OCCURRENCES OF LUMPY SKIN DISEASE (LSD) IN CATTLE AT SATURIA UPAZILA IN MANIKGANJ DISTRICT

RASHNA RAHAT SHAOKY

DEPARTMENT OF ANIMAL PRODUCTION AND MANAGEMENT

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2021

OCCURRENCES OF LUMPY SKIN DISEASE (LSD) IN CATTLE AT SATURIA UPAZILA IN MANIKGANJ DISTRICT

BY

RASHNA RAHAT SHAOKY

REGISTRATION NO. 19-10059

A Thesis

Submitted to the Faculty of Animal Science & Veterinary Medicine,

Sher-e-Bangla Agricultural University, Dhaka-1207,

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE (MS)

IN

ANIMAL SCIENCE

SEMESTER: JANUARY-JUNE, 2021

Approved by:

Prof. Dr. Md. Jahangir Alam
Supervisor
Department of Animal Production & Management
Sher-e-Bangla Agricultural University
Dhaka-1207

Dr. Amina Khatun
Co-Supervisor
Assistant Professor & Chairman
Department of Pathology
Sher-e-Bangla Agricultural University
Dhaka-1207

Dr. Md. Saiful Islam
Chairman of Examination Committee
Department of Animal Production and Management
Sher-e-Bangla Agricultural University, Dhaka-1207

Prof. Dr. Md. Jahangir Alam Department of
Animal Production and Management Sher-e-Bangla
Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Cell: +880 1712-618555
E-mail: jangalam@yahoo.com

CERTIFICATE

*This is to certify that the thesis entitled "**OCCURRENCES OF LUMPY SKIN DISEASE (LSD) IN CATTLE AT SATURIA UPAZILA IN MANIKGANJ DISTRICT**" submitted to the Department of Animal Production and Management, Faculty of Animal Science & Veterinary Medicine, Sher-e-Bangla Agricultural University, Dhaka-1207, as partial fulfillment for the requirements of the degree of **MASTER OF SCIENCE (MS) in ANIMAL SCIENCE**, embodies the result of a piece of bona fide research work carried out by **RASHNA RAHAT SHAOKY**, Registration No.: **19-10059**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Dhaka, Bangladesh

Prof. Dr. Md. Jahangir Alam
Supervisor,
Department of Animal Production & Management,
Sher-e- Bangla Agricultural University, Dhaka, 1207

DEDICATED TO MY BELOVED PARENTS

ACKNOWLEDGEMENT

At the beginning, the author bows the grace and mercy of the "Almighty Allah", the omnipresent, omnipotent and omniscient, whose blessings enabled her to complete this thesis.

The author expresses her grateful acknowledgement and indebtedness to his beloved father Kbd Golam Rabbani and mother Ismat Jesmine for their ending prayer, encouragement, sacrifice and dedicated efforts in all phases of this academic pursuit from beginning to the end.

The author with a sense of respect, expresses her heart felt gratitude to his ***Supervisor Dr. Md. Jahangir Alam****, Professor, Department of Animal Production and Management, Sher-e-Bangla Agricultural University, Dhaka-1207 for his untiring and painstaking guidance, invaluable suggestions, continuous supervision, timely instructions, inspirations and constructive criticism throughout the tenure of research work.*

Heartfelt gratitude and profound respect to her ***Co-supervisor DR. Amina Khatun****, Assistant Professor, Department of Pathology, Sher-e-Bangla Agricultural University, Dhaka-1207 for her co-operation, constructive criticism, and valuable suggestions during the entire period of course and research work and preparation of this thesis.*

Thanks are also to ***Dr. Md. Saiful ISlam****, Chairman, Department of Animal Production & Management, Sher-e-Bangla Agricultural University, Dhaka-1207, for his cordial cooperation, sagacious advice and affectionate feelings during the study period.*

The author is especially grateful to Dr. Md. ***Salim Jahan,*** *Upazila Livestock Officer, Saturia, Manikganj for his advice and sincere co-operation for the completion of the study.*

The author is also boundless grateful to all theteachers and staffs of the Department of Animal Production and Management, Sher-e-Bangla Agricultural University, Dhaka-1207 for their co-operation.

The author expresses her deep and boundless gratefulness and profound respect to her beloved brother, sister and friends for their love, blessings, prayers, sacrifices and moral support.

The author expressed her heartily gratitude and affectionate love to her beloved husband Engr. Md. Jahangir Alam Jisan, for his kind support, continuous motivation, research guidance and mental support to complete the research work. At last not to the least, the author expressed deep thanks to her beloved daughter Subaita Sehrish Jaifa, who deprived a lot from her during the study period.

The Author

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATION

ABBREVIATION	FULL MEANING
BoHV2	Bovine herpesvirus 2
CaPVs	Capri pox viruses
CDIL	Central Disease Investigation Laboratory
CI	Confidence Interval
DLS	Department of Livestock Services
e.g.	For example
ESRI	Environmental Systems Research Institute
ETB	Ethiopian birr
FDIL	Field Disease Investigation Laboratory
GTP	Goat Pox
GTPV	Goat pox virus
KOH	Potassium Hydroxide
LSD	Lumpy Skin Disease
LSDV	Lumpy Skin Disease Virus
OIE	Office International des Epizooties
OR	Odds Ratio

PCR	Polymerase Chain Reaction
SPPV	Sheep pox virus
SPSS	Statistical Package for the Social Sciences
US$	United States dollar
USD	United States dollar

OCCURRENCES OF LUMPY SKIN DISEASE (LSD) IN CATTLE AT SATURIA UPAZILA IN MANIKGANJ DISTRICT

BY

RASHNA RAHAT SHAOKY

ABSTRACT

Lumpy skin disease (LSD) is an economically important viral disease of cattle in Bangladesh. The current study was conducted from April 2020 to July 2020 with the objectives of investigating the occurrences of Lumpy Skin Disease (LSD) at Saturia Upazila of Manikganj District. A total of 104 cattle from different unions of the upazila were the study subjects. Cattle were examined for the presence of skin lesions for confirmation of LSD. The results of the study revealed that the overall prevalence of LSD was 44.2% in cattle. Significantly ($p<0.05$) highest prevalence (37%) was occurred on June 2020. Moreover, the young cattle less than two years (73.9%) were significantly ($p<0.001$) higher for LSD with the significant ($p<0.001$) skin lesions in whole body (73.9%). Significantly ($p<0.05$) higher Prevalence (62.5%) was found for cross breed cattle. In addition, the animal non-vaccinated (76.1%), without disinfectant (67.4%) and without fly repellent (78.3%) were significantly ($p<0.05$) higher for LSD. In conclusion, the young cattle of cross breed were at highest risk for the disease. LSD can be reduced by using disinfectant and by controlling vectors with fly repellent. Regular annual vaccination and awareness creation for cattle owners are highly recommended.

CHAPTER I
INTRODUCTION

Lumpy skin disease (LSD) which was occurred as new skin disease, referred as "pseudo urticaria", of cattle was first reported in 1929 in Northern Rhodesia (now Zambia) from where the disease spreads to other southern African countries by the 1940s (Abdulqa *et al.*, 2016). In 1929 it was considered to be the result of poisoning or a hypersensitivity to insect bites due to its clinical appearance. The disease was then spread to other African countries like Botswana (Bechuanaland), Zimbabwe (Southern Rhodesia) and the Republic of South Africa in the years between 1943 and 1945 (Abdulqa *et al.*, 2016). During the following decades, LSD spreads slowly northwards and is currently present throughout the entire continent of Africa, including Madagascar but with some exceptional free countries like Libya, Algeria, Morocco and Tunisia (Abdulqa *et al.*, 2016; Tuppurainen and Oura, 2011). In East Africa LSD was identified in Kenya in 1957 and Sudan in 1972 Sudan (Ali and Obeid 1977) and West Africa in 1974 while, it was spreading into Somalia in 1983. Lumpy skin disease was limited to African continent until 1989 but later it moved outside Africa to Madagascar and the Middle East and caused a serious economic loss to the livestock production. Prior to 2012, only sporadic LSDV outbreaks were reported in the Middle East region (Tuppurainen and Oura, 2011).

The disease has currently been spreading aggressively in many parts of Asia including Bangladesh (Beard, 2016). Three countries in Asia have reported the first occurrence of the disease to OIE in 2019: Bangladesh (outbreak start date 14/07/2019), China (outbreak start date 03/08/2019), and India (outbreak start date 12/08/2019) (OIE, 2019). The first outbreak in Bangladesh was reported to the Department of Livestock Services (DLS) on July, 2019 (DLS, 2019). More than half a million cattle in Bangladesh are thought to have been affected. The outbreak was known to start in Karnaphuli Upazila (sub-district) of Chattogram

district on 22 July, 2019 although confirmed as Lumpy skin disease through real-time PCR on 27 August, 2019 (DLS, 2019). Cases occurred in three upazilas (Anowara, Karofuli, and Patia) in Chattogram district of Chattogram division. An investigation revealed 66 cases in cattle with LSD clinical signs of 360 susceptible animals (attack rate of 18%) and no deaths. Samples were collected and tested positive for Capripoxvirus by real-time PCR at the DLS Central Disease Investigation Laboratory (CDIL) (DLS, 2019).

Within a short time, the disease has surged to all parts of the country. According to the situation report published by the department of livestock services total cases reached to 553,528 among the 25 million cattle population and recorded total death of 97 since 3 December, 2019. (DLS, 2019)

LSD is caused by LSD virus which is a member of Capri pox viruses (CaPVs) that are large double-stranded DNA viruses belonging to the family Poxviridae. The genus includes Sheep pox virus (SPPV), Goat pox virus (GTPV) and Lumpy skin disease virus (LSDV) (Facquet *et al.*, 2005; Murphy, 2012). CaPV infections are generally host specific and not reported on CaPV infecting all three species: sheep, goats and cattle (Bhanuprakash *et al.*, 2010; Tuppurainen *et al.*, 2014). They have also specific geographic distributions in which diseases of GTP and SPP are prevalent in Africa above the equator, Asia, the Middle East, and occasional outbreaks occur in regions of Europe surrounding the Middle East.

The mode of transmission of LSD has not been described fully but the biting flies and some tick species are probably the most important method of transmission of LSD and therefore, quarantine and movement control is usually not very effective (Abdulqa *et al.*, 2016). The disease is usually more prevalent during wet summer and autumn months, particularly in low-land and mid land areas and around water courses, but outbreaks may also occur during the dry season and winter months (Coezer and Tuppurainen, 2004; Gari *et al.*, 2010). LSD is an acute, sub-acute or in apparent viral disease of cattle, characterized by fever, lacrimation and the sudden appearance of firm circumscribed skin

nodules which undergo necrosis. Similar lesions may be present in the skeletal muscles and the mucosa of the digestive and respiratory tracts. Animals affected by capripox viruses (CaPVs) will eventually clear the infection and do not become carriers (Rao and Bandyopadhyay, 2000; Babuik *et al.*, 2008; Gari *et al.*, 2015).

A number of animal and environmental factors are associated with the occurrence and spread of LSD: abundance of arthropod vectors, susceptibility of the cattle population, animal movement, wild animals including birds, and rain fall pattern (Woods, 1990). Except animals that have recovered from LSD, all breeds, sexes and ages of cattle are susceptible to the virus infection (Von Backstrom, 1945; Weiss, 1968; Radostits *et al.*, 2007). The severity of LSD depends on the strain of capripoxvirus, the route of virus inoculation and the species, breed, production stage, age, and immune status of the host (Carn and Kitching, 1995b; Quinn *et al.*, 2002; Babiuk *et al.*, 2008a; OIE, 2010; Gari *et al.*, 2011; EFSA AHAW Panel, 2015).

All types of cattle breeds, ages and sexes are found susceptible although the disease is more severe in cross breed and young calves (Aboelkhair *et al.*, 2019). Lactating cows cause severe production losses due to LSDV with decrease skin quality. Morbidity rate of the virus is high (up to∼45%) but the mortality is generally rare (less than 10%) (Coetzer, 2004; OIE, 2017). The disease is highly host specific and mainly cattle and water buffalo are more susceptible to this virus. Holstein Friesian and its crossbreed cattle are exhibiting higher morbidity and mortality due to this disease outbreak, when compared to local cattle (OIE, 2017).The wild ruminant species in Africa have not identified during extensive serological surveys which appears to be highly host specific (OIE, 2017).

The treatment of LSD is only symptomatic and targeted at preventing secondary bacterial complications using combination of antimicrobial and Anti-inflammatory drugs (Salib, 2011; Abutarbush, 2013). The outbreak of LSD in Bangladesh is having a significant impact on the livelihoods of small-

scale farmers, which make up the majority of cattle owners in the country. The cost of providing supportive treatment for 2-3 months during the recovery period is unrealistic for many of these low-income families.

The disease's economic impact is considerable for livestock industry in affected regions and nations (Tuppurainen *et al.*, 2017). However, this disease causes considerable economic losses due to emaciation, permanent damage to hides, infertility, mastitis, loss of milk production, and also mortality (Salib *et al.*, 2011), but limited research investigation was conducted in Bangladesh to reveal the disease risk factors, transmission, role of vectors, in Bangladesh. Therefore, it demands high priority for actionable research and policies facilitating the most efficient control strategy to prevent the consecutive outbreaks. Studying and understanding the occurrence, transmission dynamics, consequences for production and the economy, factors associated with the spread, and cost effectiveness of the available intervention measures are essential prerequisites to formulate an appropriate control strategy for such a neglected transboundary animal disease.

With this background the research was planned with the following objectives:

1. To investigate the prevalence of Lumpy Skin Disease (LSD) associated with herd level status of cattle at Saturia upazila in Manikganj
2. To investigate the prevalence of LSD associated with some of management status of cattle

CHAPTER II
REVIEW OF LITERATURE

Source of literature

i. Books and journals in Sher- e- Bangla Agricultural University (SAU) library
ii. Internet browsing

About hundred literatures were reviewed to identify the drawbacks and prospects of research, background of research, understand previous findings and to answer the research status of this field. Among them twenty were full article and fifty abstracts and some were miscellaneous. Monitoring the references, a very critical enquires was made of each article and significant information was collected and arranged. A brief account is given below.

2.1. History of Lumpy Skin Disease (LSD)

Lumpy skin disease was first described in Zambia in 1929 and it was considered to be the result of poisoning or a hypersensitivity to insect bites due to its clinical appearance. The disease was then spread to other African countries like Botswana (Bechuanaland), Zimbabwe (Southern Rhodesia) and the Republic of South Africa in the years between 1943 and 1945. During the following decades, LSD spreads slowly northwards and is currently present throughout the entire continent of Africa, including Madagascar but with some exceptional free countries like Libya, Algeria, Morocco and Tunisia (Abdulqa *et al.*, 2016; Tuppurainen and Oura, 2011). In East Africa LSD was identified in Kenya in 1957and Sudan in 1972 Sudan (Ali and Obeid 1977) and West Africa in 1974 while, it was spreading into Somalia in 1983. Lumpy skin disease was limited to African continent until 1989 but later it moved outside Africa to Madagascar and the Middle East and caused a serious economic loss to the livestock production. Prior to 2012, only sporadic LSDV outbreaks were reported in the Middle East region (Tuppurainen and Oura, 2011).

In Bangladesh, the first outbreak was reported to the Department of Livestock Services (DLS) in July 2019. More than half a million cattle in Bangladesh are thought to have been affected. The outbreak was known to start in Karnaphuli Upazila of Chattogram district on July 22, 2019. With a short time the disease spread all over the country. According to the 'Situation Report: Lumpy Skin Disease in Bangladesh' published by the DLS total cases reached to 553,528 among the 25,327,896 cattle population and recorded total death of 97 since December 3, 2019. (DLS, 2019)

2.2. Lumpy Skin Disease Virus

Lumpy skin disease is caused by Lumpy skin disease virus, one of the members of Capri pox viruses which are enveloped, brick shaped with complex symmetry, measuring 300x270x200 nm in size (Shakya, 2001). Mature Capripoxvirions have a more oval profile and larger lateral bodies than Orthopoxvirions (Abdulqa *et al.*, 2016). These 5 viruses are generally resistant to drying, survive freezing and thawing, and remain viable for months in the lyophilized state. Sensitivity to heat differs among strains (Rao and Bandyopadhyay, 2000).

CaPVs are double-stranded DNA viruses with genomes approximately 150 kbp in size. LSDV shares a close genetic relationship with SPPV and GTPV (Gelaye *et al.*, 2015) but has an additional nine genes that are non-functional in SPP and GTP viruses, some of which are likely responsible for their ability to infect cattle (Tulman *et al.*, 2001). CaPV isolates are extremely conserved with genome identities of at least 96% between SPPV, GTPV and LSDV (Tulman *et al.*, 2001; Babuik *et al.*, 2008). LSDV genome consists of a central coding region which is bounded by identical 2.4 kbpinverted terminal repeats and contains 156 putative genes. LSDV genes share a high degree of colinearity and amino acid identity (average of 65%) of its genomic region with genes of other known mammalian poxviruses like suipoxvirus, yatapoxvirus, and leporipoxviruses (Madhavan *et al.*, 2016; Tulman *et al.*, 2001). Even if CaPVs share high nucleotide sequence identity, they are phylogenetically distinct.

Phylogenetic analysis showed that members of the genus could be delineated 6 into three distinct clusters of GTPV, SPPV and LSDV based on the P32 genomic sequence. There is an additional aspartic acid at 55th position of P32 present in sheep poxvirus which is absent in GTP and LSD viruses (Hosamani *et al.*, 2004).

2.3. Epidemiology of LSD

2.3.1. Occurrence of the disease

LSD is an endemic disease of most African countries particularly in those of the subSaharan region. After 2012 it has spread rapidly through the Middle East, south-east Europe, the Balkans, Caucasus, Russia and Kazakhstan (OIE, 2017; Coezer and Tuppurainen, 2004). Mostly, field outbreaks can be severe and generalized infection with high morbidity and mortality rates, while in others there may be few affected animals and few or no deaths recorded but in general outbreaks are more severe with the initial 7 introduction of the infection to a region and then will decrease, probably associated with the development of widespread immunity. Morbidity rates reach 80% during epizootics, but are nearer 20% in endemic areas (Radostits *et al.*, 2006).

2.3.2. Hosts and susceptibility

Domestic cattle and Asian water buffalo are the animals affected by LSDV naturally during field outbreaks (El-Nahas *et al.*, 2011; Al-Salihi, 2014). Some strains may replicate in sheep and goats but to date no epidemiological studies have evidenced small ruminants as reservoirs for the virus (Tuppurainen, 2017).Very little is known about the susceptibility of wild ruminants to LSDV.

2.3.3. Age susceptibility

The susceptibility of host animals mostly depends on immune status, age and breed rather than the virulence of the virus. European cattle breeds are generally more susceptible than indigenous African and Asian breeds (Tageldin *et al.*, 2014).

2.3.4. Sources of the virus

Capripox viruses are highly resistant viruses to physical and chemical action. They can survive in scab or tissue fragments for very long periods of time (Davies, 1991). It can be recovered from skin nodules kept at –80 °C for ten years and from infected tissue culture fluid stored at 4 °C for about six months (Coezer and Tuppurainen, 2004). LSDV can be isolated for up to 35 days or longer from skin nodules, scabs and crusts which are known to contain relatively high amounts of virus. It can also be isolated from blood, saliva, ocular and nasal discharges (Weiss, 1968), and semen (Irons *et al.*, 2005) of infected animals. LSDV is found in the blood intermittently from approximately 7 to 21 days post-infection at lower levels than present in skin nodules. Viral shedding in semen can be prolonged and it has been isolated from the semen of an experimentally infected bull after 42 days (OIE, 2017).

2.3.5. Transmission

Studies have shown that the main route of transmission for LSD is through vectors whereas transmission ways like direct contact are not effective (Magori-Cohen *et al.*, 2012). Stomoxys, Musca confiscate and Aedes egypti mosquitos and the three common African hard tick species, namely, Rhipicephalus appendiculatus, Amblyomma hebraeum and the African blue tick Rhipicephalus (Boophilus) decoloratus, were reported to have a great role in the transmission of LSD (Chihota *et al.*, 2003).

Studies have shown that it is possible to transmit LSDV by Aeidesa egypti to susceptible animals without the subsequent development of clinical disease in the animals (Chihota *et al.*, 2001). Transstadial and transovarial transmission of LSDV by Boophilus decoloratus ticks and mechanical or intrastadial transmissionby Rhipicephalus appendiculatus and Amblyomma hebraeum ticks has been shown (Tuppurainen *et al.*, 2011). Studies also showed that the disease can also transmit when common drinking troughs are used, thus confirming the suspicion that infected saliva might contribute towards the

spread of the disease. The disease is transmissible to young calves through infected milk (Coezer and Tuppurainen, 2004).

2.3.6. Seasonal Outbreaks

Ayelet, Gelagay & Haftu, R & Jenberie, Shiferaw & Belay, Alebachew & Gelaye, Esayas & Sibhat, Berhanu & Skjerve, Eystein & Asmare, Kassahun. (2014) shows that, outbreaks were more frequently observed between September and December.

2.4. Pathogenesis and Clinical Signs

The actual incubation period of LSD under field conditions has not been reported, but following experimental inoculation of the virus is 6–9 days until the onset of fever. LSDV replicates inside the host cells such as macrophages, fibroblasts, pericytes and endothelial cells in the lymphatics and blood vessels walls leads to vasculitis and lymphangitis, in severe cases thrombosis and infarction may also develop (Al Salhi, 2014).

In the acutely infected animal, there is initial pyrexia, which may exceed 41°C and can persist for 1 week. The superficial lymph nodes become enlarged and lesions may develop over the body, particularly on the head, neck, udder, scrotum, vulva and perineum between 7 and 19 days and the first ones usually appearing in the perineum. In lactating cattle there is a marked reduction in milk yield (OIE, 2017; Radostits *et al.*, 2006). Lesions of LSD are round and firm, 1 to 4 cm in diameter, and are flattened and the hair on them stands on end. They vary in number from a few to hundreds; they are intradermal and, mostly confined to the skin area. Lacrimation, nasal discharge, salivation, and lameness can also be observed in association with the pyrexia. Lesions in the nostrils and on the turbinates, causing mucopurulent nasal discharge, respiratory obstruction and snoring; plaques and ulcers in the mouth causing salivation, nodules on the conjunctiva, causing severe lacrimation can be observed in severe cases. Lymph nodes draining the affected area become enlarged and cause local edema (Radostits *et al.*, 2006; Maclanchilan and

Dubovi, 2011). In experimental studies, the intravenous route develops severe generalized infection, while in the intradermal inoculation only 40-50% of animals may develop localized lesions or no apparent disease at all. A localized swelling at the site of inoculation after four to seven days and enlargement of the regional lymph nodes, develop after subcutaneous or intradermal inoculation of cattle with LSDV (Al-Salihi, 2014; Abdulqa *et al.,* 2016).

2.5. Economic Importance

LSD is an economically important disease of cattle, serious economic losses from outbreaks that have a high morbidity and can produce a chronic debility in infected cattle. There is a great loss of milk production since the disease is more severe in cows in the peak of lactation and causes a sharp drop in milk yield because of high fever caused by the viral infection itself and secondary bacterial mastitis predisposed by the development of lesions on the teats (Abera *et al.*, 2015; Radostits *et al.,* 2006). Even though the mortality rates of LSD are usually low, it is an economically important disease of cattle in Africa because of the prolonged loss of productivity of dairy and beef cattle, use of the animals for traction, decrease in body weight, mastitis, severe orchitis, which may result in temporary infertility and sometimes permanent sterility (Abera *et al.*, 2015; OIE, 2017; Gari *et al.*, 2011). A study done in Ethiopia has shown that the annual financial cost calculated as the sum of the average production losses due to morbidity and mortality arising from milk loss, beef loss, traction power loss, and treatment and vaccination costs at the herd level was estimated to be USD 6.43 (5.12–8) per head for local zebu and USD 58 (42–73) per head for HF/crossbred cattle (Gari *et al.*, 2011). Another study also showed that the average cost of a single ox dying from LSD was calculated as 9,000 Ethiopian birr (ETB), equivalent to US$477.7 (USD1 = 18.84 ETB) (Ayelet *et al.*, 2014).

In addition to quality degradation of skin and hides skin LSD induces associated economic losses due to reduction of wool quality, meat, losses as a result of culling and mortalities and related with cost of treatment and prevention of the diseases. Even though there are no specific antiviral

treatments for LSD-infected cattle, there will be treatment cost for secondary bacterial infection. Treatment cost represents the expenses incurred by farmers for medication at the local public veterinary clinics when farmers bring their clinically sick animals for treatment (Abera *et al.*, 2015b). Emaciation and a long convalescence period can also significantly decrease the growth rate in beef cattle (Tuppurainen *et al.*, 2015).

LSD have been identified as one of the major impediments for genetic improvement of cattle populations and, consequently, for the development of intensive production units in Africa. It is well known that high producing dairy cattle, such as Holstein-Friesian (HF) and Jersey are more susceptible to CaPV infection than indigenous African and Asian cattle breeds (Bhanuprakash *et al.*, 2011; Tuppurainen and Oura, 2011).

Costly control and eradication measures such as vaccination campaigns as well as the indirect costs because of the compulsory limitations in animal movements also cause significant financial losses on national level (Tuppurainen and Oura, 2011; Gari *et al.*, 2011; Abera *et al.*, 2015b).

2.6. Diagnosis of LSD

There are no available commercial diagnostic test kits for LSD virus detection. Thus, the tentative diagnosis of LSD is usually based on the characteristic clinical signs, differential diagnosis, and confirmation is done by laboratory tests using molecular techniques of conventional or real time polymerase chain reaction (PCR) and cell culturing. LSD should be suspected clinically when there are characteristic skin nodules, fever and enlargement of superficial lymph nodes (Abdulqa *et al.*, 2016;Tuppurainen, 2017a; OIE, 2017).

2.6.1. Differential diagnosis

The main differential diagnosis is pseudo-LSD caused by bovine herpesvirus 2 (BoHV2). This is usually a milder clinical condition, characterized by superficial nodules, resembling only the early stage of LSD. Intra-nuclear inclusion bodies and viral syncytia are histopathological characteristics of

BoHV-2 infection not seen in LSD (OIE, 2017; Radostits *et al.*, 2006). Other differential diagnoses (for integumentary lesions) include: dermatophilosis, dermatophytosis, bovine farcy, photosensitisation, actinomycosis, actinobacilosis, urticaria, insect bites, besnoitiosis, nocardiasis, demodicosis, onchocerciasis, pseudo-cowpox, and cowpox. Differential diagnoses for mucosal lesions include: foot and mouth disease, bluetongue, bovine viral diarrhoea, malignant catarrhal fever, infectious bovine rhinotracheitis, and bovine popular stomatitis (OIE, 2017; Abera *et al.*, 2015).

2.7. Vaccination

Abera *et al.*, 2015 and OIE, 2017 studied that, for lumpy skin disease, control measures with the exception of vaccination are usually not effective. Vaccination will greatly reduce the morbidity and epizootics but may not completely limit the extension. In endemic countries, vaccination is considered the only economically feasible way to control the spread of LSD and improve cattle productivity (OIE, 2017; Abera *et al.*, 2015). Numerous live attenuated vaccines have been developed and used worldwide, while inactivated vaccines are considered less effective (Boumart *et al.*, 2016). In addition, live attenuated vaccines are currently available which are cheap and provide good protection if sufficient herd immunity (over 80%) is maintained by carrying out annual vaccinations (Tuppurainen *et al.*, 2015).

Live vaccines can help to control losses from lumpy skin disease in endemic areas. Four live attenuated strains of CaPVs have been used as vaccines specifically for the control of LSD (OIE, 2017; Brenner *et al.*, 2009;). These are: a strain of Kenyan sheep and goat pox virus, Yugoslavian RM 65 sheep pox strain, Romanian sheep pox strain and lumpy skin disease virus strain from South Africa (Al-Salihi, 2014). In endemic regions vaccine failure is a great problem for the effective control of LSD (Gari *et al.*, 2015). It was also reported that CaPV vaccine strains produce a large local reaction at the site of inoculation in Bos taurus breeds (Davies, 1991) which some stock owners find

unacceptable. This has discouraged the use of vaccine, even though the consequences of an outbreak of LSD are usually more severe (OIE, 2017b).

Outbreaks can also be controlled by strict quarantines to avoid introduction of infected animals into safe herds, isolation and prohibition of animal movements, slaughtering of all sick and infected animals (Depopulation of infected and exposed animals), proper disposal of carcasses (Incineration), cleaning and disinfection of the premises and insect control (Abera *et al.*, 2015; Tuppurainen and Oura, 2011).

2.8. Medication

Unfortunately there are no proven specific antiviral drugs available in Bangladesh for the treatment of LSD virus. The only treatment available is supportive care &management of animals or symptomatic medications such as paracetamol and antihistamine for pain, fever and swelling seem effective. This can include treatment of skin lesions using wound care sprays. Recently, the Ministry of Fisheries and Livestock has issued instructions in this regard and sent to the Department of Livestock Services. Every union in the affected area has been directed to form a Veterinary Medical Team consisting of an Upazila Livestock Officer or a Veterinary Surgeon or a Livestock Extension Officer and a Deputy Assistant Livestock Officer or a Veterinary Field Assistant or Field Assistant (AI). The medical team has been instructed to ensure on-the-spot inspection of every cattle affected by LSD. Moreover, the departmental and district livestock officers have been given the responsibility to monitor the medical work. If necessary, livestock officers and employees from the surrounding districts or upazilas of the affected districts have also been instructed to be assigned to the medical team (OIE, 2019).

2.9. Status of LSD in Bangladesh

In Bangladesh first outbreak was known to start in Karnaphuli Upazila (sub-district) of Chattogram district on 22 July, 2019 although confirmed as Lumpy skin disease through real-time PCR on 27 August, 2019. Cases occurred in

three upazilas (Anowara, Karofuli, and Patia) in Chattogram district of Chattogram division. An investigation revealed 66 cases in cattle with LSD clinical signs of 360 susceptible animals (attack rate of 18%) and no deaths. Samples were collected and tested positive for Capripoxvirus by real-time PCR at the DLS Central Disease Investigation Laboratory (CDIL). (DLS, 2019)

Within a short time, the disease has surged to all parts of the country. According to the situation report published by the department of livestock services total cases reached to 553,528 among the 25 million cattle population and recorded total death of 97 since 3 December, 2019. LSD occurred in subacute and acute form having more severity in milking cows and calves (DLS, 2019).

CHAPTER III
METHODOLOGY

3.1. Study Area

The research was carried out at Saturia Upazila of Manikganj District in the Division of Dhaka of Bangladesh. The area is located in between 23°51' and 24°03' north latitudes and in between 89°55' and 90°08' east longitudes (Banglapedia).

Figure 1: Geographical Distribution of the Study Area

It is bounded by Nagarpur and Dhamrai upazilas on the north, Manikganj sadar upazila on the south, Dhamrai upazila on the east, Daulatpur (Manikganj) and Ghior upazilas on the west (Banglapedia).

According to Bangladesh National Portal, It has 38589 households and total area is 140.10 km². As of the 2011 Bangladesh census, Saturia has a population of 171494. There are 83653 male and 87841 female. The number of total village is 213. There are nine unions namely Baliati, Boraid, Dhankora, Digholia, Dorogram, Fukurhati, Horgoz, Saturia and Tilli. This area was selected due to abundant of livestock population of this area. The main livelihood of this area is crop–livestock mixed farming. 59.45% of source of income comes from agriculture (Banglapedia). Farmers usually generate income by selling milk and milk products, fattened mature male animals, and barren and culled females. Milk and milk products are used for household consumption and sale. The small-scale farmers of this area faced a significant economic loss due to the outbreak of LSD. The spatial location of the study areas was presented in Figure 1.

3.2. Study population

The total cattle population of the area was estimated to be 66338 (Upazila Livestock Office and Veterinary Hospital, Saturia, 2021). The average number of cattle per household varies from 1 to 10. The study animal population comprised of 104 sick cattle of the study area. Active disease outbreak investigation was made based on information obtained from direct interview and from Upazila Livestock Office and Veterinary Hospital, Saturia, Manikganj. All investigations were in response to LSD outbreaks.

3.3. Field Data Collection

The households under investigation were purposively selected on the basis of outbreak reports from Upazila Livestock Office and Veterinary Hospital, Saturia. Animals were examined for characteristic clinical signs of LSD, such as visible skin nodules, enlarged lymph nodes, lameness and fever. In Addition, data like vaccination history, age, sex and breeds of animals were collected.

The study was conducted from April to July 2020. The questionnaire was administered to individual herd owners. The data were collected by face to face interview using the local language by visiting their farm. An oral consent to use the data for scientific research was obtained from each participating herd owner before the interview started.

The questionnaire was designed primarily to record the magnitude of production losses, mortality, and cost of control for LSD in several categories of bovines in a herd (a group of cattle owned by a household or an organization), and perception of farmers on livelihood impact and its influence on cattle marketing during the outbreak period.

Information related to the composition of the herd, herd dynamics, the management system used, the number, age and sex of the animals that had been affected by LSD and subsequently died, if vaccination or any other treatment had been applied during/after the course of the disease were recorded. The data on vaccination with goat pox vaccine was considered to determine the vaccination history. A total of 453 questionnaires were collected from 9 unions all over the Upazila. Collected information was cross-checked in discussion with experts of the Upazila Livestock Office and Veterinary Hospital.

3.4. Clinical Examination

The farmer's ability to identify LSD infection was cross-checked by enquiring about the clinical signs of LSD. Each farmer who reported that LSD had infected his or her herd was asked to describe the clinical signs of the disease. Then close inspection was done carefully to observe the clinical signs included

the typical fever for three days and marked decrease in the milk production at the first stage (acute form). Moreover, others clinical signs like as nasal discharge, lacrimation, anorexia, emaciation, enlarged lymph nodes and lesions in the skin and oral mucous membranes were common in LSD which considered for clinical diagnosis (El-mandrawy and Alam, 2018).

3.5. Statistical Analysis

All the data were inputted in SPSS version 28.0 for statistical analysis. At first, all the assumption were tested and found to be fit. Then Pearson's Chi-square test was done. Phi and Cramer'V was also calculated to measure the strength of effect of the variables. In case of 2×2 contingency table the Phi and if the table is not 2×2 then Cramer'V value was considered. All p-value <0.05 was considered statistically significant.

CHAPTER IV
RESULTS

Total 104 cases were recorded in this study and among them 46 cases were confirmed for LSD which revealed that the prevalence of LSD was 44.2% in cattle. All the cases were presented according to area (union) and time period (month) of the study (Table 1). Among the recorded cases the highest prevalence was found at Baliati union (19.6%), but there is no significant association ($p = 0.647$) of area with LSD occurrence. Time period had significant ($p<0.05$) association with LSD occurrence. The highest prevalence (37.0%) was found on the month of June. Symmetry analysis indicated that time period had medium effect (Cramer's $V = 0.358$) on LSD occurrence.

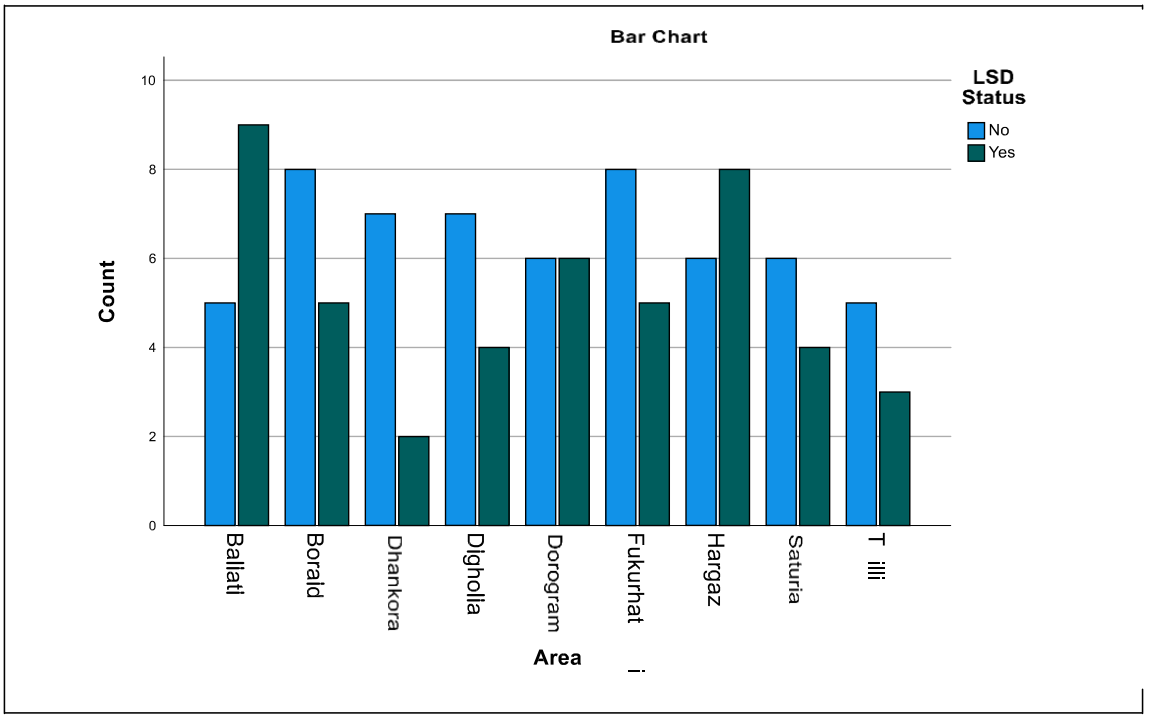
The herd level information of cattle was presented in Table 2. This table showed that age, breed and skin lesions of cattle had significant ($p<0.001$) association with LSD occurrence. According to the all recorded cases the, the higher percentages of LSD positive cases were 73.9% in aged less than 2 years, 65.2% in cross bred cattle, 54.3% in female cattle, 89.1% in non-pregnant cattle and with 73.9%skin lesion through all over the body. The symmetry analysis indicated that the age had medium effect and the skin lesions had strong effect on the number of LSD cases expressed by the Phi = 0.325 and Cramer's $V = 0.591$ respectively.

Table 1. Frequencies of LSD outbreak in cattle according to area (Union) and Time period (months) of study

Variables	Category Level	Number of Sample		LSD Status				P-Value	Symmetry analysis
				Yes		No			
		N	%	N	%	N	%		
Area (Union)	Baliati	14	13.5	9	19.6	5	8.6	0.647	0.240^{NS}
	Boraid	13	12.5	5	10.9	8	13.8		
	Dhankora	9	8.7	2	4.3	7	12.1		
	Digholia	11	10.6	4	8.7	7	12.1		
	Dorogram	12	11.5	6	13.0	6	10.3		
	Fukurhati	13	12.5	5	10.9	8	13.8		
	Hargaz	14	13.5	8	17.4	6	10.3		
	Saturia	10	9.6	4	8.7	6	10.3		
	Tilli	8	7.7	3	6.5	5	8.6		
Month	March	15	14.4	4	8.7	11	19.0	0.020	0.358
	April	16	15.4	5	10.9	11	19.0		
	May	16	15.4	6	13.0	10	17.2		
	June	22	21.2	17	37.0*	5	8.6		
	July	19	18.3	8	17.4	11	19.0		
	August	16	15.4	6	13.0	10	17.2		

*Significant at 5% ($p<0.05$), NS= Insignificant, N=Frequencies, %= Percentages

A. Union Wise Cases



B. Month Wise Cases

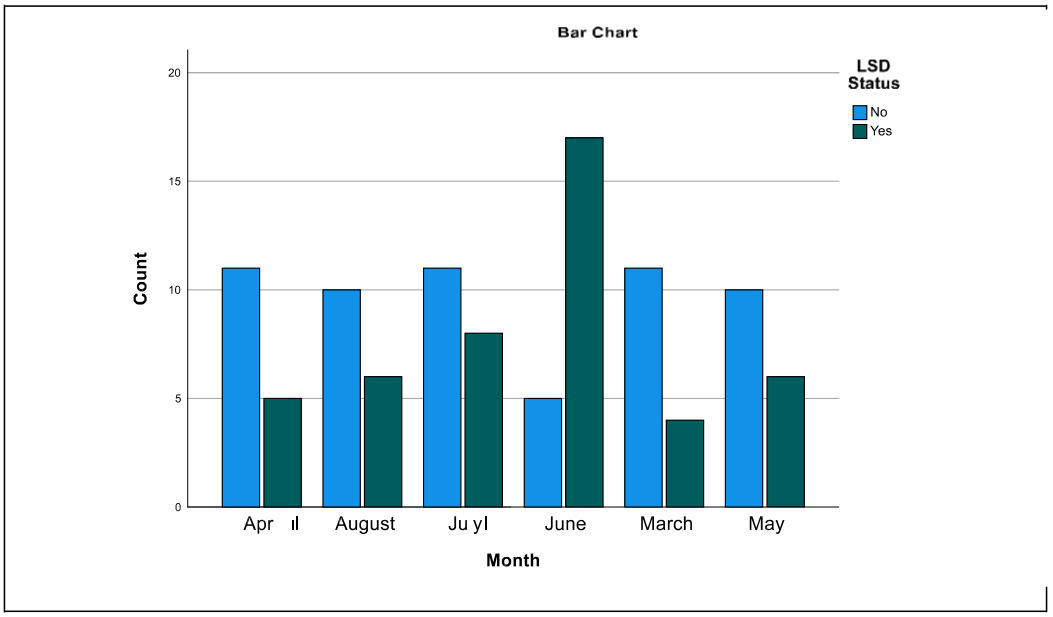


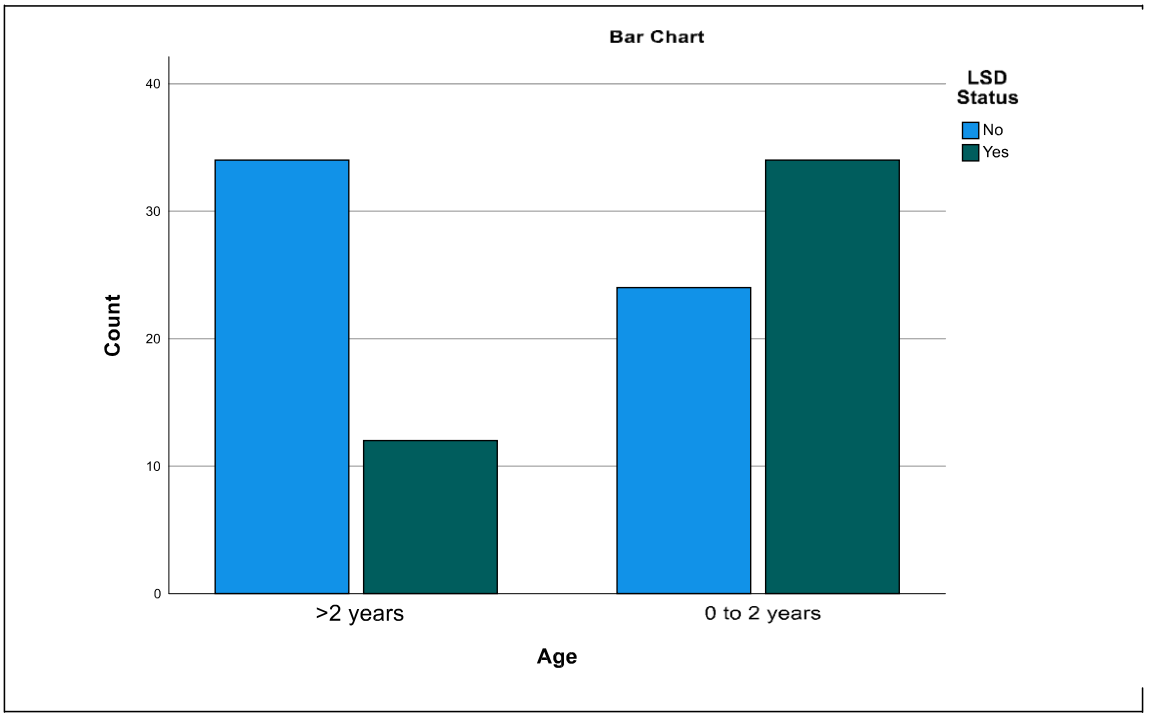
Figure 2: Bar chart showing the Proportions of LSD outbreak in relation to (A)Area of Study and (B) Month of Study .**Significant at 1% ($p<0.001$), *Significant at 5% ($p<0.05$)

Table 2: Frequencies of LSD outbreak in cattle according to their herd level information

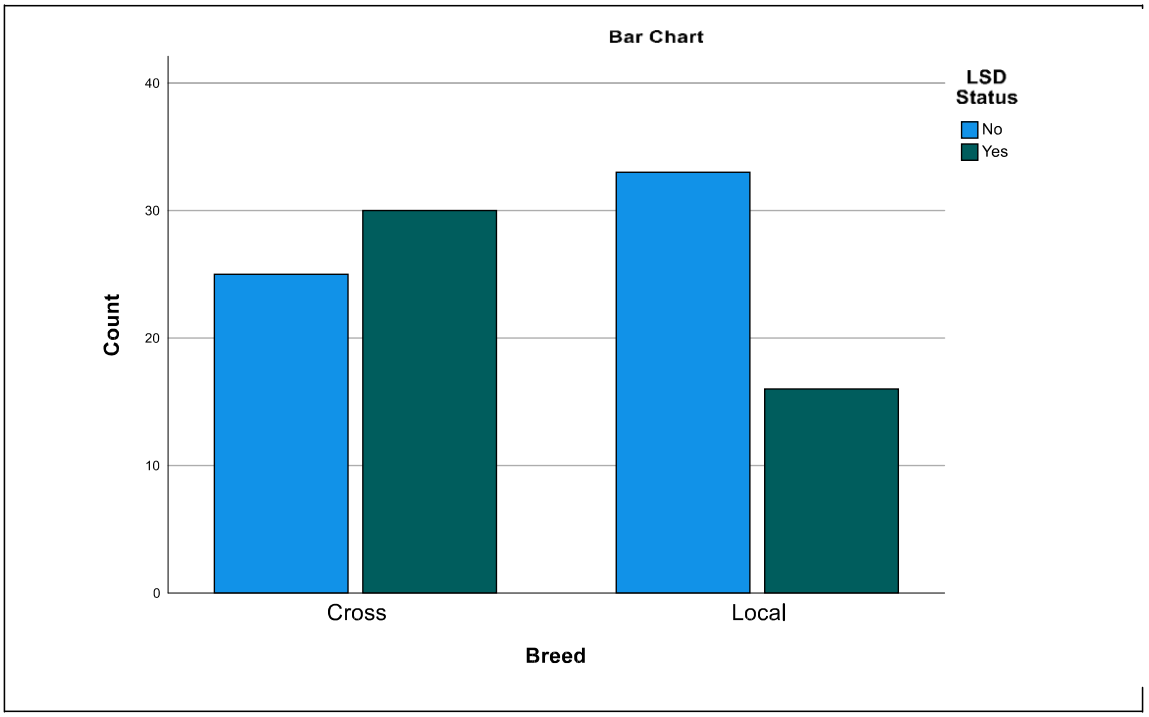
Variables	Category Level	Number of Sample		LSD Status				P-Value	Symmetry analysis
				Yes		No			
		N	%	N	%	N	%		
Age	0 to 2 years	58	55.8	34	73.9**	24	41.4	<0.001	0.325
	>2 Years	46	44.2	12	26.1	34	58.6		
Breed	Cross	55	52.9	30	65.2*	25	43.1	0.025	-0.220
	Local	49	47.1	16	34.8	33	56.9		
Sex	Female	57	54.8	25	54.3	32	55.2	0.933	0.008NS
	Male	47	45.2	21	45.7	26	44.8		
Skin Lesions	Abdominal Region	16	15.4	4	8.7	12	20.7	<0.001	0.591
	Caudal Region	15	14.4	3	6.5	12	20.7		
	Shoulder Regions	18	17.3	3	6.5	15	25.9		
	Thoracic Region	12	11.5	2	4.3	10	17.2		
	Whole body Region	43	41.3	34	73.9**	9	15.5		
Pregnancy Status	Non pregnant	88	84.6	41	89.1	47	81.0	0.256	-0.111NS
	Pregnant	16	15.4	5	10.9	11	19.0		

**Significant at 1% (p<0.001), *Significant at 5% (p<0.05), NS= Insignificant, N=Frequencies, %= Percentages

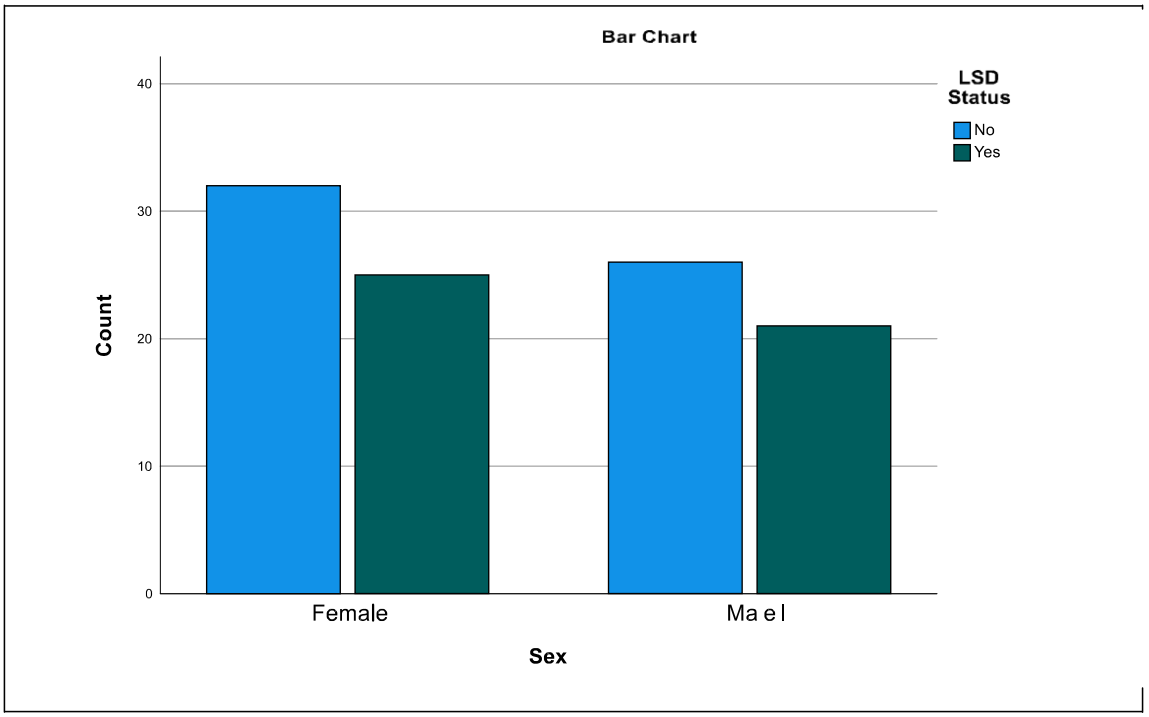
A. Age of Animals



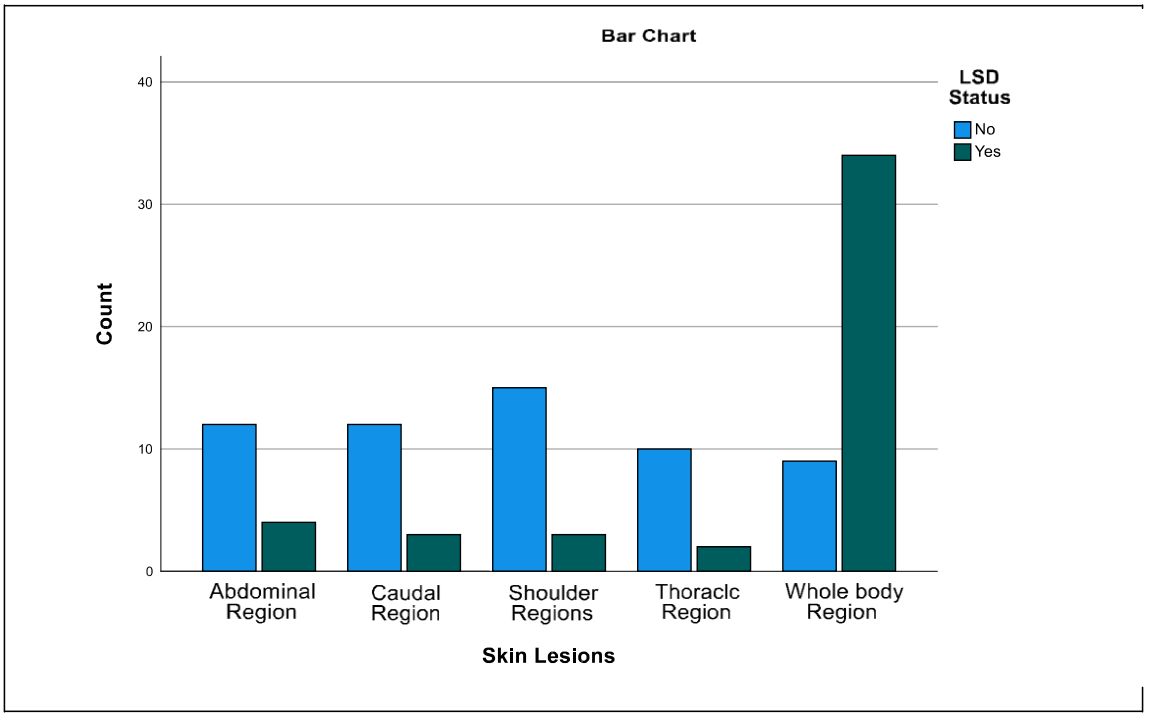
B. Breed of animals



C. Sex of animals



D. Skin lesions



E. Pregnancy Status

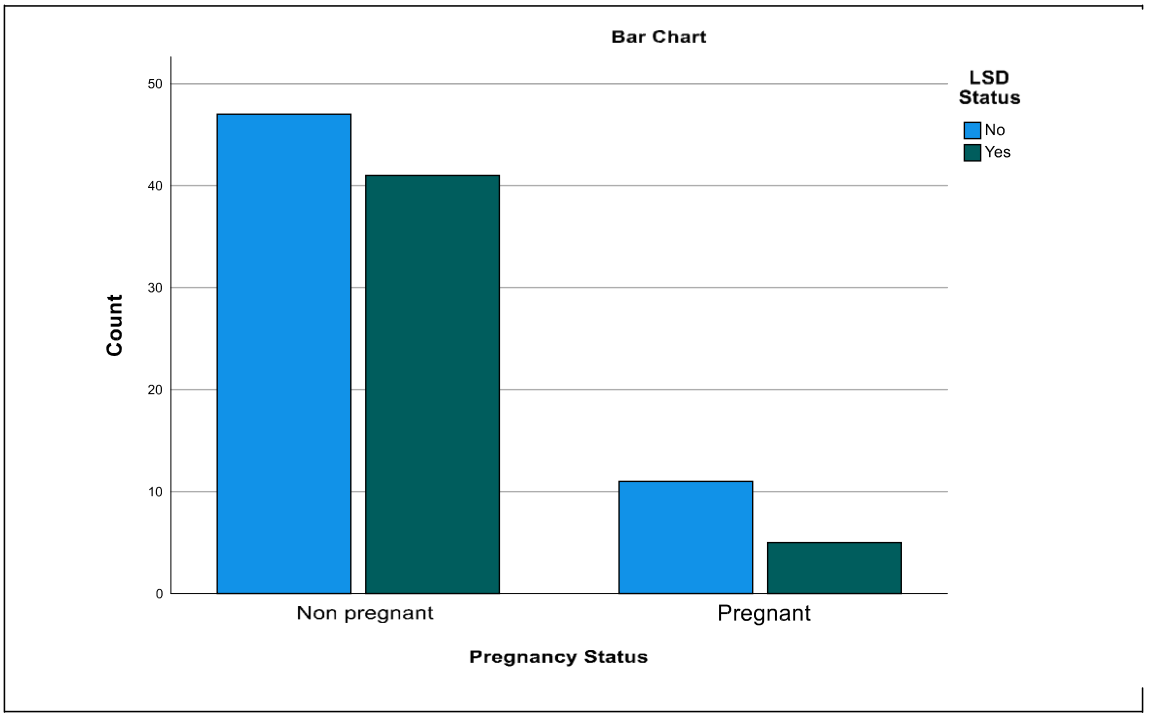


Figure 3: Bar chart showing the Proportions of LSD outbreak in relation to (A) Age of cattle, (B) Breed of cattle, (C) Sex of cattle, (D) Skin lesions and (E) Pregnancy Status of cattle. **Significant at 1% ($p<0.001$), *Significant at 5% ($p<0.05$)

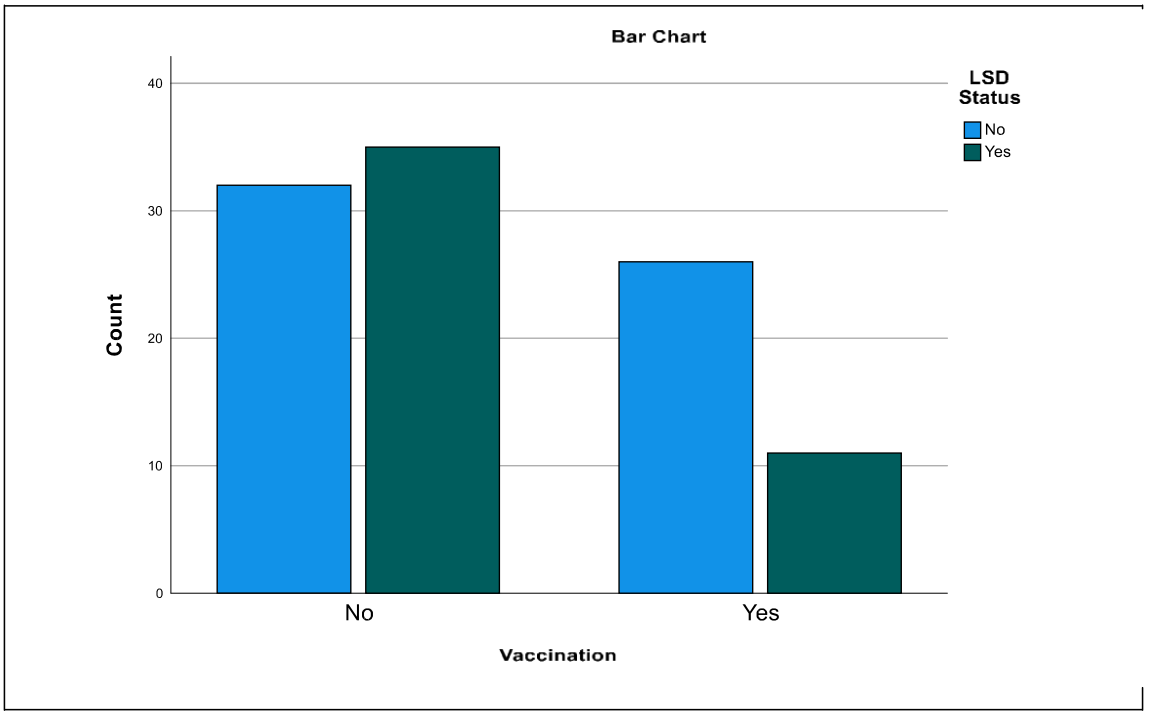
LSD outbreak information in association with management status of cattle was presented in Table 3. This table showed that vaccination, use of disinfectant and fly repellent had significant ($p <0.05$) association to LSD among the all recorded cases. In considering the all recorded cases the highest percentages of LSD positive cases within the categorical level were no vaccination of 76.1%, never use of disinfectant of 67.4% and no fly repellent of 78.3%. The symmetry analysis alluded that the most of the cases had negative effect.

Table 3: Frequencies of LSD outbreak in cattle according to management practices

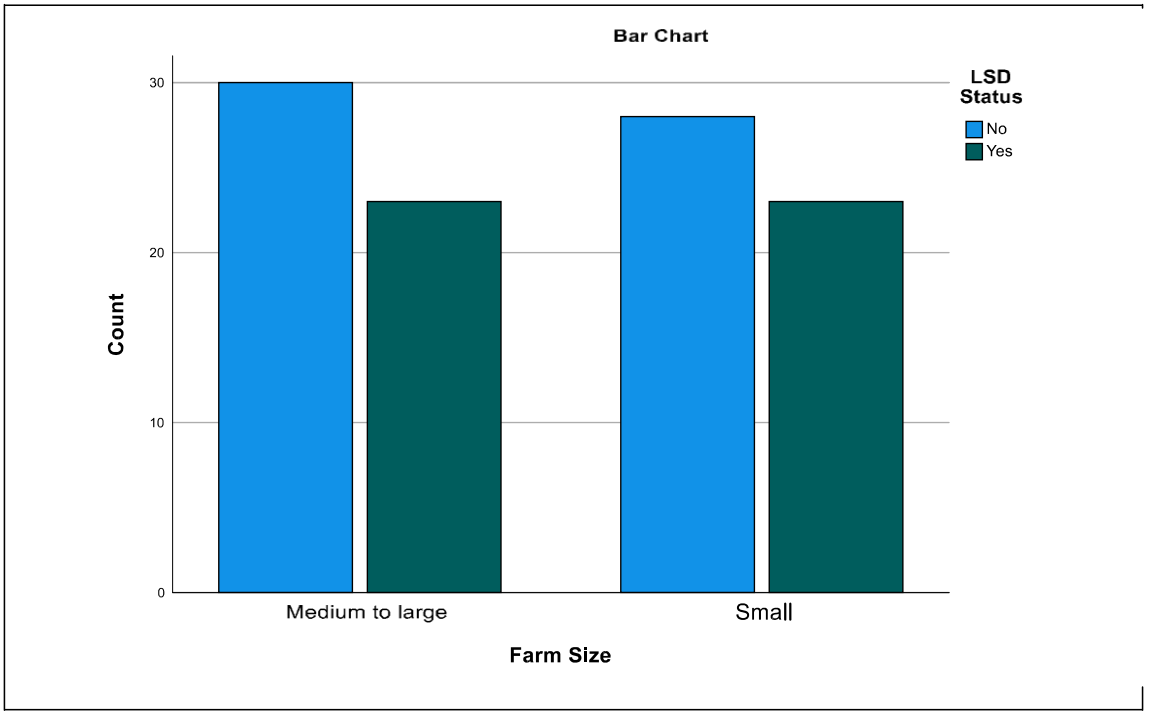
Variables	Category Level	Number of Sample		LSD Status				P-Value	Symmetry analysis
				Yes		No			
		N	%	N	%	N	%		
Vaccination	Non vaccinated	67	64.4	35	76.1*	32	55.2	0.027	-0.217
	Vaccinated	37	35.6	11	23.9	26	44.8		
Farm Size	Small	51	49.0	23	50.0	28	48.3	0.861	0.017^{NS}
	Medium to large	53	51.0	23	50.0	30	51.7		
Use of Disinfectant	Not used	58	55.8	31	67.4*	27	46.6	0.034	-0.208
	Used	46	44.2	15	32.6	31	53.4		
Source of Water	Pond	41	39.4	17	37.0	24	41.4	0.647	0.045^{NS}
	Tube well	63	60.6	29	63.0	34	58.6		
Use of Fly Repellent	Not used	70	67.3	36	78.3*	34	58.6	0.034	-0.208
	Used	34	32.7	10	21.7	24	41.4		

*Significant at 5% ($p<0.05$), NS= Insignificant, N=Frequencies, %= Percentages

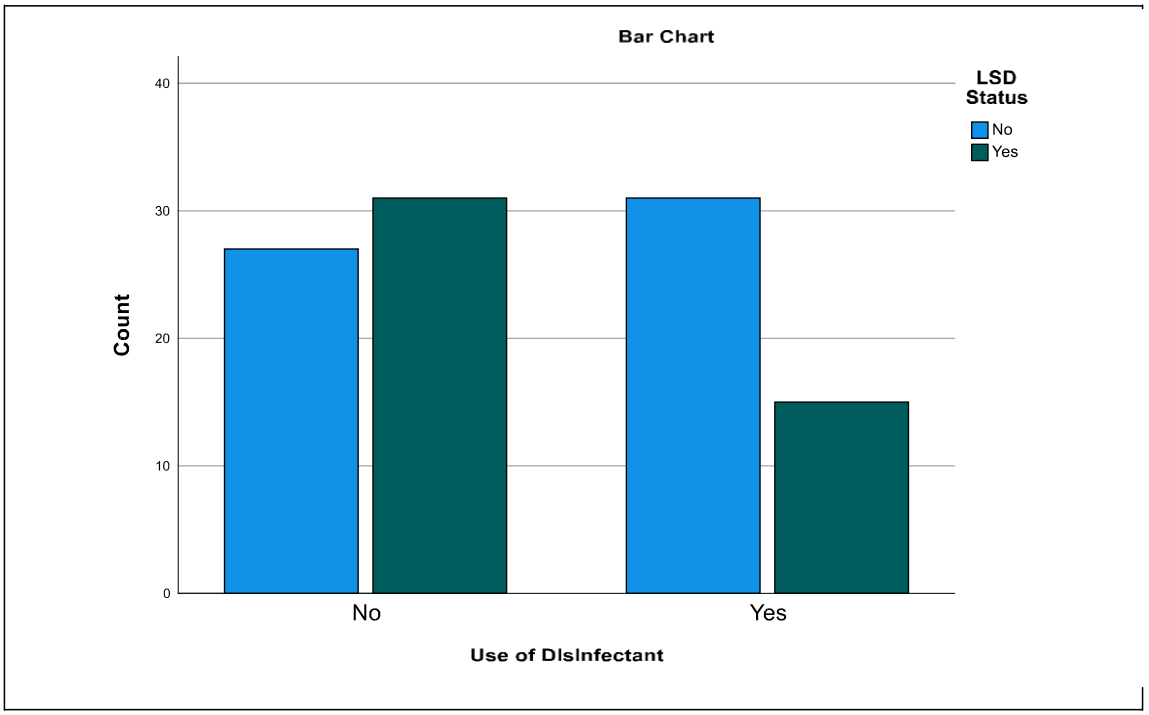
A. Vaccination status



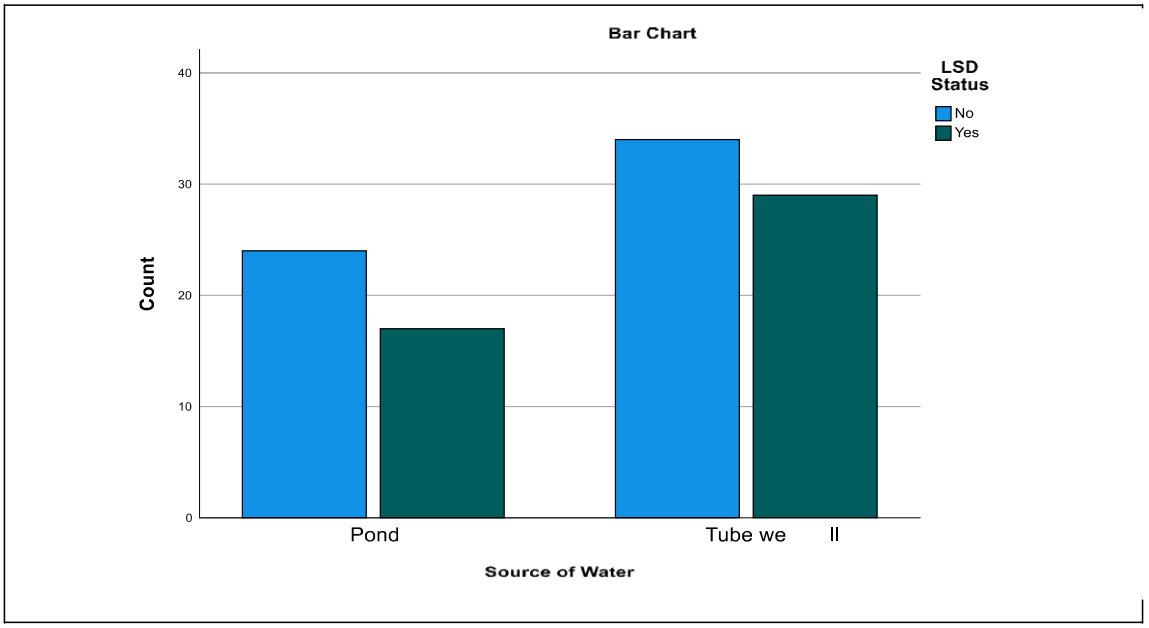
B. Farm size



C. Use of disinfectant



D. Source of water



E. Use of fly repellent

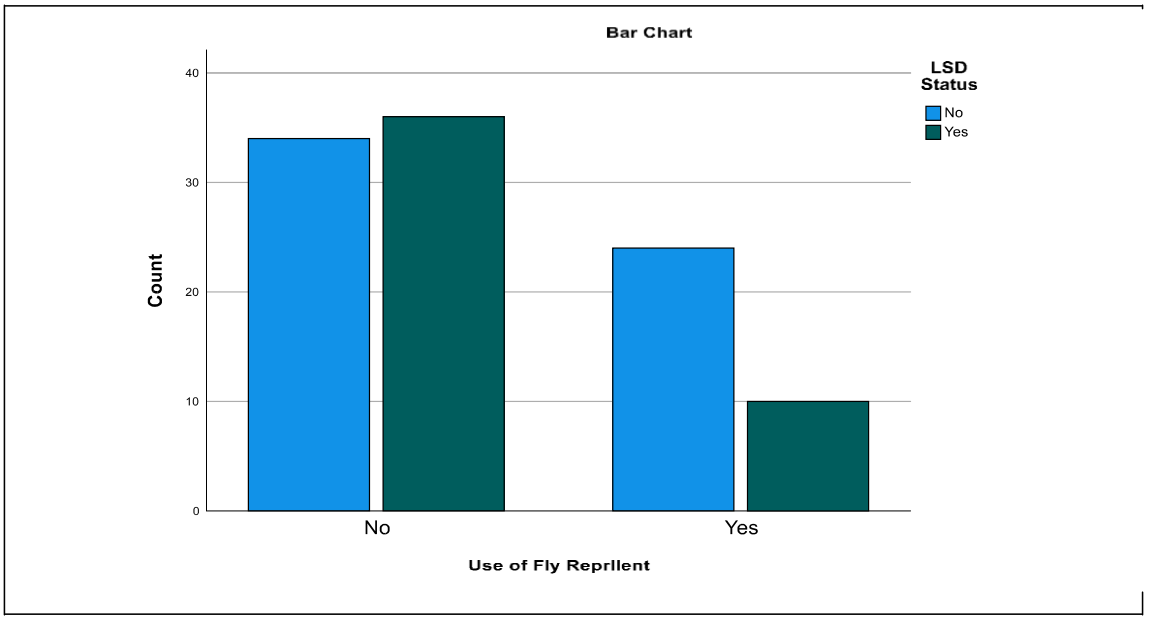


Figure 3: Bar chart showing the Proportions of LSD outbreak in relation to (A) Vaccination status of cattle, (B) Farm size of cattle, (C) Use of disinfectant in cattle farm, (D) Source of water for cattle and (G) Use of fly repellent in cattle farm. **Significant at 1% ($p<0.001$), *Significant at 5% ($p<0.05$)

CHAPTER V
DISCUSSION

This study revealed that the overall prevalence of LSD was 44.2% at Saturia Upazila of Bangladesh, whereas other authors reported that the prevalence of LSD is 27.9% in cattle of Oman (Body *et al.,* 2012) and 17.4% in Egypt (Elhaig *et al.,* 2017). In fact, the prevalence of disease may differ from region to region. Although I didn't observe any mortality in the study population, some of the previous studies reported 0.99%–2.12% of mortality (Gari *et al.,* 2010; Kasem *et al.,* 2018). Comparatively shorter duration of the actual study period and culling of diseased animals might be a reason for the paucity of mortality. My study shows that the highest prevalence of LSD was on month of July. But Molla, W. *et al.* (2017) found peak outbreak in October. However the seasonality of the disease may differ from region to region. In my study calves were affected largely with LSD in comparison to adults. The authors Elhaig *et al.* (2017) and Molla *et al.* (2018) reported the LSD prevalence was higher in adult cattle, which is dissimilar to our study. This was probably due to variation in study place and time. My study reveals that crossbred cattle were more susceptible to LSD than local cattle. This finding is in line with the findings of Al Rammahi & Jassim (2015); Kiplagat *et al.* (2020) and Klement *et al.* (2018). Higher susceptibility of crossbred cattle might be due to lower disease resistance capability in comparison to local breeds (Tageldin *et al.,* 2014). In my study there was no any significant influence of sex on LSD which was in line with the findings of Elhaig *et al.,* (2017). But some other authors found that Females were more prone to LSD compared to males (Ayelet *et al.,* 2014; Magori-Cohen *et al.,* 2012). In my study the highest prevalent had the skin lesion all over the body. But Zeynalova *et al.* (2016) found that the appearances of nodules undergone to degenerative changes on the skin surface in the abdominal and neck regions of the body. In my study, majority portion of LSD cases was non pregnant. That’s why no association was found with pregnancy status. This might be due to variation of sample size.

In my study, the prevalence was significantly higher proportion in nonvaccinated cattle which strongly agree with the findings of Kiplagat *et al.*, (2020) who reported 88% prevalence in cattle had not vaccinated in Kenya. Vaccinated animals are able to produce antibody, specially neutralizing antibodies within the 7 days of post vaccination (Kithing and Hammond, 1992). Tuppurainen and Oura (2012) found that, the prevalence of the disease was mostly associated with the presence of insect vectors, livestock grazing, watering points, husbandry systems, wet seasons and market conditions etc. My findings found no association of farm size and source of water on LSD. In my study I found signinificsnt association of use of disinfectant on the prevalence of LSD. The use of disinfectant can reduce the LSD prevalence. Perhaps, this result is due to the nature of disinfectant to eliminate the viral concentration. I found significant influence of use of fly repellent on the prevalence of LSD, which was in line with the other authors. Ochwo *et al.* (2019) found that biting flies may act as vector for the transmission of LSD virus. Alemayehu *et al.* (2015) suggested that the use of fly repellent had the effect to decrease the prevalence of LSD, because vector control is one of the most important strategies to restrict the spread of LSD.

CHAPTER VI
SUMMARY AND CONCLUSION

This study was designed to investigate the prevalence of Lumpy Skin Disease (LSD) associated with herd level status and management practice of cattle. The research was carried out at Saturia Upazila of Manikganj District in the Division of Dhaka of Bangladesh. The study animal population comprised of 104 sick cattle of the study area. Active disease outbreak investigation was made based on information obtained from direct interview and from Upazila Livestock Office and Veterinary Hospital, Saturia, Manikganj. All investigations were in response to LSD outbreaks. The households under investigation were purposively selected on the basis of outbreak reports from Upazila Livestock Office and Veterinary Hospital, Saturia. Animals were examined for characteristic clinical signs of LSD, such as visible skin nodules, enlarged lymph nodes, lameness and fever. In Addition, data like vaccination history, age, sex and breeds of animals were collected. A questionnaire was administered to individual herd owners. The data were collected by face to face interview using the local language by visiting their farm. The questionnaire was designed primarily to record the magnitude of production losses, mortality, and cost of control for LSD in several categories of bovines in a herd and perception of farmers on livelihood impact and its influence on cattle marketing during the outbreak period. Information related to the composition of the herd, herd dynamics, the management system used, the number, age and sex of the animals that had been affected by LSD and subsequently died, if vaccination or any other treatment had been applied during/after the course of the disease were recorded. The data on vaccination with goat pox vaccine was considered to determine the vaccination history. Close inspection was done carefully to observe the clinical signs included the typical fever for three days and marked decrease in the milk production at the first stage. Moreover, others clinical signs like as nasal discharge, lacrimation, anorexia, emaciation, enlarged lymph nodes and lesions in the skin and oral mucous membranes were

common in LSD which considered for clinical diagnosis. Depending on the case, skin scrapings were collected from the affected area and microscopic examination was done to distinguish the LSD with other skin diseases. After collection of data, all the data were statistically analyzed.

In conclusion, the results of this study shown that the outbreak of LSD had significant association with the season, age and breed of cattle with the skin lesions on the whole body surface. Vaccinated cattle and the farms that frequently use the disinfectant and fly repellent also have fewer trends to LSD occurrences. That's why this study suggests that LSD infection can be greatly reduced by practicing regular vaccination, disinfection and vector controlling.

CHAPTER VII
REFERENCES

Abdulqa H. Y., Rahman H. S., Dyary H. O. and Othman H. H. (2016). Lumpy Skin Disease. *Reproductive Immunology: Open Access.*

Abera Z., Degefu H. and Gari G. (2015b). Assessment of Distribution and Associated Risk Factors of Lumpy Skin Disease in Selected Districts of West Wollega Zone, Western Ethiopia. Academic Journal of Animal Diseases 4: 3, 130-140.

Abera Z., Degefu H., Gari G. and Ayana Z. (2015a). Review on Epidemiology and Economic Importance of Lumpy Skin Disease. International Journal of Basic and Applied Virology 4: 1, 8-12.

Aboelkhair, A.I., El-Deeb, A.H., Shahin, M.A. and Hussein, H.A. 2019. Lumpy skin disease is circulating among sheep pox vaccinated cattle in Egypt 2017. J. Virol. Sci. 5(1): 1-10.

Abutarbush SM, Ababneh MM, Al Zoubil IG, Al Sheyab OM, Al Zoubi MG, *et al.* (2013) Lumpy Skin Disease in Jordan: Disease Emergence, Clinical Signs, Complications and Preliminary-associated Economic Losses. Transbound Emerg Dis 62: 549-554.

Ali B. H. and Obeid H. M. (1977). Investigation of the first outbreaks of lumpy skin disease in the Sudan. British Veterinary Journal 133: 2, 184-189.

Al-Salihi K. A. (2014). Lumpy Skin disease: Review of literature. Mirror of research in veterinary sciences and animals 3: 3, 6-23.

Al-Salihi K. A. and Hassan I. Q. (2015). Lumpy Skin Disease in Iraq: Study of the Disease Emergence. Transboundary and emerging diseases 62 : 457-462.

Ayelet G., Haftu R., Jemberie S., Belay A., Gelaye E., Sibhat B., Skjerve E. and Asmare K. (2014). Lumpy skin disease in cattle in central Ethiopia: outbreak investigation 30 and isolation and molecular detection of the virus. Reveiw of Science and Technology 33: 877-887.

Babiuk, S., Bowden, T.R., Boyle, D.B., Wallace, D.B., Kitching, R.P., 2008a. Capripoxviruses: an emerging worldwide threat to sheep, goats and cattle. Transbound. Emerg. Dis. 55, 263-272.

Babiuk, S., Bowden, T.R., Parkyn, G., Dalman, B., Manning, L., Neufeld, J., EmburyHyatt, C., Copps, J., Boyle, D.B., 2008b. Quantification of lumpy skin disease virus following experimental infection in cattle. Transbound. Emerg. Dis. 55, 299-307.

Babuik S., Bowden T. R., Boyle D. B., Wallace D. B. and Kitching R. P. (2008). Capripoxviruses: An Emerging Worldwide Threat to Sheep, Goats and Cattle. Transboundary and Emerging Diseases 55: 263-272.

Beard, P.M. 2016. Lumpy skin disease: a direct threat to Europe. Vet. Rec. 178: 557–558.

Bender, J.B., Hueston, W., Osterholm, M., 2006. Recent animal disease outbreaks and their impact on human populations. J. Agromedicine 11, 5-15.

Bhanuprakash V., Hosamani M. and Singh R. K. (2011). Prospects of control and eradication of capripox from the Indian subcontinent: A perspective. Antiviral Research 91: 225-232.

Bhanuprakash V., Venkatesan G., Balamurugan V., Hosmani M., Yogisharadhya R., Chauhan R. S., Pande A., Mondal B. and Singh R. K. (2010). Pox outbreaks in Sheep and Goats at Makhdoom (Uttar

Pradesh), India: Evidence of Sheeppox Virus Infection in Goats. Transboundary and Emerging Diseases 375-382.

Body, M., Singh, P. K., Hussain, H. M., Al-rawahi, A., Al-maawali, M., Al-lamki, K., & Al-habsy, S. 2012. Clinico-histopathological findings and PCR based diagnosis of lumpy skin disease in the Sultanate of Oman. Pakistan Veterinary Journal, 32(2), 206–210.

Boumart Z., Daouam S., Belkourati I., Rafi L., Tuppurainen E., Tadlaoui K. O. and Harrak M. E. (2016). Comparative innocuity and efficacy of live and inactivated sheeppox vaccines. BMC Veterinary Researches 12.

Brenner J., Bellaiche M., Gross E., Elad D., Oved Z., Haimovitz M., Wasserman A., Friedgut O., Stram Y. and Bumbarov V. (2009). Appearance of skin lesions in cattle populations vaccinated against lumpy skin disease: statutory challenge. Vaccine 27: 10, 1500-1503.

Carn, V.M., Kitching, R.P., 1995a. The clinical response of cattle experimentally infected with lumpy skin disease (Neethling) virus. Arch. Virol. 140, 503-513.

Carn, V.M., Kitching, R.P., 1995b. An investigation of possible routes of transmission of lumpy skin disease virus (Neethling). Epidemiol. Infect. 114, 219-226.

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. Medical and veterinary entomology 17: 3, 294-300.

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). Epidemiology and Infection 126: 2, 317-321.

Coezer, J. and Tuppurainen, E. (2004). Lumpy skin disease.Oxford University Press. Cape Town, Southern Africa 2: 1268-1276

Coezer, J. and Tuppurainen, E. (2004). Lumpy skin disease.Oxford University Press. Cape Town, Southern Africa 2: 1268-1276

Davies F. G. (1991). Lumpy skin disease, an African capripox virus disease of cattle. British Veterinary Journals 147: 6, 489-503.

DLS, 2019. Situation Report: Lumpy Skin Disease in Bangladesh Background.https://fscluster.org/sites/defau lt/files/documents/sitrep_lsd_20191210.pdf

DLS. Situation Report: Lumpy Skin Disease in Bangladesh. 2019; Available from: https://fscluster.org/sites/default/files/documents/sitrep_lsd_20191210.pdf

EFSA AHAW Panel, E.P.o.A.H.a.W., 2015. Scientific Opinion on lumpy skin disease. EFSA Journal, 13.

Elhaig, M.M., Selim, A., Mahmoud, M. and Canal, S. 2017. Lumpy skin disease in cattle : Frequency of occurrence in a dairy farm and a preliminary assessment of its possible impact on Egyptian buffaloes. Onderstepoort Journal of Veterinary Research, 84: 1–6.

El-Nahas, E.M., El-Habbaa, A.S., El-Bagoury, G.F. and Radwan, M.E.I.(2011). Isolation and identification of lumpy skin disease virus from naturally infected buffaloes at Kaluobia, Egypt. Global Veterinaria 7: 234–237. Available at: 32 www.ejmanager.com/mnstemps/118/118-1476356929.pdf?t=1494798690 accessed on 4/18/2018

Facquet C. M. (2005). Virus taxonomy: VIIIth report of the International Committee on Taxonomy of Viruses. Academic Press,

FAO, 2009. The state of food and agriculture: Livestock in the balance. FAO Rome, Italy.

Gari G., Abie G., Gizew D., Wubete A., Kidane M., Asgedom H., Bayissa B., Ayelet G., Ourae C. A., Rogerc F. and Tuppurainen E. S. (2015). Evaluation of the safety, immunogenicity and efficacy of three capripoxvirus vaccine strains against lumpy skin disease virus . Vaccine 33: 3256-3261.

Gari G., Abie G., Gizew D., Wubete A., Kidane M., Asgedom H., Bayissa B., Ayelet G., Ourae C. A., Rogerc F. and Tuppurainen E. S. (2015). Evaluation of the safety, immunogenicity and efficacy of three capripoxvirus vaccine strains against lumpy skin disease virus . Vaccine 33: 3256-3261.

Gari G., Bonnet P., Roger F. and Waret-Szkuta A. S. (2011). Epidemiological aspects and financial impact of lumpy skin disease in Ethiopia. Preventive veterinary medicine 102: 4, 274-283.

Gari G., Waret-Szkuta A., Grosbois V., Jacquiet P. and Roger F. (2010). Risk factors associated with observed clinical lumpy skin disease in Ethiopia. Epidemiological Infections 138: 11, 1657-1666.

Gari, G., Bonnet, P., Roger, F., Waret-Szkuta, A., 2011. Epidemiological aspects and financial impact of lumpy skin disease in Ethiopia. Prev. Vet. Med. 102, 274- 283.

Gelaye E., Belay A., Ayelet G., Jenberie S., Yami M., Loitsch A., Tuppurainen E., Grabherr R., Diallo A. and Lamien E. C. (2015). Capripox disease in Ethiopia: Genetic differences between field isolates and vaccine strain, and implications for vaccination failure. *Antiviral Research.*

Gelaye E., Belay A., Ayelet G., Jenberie S., Yami M., Loitsch A., Tuppurainen E., Grabherr R., Diallo A. and Lamien E. C. (2015).

Capripox disease in Ethiopia: Genetic differences between field isolates and vaccine strain, and implications for vaccination failure. Antiviral Research.

Hosamani M., Mondal B., Tembhurne P. A., Bandyopadhyay S. K., Singh R. K. and Rasool T. J. (2004). Differentiation of Sheep Pox and Goat Poxviruses by Sequence Analysis and PCR-RFLP of P32 gene . Virus Genes 29: 1, 73-80.

http://en.banglapedia.org/index.php?title=Saturia_Upazila

http://saturia.manikganj.gov.bd/

Irons P.C., Tuppurainen E. S. and E.H. Venter, (2005).Excretion of lumpy skin disease virus in bull semen. Theriogenology 63, 1290–1297.

Kasem, S., Saleh, M., Qasim, I., Hashim, O., Alkarar, A., Abu-Obeida, A., Gaafer, A., Hussien, R., AL-Sahaf, A., Al-Doweriej, A., Bayoumi, F., Hodhood, A., & Abdelatif, M. 2018. Outbreak investigation and molecular diagnosis of lumpy skin disease among livestock in Saudi Arabia 2016. Transboundary and Emerging Diseases, 65(2), e494–e500. 10.1111/tbed.12769

Kiplagat, S. K., Kitala, P. M., Onono, J. O., Beard, P. M., & Lyons, N. A. 2020. Risk factors for outbreaks of lumpy skin disease and the economic impact in cattle farms of Nakuru County, Kenya. Frontiers in Veterinary Science, 7: 259. (10.3389/fvets.2020.00259)

Kithing RP, and JM Hammond,. 1992. Poxvirus infection and immunity. In Encycl. Immunol, Eds, Roitt I.M., P. Delves, Academic press, London, pp. 1261–1264.

Klement, E. 2018. Economic impact of lumpy skin disease. Lumpy skin disease. Springer. 10.1007/978-3-319-92411-3_3

MacLachlan, N. J. and Dubovi, E. J. (2011). Fenner'sVeterinary Virology 4 th edition Elsevier ,157-160.

Madhavan A., Venkatesan G. and Kumar A. (2016). Capripoxviruses of Small Ruminants: Current Updates and Future Perspectives. Asian Journal of Animal and Veterinary Advances 11: 757-770.

Magori-Cohen R., Louzoun Y., Herziger Y., Oron E., Arazi A., Tuppurainen E., Shpigel N. Y. and Klement E. (2012). Mathematical modelling and evaluation of the different routes of transmission of lumpy skin disease virus. Veterinary research 43: 1, 1.

Molla, W., de Jong, M.C.M. & Frankena, K. 2017. Temporal and spatial distribution of lumpy skin disease outbreaks in Ethiopia in the period 2000 to 2015. *BMC Vet Res* 13, 310. (https://doi.org/10.1186/s12917-017-1247-5)

Molla, W., Frankena, K., Gari, G., Kidane, M., Shegu, D., & de Jong, M. C. M. 2018. Seroprevalence and risk factors of lumpy skin disease in Ethiopia. Preventive Veterinary Medicine, 160, 99–104. 10.1016/j.prevetmed.2018.09.029

Murphy F. A. 2012. Virus taxonomy: classification and nomenclature of viruses. Edition 10. Springer Science and Business Media,

Ochwo S, K Vanderwaal, A Munsey, J Nkamwesiga, C Ndekezi, E Auma and FN Mwiine, 2019. Seroprevalence and risk factors for lumpy skin disease virus seropositivity in cattle in Uganda. BMC Veterinary Research, 15: 236.

OIE, 2010. Manual of diagnostic tests and vaccines for terrestrial animals, chapter 2.4.14, Lumpy skin disease. OIE, Paris. http://web.oie.int/eng/normes/MMANUAL/A_Index.htm. Accessed 26 February 2016

OIE. (World Organisation for Animal Health), Terristerial manual chapter 2.4.13. Lumpy Skin Disease. (2017).

OIE. (World Organisation for Animal Health), Terristerial manual chapter 2.4.13. Lumpy Skin Disease. (2017).

OIE. Technical Disease Cards: Lumpy Skin Disease. 2017; Available from: https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/LUMPY_SKIN_DISEASE_FINAL.pdf

OIE.Event summary: Lumpy skin disease, Bangladesh. 2019; Available from: https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review/viewsummary?reportid=31742

OIE.Event summary: Lumpy skin disease, China (People's Rep. of). 2019; Available from: https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review/viewsummary?reportid=31501

OIE.Event summary: Lumpy skin disease, India. 2019 [cited; Available from: https://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review/viewsummary?reportid=32387

Otte, M.J., Nugent, R., McLeod, A., 2004. Transboundary animal diseases: Assessment of socio-economic impacts and institutional response. FAO, Livestock information and policy branch, AGAL. Livestock policy discussion paper No. 9.

Quinn, P.J., Markey, B.K., Carter, M.E., Donnelly, W.J., Leonard, F.C., 2002. Veterinary Microbiology and Microbial Disease. Blackwell Science, Great Britain. pp. 335-342.

Radostits O. M., Gay C. C., Hinchcliff K. W. and Constable P.D.(2006). Veterinary Medicine: A textbook of the diseases of cattle, horses, sheep, pigs and goats. Edition 10th. Sounders Elsevier,

Radostits, O.M., Gay, C.C., Hinchcliff, K.W., Constable, P.D., 2007. Veterinary Medicine: A Textbook of the Diseases of Cattle, Sheep, Pigs, Goats and Horses. Sounders Elsevier, Spain. pp. 1424-1426.

Randolph, T.F., Schelling, E., Grace, D., Nicholson, C.F., Leroy, J.L., Cole, D.C., Demment, M.W., Omore, A., Zinsstag, J., Ruel, M., 2007. Invited Review: Role of livestock in human nutrition and health for poverty reduction in developing countries. J. Anim. Sci. 85, 2788-2800.

Rao T. V. and Bandyopadhyay S. K. (2000). A comprehensive review of goat pox and sheep pox and their diagnosis. Animal Health Research Reviews 1: 2, 127-136.

Salib FA, A Osman and A AH, 2011. Incidence of lumpy skin disease among Egyptian cattle in Giza Governorate, Egypt. Veterinary World, 4: 162.

Salib FA, Osman AH (2011) Incidence of lumpy skin disease among Egyptian cattle in Giza Governorate, Egypt. Vet World 4: 162-167.

Shakya S. (2001). Identification and Molecular Characterization of Immunogenic Proteins of Capripox Virus. G. B. Pant University of Agriculture and Technology Pantnagar - 263145, (U.S.Nagar), Uj'taranchal, India.

Tageldin M.H., Wallace D.B., Gerdes G.H., Putterill J.F., Greyling R.R., Phosiwa M.N., Al Busaidy R.M. and Al Ismaaily S.I. (2014). Lumpy skin disease of cattle: an emerging problem in the Sultanate of Oman. Tropical. Animal. Health and Production. 46:241–246.

Tulman E. R., Afonso C. L., Lu Z., Zsak L., Kutish G. F. and Rock D. L. (2001). Genome of lumpy skin disease virus. Journal of virology 75: 15, 7122-7130.

Tuppurainen E. S. and Oura C. A. (2011). Review: Lumpy Skin Disease: An Emerging Threat to Europe, the Middle East and Asia. Journal of transboundary and emerging diseases.

Tuppurainen E. S.(2017a). Diagnostic assays for the detection of lumpy skin disease virus and antibodies.Reaserch Gate |accessed on 5-10-2018.

Tuppurainen E. S.(2017b). Epidemiology of Lumpy skin disease. Research Gate. 47.accessed on 5-13-2018.

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. Transboundary and emerging diseases 58: 2, 93-104.

Tuppurainen S., Pearrson C. R., Bankowska B. K., Knowles N. K., Amareen S., Frost L., Henstock M. R., Diallo A. and Martens P. P. (2014). Characterization of sheep pox virus vaccine for cattle against lumpy skin disease virus. Antiviral Research 109: 1-6

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., Babiuk, L.A., 2017. Review: capripoxvirus diseases: current status and opportunities for control. Transbound. Emerg. Dis. 64 729-745.

Von Backstrom, U., 1945. Ngamiland cattle disease: Preliminary report on a new disease, the etiological agent being probably of an infectious nature. J. S. Afr. Vet. Assoc. 16, 29-35.

Weiss K.E., (1968). Lumpy skin disease virus. Virology. Monographs. 3,111–131

Weiss, K.E., 1968. Lumpy skin disease virus. Virol. Monogr. 3, 111-131.

Woods, J.A., 1990. Lumpy skin disease virus. In: Dinter, Z., Morein, B. eds. Virus Infections of Ruminants. Elsevier Science publishers B. V., Amesterdam. pp. 53-67.

Zeynalova S, K Asadov, F Guliyev, M Vatani and V Aliyev, 2016. Epizootology and Molecular Diagnosis of Lumpy Skin Disease among Livestock in Azerbaijan. Frontiers in Microbiology, 7: 1022.

CHAPTER VII
APPENDICES

Appendix 1: Questionnaire Format for Field Data Collection

Case No._____

Date_____

A. Owner's Information

1. Owner's Name_____
2. Village/Ward_____
3. Union_____
4. Upazila_____
5. District_____
6. Contact No._____

B. Herd Level Information

1. Have you had skin diseases of cattle in your herd?
   i. Yes
   ii. No
2. Have you had Lumpy Skin Disease (LSD) in your cattle?
   i. Yes
   ii. No

3. When did the disease commence in your farm?
    i. March
    ii. April
    iii. May
    iv. June
    v. July
    vi. August
4. What is the sex of your cattle?
    i. Male
    ii. Female
5. What is the age of your cattle?
    i. 0 to 2 years
    ii. More than 2 years
6. What is the breed of your cattle?
    i. Local
    ii. Cross
7. What type of skin lesions have you seen in your cattle?
    i. Shoulder Regions
    ii. Thoracic Region
    iii. Abdominal Region
    iv. Caudal Region
    v. Whole Body Region
8. What is the pregnancy status of your cattle?
    i. Pregnant
    ii. Non-pregnant

C. Management Practices

1. Do you dewormed your cattle?
    i. Yes
    ii. No
2. Do you vaccinate your cattle with goat pox vaccine?
    i. Yes
    ii. No
3. What is the size of your farm?
    i. Small (2 to 5 cattle)
    ii. Medium (6 to 9 cattle)
    iii. Large (10 cattle and more)
4. What is the Grazing Pattern of your cattle?
    i. Individual
    ii. Flock
5. How often do you use disinfectant to your farm?
    i. Frequent
    ii. Often
    iii. Never
6. What is the Source of Water of your farm?
    i. Pond
    ii. Tube well
7. Do you use fly repellent to your farm?
    i. Yes
    ii. No

Appendix 2: Photos of sick animals