LUMPY SKIN DISEASE STANDARD OPERATING PROCEDURES:
1. OVERVIEW OF ETIOLOGY AND ECOLOGY

FAD PReP
Foreign Animal Disease Preparedness & Response Plan

United States Department of Agriculture

United States Department of Agriculture • Animal and Plant Health Inspection Service • Veterinary Services

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The Foreign Animal Disease Preparedness and Response Plan (FAD PReP) Standard Operating Procedures (SOPs) provide operational guidance for responding to an animal health emergency in the United States.

These draft SOPs are under ongoing review. This document was last updated in **October 2016**. Please send questions or comments to:

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Lumpy skin disease, also known as Knopvelsiekte and Neethling virus.

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Varies with cattle breed and age. Mortality is often relatively low (1–3%) and morbidity usually only reaches 20% but can vary between 3–85%.

Susceptible Species

Cattle, zebu cattle, yaks, giraffes, impalas, and water buffalo.

Zoonotic Potential (yes/no)?

No.

Reservoir

No known wild reservoir.

Transmission

Biting insects are the main mode of transmission.

Persistence in the Environment

The virus is susceptible to sunlight and detergents containing lipid solvents. In dark environmental conditions, such as contaminated animal sheds, it can persist for many months. The virus can survive for a long time at ambient temperatures.

Animal Products and By-Products

LSDV is very resistant to inactivation, surviving in necrotic skin nodules for up to 33 days or longer, desiccated crusts for up to 35 days, and at least 18 days in air-dried hides.

1.1 Introduction

Lumpy skin disease (LSD) is an infectious viral disease that affects cattle. Clinical signs include nodules on the skin, mucous membranes, and internal organs, fever, emaciation, enlarged lymph nodes, edema of the skin, and sometimes death.[1] LSD fatalities are often low but economic impacts can be high, as decreased milk production, abortion, infertility, and decreased hide quality negatively impact owners of infected herds.

LSD is considered endemic in southern and central regions of Africa. In 1929, the first recorded outbreak occurred in Zambia.[2] LSD was initially only present south of the Sahara desert and in Madagascar until it spread to Egypt in 1988. Outbreaks have since occurred in the Middle East, particularly Israel in 1989, where eradication was eventually achieved through depopulation and vaccination.[3]

1.1.1 Goals

As a preparedness goal, the Animal and Plant Health Inspection Service (APHIS) will provide etiology and ecology summaries for LSD and update these summaries at regular intervals.

As a response goal, the Unified Command and stakeholders will have a common set of etiology and ecology definitions and descriptions, to ensure proper understanding of LSD when establishing or revising goals, objectives, strategies, and procedures.

1.2 Purpose

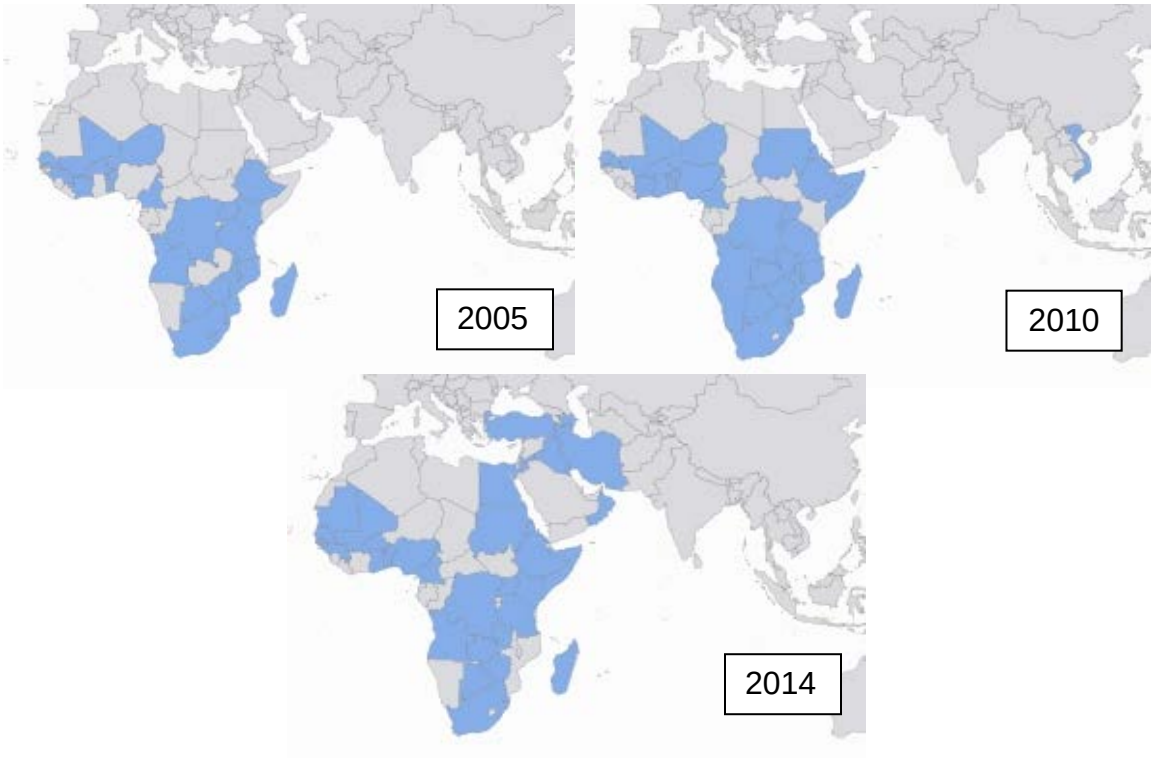
The purpose of this document is to provide responders and stakeholders with a common understanding of the disease agent.

1.3 Disease Reporting

In countries where LSD is endemic, no established systems of disease reporting, eradication, or prevention plans exist. LSD can easily go undetected and unreported due to fear of trade bans and lack of proficient veterinary staff and confirmatory laboratories. These factors promote the persistence of LSD in endemic areas.[4] As seen in Figure 1-1, LSD is endemic across wide areas of Africa, and in recent years, portions of the Middle East.

[1] World Organization for Animal Health (OIE). (2016). Lumpy Skin Disease. *Terrestrial Manual*. Retrieved from www.oie.int.
[2] Neamat-Allah, A. N. F. (2015). Immunological, Hematological, Biochemical, and Histopathological Studies on Cows Naturally Infected with Lumpy Skin Disease. *Veterinary World*, *8*(9) 1131-1136.
[3] Center for Food Security and Public Health (CFSPH), Iowa State University. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[4] European Food Safety Authority (EFSA). (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on Animal Health and Welfare (AHAW). *EFSA Journal*, *13*(1): 3986.

Figure 1-1. Global LSD prevalence in 2005, 2010, and 2014[5]



1.4 Etiology

1.4.1 Virus Characteristics

According to the International Committee on Taxonomy of Viruses, this disease has the following characteristics:

- Family: *Poxviridae*
- Genus: *Capripox*, containing three species:
  - Lumpy skin disease virus (LSDV)
  - Goat pox virus (GTPV)
  - Sheep pox virus (SPPV)

LSD is closely related to GTPV and SPPV, which affect goats and sheep. There is ongoing research determining the genetic relationship between these three viruses; it is thought that goat

[5] OIE. (2015). Disease Timelines. Retrieved from http://www.oie.int/wahis_2/public/wahid.php/Wahidhome/Home.

pox and lumpy skin disease are more closely related. All sheep and goat pox genes are found in the LSD genome.[6,7]

1.4.2 Genus Characteristics

Capripoxviruses are double-stranded DNA viruses containing around 150 kilobase pairs and are relatively large (230–260 nm). They are brick- or oval-shaped with enveloped capsids. Strains of GTPV, SPPV, and LSDV are up to 96 percent similar.[8,9]

1.5 Ecology

1.5.1 Name

LSD is also referred to as Knopvelsiekte and Neethling virus.[10]

1.5.2 Susceptible Species

- Cattle (*Bos taurus*),
- zebu cattle (*Bos indicus*),
- yaks (*Bos grunniens*),
- giraffes,
- impalas, and
- Asian water buffalo (*Bubalus bubalis*).[11,12]

In cattle, breeds of the *Bos taurus* species (predominantly Jersey, Guernsey, and Ayrshire [Channel Island breeds]) are more disposed to clinical disease than zebu cattle and their hybrids.[13]

Other species, such as the Arabian oryx (*Oryx leucoryx*), springbok (*Antidorcas marsupialis*), blue wildebeest (*Connochaetes taurinus*), black wildebeest (*Connochaetes gnu*), eland (*Taurotragus oryx*), African buffalo (*Syncerus caffer*), kudu (*Tragelaphus strepsiceros*), two waterbuck species (*Kobus ellipsiprymnus* and *Kobus defassa*), and reedbuck (*Redunca arundinum*), have been found with LSDV antibodies, but skepticism remains as infection in

[6] Tulman, E. R., et al. (2002). The Genomes of Sheeppox and Goatpox Viruses. *Journal of Virology*, *76*(12): 6054-6061.
[7] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[8] Tulman, E. R., et al. (2002). The Genomes of Sheeppox and Goatpox Viruses. *Journal of Virology*, *76*(12): 6054-6061.
[9] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[10] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[11] Center for Agriculture and Biosciences International (CABI). (2015). Lumpy Skin Disease. Retrieved from http://www.cabi.org/isc/datasheet/76780.
[12] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[13] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.

these animals could have potentially come from another related pox viruses. Infection of LSD in wild animals may be hard to notice for various reasons. Severely affected wild animals would quickly become easy prey, and since LSD can have mild physical signs, it may go unnoticed.[14,15,16]

LSDV experimentally added to sheep and goat cells is able to replicate, and injecting sheep and goats with LSDV does produce LSD-like lesions in some cases. Clinical infection in sheep and goats has never occurred, however.[17,18]

1.5.3 Maintenance Hosts

Kenyan African buffalo are thought to potentially be maintenance hosts.[19]

1.5.4 Introduction and Transmission of Lumpy Skin Disease

Biting insects are the main mode of transmission. LSDV has been isolated in the mosquito genera *Aedes* and *Culex*. Flies, such as *Stomoxys calcitrans* and *Biomyia fasciata*, in South Africa, along with other insects, like ticks (*Ixodid*, *Amblyomma hebraeum*, and *Rhipicephalus appendiculatus*), may be other mechanical vectors.[20,21] Because of the nature of these vectors, outbreaks are more frequent in wet, warm weather and in low-lying areas near water sources.

Direct contact with infected animals could potentially be another source of disease transmission, although it is less likely. LSDV is found in cutaneous lesions, saliva, respiratory secretions, milk, and semen. Fomites and animal products, such as hides, are potential sources of transmission as well. Experimentally, infected food and water via saliva have resulted in disease in animals.[22]

1.5.5 Incubation Period

The incubation period for LSD is 2 to 5 weeks. In some experiments, infected animals had fevers as soon as 6 to 9 days and lesions around the inoculation site in just 4 to 20 days after exposure.[23] The World Organization for Animal Health (OIE) *Terrestrial Animal Health Code* (2016) gives the incubation period as 28 days.[24]

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[14] Carter, G. R., Wise, D. J., and Flores, E.F. (2005). *A Concise Review of Veterinary Virology*. Retrieved from http://www.ivis.org/home.asp.
[15] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[16] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[17] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[18] CABI. (2015). Lumpy Skin Disease. Retrieved from http://www.cabi.org/isc/datasheet/76780.
[19] Gibbs, P. (2013). Pox Diseases: Lumpy Skin Disease. *The Merck Veterinary Manual*. Retrieved from http://www.merckvetmanual.com/mvm/index.html.
[20] Neamat-Allah, A. N. F. (2015). Immunological, Hematological, Biochemical, and Histopathological Studies on Cows Naturally Infected with Lumpy Skin Disease. *Veterinary World*, *8*(9) 1131-1136.
[21] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[22] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[23] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[24] OIE. (2016). Chapter 11.11. Lumpy Skin Disease. *Terrestrial Animal Health Code*. Retrieved from www.oie.int.

1.5.6 Morbidity and Mortality

Mortality is often relatively low (1–3 percent), and morbidity often only reaches 20 percent but can vary between 3–85 percent. Cows that are lactating seem to be more susceptible. In enzootic areas, infections in unvaccinated cattle often occur in epidemic form every 5–6 years.[25]

1.5.7 Clinical Signs

Clinical signs can include nodules on the skin, mucous membranes, and internal organs, fever, emaciation, enlarged lymph nodes, nasal discharge, lacrimation, abortion, edema of the skin, and sometimes death. Nodules can become necrotic, which poses a risk for further infection. Only 40–50 percent of animals will develop skin lesions. Milk yield can also drop significantly and bulls many become temporarily or permanently sterile. Young calves and lactating cows usually have more severe clinical signs. Overall, lesions can vary widely from one animal to another even within the same herd. Recovery is slow and often scars are left on the hides of animals.[26,27]

1.5.8 Humans and Lumpy Skin Disease

LSD does not infect humans.[28]

1.5.9 Diagnostic Testing

1.5.9.1 Differential Diagnosis

Nodules, fever, and enlarged lymph nodes are characteristic of LSD but occur in other diseases of cattle as well. Differentials include:

- pseudo-lumpy skin disease/bovine herpes mammillitis,
- dermatophilosis,
- ringworm,
- insect or tick bites,
- vaccinia virus and cowpox virus (*Orthopoxviruses*),
- rinderpest,
- demodicosis,
- onchocercosis,
- pseudocowpox (*Parapoxvirus*)
- besnoitiosis,
- *Hypoderma bovis* infestation,

[25] Carter, G. R., Wise, D. J., and Flores, E.F. (2005). *A Concise Review of Veterinary Virology*. Retrieved from http://www.ivis.org/home.asp.
[26] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[27] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[28] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.

- photosensitization,
- bovine papular stomatitis,
- urticaria, and
- cutaneous tuberculosis.[29,30]

1.5.9.2 Laboratory Tests

SPPV, GTPV, and LSDV cannot be differentiated from each other by serological tests. Therefore, serum neutralization test (SNT), fluorescent antibody test (FAT), indirect fluorescent antibody test (IFAT), and agar gel immunodiffusion (AGID) will not be able to distinguish between the three capripoxviruses.[31]

Laboratory confirmation of LSDV is found through polymerase chain reaction (PCR) for *capripoxviruses*, transmission electron microscopy, virus isolation, or a capripox antigen detection enzyme-linked immunosorbent assays enzyme-linked immunosorbent assay (ELISA).[32]

1.6 Environmental Persistence of Lumpy Skin Disease

OIE states the following about the resistance of LSDV to physical and chemical action.[33]

- Temperature: Susceptible to 55°C/2 hours, 65°C/30 minutes. Can be recovered from skin nodules kept at -80°C for 10 years and infected tissue culture fluid stored at 4°C for 6 months.
- pH: Susceptible to highly alkaline or acid pH. No significant reduction in titre when held at pH 6.6–8.6 for 5 days at 37°C.
- Chemicals/disinfectants: Susceptible to ether (20 percent), chloroform, formalin (1 percent), and some detergents, e.g., sodium dodecyl sulphate. Susceptible to phenol (2 percent/15 minutes), sodium hypochlorite (2–3 percent), iodine compounds (1:33 dilution), Virkon® (2 percent), and quarternary ammonium compounds (0.5 percent).
- Survival: LSDV is remarkably stable, surviving for long periods at ambient temperature, especially in dried scabs. LSDV is very resistant to inactivation, surviving in necrotic skin nodules for up to 33 days or longer, desiccated crusts for up to 35 days, and at least 18 days in air-dried hides. It can remain viable for long periods in the environment. The virus is susceptible to sunlight and detergents containing lipid solvents, but in dark environmental conditions, such as contaminated animal sheds, it can persist for many months.

[29] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet.* Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[30] OIE. (2013). Lumpy Skin Disease. *Technical Disease Card*. Retrieved from www.oie.int.
[31] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[32] OIE. (2013). Lumpy Skin Disease. *Technical Disease Card*. Retrieved from www.oie.int.
[33] OIE. (2013). Lumpy Skin Disease. *Technical Disease Card*. Retrieved from www.oie.int.

1.7 Vaccination

Historically, four live attenuated strains of capripoxvirus vaccines have been used in order to control LSDV outbreaks (not licensed for use in the United States):

- Kenyan sheep and goat pox virus strain,
- Yugoslavian RM 65 sheep pox strain,
- Romanian sheep pox strain, and
- LSDV strain from South Africa.

Cattle are protected from vaccinations derived from sheep or goats because all strains of *capripoxviruses* share a major neutralizing site. Theoretically, inoculation with one strain leads to immunity against all others. In practice, cattle vaccination with sheep and goat pox strains leads to insufficient protection, so they are only used in countries where sheep and goat pox are endemic. Since sheep and goat pox have not occurred in South Africa, only the LSDV strain vaccine is used in this region. There are no vaccines or tests to differentiate infected from vaccinated animals (DIVA).[34]

The OIE recommends that when using a vaccine meant for sheep or goats, it should first be tested on the most susceptible breeds in peak lactation. Capripoxvirus vaccines cause a visible reaction at the inoculation site in *Bos taurus*. The risk for LSDV outbreaks in herds with these species can be much higher, as many owners refuse to vaccinate their animals because of this side effect.[35]

1.8 Disease Control

LSD is a reportable disease in the United States. Since fomites, animals, and animal products can spread disease, quarantines, movement control, insect control (insecticides/repellants), and stamping-out methods followed by cleaning and disinfection are critical in controlling the spread of LSD. Vaccination is another method of control. Antibiotics may be important for treatment of secondary infections. In 1989, Egypt and Israel used both vaccination and depopulation to control LSD outbreaks.[36] The European Food Safety Authority also view vaccination as a highly effective disease control mechanism.[37]

1.9 Recent Outbreaks

1.9.1 Israel

LSD outbreaks occurred in Israel in 1989, 2006, 2007, and 2012. Depopulation and vaccination methods were used to control these outbreaks. In the 2007 outbreak, LSD infected cattle had already been vaccinated with the Yugoslavian RM 65 sheep pox strain vaccine, indicating that it failed at preventing initial infection and spread. In the 2012 Israel outbreak, infected cattle were

[34] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[35] OIE. (2016). Lumpy Skin Disease. *Terrestrial Manual*. Retrieved from www.oie.int.
[36] CFSPH. (2008). Lumpy Skin Disease. *Technical Factsheet*. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/lumpy_skin_disease.pdf.
[37] EFSA. (2016). Lumpy Skin Disease: Vaccination is Most Effective Control Method. Press Release. Retrieved from http://www.efsa.europa.eu/en/press/news/160809.

originally vaccinated with the RM 65 sheep pox strain vaccine. Nine months later, the LSDV South African strain or a 10-fold dose of RM 65 strain vaccine were administered to the same animals previously vaccinated. Both vaccines were more effective than the original RM 65 vaccination, with the LSDV vaccine proving to be the most effective.[38]

1.9.2 Turkey and Jordan

Turkey and Jordan both reported first outbreaks of LSD in 2013. The outbreak in Turkey occurred during the winter season, when potential arthropod vectors are at their lowest numbers. It is suspected then that illegal movement of sick or asymptotic cattle were responsible for the disease spread.[39]

1.9.3 Eastern Africa and the Middle East

Cattle trade typically flows from Eastern Africa to the Middle East. Movements surge during Islamic celebrations when cattle trade increases rapidly. Regulations and monitoring for disease in animals during these times may lessen, allowing LSD to be introduced into new regions. Furthermore, droughts and civil unrest, such as the ongoing situation in Syria and neighboring countries, increase the risk for LSD spread. National crises lead to a weakening of all government and regulatory systems—Syrian veterinary services halted in 2012, leaving livestock unvaccinated and vulnerable to many diseases. Refugees fleeing violence bring unregulated livestock into neighboring countries, potentially introducing and spreading disease.[40]

1.9.4 Russia and Kazakhstan

July 7, 2015 marked the first time tests came back positive for LSD in Russian history. Outbreaks continued until December 30th. There were a total of 130 positive cases in three separate southwestern republics. Currently, in 2016, there have been 52 outbreaks since July, with 155 positive cases in similar regions of Russia as in 2015. The source of these outbreaks remains unknown.[41,42]

LSD was confirmed in Kazakhstan for the first time on July 21, 2016. So far there have been 459 positive cases. The infected regions of Kazakhstan are just across the border from the similarly infected regions of Russia.[43]

[38] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[39] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[40] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[41] OIE. (2016). Immediate notifications and Follow-ups. Retrieved from http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/Immsummary.
[42] Lebedev, N. (2016). Standing Group of Experts on Lumpy Skin Disease in Europe under the GF-TADs Umbrella. Retrieved from http://web.oie.int/RR-Europe/eng/Regprog/docs/docs/LSD1/LSD1%20-%20Russia.pdf.
[43] OIE. (2016). Immediate notifications and Follow-ups. Retrieved from http://www.oie.int/wahis_2/public/wahid.php/Diseaseinformation/Immsummary.

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World Health Organization (OIE). (2016). Lumpy Skin Disease. *Terrestrial Manual*. Retrieved from http://www.oie.int/.

Attachment 1.B Abbreviations

AGID	agar gel immunodiffusion
AHAW	Animal Health and Welfare
APHIS	Animal and Plant Health Inspection Service
CABI	Center for Agriculture and Biosciences International
CFSPH	Center for Food Security and Public Health
DIVA	differentiating infected from vaccinated animals
DNA	deoxyribonucleic acid
EFSA	European Food Safety Authority
ELISA	enzyme-linked immunosorbent assay
FAD PReP	Foreign Animal Disease Preparedness and Response Plan
FAT	fluorescent antibody test
GTPV	goat pox virus
IFAT	indirect fluorescent antibody test
LSD	lumpy skin disease
LSDV	lumpy skin disease virus
OIE	World Organization for Animal Health
PCR	polymerase chain reaction
SNT	serum neutralization test
SOP	standard operating procedure
SPPV	sheep pox virus
USDA	U.S. Department of Agriculture