INFECTION WITH SARS-COV-2 IN ANIMALS

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Severe Acute Respiratory Syndrome-Coronavirus-2 (SARS-CoV-2) is the pathogenic agent that causes the disease COVID-19. SARS-CoV-2 is thought to have emerged from an animal source and then spilled over to the human population. Although genetically closely related viruses have been isolated from *Rhinolophus* bats, the exact source of SARS-CoV-2 and route of introduction into the human population has not been established.

The current COVID-19 pandemic is being sustained through human-to-human transmission. Animal infections with SARS-CoV-2 have been reported by several countries. Several animal species have proven to be susceptible to infection with SARS-CoV-2 either naturally and/or by experimental infection. Important livestock species do not seem to be susceptible to infection through experimental studies (Table 1). Further studies are needed to understand if and how different animals could be affected by SARS-CoV-2.

It is important to monitor infections in animals to better understand their epidemiological significance for animal health, biodiversity, and human health. Evidence from risk assessments, epidemiological investigations, and experimental studies indicate that animals do not play a significant role in the spread of SARS-CoV-2 , which is sustained by human-to-human transmission.

Infection with SARS-CoV-2 is not included in the OIE List of Diseases. However, consistent with the reporting obligations of Members outlined in Articles 1.1.4.. of the OIE *Terrestrial Animal Health Code* relating to emerging diseases, the disease should be notified to the OIE through the OIE's World Animal Health Information System or via email.

The information presented in this technical factsheet reflects the epidemiological observations and research done to date and will be updated when additional information is available.

AETIOLOGY

Classification of the causative agent

Coronaviruses (CoVs) are enveloped, positive-sense, single-stranded RNA viruses. SARS-CoV-2 is a *betacoronavirus*, a genus that includes several coronaviruses (SARS-CoV, MERS-CoV, bat SARS-like CoV, and others) isolated from humans, bats, camels, civets, and other animals.

Susceptibility to physical and chemical action

SARS-CoV-2 is inactivated by

- 62–71% ethanol, 0.5% hydrogen peroxide or 0.1% sodium hypochlorite, within 1 minute, or
- 0.05–0.2% benzalkonium chloride or 0.02% chlorhexidine digluconate with less effectivity.

Survival:

Under experimental conditions, SARS-CoV-2 remained viable in the environment after aerosolization for at least 180 minutes. Also under experimental conditions, it was shown that SARS-CoV-2:

- can persist on surfaces such as plastic, stainless steel or glass for 3-7 days, depending on the initial viral load and environmental conditions, but can be efficiently inactivated by surface disinfection procedures, as listed above
- can persist in cloth, paper, wood, and bank notes for 1-2 days
- SARS-CoV was found to remain infectious for 14 days at 4°C, but for only 2 days at 20°C in sewage water.

Epidemiology

Hosts

Although current evidence suggests that SARS-CoV-2 emerged from an animal source, likely a bat, that source has yet to be identified. The pandemic is driven by human-to-human transmission, which happens through respiratory droplets from coughing, sneezing, and talking, that can remain in the air for some time as aerosols. Genetic sequence data reveal that SARS-CoV-2 is genetically closely related to other coronaviruses circulating in *Rhinolophus* bat (horseshoe bat) populations. To date, there is not enough scientific evidence to identify the source of SARS-CoV-2 or to explain the original route of transmission to humans (which may involve an intermediate host).

Several animal species have tested positive for SARS-CoV-2, with infection being introduced to a population as a result of close contact with humans or animals infected with SARS-CoV-2 or in experimental infection studies performed in laboratory settings. The list of animal species for which information on natural or experimental infection is available is presented in Table 1.

Table 1. Summary of findings in animals to date[1]

Species	**Type of infection[2]** [experimental (laboratory)/natural (field)]	**Susceptibility to infection** [none/extremely low/low/medium/high]	**Clinical signs**	**Transmission**
Farmed animals				
American mink (*Neovison vison*)	Natural and experimental	High	Yes (in some cases)	Yes, between minks and from mink to humans
Ferrets	Natural and experimental	High	Yes (only in few cases)	Yes, between ferrets
Racoon dogs (*Nyctereutes procyonoides*)	Experimental	High	No	Yes, between racoon dogs
Rabbits (New Zealand White rabbits, *Oryctolagus cuniculus*)	Experimental	High	No	No
Pigs (American Yorkshire crossbred pigs, *Sus scrofa*)	Experimental	Extremely low	No	No
Cattle (*Bos taurus*)	Experimental	Extremely low	No	No
Poultry (chicken, ducks, and turkeys)	Experimental	None	No	No

[1] Some of the information on the table is available through pre-prints of experimental infection studies. References to peer-reviewed publications will be added once available.

[2] Please note that extrapolating susceptibility information derived from animal challenge studies conducted under laboratory conditions to external, 'real-world' situations might be difficult as the viral challenge dose tends to be very high in experimental settings when compared to viral dose that animals would be exposed to in natural infection scenarios.

Species	Type of infection[2] [experimental (laboratory)/natural (field)]	Susceptibility to infection [none/extremely low/low/medium/high]	Clinical signs	Transmission
Companion animals				
Cats (domestic)	Natural and experimental	High	Yes (but not observed in all cases)	Yes, between cats
Golden Syrian hamsters	Experimental	High	Yes (none to very mild in some cases, depending on age)	Yes, between hamsters
Dogs	Natural and experimental	Low	Yes (but not observed in all cases)	No
Wildlife				
Large cats (tigers, lions, snow leopards and pumas)	Natural	High	Yes, in most cases	Yes, between animals
Egyptian fruit bats (*Rousettus aegyptiacus*)	Experimental	High	No	Yes, between fruit bats
Gorillas (*Gorilla gorilla*)	Natural	High	Yes	Yes
White tailed deer (*Odocoileus virginianus*)	Experimental	High	No	Yes, to other white-tailed deer
Marmosets (*Callithrix jacchus*)	Experimental	High	No	No
Macaques (*Macaca fascicularis* and *Macaca mulatta*)	Experimental	High	Yes (none to severe in some cases)	Yes

Transmission

Information on the routes of transmission of SARS-CoV-2 between animals is growing due to the events in mink farms and numerous experimental infection studies. As with other respiratory viruses, SARS-CoV-2 appears to be transmitted to animals and between animals by direct contact (e.g., droplets) and through aerosols that can persist in closed environments for some time. SARS-CoV-2 has been found in secretions from the respiratory tract and in faeces.

Viraemia, incubation and infectious period

In laboratory settings, the incubation period in animals appears to be similar to that seen in humans (i.e., between 2 and 14 days). However, more studies are required to better estimate the mean duration of incubation and the infectious periods for the different susceptible animal species.

Sources of virus

The main source of the virus is respiratory droplets, aerosols, and respiratory secretions, although it is possible to isolate SARS-CoV-2 from faeces of some infected animal species.

Pathogenesis

In laboratory settings, infected animals showed presence of the virus in the respiratory tract and, in some cases, lesions in the trachea and lungs, associated with dyspnoea and cough.

Occurrence and impact

There have been reports of companion animals and captive wild animals infected with SARS-CoV-2. With respect to production animals, to date, SARS-CoV-2 is known to have affected mink farms in multiple countries, with varying degrees of morbidity and mortality.

Diagnosis

Knowledge about the susceptibility of different animal species to SARS-CoV-2 infection and clinical signs is, to date, limited (see Table 1).

Clinical diagnosis

Knowledge about clinical disease manifestations in animals is limited. Current evidence suggests clinical signs may include, but are not limited to, coughing, sneezing, respiratory distress, nasal discharge, ocular discharge, vomiting or diarrhoea, fever, inappetence, and lethargy. As in humans, asymptomatic infections can occur in animals.

Lesions

More studies are needed to systematically categorise the lesions resulting from infection with SARS-CoV-2 in animals.

In transgenic mice expressing the human version of the SARS-CoV-2 ACE2 receptor, the typical histopathology outcome was interstitial pneumonia with significant inflammatory cell infiltration around the bronchioles and blood vessels, and viral antigens were detected in bronchial epithelial cells and alveolar epithelial cells. These pathological findings were not seen in wild type mice infected with SARS-CoV-2. In golden Syrian hamsters, histopathological changes were reported in the respiratory tract and spleen. Rhesus macaques infected with SARS-CoV-2 presented lesions similar to those seen in humans. Juvenile cats infected with SARS-CoV-2 presented massive lesions in the nasal and tracheal mucosa epithelia, and lungs. SARS-CoV-2 can replicate in the upper respiratory tract of ferrets without causing severe disease and only resulting in pathological findings such as severe lymphoplasmacytic perivasculitis and vasculitis, increased numbers of type II pneumocytes, macrophages, and neutrophils in the alveolar septa and alveolar lumen, and mild peribronchitis in the lungs. Some of the experimentally infected rabbits showed enlarged tracheo-bronchial lymph nodes consistent with mild lymphoid hyperplasia. Although no gross lesions were identified during the necropsy of experimentally infected racoon dogs, histopathology techniques allowed for the identification of several microscopic lesions in the respiratory tract.

Differential diagnosis

All other causes for respiratory or digestive illness should be excluded before a tentative diagnosis for infection with SARS-CoV-2 is made. Existence of an epidemiological link with a confirmed infection, in humans or other animals, should be considered when narrowing down the list of differential diagnoses.

Laboratory confirmatory tests are necessary for a final diagnosis.

Laboratory diagnosis

Samples

Depending on the type of test, samples may include single or combinations of nasal, oropharyngeal, and rectal swabs, and blood. Faecal samples may be used in situations where direct sampling is not possible due to risks to the animal or testing staff. Tests should be validated for the purpose, species and matrix to be analysed.

Procedures

Agent identification

- Reverse-transcription polymerase chain reaction (RT-PCR)
- Reverse transcription loop-mediated isothermal amplification (RT-LAMP)
- Virus isolation
- Virus genome sequencing
- Other molecular tests developed for use in humans.

Detection of immune response

- ELISA antibody test
- Virus neutralisation test (VNT)
- Several other tests for antibody detection.

Prevention and control

Biosecurity and hygiene measures are key to preventing transmission of SARS-CoV-2.

People who are suspected or confirmed to be infected with SARS-CoV-2 should restrict contact with mammalian animals, including pets, just like they would with people during their illness.

Animals suspected or confirmed to be infected with SARS-CoV-2 should remain separated from other animals and humans while infected.

Due to their susceptibility, some animal species are being used as models to test vaccines for use in humans.

A number of SARS-CoV-2 vaccines for use in mink and other animal species susceptible to infection with SARS-CoV-2 are under development,

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