2016; OIE, 2020; Tuppurainen et al., 2017; Wainwright et al., 2013). Vectors play an important role in the transmission of this disease but import/export of live animals and animal products, illegal trade of animals from infected areas and migration of people along with their animals after the domestic crisis in the country are also some of the contributing factors for the rapid spread of LSDV (Babiuket al., 2008; Sprygin et al., 2019; Tuppurainen et al., 2017).

The World Organization for Animal Health (OIE) has listed lumpy skin disease as a notifiable disease under “Cattle diseases and infections” (OIE, 2019; Tuppurainen & Oura, 2012). Lumpy skin disease severely affects lactating cows at their peak lactation which results in reduced milk production due to high fever and secondary bacterial mastitis (Tuppurainen et al., 2017; Tuppurainen & Oura, 2012). Substantial economic losses are associated with the disease due to death of animals, abortion in pregnant animals, a significant reduction in milk yield, sterility, and permanent damage to the skin and hides (Agonafir et al., 2016; Ali & Gumbe, 2018; Tuppurainen et al., 2017; Tuppurainen & Oura, 2012). Besides, restrictions imposed on the international trade of animal and animal products in the affected countries, high production costs due to associated control measures and limited animal movement causes significant financial loss (Tuppurainen & Oura, 2012).

In this study, we collected the data on LSD outbreaks from 2005 to Mid-September, 2020 available on the public domain of the “OIE World Animal Health Information System” to understand the temporal and spatial pattern of LSD outbreaks in the last 15 years. The data retrieved included year/month, country of the outbreak, the reason for notification, disease manifestation and numbers of the outbreaks. Also, secondary data from scientific publications, proceedings, and grey literature were also considered. Descriptive analysis of the retrieved data was conducted using Microsoft Excel 16. The map was prepared using Arc GIS 10.7 version.

Causative agent and transmission of lumpy skin disease

Lumpy skin disease is caused by lumpy skin disease virus (LSDV), a member of the genus *Capripoxvirus* of *Poxviridae.* The genus *Capripoxvirus* comprises lumpy skin disease virus (LSDV), sheeppox virus (ShPV), and goatpox virus (GPV) (Tulman et al., 2001). *Capripoxvirus* consists of a large double-stranded enveloped DNA and there is a close genetic relationship among the species of this genus (Rashid et al., 2017). Species of *Capripoxvirus* cannot be identified serologically and are capable of inducing heterologous cross-protection to each other (Carn, 1993; Davies, 1991; Davies, 1982; Kitching et al., 1986). Poxviruses are capable of producing characteristic skin lesions in the host (Babiuk et al., 2008).

Since the first occurrence of LSD in 1929 in Zambia, the disease spread to various countries of Africa in the following 50 years (Woods, 1988). Currently, the disease is endemic in Africa and has spread to various Asian and European countries. The transmission of LSDV generally occurs through vectors (insects and ticks) but sometimes it also occurs through direct/indirect contacts with infected animals (Sprygin et al., 2019). Experimental works and field observations have shown the possible transmission of LSDV via direct contact but the rates of transmission were considered low (Diesel, 1949; Weiss, 1968; Aleksandr et al., 2020). The common vectors involved in LSDV transmission include stable fly (*Stomoxys calcitrans*), biting midge (*Culicoides punctatus*), *Aedes aegypti* mosquito and, African tick species of *Rhipicephalus* and

Amblyomma spp. (Sprygin et al., 2019; Tuppurainen et al., 2017). Only mechanical transmission of LSDV is implicated but the multiplication of virus inside the vectors cannot be excluded (Sprygin et al., 2019; Tuppurainen et al., 2017). Illegal trade of infected animals, animal products, and the movement of insect vectors also contribute to the spread of LSDV in a large geographical region (Babiuk et al., 2008).

Geographical distribution and global status of LSD

Lumpy skin disease was first reported in the South African country of Zambia in 1929 (Morris, 1931; Woods, 1988). For almost 60 years since the initial outbreak, the disease spread to most parts of Africa and remained there until 1989 when Israel confirmed the first outbreak of LSD (Davies, 1982, 1991; FAO, 2013; Nawathe et al.,1982; Woods, 1988). Since then, the disease was reported in various countries in the Middle East including Palestinian Autonomous Territories, Jordan, Lebanon, Kuwait, Iraq, Iran, Saudi Arabia, Bahrain, Oman, Yemen, Syria, and the United Arab Emirates (OIE, 2019; Tuppurainen et al., 2017; Tuppurainen & Oura, 2012; Tuppurainen et al., 2014; Yeruham et al., 1995). Since 2012, LSD has been spreading rapidly to Europe and Asia. The LSD outbreaks in Europe were reported from Turkey in 2013, Azerbaijan in 2014, Greece, Cyprus, Russia and Armenia in 2015, Albania, Bulgaria, Former Yugoslav Republic of Macedonia, Georgia, Montenegro, Kosovo, and Serbia in 2016 (Calistri et al., 2020; OIE, 2020; Tuppurainen et al., 2017). Similarly, in Asia outbreaks were reported in Israel and Lebanon in 2012, Iraq, Jordan and Palestinian Autonomous Territories in 2013, Iran and Kuwait in 2014, Saudi Arabia in 2015, Kazakhstan in 2016, Bangladesh, China, Syria and India in 2019, Chinese Taipei and Nepal in 2020 (OIE, 2020; Rahman, 2020; Sudhakar et al., 2020).
There was a total of 3118 outbreaks of LSD reported to OIE from Africa, Europe, and Asia from 2005 to Mid-September of 2020. Of the total outbreaks, 462, 2265, and 391 outbreaks were

reported from Asia, Europe, and Africa respectively (Table 1). Temporally, there was a total of 48 outbreaks from 2005-2011, whereas there was a total of 3070 (98.46%) outbreaks from the year 2012-Mid September of 2020, with 1967 outbreaks in the year 2016 alone (Table 1; Fig. 2). Since 2012, there is a rapid increase in the spatiotemporal occurrence of LSD outbreaks, and around 2.78 new countries per year are being affected by LSD which indicates the continuous spread of the disease (Fig. 1) (Alkhamis & VanderWaal, 2016; Calistri et al., 2020; OIE, 2020; Tuppurainen et al., 2017). Seasonally, there were about 413 outbreaks in autumn, 746 in spring, 1873 in summer, and 86 in winter. The highest number of outbreaks in summer corresponds with the vector season (Fig. 4). Month wise, July has the highest number of outbreaks (778) and March has the lowest number of outbreaks (1) (Fig. 3).

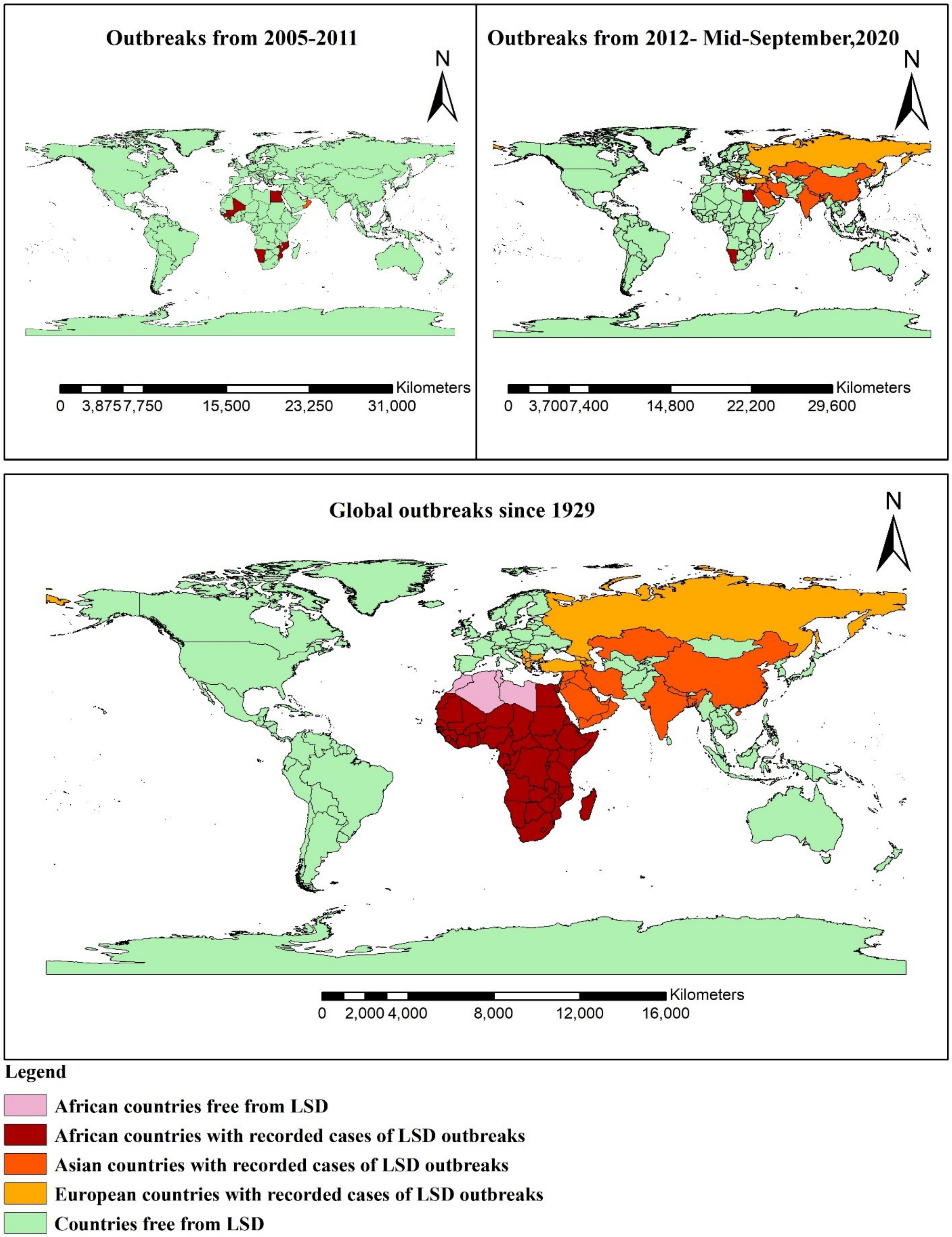

Fig. 1. Spatiotemporal pattern of LSD outbreaks: 2005-2011 (top-left); 2012- 2020 (top-right) and overall LSD outbreak recorded since 1929 (bottom); Data source for map: (Calistri et al., 2020; OIE, 2020; Tuppurainen et al., 2017; Tuppurainen & Oura, 2012; Beard, 2016).

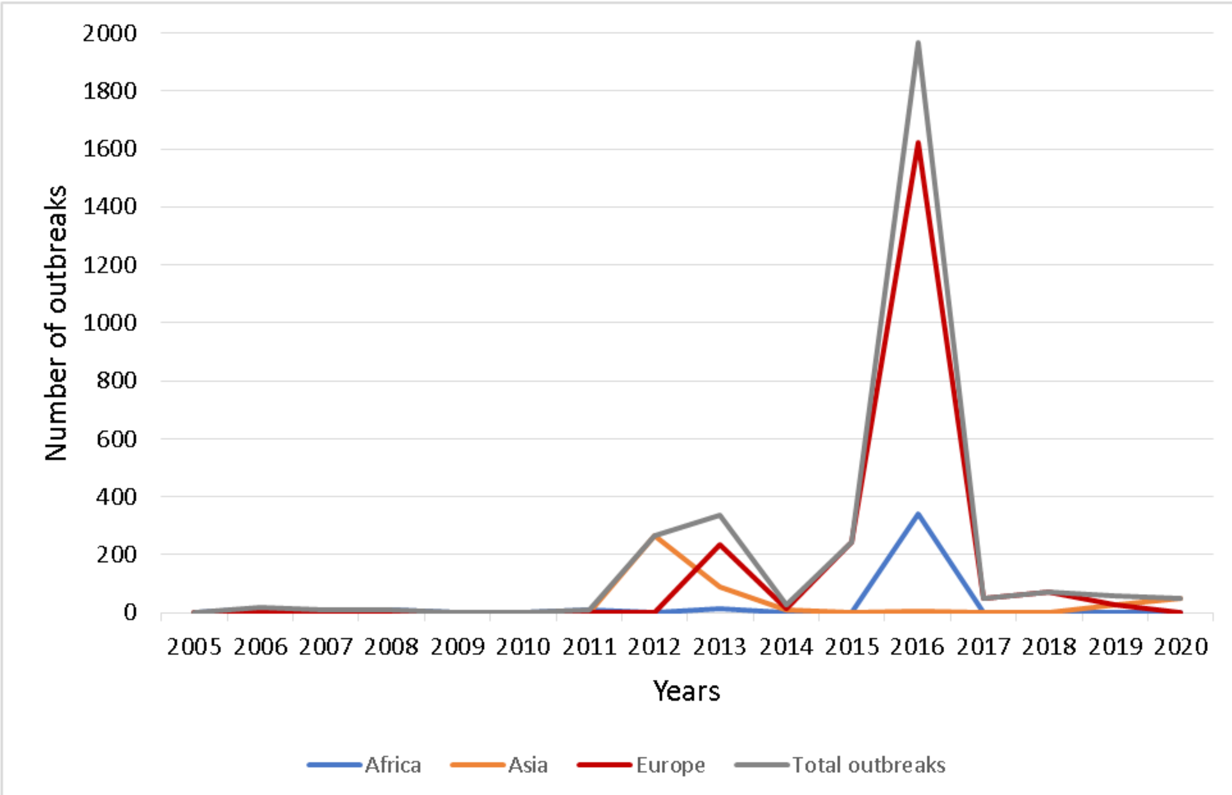

Fig. 2. Total global and regional outbreaks of LSD from 2005-Mid September, 2020 (OIE, 2020).

Table 1. Outbreak Status of LSD in Asia, Europe, and Africa from 2005 to Mid-September 2020 (OIE, 2020).

Region	Total no. of outbreaks	No. of outbreaks form 2005-2011	No. of outbreaks from 2012-mid September,2020	Most affected country in the region with number of outbreaks	Year with highest number of outbreaks
Asia	462	10	452	Israel (260)	2012 (266)
Europe	2265	0	2265	Russia (469)	2016 (1620)
Africa	391	38	353	Namibia (340)	2016 (341)

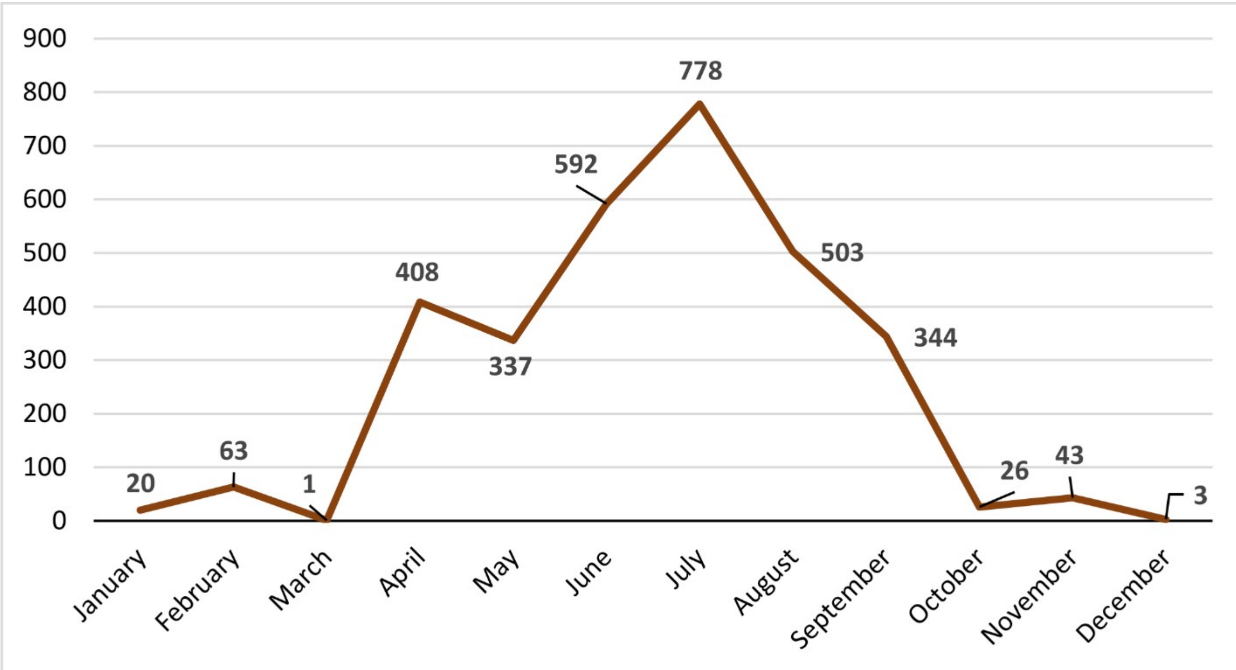

Fig. 3. Months wise outbreaks of lumpy skin disease from 2005-Mid September, 2020 (OIE, 2020).

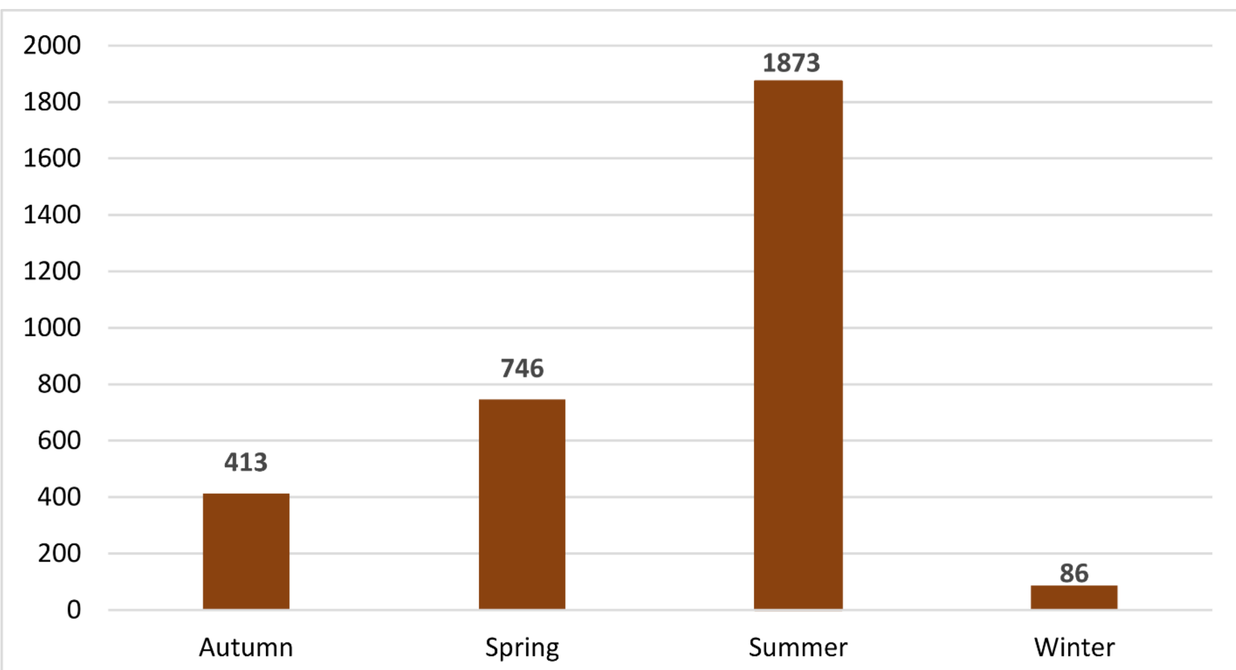

Fig. 4. Season wise outbreaks of lumpy skin disease from 2005-Mid September, 2020 (OIE, 2020).

Lumpy Skin disease in Africa

Africa is endemic to lumpy skin disease. Since the first appearance of the disease in Zambia in 1929, the disease has travelled all over Africa besides Algeria, Morocco, Tunisia, and Libya (Morris, 1931; Tuppurainen et al., 2017; Woods, 1988). After 14 years of the first outbreak, the disease was reported in Ngamiland district of Botswana with characteristic signs of lameness, leg swelling, skin nodules, and generalized lymphadenopathy (Von Backstrom, 1945). In 1944, a similar type of disease called "Knopvelsiekte" was seen in Marico district in South Africa (Thomas & Maré, 1945). The disease then caused a panzootic in South Africa which lasted until 1949 affecting millions of cows with some serious economic losses (Diesel, 1949). In 1945, the disease spread across Southern Rhodesia (Zimbabwe) (Houston, 1945). The disease was later identified in Kenya in 1957 (MacOwan, 1959), Sudan in 1971 (Ali & Obeid, 1977), Chad and Niger in 1973 (Nawathe et al., 1978), Nigeria in 1974 (Nawathe et al., 1978), Ethiopia in 1981-1983 (Mebratu et al., 1984). From 1970 to 1985 LSD occurred in most of the central and western African countries (Davies, 1991b). In 1988, LSD was detected in Egypt (Davies, 1991a; House et al., 1990).

Since 2005 to Mid-September, 2020, OIE has records of around 391 total LSD outbreaks from Africa which is comparatively lower than Asia and Europe. Among the total outbreaks, 340 (86.95%) outbreaks were recorded from Namibia. 98.72% of the total outbreaks were recurrent outbreaks. The number of outbreaks could be even higher as there is the possibility of under-reporting or inadequate reporting to international agencies, late detection of the disease, and poor epidemiological studies.

Lumpy skin disease in Asia

In Asia, LSD was officially reported in 1989 in Israel and was supposed to be the first case of LSD outside Africa (Davies, 1991b; Wainwright et al., 2013; Yeruham et al., 1995). However, some articles suggest that cases of LSD were already reported in Kuwait in 1986 (Brenner et al., 2006; Greta et al., 1992; Lefevre & Ordner, 1987; House et al., 1990). Since 1989 outbreaks were reported in Kuwait in 1991, Lebanon in 1993, Yemen in 1995, UAE in 2000, Bahrain in 2003, and Oman in 2010 (Tuppurainen & Oura, 2012).

In 2006, the recurrence of LSD outbreaks was observed in Israel after 1989 (Brenner et al., 2009; Brenner et al., 2006). There were around 10 total outbreaks in Israel between 2006-2007 (OIE, 2007). Although Israel was able to deal with the outbreaks of 2006-2007 with early diagnosis, vaccination of the all the herds around 10 km radius, modified stamping out, movement restriction in 10 km zone, and vector control, OIE reports recurrent LSD outbreaks in the country in 2012 and 2019 (Boris, 2015).

According to OIE, multiple outbreaks of LSD were reported in Asian countries since 2012. OIE reports LSD outbreaks in countries like Lebanon and Israel in 2012, Iraq, Jordan and Palestinian Autonomous Territories in 2013, Iran and Kuwait in 2014, Saudi Arabia in 2015, Kazakhstan and Saudi Arabia in 2016, Bangladesh, China, India, Israel, Palestinian Autonomous Territories and Syria in 2019 and China, Chinese Taipei, Nepal and Syria in 2020. Asia has recorded about 462 total outbreaks of LSD from 2005-Mid-September, 2020 out of which 452 (97.83%) outbreaks were from the year 2012 and 260 (56.27%) of the total outbreaks were from Israel. To date around 19 Asian countries i.e. Bangladesh, Bahrain, China, Chinese Taipei, Israel, Iran, Iraq, India, Jordan, Kazakhstan, Kuwait, Lebanon, Nepal, Oman, Palestinian Autonomous Territories, Saudi Arabia, Syria, UAE, and Yemen have reported the outbreaks of LSD (OIE, 2020; Tuppurainen et al., 2017). The number of outbreaks again could be higher due to late diagnosis, poor surveillance, inadequate epidemiological studies, and under reporting of the disease.

The rapid increase in demand for live cattle, frozen meat, and animals feed in the Middle East and the tendency to import improved cattle in Asian countries to meet the demand of the increasing human population could be the reason for the rapid spread of LSD (Shimshony & Economides, 2006). Since the conflict that started from Syria in the spring of 2011, a large number of people have migrated to countries like Jordan, Lebanon, Iraq, Egypt, Turkey, and other European and Asian counties (Ostrand, 2015). These people may have travelled with their livestock and the movement of livestock from one place to another could have contributed to the spread of the virus from one country to another (Tuppurainen et al., 2017).

Lumpy skin disease in Europe

The first confirmed case of LSD in Europe was reported from Turkey in 2013 (Dilaveris, 2019; Kreindel et al., 2015; OIE, 2013; Tuppurainen et al., 2017). Since then, cases of LSD have been reported in Azerbaijan in 2014, Greece, Cyprus, Russia, and Armenia in 2015, Albania, Bulgaria, Former Yugoslav Republic of Macedonia, Georgia, Montenegro, Kosovo, and Serbia in 2016 (Fig. 5) (Dilaveris, 2019; OIE, 2020). To date, 13 European countries have reported the outbreaks of LSD (Calistri et al., 2020; OIE, 2020; Tuppurainen et al., 2017).

Since its first incursion in Europe, 2265 outbreaks of LSD were reported from 2013 to Mid-September of 2020. Of the total outbreaks, Russia alone contributes to 20.71% of the outbreaks. There have been regular outbreaks of LSD in Russia since 2015 (Aleksandr et al., 2020; Beard, 2016; OIE, 2020; Sprygin et al., 2018). Besides the outbreaks of LSD reported to OIE from 11

European countries, the literature indicates outbreaks of LSD in Kosovo and Cyprus too (Dilaveris, 2019; Findik, 2017).

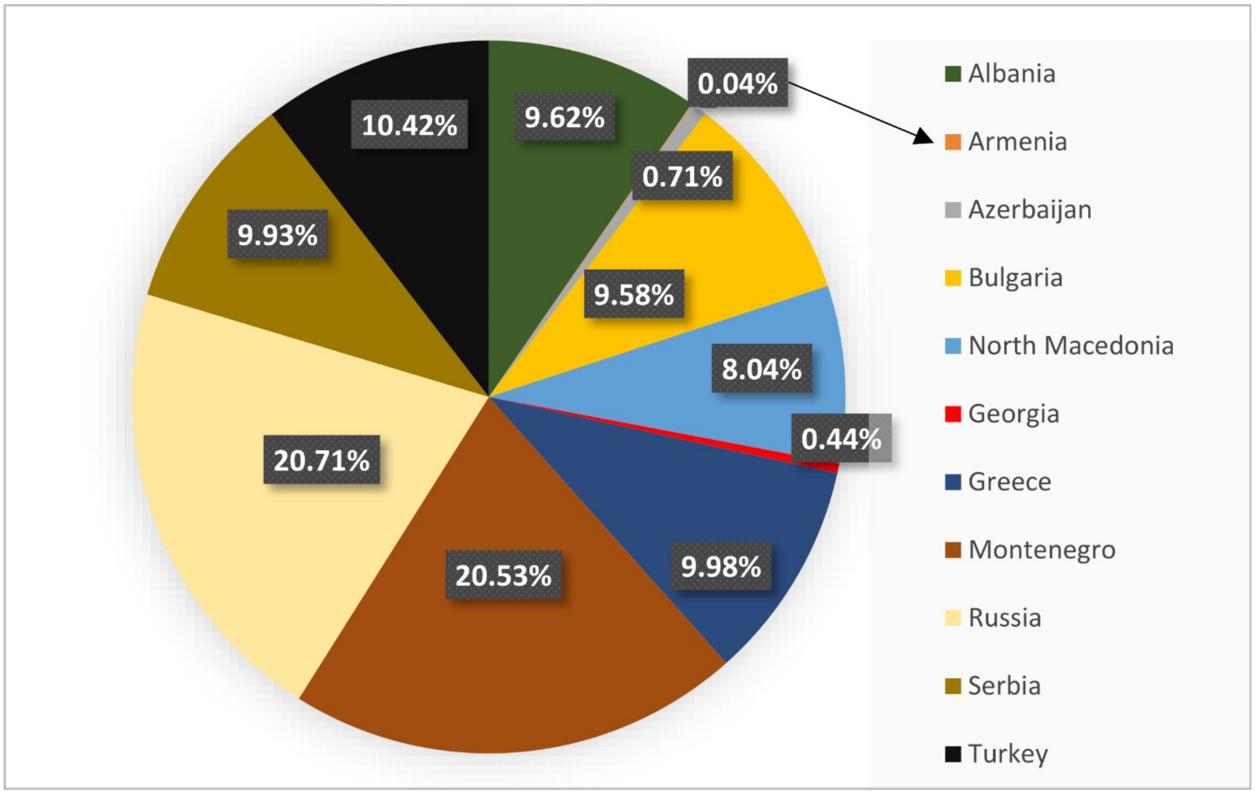

Fig. 5. Outbreaks of LSD in European countries since 2013 (OIE, 2020).

Out of total LSD outbreaks during the study period, 94.19% of the total global outbreaks in new countries were from Europe which clearly explains the rapid spread of LSD across Europe. Comparing the outbreak numbers from the year 2013-2016 and 2017- Mid-September, 2020 there is the difference in the number of outbreaks ($p=0.003$) with the lower number of outbreaks since 2017. The reduction in the number of outbreaks since 2017 could be due to various vaccination campaigns, disinfection of affected areas, strict quarantine measures, stamping out, vector control, proper disposal of carcasses, and movement control inside the countries (OIE, 2020).

Economic impacts of lumpy skin disease

Lumpy skin disease is one of the economically important diseases of livestock that causes severe production losses and chronic debilitation in infected animals (Gari et al., 2010; Gari et al., 2011). The OIE categorizes LSD under “Cattle diseases and infections” which has the potential to cause significant economic loss upon its outbreak (OIE, 2019; Tuppurainen & Oura, 2012). Fine-skinned breeds of cattle such as Holstein-Friesian and Jersey breeds are more susceptible to this disease (Davies, 1991b). The morbidity and the mortality rate of LSD usually vary by the breed and immunological status of the animal but generally has variable morbidity (2%-45%) and low mortality (<10%) (Tuppurainen et al., 2017). Milking cows at their peak lactation are severely affected leading to reduced milk production due to high fever and secondary bacterial mastitis (Tuppurainen & Oura, 2012; Degu, 2020). In addition, permanent damage to the skin and hide due to deep skin lesion causes economic loss in the leather industry (Agonafir et al., 2016; Ali & Gumbe, 2018). Abortion may occur in pregnant cows with chances of infertility in the succeeding year of the infection and infected bulls may remain infertile for 3-6 months after the disease due to the painful lesions of genitalia which prevent them from serving (Davies, 1991b). Even the recovered animals are found to produce less milk and have compromised strength for the draft purpose (Ayelet et al., 2014). Restrictions to the international trade of animal and animal products, high production costs due to control measures like vaccination, and limitations in animal movement cause significant financial loss (Tuppurainen & Oura, 2012). Prolonged loss of productivity of dairy and beef cattle, reduced milk production, decrease in body weight, mastitis, severe orchitis, infertility, and death result in a severe economic loss (Abdulqa et al., 2016).

There have been few studies to quantify the financial losses due to LSD. In Ethiopia, the financial loss based on milk loss, beef loss, draught power loss, mortality, treatment, and vaccination costs per head were estimated to be US$6.43 for local zebu and US$58 for Holstein Friesian (Gari et al., 2011). In another study in Ethiopia, the direct economic losses resulting from animals dying from LSD was estimated to be US$477.7 per animal (Ayelet et al., 2014). Similarly, a study in Nigeria revealed the overall economic losses at the farm to be around US$9.6 to US$6,340 depending upon the species affected and production system (Limon et al., 2020). In the same study, the cost of antibiotics used to prevent the secondary infection per herd per day was estimated to be US$1.96 (min US$0.19–max US$27.5) (Limon et al., 2020). In another study in Ethiopia, a median loss of US$375 per dead animal and US$141 per lactating animal affected by LSD was estimated (Molla et al., 2017). In Kenya, a study showed a loss of US$123 per indigenous cattle farm and US$755 per exotic cattle farm (Kiplagat et al., 2020). The same study showed the loss from milk reduction to be US$266 and US$97 per farm keeping exotic and local breeds of cattle respectively (Kiplagat et al., 2020). The economic losses vary in accordance with the regions or countries and depend upon the species, breed, and factors considered for the economic calculation.

Prevention and control strategies for LSD

The prevention and control strategy for LSD varies by country or region. Various strategies including strict quarantine measures, disease surveillance programs, restriction on imports of animals and animal products from affected countries, and vector control with the proper application of insect repellents have been applied in different countries to prevent the outbreak of the disease. Similarly, early disease diagnosis and quick implementation of strategies such as stamping-out of infected and in-contact animals with proper disposal, vigorous disinfection of affected sites, strict movement control, and proper quarantine measures are some of the ways to control the disease in affected regions.

Besides all the above-mentioned strategies, vaccination is one of the important and cost-efficient methods for the control of LSD (Molla et al., 2017). Currently, only live- attenuated vaccines are being used for the control of LSD (Gelaye & Lamien, 2019; Tuppurainen et al., 2017). Due to very similar antigenic characteristics among the members of *Capripoxvirus*, cross-protection exists between them (Kitching, 1983). It is claimed that vaccines made from strains of *Capripoxvirus* derived from sheep and goat can protect cattle against LSDV (Carn, 1993). Currently, 3 types of vaccines i.e. attenuated LSDV vaccine, attenuated SPPV vaccine, and attenuated GTPV vaccine are available for the control and prevention of outbreaks of lumpy skin disease (Tuppurainen et al., 2017). In a study conducted in Israel, attenuated LSDV vaccines (Neethling LSDV vaccine) are found significantly more effective in comparison to attenuated SPPV (x10RM65) vaccine (Ben-Gera et al., 2015). Attenuated LSDV vaccines are found to provide good protection in cattle if 80% vaccination coverage is obtained and all groups of cattle can be vaccinated including pregnant cows and small calves (Tuppurainen et al., 2017). In contrast to attenuated LSDV vaccine, attenuated SPPV vaccines are found to provide incomplete protection against LSDV (Ali et al., 1990; Ayelet et al., 2013; Brenner et al., 2009; Kumar, 2014). A study in Israel confirmed the clinical manifestation of LSD in cattle which were previously vaccinated with RM65 vaccine (attenuated SPPV vaccine) (Brenner et al., 2009). Similarly, other studies suggest Kenyan sheep and goat pox strain vaccine (KSGP O-240) did not provide satisfactory protection against LSDV (Ayelet et al., 2013; Kumar, 2014). After many years of using KSGP 0-240 to control LSD thinking it contains the strain of SPPV, it is now claimed that KSGP 0-240 vaccine virus actually shows similarities with LSDV rather than SPPV

(Tulman et al., 2002; Tuppurainen et al., 2014). Additionally, in another study, Gorgan goat pox (GTP) vaccine was shown to provide protection against LSDV (Gari et al., 2015).

Although there is no vaccine that guarantees full protection against LSDV, vaccination is still one of the best options available to control LSD. In 2017, a study conducted in Ethiopia showed a positive net profit of USD 136 (USD 56 for subsistence farm herds and USD 283 for commercial herds) per herd due to the use of LSD vaccine (Molla et al., 2017). The same study claimed that investment in the LSD vaccine can reduce financial loss by 11.6% per herd (Molla et al., 2017). The vaccination strategy in countries might vary depending upon the epidemiology of LSD in the country (Table 2).

Table 2. Vaccination strategies against LSD for countries based on disease status

S. N.	LSD status for the country	Vaccination strategy for LSD	Type of vaccines to use
1	Endemic	Annual vaccination	1. LSDV strain vaccine if only LSDV is prevalent and no sheep pox or goat pox outbreaks are recorded in the country. 2. SPPV or GTPV strain vaccine if sheep pox or goat pox disease overlap with lumpy skin disease in the country.
2.	Newly affected	Prophylactic vaccination of susceptible population (Gelaye & Lamien, 2019;Kitching, 2003).	1. LSDV strain vaccine if only LSDV is recorded and no sheep pox or goat pox outbreaks in the country 2. SPPV or GTPV strain vaccine if sheep pox or goat pox disease overlap with lumpy skin disease in the country (recommended over LSDV vaccine if all the disease overlap because of potential safety issues

			associated with LSDV vaccine) (Tuppurainen & Oura, 2012).
3.	LSD free	If the country is apparently LSD free but the cases of LSD is seen in the region of nearby countries then no vaccination is recommended but strict quarantine, import ban from affected areas, active surveillance and regular laboratory checkups of suspected animals can be followed	No vaccination is recommended

Considering the rapid spread of LSDV, vaccination failures and evidences of recombinant strain of LSDV, more research and experiments for the development of a better vaccine for the effective control and prevention of LSD is necessary (Brenner et al., 2009; Gari et al., 2015 ; Sprygin et al., 2020).

Conclusion

Lumpy skin disease is an emerging threat to the livestock industry globally due to its rapid spread in recent years causing huge economic impacts. Since 2012, LSDV is rapidly spreading at an alarming rate across Europe and Asia. If the disease keeps on spreading at the current rate, a huge loss to the livestock industry and the national economy is inevitable. The dairy industry in developing countries that are already struggling with Foot and Mouth outbreaks will have an additional burden if LSD becomes endemic. Vaccination, control of vectors, quarantine measures, disease surveillance programs, restriction on imports of animals and animal products from affected countries, early disease diagnosis, stamping-out of infected and in-contact animals (if applicable) with proper disposal, disinfection of affected sites, and strict movement control will aid to control and prevent the outbreaks of LSD. There is also a need to conduct further research in developing more effective vaccines and international collaboration is crucial to limit the spread of LSD.

Author's contribution

Conceptualization of the study: S.J.; Data collection and literature review: S.J., R.N.; Analysis: S.J., S.K.; Writing of original paper: S.J., R.N., S.K.; Mapping: S.J.; Review and editing: S.K., K.K., S.J.; Supervision: K.K., S.K.

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Data availability

The data that were considered for this study were retrieved from the World Animal Health Information System (WAHIS) interface of the World Organization for Animal Health.

Conflicts of Interest

The authors declare no conflicts of interest.

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