

Pox viruses (other than those listed by the OIE) (Infection with)

Aetiology Epidemiology Diagnosis Prevention and Control
Potential Impacts of Disease Agent Beyond Clinical Illness References

AETIOLOGY

Classification of the causative agent

Poxviruses are linear, enveloped, double-stranded DNA viruses in the family *Poxviridae*, which is divided into two subfamilies: *Chordopoxvirinae* and *Entomopoxvirinae*. Additionally, there are several unclassified poxviruses in both subfamilies. The subfamily *Chordopoxvirinae*, which infects vertebrates, contains nine genera: *Avipoxvirus*, *Capripoxvirus*, *Cervidpoxvirus*, *Leporipoxvirus*, *Molluscipoxvirus*, *Orthopoxvirus*, *Parapoxvirus*, *Suipoxvirus*, and *Yatapoxvirus*. Viruses belonging to the *Entomopoxvirinae* family infect insects and will not be discussed at length in this technical card.

For the purpose of voluntary reporting on non OIE-listed disease in wildlife, “infection with poxviruses” refers to poxvirus infections in **non-domestic species** (other than those caused by crocodile poxviruses, which is reportable on a voluntary basis but is discussed individually in a separate technical card). Information on **sheep and goat infections with poxviruses, myxomatosis, camel pox, and lumpy skin disease virus** must be submitted through the mandatory reports for the OIE-listed diseases. There are separate technical cards available for: lumpy skin disease virus, crocodilepox virus, and sheep and goat poxviruses.

Resistance to physical and chemical action

Temperature: Inactivated at 59°C after 30 minutes

pH: Sheep and goat poxviruses are susceptible to solutions that have a very acidic or alkaline pH

Chemicals/Disinfectants: 5% sodium hypochlorite solution, quaternary ammonium-based disinfectants, alkalis, detergents, glutaraldehyde, and Virkon®; squirrelpox virus (SQPV) is resistant to many disinfectants

Survival: Poxviruses can survive in the environment for several days to weeks; CE virus persists in scabs for years in dry conditions

EPIDEMIOLOGY

Hosts

The poxviruses as a group affect a wide range of hosts and are generally named for the species they infect. The list is not extensive, therefore not all host species or viruses will be listed.

- Avipoxviruses have been found in 23 orders of birds and at least 270 wild and domestic bird species
 - Most avipoxviruses are named for the specific bird species they infect (e.g., pigeon poxvirus, canary poxvirus)
- Cetaceanpox virus
 - Harbour porpoises (*Phocoena phocoena*)
 - Long-finned pilot whales (*Globicephala melaena*)
 - Striped dolphins (*Stenella coeruleoalba*)
 - White-beaked dolphins (*Lagenorhynchus albirostris*)
- Contagious ecthyma (CE)
 - Bighorn sheep (*Ovis canadensis*)
 - Chamois (*Rupicapra rupicapra*) and Southern chamois (*R. pyrenaica*)
 - Domestic goats (*Capra aegagrus hircus*)
 - Domestic sheep (*Ovis aries*)
 - Ibex (*Capra ibex*)

- Mountain goats (*Oreamnos americanus*)
- Oxen (*Ovibos moschatus*)
- Reindeer (*Rangifer tarandus*)
- Cowpox virus
 - In Europe, reservoir hosts are thought to be bank voles (*Microtus agrestis*) and field voles (*Clethrionomys glareolus*)
 - Brown rats (*Rattus norvegicus*)
 - Cheetahs (*Acinonyx jubatus*)
 - Common shrews (*Sorex araneus*)
 - Domestic felines (*Felis domesticus*)
 - Domestic cattle (*Bos taurus* and *B. indicus*)
 - Eurasian lynx (*Lynx lynx*) and Iberian lynx (*L. pardinus*)
 - Great gerbils (*Rhombomys opimus*)
 - House mice (*Mus musculus*)
 - Water buffalo (*Bubalus bubalis*)
 - Wild cats (*Felis silvestris*)
 - Wood mice (*Apodemus sylvaticus*)
 - Yellow susliks (*Citellus fulvus*)
- Hare fibroma virus
 - European brown hares (*Lepus europaeus*)
- Rabbit fibroma virus (RFV)
 - Eastern cottontail rabbits (*Sylvilagus floridanus*)
 - European rabbits (*Oryctolagus cuniculus*)
- Sealpox virus
 - Californian sea lions (*Zalophus californicus*)
 - Grey seals (*Halichoerus grypus*)
 - Harbour seals (*Phoca vitulina*)
- Squirrelpox virus (SQPV)
 - Grey squirrels (*Sciurus carolinensis*) and red squirrels (*Sciurus vulgaris*)
 - The grey squirrel is thought to be the reservoir host and rarely presents with clinical disease
- Swinepox virus
 - Domestic (*Sus scrofa domesticus*) and wild swine (*S. scrofa*)

Transmission

- Avipoxviruses
 - Inhalation of infectious viral particles
 - Contamination of a wound, scratch, or abrasion
 - Mechanical vectors (fleas, many mosquito species)
- CE
 - Direct transmission
 - Contact with scabs or fomites
- Cowpox
 - Direct contact with rodents
 - Ingested or inhaled viral particles
- Hare fibroma virus
 - Direct transmission
 - Arthropods (mechanical vectors)
- RFV
 - Mechanical vectors (mosquitoes, fleas)
 - Direct transmission is not significant
- Sealpox
 - Direct transmission
- SQPV
 - Direct contact with grey squirrels or contact with fomites (e.g. branches, feeders); the exact mode of transmission is uncertain
 - Mechanical vectors are uncertain/unknown

- Swinepox virus
 - Direct transmission
 - Pig lice (*Haematopinus suis*) and house flies (*Musca domestica*) act as mechanical vectors

Sources

The relative importance of specific sources varies according to the natural history and pathogenesis of the virus

- Fomites
- Infected animals
- Mechanical vectors

Occurrence

Avipoxviruses have a worldwide distribution, excluding Antarctica and the Arctic, and are more common in warmer climates. These viruses are very prevalent in great tits (*Parus major*) in the United Kingdom, Hungary, and Austria, and in wild turkeys (*Meleagris gallopavo*) in the southeastern United States. Additionally, the virus is commonly found in house finches (*Haemorhous mexicanus*) in California, and northern bobwhites (*Colinus virginianus*) in Florida and Georgia (United States). Outbreaks correspond with high mosquito activity. Avipoxviruses have also caused a decline in native Hawaiian bird populations, including Hawaiian geese (*Branta sandvicensis*), palila (*Loxiodes baillieu*), and Hawaiian crows (*Corvus hawaiiensis*).

Cowpox most commonly occurs in domestic cats in the fall. Though it has not been reported in wild cats, felids in zoos have become infected with the virus.

CE has been reported in mountain goats and bighorn sheep from Canada. A population of musk oxen in Norway declined due to infection with CE; young individuals were affected most significantly, and predominantly adults survived.

Hare fibroma virus is relatively uncommon but has been reported in European brown hares in Italy, France, Germany, and the United Kingdom. Outbreaks occur in late summer and fall.

RFV occurs in Eastern cottontail rabbits in the United States and Canada, and in European rabbits in Europe. Risk of infection is highest during the fall when both mosquitoes and rabbits are most active.

SQPV has caused a decline in the red squirrel population in the United Kingdom, and lethal outbreaks are believed to be caused by the introduction of grey squirrels to naïve red squirrel populations.

DIAGNOSIS

Avipoxviruses multiply in the host's epithelium. Non- to low-pathogenicity strains will continue replicating in the skin, whereas more pathogenic strains will migrate to internal organs and cause pathology. The incubation period lasts from 4 days (poultry, pigeons) to several months (wild birds). Secondary bacterial or fungal infections may occur due to the skin lesions. Avipoxviruses cause greater pathology in young birds compared to adults. Disease may manifest as dry pox (cutaneous pox), wet pox (diphtheritic pox) lesions, or as septicaemia.

In captive bottlenose dolphins (*Tursiops* spp.), cetacean poxvirus lesions have been found to fade or disappear with warmer water temperatures.

The virus that causes CE replicates in epidermal keratinocytes. Calves of moose (*Alces alces*), wapiti (*Cervus elaphus nelsoni*), and white-tailed deer (*Odocoileus virginianus*) that were experimentally infected with CE

showed mild lesions. Juvenile animals are more susceptible to infection than adults. Clinical signs may be exacerbated by harsh environmental conditions, poor nutrition, or immunosuppression. CE lesions may become infested with fly larvae (cutaneous myiasis). Oral lesions can interfere with eating and drinking, while hoof lesions may make walking difficult.

Cowpox virus is not thought to cause clinical disease in rodents, though it is thought to contribute to decreased fitness and reproductive ability in experimentally infected wood mice and bank voles.

RFV causes severe disease in cottontail rabbits and milder clinical signs in European rabbits. Death may occur in nursing or immunocompromised rabbits.

SQPV in red squirrels may also result in bacterial infection of pox lesions (commonly *Staphylococcus* spp.) and septicaemia.

Clinical diagnosis

Dry pox lesions are wart-like and nodular growths that develop on non-feathered areas of the body (e.g. wattles, legs, around eyes and beak). For passerines, nodules are red and may burst and proliferate. For birds with webbed feet, nodules appear along blood vessels and may burst; severe infection may cause birds to lose digits. Wet pox lesions occur on the mucosa of the upper respiratory tract and oral cavity. These are characterised by necrotic, grey to brown lesions that may bleed. Wet pox is the more severe manifestation of avipoxvirus infection.

CE infection progresses from focal erythaema to papule to vesicle to pustule to scab, all in a week's time. Lesions can then transform into wart-like papillomas. Lesions occur most commonly around the mouth and nostrils but may appear on the mucosa, limbs, genitals, udder, and oesophagus. Cauliflower-like lesions may develop if the papillomas coalesce.

Cetacean poxvirus lesions are characterised as paisley or tattoo pattern depending on the morphology. They may appear anywhere on the body, though less commonly on the tail and flippers, and can disappear and reappear over many years.

Cowpox virus in felines may manifest as diarrhoea, depression, pyrexia, and pneumonia. Lesions may appear on the face, limbs, and mouth. Respiratory illness most often occurs in cheetahs.

Infection with hare fibroma virus causes fibromas, and RFV causes multiple, movable, cutaneous fibromas on the feet, legs, muzzle, and ears. Fibromas fade around 3-4 weeks after initial infection.

Sealpox virus causes localized lesions on the skin of the head, neck, body, and mouth. The lesions may heal in about 6 weeks or develop into suppurative skin swellings. Oral ulcers may develop into granulomatous lesions.

SQPV causes dehydration, exudative erythematous dermatitis, weight loss, conjunctivitis, and death. Behavioural changes associated with infection may also include dullness, difficulty climbing and moving, and rubbing at pox lesions with their paws.

A report of a wild boar infected with swinepox virus was described to have "cherry-sized" papules, pustules, and scabs, in addition to abnormal behaviour.

Lesions

- Avipoxviruses
 - Bollinger bodies
 - Dry pox
 - White nodules turning yellow, grey, to brown
 - Base of nodule becomes haemorrhagic and inflamed after two weeks

- Scab contains haemorrhaging and granulating surface with a moist, seropurulent exudate layer; can last 1 to 2 weeks
 - Wet pox
 - Moist, diphtheritic lesions that are whitish and slightly raised, later forming a yellowing, caseous pseudomembrane
 - Lesions are located in the mucous membranes of the mouth, upper respiratory tract, oesophagus, and crop
- CE
 - Pustular dermatitis
 - Epidermal proliferation with degenerating keratinocytes and intracytoplasmic eosinophilic inclusion bodies
 - Multifocal ulcerations of epidermis covered by serocellular crust
 - Oedematous lips
 - Hyperplastic and hyperkeratotic non-pigmented squamous epithelium
 - Lymphocytes, neutrophils, eosinophils, and plasmacytes in the dermis
- Cetaceanpox virus
 - Paisley lesions
 - Concentric dark lines about 2-5 cm in diameter
 - Ballooning and vacuolation of the stratum intermedium
 - Intracytoplasmic inclusion bodies superficial to the germinal skin layer
 - Tattoo lesions
 - Dark lines 1 mm wide; depressed, punctiform/linear black ulcers
 - If 2-5 cm in diameter, lesion characterisation similar to the paisley lesions
 - Present near broken skin
- Cowpox
 - Eosinophilic intracytoplasmic inclusion bodies in keratinocytes
 - Ulcerated papules 0.5-1 cm in diameter
 - Small, erythematous nodules
 - Skin necrosis and oedema
- Hare fibroma virus
 - Solid skin tumours that are 1-3 cm in diameter on the head, eyelids, ears, and flank
 - Tumours decrease in size over about 4-6 weeks, crust, and may fall off
 - Proliferation of connective tissue
 - Connective tissues has large, spindle- or star-shaped fibroblasts with large nuclei
 - Periodic acid-Schiff (PAS)-positive inclusions
 - Vascular hyperplasia
- RFV
 - Nodules approximately 0.5-0.6 cm in diameter with necrotic center and scabbing
- Sealpox virus
 - Lesions are approximately 1.5-2.5 cm in diameter
 - Hyperkeratosis and parakeratosis of the stratum corneum
 - Hypertrophy, hyperplasia, and cytoplasmic vacuolation of the stratum spinosum
 - Neutrophil infiltration of dermis accompanied by fibroblastic hyperplasia
- SQPV
 - Necrotising purulent dermatitis and cellulitis of the face, lips, eyelids, and ears
 - Ballooning degeneration of epidermis
 - Mixed inflammatory cell dermatitis
 - Intracytoplasmic amphophilic or eosinophilic inclusions
- Swinepox
 - Ballooning degeneration of keratinocytes

Differential diagnoses

- Birds (avipoxviruses)
 - Benign or malignant neoplasms
 - Cysts
 - Dry pox

- Bacterial skin infections
 - Mite infestations
 - Wet pox
 - Avian influenza
 - Candidiasis
 - Capillariasis
 - Infectious bronchitis
 - *Trichomonas gallinae* (pigeons, doves)
- Cetaceans (cetaceanpox virus)
 - Calicivirus
 - Cutaneous streptothricosis
- Felids (cowpox)
 - Bacterial or fungal infections
 - Benign or malignant neoplasms
 - Bite wounds
 - Cysts
 - Eosinophilic granuloma
 - Feline calicivirus
 - Feline herpesvirus
 - Miliary dermatitis
 - Ringworm
- Hares (hare fibroma virus) and rabbits (RFV)
 - Benign or malignant neoplasms
 - Cysts
 - Myxomatosis
 - Papillomatosis
 - Rabbitpox
- Ruminants (CE)
 - Bluetongue
 - Cysts
 - Foot-and-mouth disease
 - Staphylococcal folliculitis
 - Ulcerative dermatitis
- Seals (sealpox)
 - Streptothricosis (due to *Dermatophilus congolensis* infection)
- Squirrels (SQPV)
 - Mange due to harvest mites (*Neotrombicula* spp.)
 - Myxomatosis
- Swinepox
 - Calicivirus
 - Dermatitis vegetans
 - Foot-and-mouth disease
 - Greasy pig disease
 - Pityriasis rosea
 - Ringworm
 - Streptococcal dermatitis
 - Swine vesicular disease
 - Vesicular stomatitis

Laboratory diagnosis

Samples

For isolation of agent

- Sample of lesion

Serological tests

- Serum

Procedures

Identification of the agent

- Avipoxviruses
 - Polymerase chain reaction (PCR)
 - Quantitative assays commonly used
 - Transmission electron microscopy (TEM)
 - Viral culture in chorioallantoic membranes from chicken embryos or avian cell cultures
 - Viral neutralisation test
 - Restriction fragment length polymorphism (RFLP) analysis
- CE
 - Electron microscopy
 - PCR
 - Cycle sequencing of viral DNA with BLAST
- Cetaceanpox virus
 - Scanning and transmission electron microscopy (SEM and TEM)
- Cowpox virus
 - PCR
 - Viral isolation in chick chorioallantois or cell culture
- Hare fibroma virus
 - Electron microscopy
 - Viral inoculation of embryonated chicken eggs
- RFV
 - Cell culture using RK-13 or SIRC cell lines, or chorioallantoic membrane of embryonated chicken eggs
- SQPV
 - Electron microscopy
 - PCR
- Swinepox virus
 - Negative contrast electron microscopy
 - PCR

Serological tests

- Direct antibody capture enzyme-linked immunosorbent assays (ELISAs) are available for most of the poxviruses listed

PREVENTION AND CONTROL

Sanitary prophylaxis

- Seal and rodent-proof barns or other animal housing to prevent the entry of rodents
- Destroy rodent nests on property
- For viruses spread by mechanical vectors, ensure that animals are in enclosed housing or housing with screens to prevent being bitten by mosquitoes or flies
- Regularly remove manure to prevent flies from laying eggs
- Install fans and ensure adequate ventilation in barns to prevent flies from landing frequently on animals
- Utilise acaricides as necessary to prevent mite and lice infestations on captive animals
- Ensure that people are taking proper sanitary precautions to prevent the spread of viruses in petting zoos (e.g., proper hand-washing)
- Avipoxviruses

- In captivity or sites where feeding wild birds is common (e.g., backyard bird feeders), it is recommended to ensure feed is properly stored to prevent inappropriate access. Routine cleaning and sanitation of feeders is recommended, and the feed and water should be changed daily.
- Generally, large gatherings of birds at feeding and watering sites should be discouraged to reduce the possibility for transmission
- Vector control of mosquitoes and ticks
- SQPV
 - Clean squirrel feeders and regularly change feed
 - Remove squirrel feeders from areas with SQPV outbreaks
 - Trap and remove grey squirrels from red squirrel habitats

Medical prophylaxis

- Nonattenuated vaccines are available against avipoxviruses in commercial poultry, pigeons, and canary aviaries
- A live virus vaccine is available against CE; vaccinated animals should be quarantined from unvaccinated herd members until the lesion from the vaccine has scabbed and fallen off, and the vaccine should only be administered where CE has been previously present

POTENTIAL IMPACTS OF DISEASE AGENT BEYOND CLINICAL ILLNESS

Risks to public health

- Sealpox virus infection has been reported in humans
 - In Canada, two grey seal handlers developed “milker’s nodules” on their fingers after contact with infected grey seals
- There are reports of cats, rodents, and dairy cattle spreading cowpox to humans
- Pet rabbits may become infected with RFV if they come into contact with wild rabbits or hares
- People, especially animal handlers and veterinarians, should utilise proper sanitation methods to prevent infection
 - CE may spread to humans if they come into contact with an infected animal or an animal who has recently been vaccinated; immunocompromised individuals are especially at risk. People who handle sheep wool or small ruminant hides may contract the disease; individuals who are involved in the slaughtering of small ruminants for religious or cultural purposes are also at risk.
 - Petting zoos, where many livestock and wildlife species are co-housed, are potential sources of poxvirus infection
-

Risks to agriculture

- Avipoxvirus infections are common in commercial poultry, particularly chickens and turkeys
- Domestic cows, sheep, and goats are at risk for infection with CE
 - For wildlife populations, domestic sheep or goats may cause outbreaks if species inhabit the same pasture
- Cowpox rarely occurs in cattle, though it is still occasionally seen in European herds due to infection from rodents and cats
- Swinepox virus mainly occurs on pig operations; reports in wild boar are sparse, though they may contract the virus if they come in contact with infected pigs

REFERENCES AND OTHER INFORMATION

- Baldwin, J., Foil, L., & Foil, C. (n. d.). Fly control for horses. *Louisiana State University Agricultural Center*. Accessed 2020: <https://www.lsuagcenter.com/NR/rdonlyres/27E97E4D-72F0-49D4-A004-9861FA5A430C/3631/pub2915.pdf>

- Bourne, D., Duff, J. P., & Vikøren, T. (2012). Chapter 13: Poxvirus infections. In A. Meredith, J. P. Duff, and D. Gaviera-Widen (Eds.), *Infectious Diseases of Wild Mammals and Birds in Europe* (pp. 191-192, 194-199, 203-207). Blackwell Publishing Ltd.
- Cornell University. (2008). Avian pox. *Cornell University College of Veterinary Medicine*. Accessed 2020: <https://partnersah.vet.cornell.edu/content/avian-pox>
- Gibbs, P. (2013). Cowpox virus infections in cats and other species. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/integumentary-system/pox-diseases/cowpox-virus-infections-in-cats-and-other-species>
- Iowa State University (2020). Pox (swine pox). *Iowa State University College of Veterinary Medicine*. Accessed 2020: <https://vetmed.iastate.edu/vdpam/FSVD/swine/index-diseases/pox>
- Kerr, P. J. & Donnelly, T. M. (2013). Viral infections of rabbits. *Veterinary Clinics: Exotic Animal Practice*, 16, 437-468.
- Mayer, J. (2015). Viral diseases of rabbits. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/exotic-and-laboratory-animals/rabbits/viral-diseases-of-rabbits?query=rabbit%20fibroma%20virus#v3306622>
- McInnes, C. J., Coulter, L., Dagleish, M. P., Fiegna, C., et al. (2009). First cases of squirrelpox in red squirrels (*Sciurus vulgaris*) in Scotland. *Veterinary Record Case Reports*, 1:e528.
- Mech, P., Bora, D. P., Neher, S., Barman, N. N., et al. (2018). Identification of swinepox virus from natural outbreaks in pig population of Assam. *Virus Disease*, 29(3), 395-399.
- Samuel, W. M., Chalmers, G. A., Steflox, J. G., Loewen, A., & Thomsen, J. J. (1975). Contagious ecthyma in bighorn sheep and mountain goat in western Canada. *Journal of Wildlife Diseases*, 11, 26-31.
- Scott, P. R. (2014). Overview of contagious ecthyma. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/integumentary-system/contagious-ecthyma/overview-of-contagious-ecthyma?query=contagious%20ecthyma>
- Simpson, V. R., Hargreaves, J., Everest, D. J., Baker, A. S., et al. (2010). Mortality in red squirrels (*Sciurus vulgaris*) associated with exudative dermatitis. *Veterinary Record*, 167, 59-62.
- Spickler, A. R. (2015). Contagious ecthyma. *The Center for Food Security and Public Health, Iowa State University*. Accessed 2020: http://www.cfsph.iastate.edu/Factsheets/pdfs/contagious_ecthyma.pdf
- St. Leger, J., Raverty, S., & Mena, A. (2018). Chapter 22: Cetacea. In K. A. Terio, D. McAloose, and J. St. Leger (Eds.), *Pathology of Wildlife and Zoo Animals* (p. 552). Academic Press.
- Stoskopf, M. K. (2015). Bacterial diseases of marine mammals. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/exotic-and-laboratory-animals/marine-mammals/bacterial-diseases-of-marine-mammals?query=sealpox>
- Stoskopf, M. K. (2015). Viral diseases of marine mammals. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/exotic-and-laboratory-animals/marine-mammals/viral-diseases-of-marine-mammals?query=cetacean%20pox>
- Tripathy, D. N. (2019). Pox infections in birds other than chickens and turkeys. *Merck Veterinary Manual*. Accessed 2020: <https://www.merckvetmanual.com/poultry/fowlpox/pox-infections-in-birds-other-than-chickens-and-turkeys>
- van Riper III, C. & Forrester, D. J. (2007). Avian pox. In N. J. Thomas, D. B. Hunter, and C. T. Atkinson (Eds.), *Infectious Diseases of Wild Birds* (pp. 132, 135, 139). Blackwell Publishing.
- Vikøren, T., Lillehaug, A., Åkerstedt, J., Bretten, T., Haugum, M., & Tryland, M. (2008). A severe outbreak of contagious ecthyma (orf) in a free-ranging musk ox (*Ovibos moschatus*) population in Norway. *Veterinary Microbiology*, 127(1-2), 10-20.
- The World Organisation for Animal Health (2013). Sheep pox and goat pox. *OIE*. Accessed 2020: https://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/SHEEP_GOAT_POX.pdf

*

* *

The OIE will periodically update the OIE Technical Disease Cards. Please send relevant new references and proposed modifications to the OIE Science Department (scientific.dept@oie.int). Last updated 2020. Written by Samantha Gieger and Erin Furmaga with assistance from the USGS National Wildlife Health Center.