SHEEP AND GOAT POX
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 **September 2016**. Please send questions or comments to:

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Disease

Sheep pox and goat pox.

Mortality and Morbidity

Varies with animal breed. Morbidity can range from 1–100 percent. Mortality is often less than 10 percent but can reach 100 percent in the young and those without immunity.

Susceptible Species

Small ruminants.

Zoonotic Potential (yes/no)?

No.

Reservoir

No known wild reservoir.

Transmission

Typically close contact. Inhalation is the most common transmission pathway. The viruses may also enter through broken skin or through mucous membranes.

Persistence in the Environment

Susceptible to sunlight. Survives freeze–thaw cycles, but infectivity may be reduced.

Animal Products and By-Products

Remain viable in wool/hair and dry scabs on skin for up to 3 months. Persist in shaded pens with organic matter for as long as 6 months.

1.1 Introduction

Sheep pox and goat pox are infectious viral diseases that affect small ruminants. These diseases are caused by the sheep pox virus (SPPV) and goat pox virus (GTPV)[1]. Clinical signs can include fever, nodules and papules, vesicles, internal lesions (particularly in the lungs), and death.[2] The clinical signs of SPPV and GTPV infection are often mild in endemic areas with indigenous animals. Newly introduced individuals may experience high mortality rates. These diseases have the potential cause significant economic consequences due to decreased milk, mutton, and wool production along with lower quality hides. Naïve animals exposed to SPPV and/or GTPV are highly susceptible due to the lack of immunity; an SPPV and GTPV introduction is concerning due to the potential for severe clinical signs and high mortality rates.[3,4]

SPPV and GTPV are considered endemic viruses in Africa, India, parts of Asia, and Middle Eastern countries including Egypt, Turkey, Iraq, Iran, and Afghanistan.[5]

1.1.1 Goals

As a preparedness goal, the Animal and Plant Health Inspection Service (APHIS) will provide etiology and ecology summaries for sheep pox and goat pox 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 sheep pox and goat pox 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 Recent Outbreaks

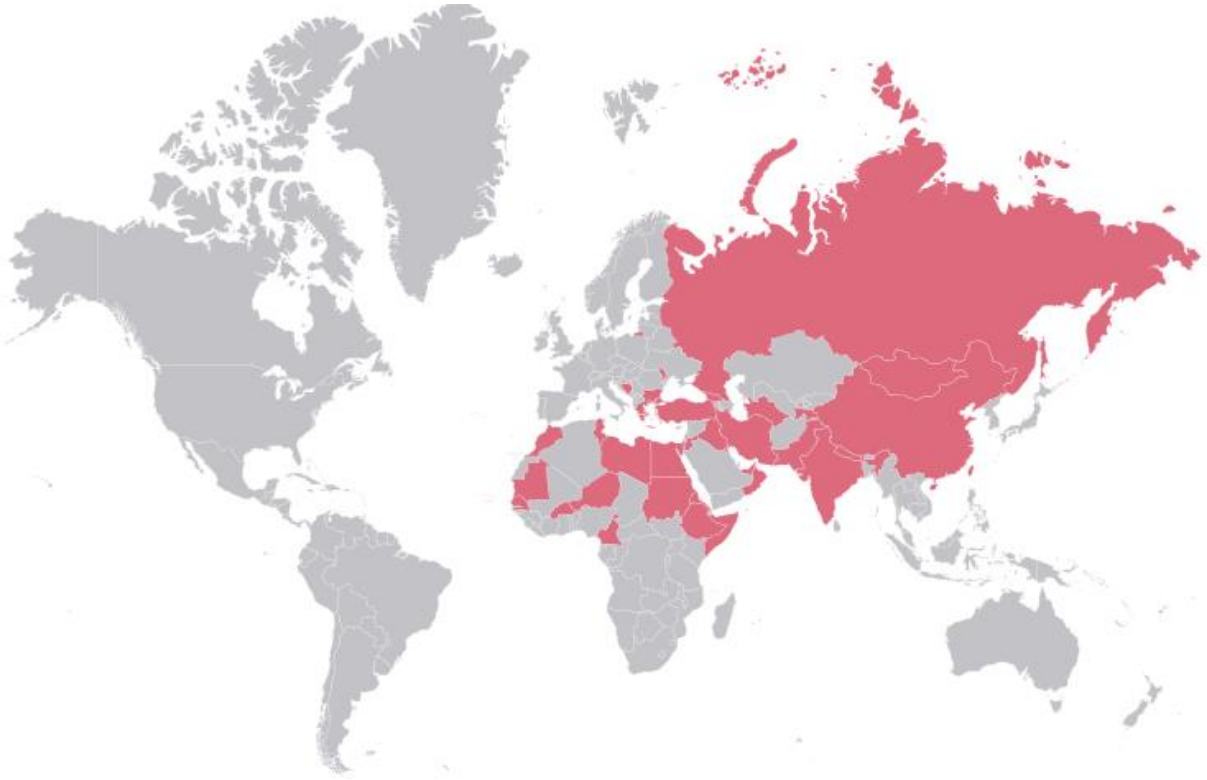
The most recent outbreaks of sheep pox and goat pox occurred in Bulgaria and Greece in 2013, Israel in 2014, and Russia and Mongolia in 2015. As seen in Figure 1-1, SPPV and GTPV are endemic across wide areas of Africa, the Middle East, and Asia.

In many countries where sheep pox and goat pox are endemic, effective and timely disease reporting, eradication activities, response capabilities, and established veterinary infrastructure do not exist or are underfunded. Sheep pox and goat pox can easily go undetected and/or

[1] World Organization for Animal Health (OIE). (2013). Sheep Pox and Goat Pox. *Technical Disease Card*. Retrieved from www.oie.int.
[2] OIE. (2016). Chapter 2.7.13. Sheep and Goat Pox. *Terrestrial Manual*. Retrieved from www.oie.int.
[3] Center for Food Security and Public Health (CFSPH), Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[4] Center for Agriculture and Biosciences International (CABI). (2015). Sheep and Goat Pox. Retrieved from http://www.cabi.org/isc/datasheet/81537.
[5] Santhamani, R., et al. (2013). Detection and Differentiation of Sheeppox Virus and Goatpox Virus from Clinical Samples Using 30 KDa RNA Polymerase Subunit (RPO30) Gene Based PCR. *Veterinary World*, 923-925.

unreported. These factors can foster the persistence of sheep pox and goat pox in these endemic areas. [6]

Figure 1-1. Past Sheep Pox and Goat Pox Outbreaks, by Country[7]



1.4 Etiology

1.4.1 Virus Characteristics

According to the International Committee on Taxonomy of Viruses, these diseases have the following characteristics:

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

Sheep pox and goat pox are closely related to lumpy skin disease, which affects cattle. There is ongoing research determining the genetic relationship between these three viruses; it is thought

[6] 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.
[7] OIE. (2015). Disease Timelines. Retrieved from http://www.oie.int/wahis_2/public/wahid.php/Wahidhome/Home.

that goat pox and lumpy skin disease are more closely related.[8] All sheep pox and goat pox genes are found within the lumpy skin disease genome.[9]

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. GTPV and SPPV share at least 147 genes. Strains of GTPV, SPPV, and LSDV are up to 96 percent similar.[10,11] There is no evidence that LSDV can cause disease in sheep and goats.

1.5 Ecology

1.5.1 Susceptible Species

- Sheep (*ovia aries*), and
- goats (*capra hircus*).

SPPV isolates cause disease primarily in sheep while GTPV isolates cause disease primarily in goats. Some SPPV and GTPV isolates can cause serious disease in both species. The Kenyan isolate, Yemen isolate, and Oman sheep isolate cause disease in both sheep and goats. To-date, Middle Eastern and Indian isolates only affect goats.

1.5.2 Reservoirs

There is no known wild reservoir for these viruses.

1.5.3 Introduction and Transmission of Sheep Pox and Goat Pox Virus

Once infected, the viruses are present in saliva, nasal and conjunctival secretions, milk, urine, feces, and skin lesions under scabs. Respiratory transmission is the most common mode of introduction of sheep pox and goat pox. Contact with open wounds or mucous membranes (especially where ulcers exist) are other routes of transmission. Vertical transmission from ewe to lamb or doe to kid in-utero has been reported.[12] Viral transmission via semen or embryos is unknown.[13]

Fomites, insects (e.g. stable flies, *Stomoxys calcitrans*), and aerosols containing pox scab particles are additional modes of transmission. In some flies, these viruses have survived for up

[8] CFSPH, Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[9] Tulman, E. R., et al. (2002). The Genomes of Sheeppox and Goatpox Viruses. *Journal of Virology*, *76*(12): 6054-6061.
[10] Tulman, E. R., et al. (2002). The Genomes of Sheeppox and Goatpox Viruses. *Journal of Virology*, *76*(12): 6054-6061.
[11] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[12] Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP). (2009). Technical Bulletin No. 29, Sheep and Goat Pox: Causes, Prevention and Treatment. Retrieved from http://www.esgpip.org/PDF/technical%20bulletin%20no.29.pdf.
[13] CABI. (2015). Sheep and Goat Pox. Retrieved from http://www.cabi.org/isc/datasheet/81537.

to 4 days in laboratory settings.[14] Furthermore, SPPV and GTPV can stay in wool and animal hair for up to 3 months and up to 6 months in sheep pens.[15]

1.5.4 Incubation and Infectious Periods

Incubation periods for sheep pox and goat pox are variable. Typically, the incubation period ranges from four to 21 days, but is usually one or two weeks.[16] The World Organization for Animal Health (OIE) *Terrestrial Animal Health Code* (2016) gives the incubation period as 21 days.[17]

About a week after clinical signs develop, sheep and goats are the most contagious, as antibodies have yet to develop. After two weeks, viral shedding drastically decreases. Sheep that were infected experientially have shed virus for one to two months.[18]

1.5.5 Morbidity and Mortality

Morbidity and mortality in sheep and goats depends on the breed, level of immunity, and previous exposure to sheep pox or goat pox, the age of the animal, and the strain of the virus. In endemic areas, mild infections are common in healthy, adult individuals. Mortality can reach up to 100 percent in newly introduced exotic sheep or goats, young lambs and kids, lactating females, animals with weekend immune system, or those living in an area that hasn't experienced SPPV and GTPV infections in some time. In flocks with reoccurring sheep pox and goat pox infections, morbidity rates can vary from 1–75 percent, but mortality is almost always less than 10 percent.[19] Infection results in robust and long-lasting immunity.[20]

1.5.6 Clinical Signs

Infection can give rise to a wide variety of clinical signs that may vary according to the breed, animal's age, immunity, and stress level.[21] Infection often starts with a fever, followed by the formation of red macules 1 to 5 days later. The macules develop into 0.5–1.5 cm hard papules (raised lesions) that become depressed, gray, and necrotic, surrounded by an excess of blood. Animals are most infectious right when these papules appear and before sufficient antibodies are created. Lesions can develop on over half of the skin's surface although some infections are mild and can be easily missed. Scabs form over areas that are necrotic. In animals with heavy wool, the lesions can be easier to find by palpation than visual inspection.

[14] Mellor P. S., Kitching R. P., and Wilkinson P. J. (1987). Mechanical transmission of capripox virus and African swine fever virus by *Stomoxys calcitrans*. *Research in Veterinary Science*, *43*(1): 109-12.
[15] USDA APHIS. (n.d.). Sheep Pox and Goat Pox Factsheet. Retrieved from https://aglearn.usda.gov/customcontent/APHIS/Disposal/FAD/images/sheepGoatPoxFactsheet.pdf.
[16] CFSPH, Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[17] OIE. (2016). Article 14.9.1: General Provisions. *Terrestrial Animal Health Code*. Retrieved from www.oie.int.
[18] CFSPH, Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[19] CABI. (2015). Sheep and Goat Pox. Retrieved from http://www.cabi.org/isc/datasheet/81537.
[20] USDA APHIS. (n.d.). Sheep Pox and Goat Pox Factsheet. Retrieved from https://aglearn.usda.gov/customcontent/APHIS/Disposal/FAD/images/sheepGoatPoxFactsheet.pdf.
[21] OIE. (2013). Sheep Pox and Goat Pox. *Technical Disease Card*. Retrieved from www.oie.int.

Sheep pox and goat pox can affect the digestive, respiratory, urinary systems as well. Systemic signs may include conjunctivitis, rhinitis, enlargement of the lymph nodes, depression, anorexia, and edema. Lung lesions can cause labored breathing. The mucous membranes can become necrotic and animals may develop nasal or ocular discharge. Secondary bacterial infections are common and death can occur at any stage of the disease. Non-native animals may die before distinctive lesions are present.[22] Sheep usually present with more severe clinical signs than goats.[23] Recovery is slow and scars are often left on the hides of animals.[24]

1.5.7 Humans and Sheep Pox and Goat Pox Viruses

Sheep pox and goat pox viruses do not infect humans.[25]

1.5.8 Diagnostics

1.5.8.1 Differential Diagnosis

Sheep pox and goat pox should be suspected in animals with skin lesions, fever, and enlarged lymph nodes. Mild forms of SPPV and GTPV may be confused for:

- contagious ecthyma (contagious pustular dermatitis, orf),
- insect bites,
- bluetongue,
- peste des petits ruminants,
- photosensitization/urticaria,
- dermatophilosis,
- parasitic pneumonia,
- caseous lymphadenitis, or
- mange (for example, psoroptic mange/sheep scab).[26]

1.5.8.2 Laboratory Tests

Capripoxviruses are readily distinguishable in the laboratory from other poxviruses that cause similar clinical sings in ruminants, making electron microscopy a reliable method for early identification. Histopathology will also show distinguishable characteristics such as edema, vasculitis, and cellular infiltration.

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

[22] USDA APHIS. (n.d.). Sheep Pox and Goat Pox Factsheet. Retrieved from https://aglearn.usda.gov/customcontent/APHIS/Disposal/FAD/images/sheepGoatPoxFactsheet.pdf.
[23] CABI. (2015). Sheep and Goat Pox. Retrieved from http://www.cabi.org/isc/datasheet/81537.
[24] USDA APHIS. (n.d.). Sheep Pox and Goat Pox Factsheet. Retrieved from https://aglearn.usda.gov/customcontent/APHIS/Disposal/FAD/images/sheepGoatPoxFactsheet.pdf.
[25] EFSA. (2015). Scientific Opinion on Sheep and Goat Pox. EFSA Panel on AHAW. *EFSA Journal*, *12*(11): 3885
[26] OIE. (2013). Sheep Pox and Goat Pox. *Technical Disease Card*. Retrieved from www.oie.int.

test (IFAT), and agar gel immunodiffusion (AGID) will not be able to distinguish between the three capripoxviruses.[27]

Sheep pox and goat pox are not serologically distinguishable due to their almost identical genomes. In order to make a definitive diagnosis, SPPV and GTPV can be isolated in lamb testis, sheep or goat kidney cell cultures, and sheep, goat, or bovine cell lines. Immunofluorescence, immunoperoxidase staining, nucleic acid recognition methods, and polymerase chain reaction (PCR) assays can distinguish the agent as a capripoxvirus, but not by specific species. If PCR is used alongside a restriction fragment length polymorphism (RFLP) assay, it may be possible to identify whether SPPV or GTPV is responsible.

Other immunological methods can differentiate capripoxviruses from other poxviruses, such as AGID (cannot distinguish between capripox and contagious pustular dermatitis [orf]), enzyme-linked immunosorbent assays (ELISAs), Western blot analysis, counter-immuno-electrophoresis, latex agglutination, and indirect agglutination tests (reverse-phase passive hemagglutination, coagglutination, passive hemagglutination and spot agglutination).[28,29]

1.6 Environmental Persistence of Sheep Pox and Goat Pox Viruses

The OIE states the following about the resistance of sheep pox and goat pox viruses to physical and chemical action.[30]

- Temperature: Susceptible to 56°C/2 hours; 65°C/30 minutes. Some isolates inactivated at 56°C/60 minutes.
- pH: Susceptible to highly alkaline or acid pH (hydrochloric or sulphuric acid at 2 percent for 15 minutes).
- Chemicals/disinfectants: Inactivated by phenol (2 percent) in 15 minutes. Sensitive to detergents, e.g., sodium dodecyl sulphate. Sensitive to ether (20 percent), chloroform, formalin (1 percent), and sodium hypochlorite (2–3 percent), iodine compounds (1:33 dilution), Virkon® 2 percent, quarternary ammonium compounds 0.5 percent.
- Survival: Susceptible to sunlight, but remains viable in wool/hair/fleece and dry scabs on skin for up to 3 months. Persists in unclean shaded pens for as long as 6 months. Survives drying and freeze—thaw cycles, but infectivity may be reduced.

1.7 Vaccination

Live and inactivated virus vaccines are available (however, not licensed for use in the United States).[31] Because of the close similarity of capripoxvirus strains, natural infection or vaccination

[27] EFSA. (2015). Scientific Opinion on Lumpy Skin Disease. EFSA Panel on AHAW. *EFSA Journal*, *13*(1): 3986.
[28] OIE. (2016). Chapter 2.7.13. Sheep and Goat Pox. *Terrestrial Manual*. Retrieved from www.oie.int.
[29] CFSPH, Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[30] OIE. (2013). Sheep Pox and Goat Pox. *Technical Disease Card*. Retrieved from www.oie.int.
[31] USDA. (2016). Veterinary Biological Products. Retrieved from https://www.aphis.usda.gov/animal_health/vet_biologics/publications/CurrentProdCodeBook.pdf.

gives individuals immunity between strains.[32] Inactivated vaccines are less effective than live and only provide temporary protection against capripoxviruses, while live vaccines may last up to two years.[33]

In countries such as Iran, India, and Turkey, mixed flocks consisting of both sheep and goats are common. Certain strains of sheep pox and goat pox may only give rise to visible signs in one species while the other is also infected, but has mild or absent clinical signs. Thus, it is desirable to vaccinate in endemic countries with a vaccine that can be used in both sheep and goats.[34]

1.8 Conclusion

Sheep pox and goat pox are considered foreign animal diseases (FADs) in the United States and are notifiable to the OIE. Since fomites and animal products can spread disease, quarantines, movement control, and rapid stamping-out followed by effective cleaning and disinfection are critical in controlling the spread of capripoxviruses. Specific response activities are not further described in the document; further work (with all stakesholders) is needed to develop effective procedures for reesponding to an introduction of SPPV/GTPV into the United States. Additionally, biosecurity is critical to prevent introduction in naïve herds. New animals being introduced to a herd should always be quarantined prior to adding them to existing flocks. To prevent re-infection, infected flocks and sick animals are typically quarantined for a minimum of 45 days after recovery from clinical signs.[35]

The long tradition of husbandry and free trade in areas of African, Asia, and Eastern Europe mean that animals intermingle and often go unmonitored. Without well-established veterinary services or surveillance systems, controlling sheep pox and goat pox can be difficult in these areas. Political crises and drought can further disrupt national efforts towards eradication.[36,37,38]

[32] Kitching, R.P. (2003). Vaccines for Lumpy Skin Disease, Sheep Pox and Goat Pox. *Developmental Biology*, 114: 161–167.
[33] OIE. (2016). Chapter 2.7.13. Sheep and Goat Pox. *Terrestrial Manual*. Retrieved from www.oie.int.
[34] Sadri, R. and Fallahi, R. (2009). A new approach to develop a vaccine against capripox infection in sheep and goats using a new strain of sheep pox virus in Iran. *International Journal of Veterinary Research*, *4*(4): 221-224.
[35] CFSPH, Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[36] CFSPH, Iowa State University. (2008). Sheep & Goat Pox. Retrieved from http://www.cfsph.iastate.edu/Factsheets/pdfs/sheep_and_goat_pox.pdf.
[37] CABI. (2015). Sheep and Goat Pox. Retrieved from http://www.cabi.org/isc/datasheet/81537.
[38] Carter, G. R., Wise, D. J., and Flores, E.F. (2005). A Concise Review of Veterinary Virology. Retrieved from http://www.libyanvet.com/concisereviewofveterinaryvirology.htm.

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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
DNA	deoxyribonucleic acid
EFSA	European Food Safety Authority
ELISA	enzyme-linked immunosorbent assay
ESGPIP	Ethiopia Sheep and Goat Productivity Improvement Program
FAD	foreign animal disease
FAD PReP	Foreign Animal Disease Preparedness and Response Plan
FAT	fluorescent antibody test
GTPV	goat pox virus
IFAT	indirect fluorescent antibody test
LSDV	lumpy Skin Disease virus
OIE	World Organization for Animal Health
PCR	polymerase chain reaction
RFLP	restriction fragment length polymorphism
SNT	serum neutralization test
SOP	standard operating procedure
SPPV	sheep pox virus
USDA	U.S. Department of Agriculture