



Epidemiological Survey of Lumpy Skin Disease of Cattle in Ballari and Vijayanagara Districts, Karnataka, India

Krishnaveni R.^{1*}, Laxmi Prasanna², Rajashekhar N.³, Neelufur⁴, Prasad K. V.⁵ and Sharangouda J. Patil^{6*}

^{1,2}Department of Microbiology, Vijayanagara Sri Krishnadevaraya University, Ballari, Karnataka, India

^{3,4}Veterinary Department, Ballari, Karnataka, India

⁵Department of Mathematics, Vijayanagara Sri Krishnadevaraya University, Ballari, Karnataka, India

⁶Department of Zoology, NMKRV College for Women, Bengaluru, Karnataka, India

***Corresponding Authors:** Krishnaveni R.¹, Sharangouda J. Patil⁶

E-Mail: krishnaveni.chikkam11@gmail.com¹; shajapatil@gmail.com⁶

Article History	Abstract
Received: 13 March 2023 Revised: 13 May 2023 Accepted: 13 June 2023	The present research is to study the epidemiological survey of Lumpy skin disease (LSD) of cattle caused by Lumpy skin disease virus (LSDV) in Ballari and Vijayanagara districts, Karnataka, India. LSD is an economically significant disease in cattle caused by Lumpy skin disease virus (LSDV), in India. The disease incidence, mortality rate and severity of the disease during the outbreak is the measure of the infection. The impact of this disease is creating problems in the livelihood of farmers as the milk production go down and major loss for dairy and meat industries. The data of total cattle population and disease incidence of LSD in different villages of Ballari district are collected during August 2021-September 2022 from District veterinary hospital, Ballari and Vijayanagara which was analysed statistically. LSD is more prevalent in Ballari and Vijayanagara showing highest morbidity rate of 7.91% and 12.9% respectively with 0% of mortality rate. Further study will be taken up on the present outbreak in 2022 October and molecular characterization of isolated LSDV.
CC License CC-BY-NC-SA 4.0	Keywords: Lumpy skin disease virus, Vaccination, Mortality, Infection, Dairy

1. Introduction

Lumpy skin disease (LSD) is a viral disease of cattle caused by Lumpy skin disease virus (LSDV) and is included in the OIE list of notifiable animal diseases. LSD was first identified in Zambia in 1929, then slowly spread in Africa thereafter [1]. In 1989, LSD spread to Israel [2] and eventually circulated in the Middle East

countries [3]. In 2013, LSD spread to Europe and then circulated in 11-53 European countries, including Turkey, Greece, and Russia [4]. In 2020, China reported LSD outbreaks since 2019 [5]. Later, in 2019 the disease spread to Bangladesh and infected several cattle in Bangladesh [6].

LSDV belongs to the family Poxviridae and the genus Capripoxvirus. Poxviridae has another two types i.e., sheep pox (SPP) and goat pox (GTP) virus [7]. The members of the Capripoxvirus genus, including sheep pox virus and goat pox virus and LSDV share 97% nucleotide identity and are serologically cross-protective. It is a highly infectious transboundary disease in cattle of all ages and breeds, but especially in young and lactating cattle [8] characterized by fever, lymphadenopathy and nodular skin lesions (Figure 2) which can also observed on mucous membranes of the eyes and in the respiratory and gastrointestinal tracts, weight loss and depression. This directly affects the cattle milk production, reduce the meat production, and reduce reproduction due to increase infertility and abortions. This disease is transmitted mainly through blood-feeding insects [8]. LSDV causes significant economic loss, primarily through severe reduction in milk production, weight loss, infertility, abortion and skin damage, and finally leads to death of the cattle. It indirectly affects the livelihood of farmers.

LSDV exists in two infectious forms: one is the mature virions (MVs) that have a singular outer membrane and the other enveloped virions (EVs) that have an additional membrane, specialized in cell to cell spread [9]. Host susceptibility to LSDV infection is affected by many factors and the interaction between the host immune response and the virus determines the outcome. Immunity to CaPV infection is primarily cell mediated because most progenitor viruses remain within the infected cells. By spreading locally and directly from one cell to another, the virus is beyond the reach of antibodies in circulation. Extracellular enveloped virions, which are released from buds of infected cells, can infect neighbouring cells or escape into the bloodstream and be disseminated throughout the body.

According to the OIE, in August 2019 India faced three primary outbreaks of LSD at Mayurbhanj district in the state of Odisha, followed by an incursion each in four more districts, bringing the total number of outbreaks in the eastern parts of the country. There were 182 clinically affected cattle among 2539 susceptible animals, which accounts for the apparent morbidity rate 7.1% with no recorded mortalities [9]. Subsequently the disease was reported from other states like Karnataka, West Bengal, Chattisgarh, Jharkhand, Assam, Maharashtra, Madhya Pradesh, Kerala, Tamil Nadu, Telangana and Andhra Pradesh. In January 2020, outbreak of lumpy skin disease was noted in Palakkad, Thrissur and Malappuram districts of Kerala, nevertheless the disease was controlled by proper preventive measures. In Karnataka, LSD was reported in cattle of Ballari, Koppal, Raichur, Belugum, Haveri, Vijayanagara, Gulbarga, Yadgiri districts in 2020 [10].

In 2022, cattle are again severely infected by another strain of LSDV. At present, the infection rate is high, and mortality of the cattle reached more than 50,000. Milk production is reduced, increase of infertility of the cattle, reduce the meat production, death of the cattle. This affects the farmers economically; people may get other infections easily by drinking infected milk the present outbreak of LSD is distinct from 2019. The current outbreak of LSDV, which spread to nearly 15 states and affected 18.5 lakh bovine animals in the country, it is different from the virus that was spread in India in 2019, adding that 47 unique variants have been found in the current version of the deadly viral disease that has killed over 80,000 cattle [11]. According to Sivasubbu, senior principal scientist, CSIR-IGIB and one of the scientists associated with the genome sequencing study, it is found that IGIB sequenced samples differ from genomes available globally that were sequenced in 2019. Although previously restricted to regions within Africa, the LSD has been experienced a significantly large outbreaks in many regions of the world in recent years. The LSDV has been reported in several states, but the most affected are Rajasthan, Gujarat and Haryana. The other states include Andaman and Nicobar Islands, Himachal Pradesh, Punjab, Uttarakhand, Madhya Pradesh, Jammu and Kashmir, Uttar Pradesh, Maharashtra and Goa. LSD is the bane for the dairy industry and hits the economic status of the farmers and overall health of humans. Hence, the present study is mainly focused on understanding the disease prevalence by conventional epidemiology studies and further studies on molecular characterization.

2. Materials and Methods

2.1 Survey of Ballari and Vijayanagara District

Ballari is a major district of Karnataka. It is located in north-east part of Karnataka. This district belongs to part of Kalyana-Karnataka. This district is one of the largest districts in Karnataka until the Vijayanagara district was officially excluded in the Ballari district in 2021. Ballari has total 5 talukas, Ballari, Kampli, Kurugodu, Siruguppa and Sandur. Vijayanagara district has 6 talukas Hospet, Harappanahalli, Hoovinahadagali, Hagaribommanahalli, and Koodligi (Figure 1). Ballari district extends from southwest to northeast and is located on the eastern side of Karnataka State. The district is 15° 30' and 15°50' north latitude and 75° 40' and 77° 11' east longitude. The geographical area is 8447 km². The survey was focused on the major villages of Ballari, Sirguppa, Sandur, Hospet, H B Halli, Hoovina Hadagali and Koodligi.



Figure 1: Vijayanagara and Ballari District Outer Boundary Map (The Hindu newspaper November 2021). Ballari has total 5 talukas, Ballari, Kampli, Kurugodu, Siruguppa and Sandur. Vijayanagara district has 6 talukas Hospet, Harappanahalli, Hoovinahadagali, Hagaribommanahalli, and Koodligi.

This district is bounded by Raichur District on the North, Koppal District, Vijayanagara District on the west, Chitradurga District and Davanagere District on the south, and Anantapur District and Kurnool District of Andhra Pradesh on the east. Normal rainfall is 639 mm.

2.2 Data Collection of LSDV Infected Cattle and Healthy cattle

Disease surveillance studies was done in various taluks of Ballari district in 2021 i.e., August 2021 to September 2022 namely Ballari, Siruguppa, Sandur, and Vijayanagara districts Hospet, Hagaribommanahalli, Harapanahalli, Hadagali, and Koodligi. The data of total cattle population, infected population of cattle and vaccinated cattle was collected from Dr. Manjunath and Dr. Rajashekar B. Nagur, Assistant Director, District Veterinary Department, Ballari, Karnataka, India.

2.3 Statistical Analysis

The data was analysed and graphs was prepared using excel. The percentage of disease incidence Percentage of mortality, Percentage of morbidity was calculated [12] by the given formula among various villages of Ballari and Vijayanagar Districts. The percentage of vaccinated cattle was also calculated.

Percentage of morbidity: Morbidity is the rate of disease in a population. The percentage of morbidity rate is calculated by given formula:

$$\text{Morbidity rate} = \frac{\text{number of cases of disease incidence}}{\text{Total cattle population}} \times 100$$

Percentage of mortality: Mortality is the number of deaths in a given area. The percentage of Mortality rate is calculated by given formula:

$$\text{Mortality rate} = \frac{\text{number of cases of deaths}}{\text{Total cattle population}} \times 100$$

Descriptive analysis was conducted using Microsoft Office Excel and graphs are constructed based on above data using origin software by Ms. Neelufer, Assistant Professor, Department of Mathematics in Vijayanagara Si Krishnadevaraya University, Ballari, Karnataka, India.

3. Result and Discussion

3.1. LSD Outbreak Investigation

All affected cattle in different areas of Ballari and Vijayanagara Districts are investigated for LSD outbreak in 2020. Total cattle population of Ballari and Vijayanagara districts are 3,26,347. All affected cattle showed the following common clinical signs: Fever, depression, loss of appetite, nasal and ocular discharges, salivation, circumscribed nodules with different sizes on the skin covering their head, neck, trunk, udder, and teats (Figure 2).



Figure 2: Infected Cattle showing skin lesions (A) and (B) wounds on the body.

It is a highly infectious transboundary disease in cattle of all ages and breeds, but especially in young and lactating cattle characterized by fever, lymphadenopathy and nodular skin lesions which can also observed on mucous membranes of the eyes and in the respiratory and gastrointestinal tracts, weight loss and depression

3.2. Data Collection of LSDV Infected Cattle and Healthy Cattle

There were 10 taluks in Ballari district in 2020. The below survey report shows that the number of villages in which LSD seen approximately in 98 villages only in Ballari taluk (Figure 3). In that 4467 cattle are affected. In Siruguppa taluk LSD seen in 72 villages, 1408 cattle are affected. In Sandur taluk LSD seen in 17 villages, 182 cattle are affected. The other taluks recorded with high LSD incidence like Hospet, Hagaribommanahalli, Harapanahalli, Hadagali, and Koodligi with number of affected cattle 3004, 187, 517, 395, and 216 respectively. From the given record we can conclude that most of the cattle population is affected by the LSD than buffalo population. The result from the table 1, 2, 3 shows rate of incidence 7.1% with zero mortality. Many cattle are vaccinated by the government schemes with goat pox vaccination.

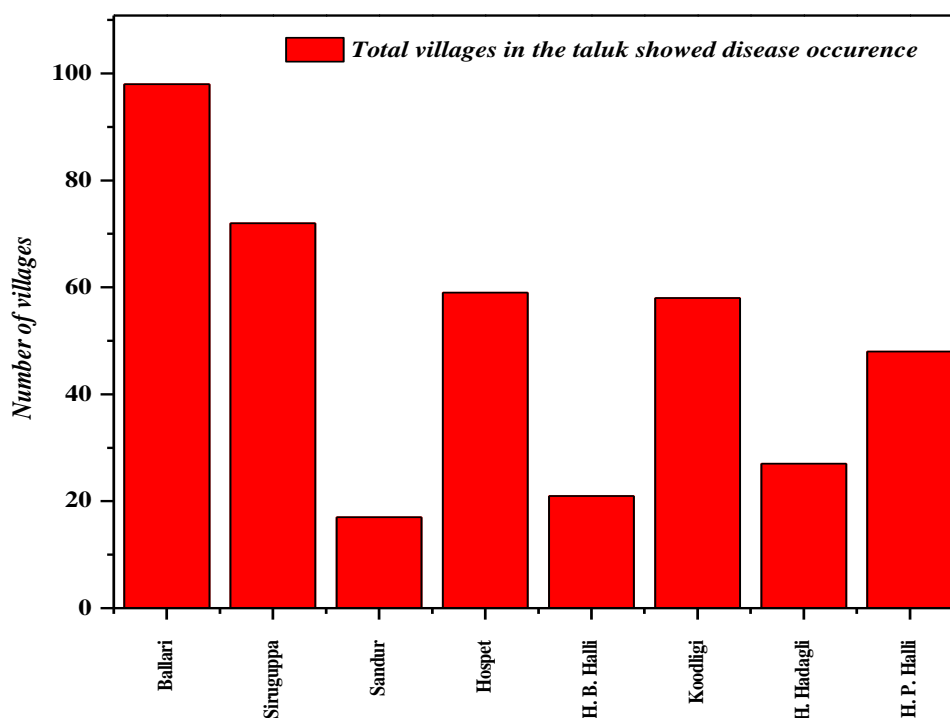


Figure 3: Bar Graph representing number of villages affected by Lumpy skin disease virus in Ballari and Vijayanagara districts.

3.3. Statistical analysis

The data was analysed by constructing graphs. list of villages affected by LSDV in different villages such as Ballari, Siruguppa, Hospet, Koodligi total villages showed occurrence with 98, 72, 59, and 58 respectively (Table 1).

Table 1: List of Villages Affected by Lumpy Skin Disease in Different Taluks of Ballari and Vijayanagara Districts, Karnataka, India

Sl. No.	Districts	Taluks	Total villages showed disease occurrence
1	Ballari	Ballari	98
		Siruguppa	72
		Sandur	17
2	Vijayanagara	Hospet	59
		H. B. Halli	21
		Koodligi	58
		Huvinahadagali	27
		Harapanahalli	48

The percentage of disease incidence and mortality rate of LSD in Ballari and Vijayanagara Districts was calculated and out of total population of 56444 cattle, 4467 cattle got infected i.e. 7.9% disease incidence with 0% mortality rates and Hospet contain 23,142 cattle population of cattle and 3004 cattle got infected showing 12.9% disease incidence (Table 2; Figure 4). Siruguppa taluk of Ballari district is showing 6.25% with zero mortality rates. The data of Table 3 showed number of cattle vaccinated with Goat pox vaccine during the outbreak in 2020 (Figure 5).

Table 2: Percentage of Disease Incidence and Mortality Rate of Lumpy Skin Disease in Ballari And Vijayanagara Districts, Karnataka, India

Sl. No.	Taluks	Total number of cattle population	Total number of infected cattle in different villages	% of incidence	Death occurrence due to LSDV	% of death rate
1	Ballari	56444	4467	7.91	0	0
4	Siruguppa	22518	1408	6.25	0	0
5	Sandur	35415	182	0.51	0	0
6	Hospet	23142	3004	12.9	0	0
7	H. B. Halli	37911	187	0.49	0	0
8	Koodligi	50660	397	0.78	0	0
9	Huvinahadagali	40681	216	0.53	0	0
10	Harapanahalli	59576	517	0.86	0	0

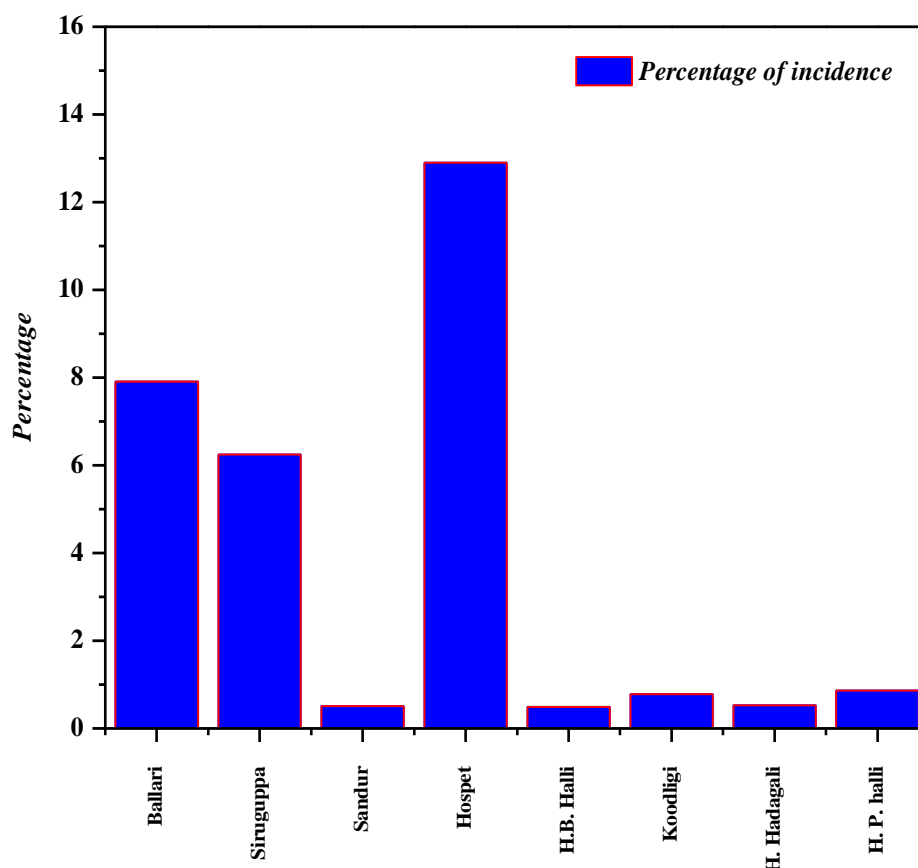


Figure 4: Bar graph representing percentage of incidence of Lumpy skin disease in Ballari and Vijayanagara Districts, Karnataka, India. Whereas Hospet contain 23142 population of cattle and 3004 cattle got infected showing 12.9% disease incidence (Table 2). Siruguppa taluk of Ballari district is showing 6.25% with zero mortality rates.

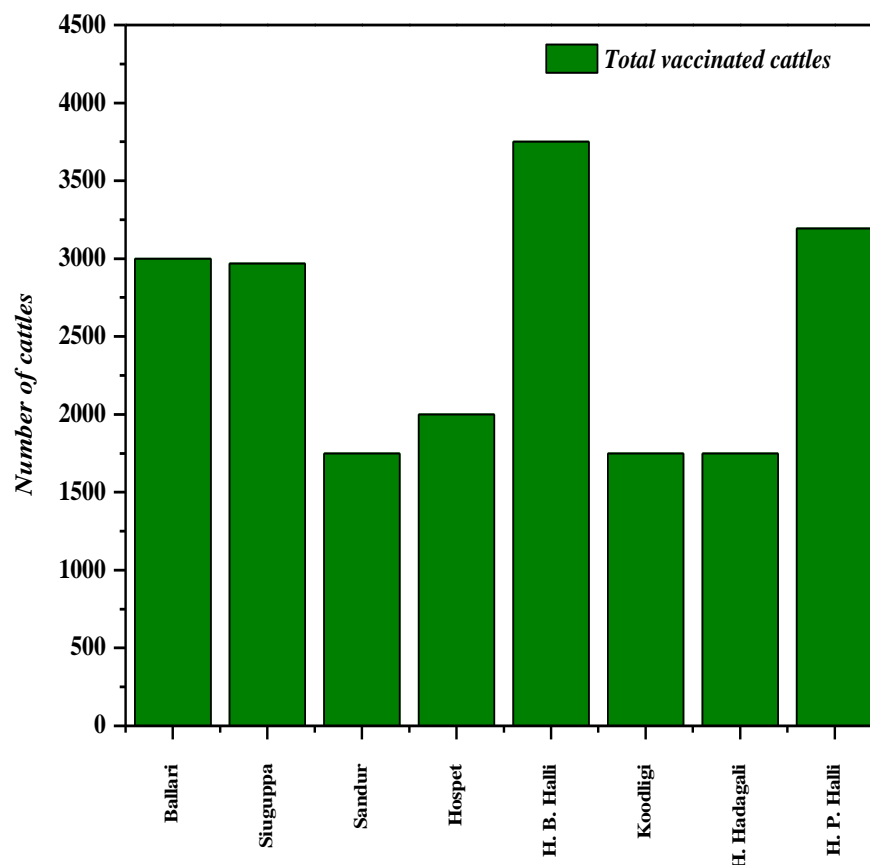


Figure 5: Bar graph representing total vaccinated cattle in Ballari and Vijayanagara districts, , Karnataka, India. The data of Table 3 is showed number of cattle vaccinated with Goat pox vaccine during the outbreak in 2020.

Table 6: Number of Cattle Vaccinated with Goat Pox Vaccine

Sl. No.	Taluks	Total vaccinated animals
1	Ballari	3000
2	Siuguppa	2969
3	Sandur	1750
4	Hospet	2000
5	H. B. Halli	3750
6	Koodligi	1750
7	Huvinahadagali	1750
8	Harapanahalli	3193

The incidence of LSD varies from 2 to 85% in different places of Africa. In endemic locations of African continent, the morbidity rate is typically reported at 10%. In European countries the epidemiological survey reported the mortality rate ranges from 1% to 3%, and was estimated that it reaches 40% in extreme cases [13]. LSD's emergence is more rapid, with disastrous consequences, and its current dissemination to several Asian countries is posing a serious threat to the livestock industry [5]. LSD is classified as a notifiable disease by the World Organization for Animal Health [14] due to its rapid spread and significant economic effect.

Apart from this, LSDV affects cattle of all ages; however, some study suggests that young animals are particularly at risk to this deadly disease [13]. Though the origin of LSD is unknown, and it was once thought to be an African sickness, it is now seen in almost every corner of the world [13]. LSD's emergence is more rapid, with disastrous consequences, and its currently spreading to several Asian countries serious threat to the livestock industry [14]. For the first time in 2019, an LSD outbreak was reported in Bangladesh 2019 [15, 16]. In 2019, LSD outbreaks in Bangladesh infected several cattle populations across the country, posing a new

threat to livestock health. In 2020, in Bangladesh's northern and north-eastern provinces LSD outbreaks were recorded, where the disease is fast spreading in thousands of cattle, resulting in at least 50 deaths and with more than 85% or even higher morbidity rate [17]. Cattle at Natore district of Bangladesh got infected with LSDV and it was reported the morbidity, mortality, and case-fatality rates 64.70%, 2.94 %, and 4.53 % and 83.02 %, 3.77 %, and 4.55 % in Baraigram Upazilas, respectively. Female animals 43.1% and young calves 34.4 % were a larger prone to LSD infection (43.1%) than animals of other ages [5]. In contrast, Biswas et al., [18] found 63.33% and 52.38% of cattle affected with LSD and 3.3 % and 1.59% mortality in Monirampur and Avoy nagor Upazilas, respectively [18]. In Badalgachi, Naogaon, observed a 49% incidence rate, with 0.99-2.12% mortality while in Dinajpur, Bangladesh [19], Sarkar et al., [20] showed 41.06% prevalence. On the other hand, Hasib et al., [21] showed 10% prevalence in commercial farms; with the most significant farm level outbreak frequency being 63.33% and the lowest was 4.22%. Cattle breed, host vulnerability, herd immunological status, and insects/mechanical vectors involved in virus transmission influence morbidity and mortality. In the endemic area, fatality rates ranged from 1% to 5%. In epidemic areas, it can sometimes reach up to 40%. According to the survey, the case fatality rate at Natore, Sadar was 4.53% and 4.55% at Baraigram. Biswas et al., [18] found a case fatality rate of 5.26% at Monirampur and 3.03% at Avoy nagor, whereas Haque and Gofur [19] reported case fatality rate of 1%. LSD was reported for the first time from India in 2019 [20]. The cases we observed in the outbreak in Ranch (India) and reported LSD was not observed in buffaloes; however, a deer exhibited skin nodules. The morbidity was ~25% without any significant mortality which is in agreement with the previous findings [7]. The disease has spread to several states like Kerala, Tamil Nadu, Andhra Pradesh, Telangana, Odisha, Jharkhand, West Bengal, Assam, Chhattisgarh, Maharashtra and Madhya Pradesh of the India and it caused considerable economic losses to the livestock industry and livelihood of farmers. This recent spread of LSDV in India and several other countries has highlighted the need for better research efforts into this rapidly emerging pathogen. The OIE guidelines directed the diagnosis of LSD based on current clinical indicators. MS Excel and origin statistical software were used to evaluate all of the data. Morbidity, mortality, and case-fatality rates were found to be 7.91, 6.25, 0.51 and 12.9 in Ballari, Siruguppa, Sandur and Hospet and 0.49, 0.78, 0.53 and 0.86 in Hagaribommanahalli, Koodligi, Huvinahadagali and Harapanahalli, respectively (Figure 6).

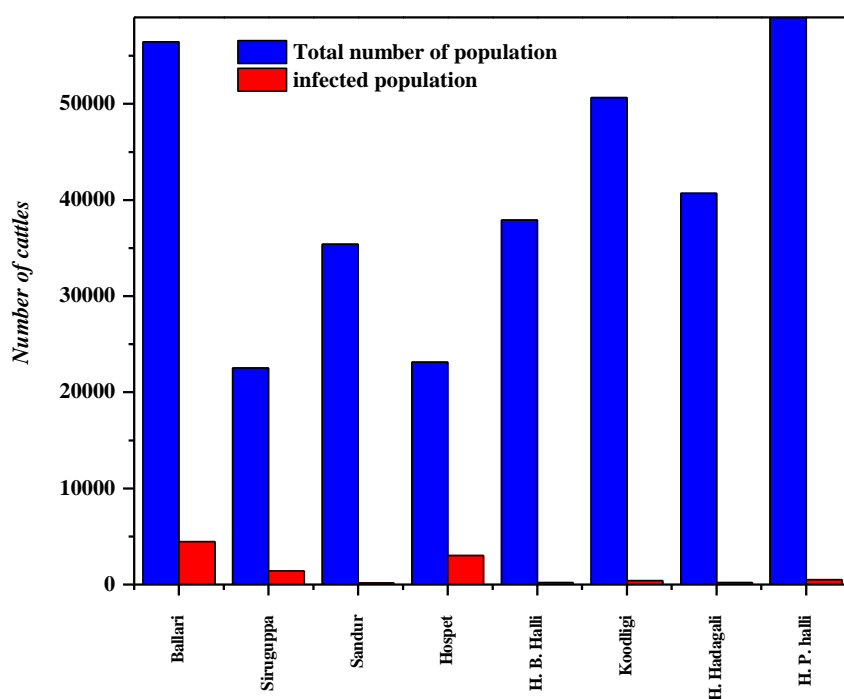


Figure 6: Bar graph representing total population and infected population of cattle in Ballari and Vijayanagara Districts, Karnataka, India

4. Conclusion

The present study is on conventional epidemiology of LSD in Northern Karnataka Ballari district, Karnataka state which states the initial spread of infection in cattle in Hospet taluk with no mortality. Further studies were carried out on molecular and phylogenetic characterization of the LSDV strains isolated in order to understand the percent similarity and origin of the virus.

Conflict of interest: No conflict of interest

Acknowledgement: The authors were thankful to Vice Chancellor, Vijayanagara Sri Krishnadevaraya University, Ballari, Karnataka, India for providing seed money grant to conduct the present work and also to Veterinary Department of Ballari and Vijayanagara district, Karnataka, India for collection of data.

Reference

1. Gupta T, Patial V, Bali D, Angaria S, Sharma M, Chahota R. A review: Lumpy skin disease and its emergence in India. *Vet Res Commun.* 2020; 44(3-4):111-118.
2. Alkhamis MA and VanderWaal K. Spatial and temporal epidemiology of lumpy skin disease in the Middle East, 2012–2015. *Front Vet Sci.* 2016; 3:19.
3. Tasioudi KE, Antoniou SE, Iliadou P, Sachpatzidis A, Plevraki E. Emergence of lumpy skin disease in Greece. *Transbound Emerg Dis.* 2016; 63: 260–265.
4. Lu G, Xie J, Luo J, Shao J, Li K. Lumpy skin disease outbreaks in China, *Transbound Emerg Dis.* 2020; 68(2): 216–219.
5. Haque MH, Roy RK, Yeasmin F, Fakhruzzaman M, Yeasmin T, Sazib MRI, Uddin MN, Sarker S. Prevalence and management practices of lumpy skin disease (LSD) in cattle at Natore district of Bangladesh. *Eur J Agri Food Sci.* 2021; 3(6): 76–81.
6. Uddin MA, Islam MA, Rahman AKMA, Rahman MM, Khasruzzaman AKM, Ward MP, Hossain MT. Epidemiological investigation of lumpy skin disease outbreaks in Bangladeshi cattle during 2019-2020. *Transbound Emerg Dis.* 2022; 69(6): 3397-3404.
7. Kumar N, Chander Y, Kumar R, Khandelwal N, Riyesh T, Chaudhary K, Shanmugasundaram K, Kumar S, Kumar A, Gupta MK, Pal Y, Barua S, Tripathi BN. Isolation and characterization of lumpy skin disease virus from cattle in India. *PLoS One.* 2021; 11;16(1): e0241022.
8. Zeedan GSG, Mahmoud AH, Abdalhamed AM, El-Razik KAEA, Khafagi MH, Zeina HAAA. Detection of lumpy skin disease virus in cattle using real-time polymerase chain reaction and serological diagnostic assays in different governorates in Egypt in 2017. *Vet World.* 2019;12(7):1093-1100.
9. Sudhakar SB, Mishra N, Kalaiyarasu S, Jhade SK, Hemadri D, Sood, R, Singh VP. Lumpy skin disease (LSD) outbreaks in cattle in Odisha state, India in August. *Transbound Emerg Dis.* 2021; 67(6):2408-2422.
10. Chaturvedi C. Lumpy skin disease: All you need to know about its spread and whether it's safe to consume milk. *India News*, September 26, 2022.
11. Sivasubbu S, Bhatt L, Bhoyar RC, Jolly B, Israni R, Vignesh H, Scaria V. Current outbreak of Lumpy skin disease from 2019, need large-scale genomic surveillance: Study need large-scale genomic surveillance, article in the new Indian express, December 8, 2022.
12. Sethi RK, Senapati SK, Selim AM, *et al.* Molecular epidemiology of lumpy skin disease outbreak in Odisha, India. *Vet Res Commun.* 2022; 46: 711–717.
13. Al Salihi K. Lumpy skin disease: Review of literature. *Mirror Res Vet Sci Anim.* 2014;3:6-23.
14. EFSA, European Food Safety Authority, “Scientific report on lumpy skin disease II,” Data collection and analysis. *EFSA J.*, 16: e05176. OIE, 2019.
15. OIE, Event summary: Lumpy skin disease, Bangladesh, 2019.

16. Calistri K, DeClercq SG, Klement E, Stegeman A, Abrahantes JC, Marojevic D, Antoniou SE, Broglia A. European Food Safety Authority (EFSA). Lumpy skin disease epidemiological report IV: Data collection and analysis. *EFSA J.*, 18: e06010, 2020.
17. Dhaka Tribune. LSD disease returns: Loss of cattle in rapid contagion worries farmers ahead of Eid. June 24, 2020.
18. Biswas D, Saha SS, Biswas S, Sayeed MA. Outbreak of lumpy skin disease of cattle in south-west part of Bangladesh and its clinical management. *Vet Sci: Res Rev.* 2020; 6:100-108.
19. Haque MN, Gofur MR. Investigation of lumpy skin disease outbreak in cattle in Naogaon, Bangladesh. *Bangladesh J Agri Life Sci.* 2020; 1:89-93.
20. Sarkar S, Meher MM, Parvez MMM, Akther M. Occurrences of lumpy skin disease in cattle in Dinajpur sadar of Bangladesh. *Res. Agric. Livest. Fish. Dec.* 2020; 7:445-455.
21. Hasib FMY, Islam M.S., Das T., et al. 2021. Lumpy skin disease outbreak in cattle population of Chattogram, Bangladesh. *Vet Med Sci.*;00: 1-9.
22. Kasem S, Saleh M, Qasim I, Hashim O, Alkarar A, et al. Outbreak investigation and molecular diagnosis of lumpy skin disease among livestock in Saudi Arabia 2016. *Transbound Emerg Dis.* 2018; 65:e494-e500.