COVID-19
(SARS-CoV-2 virus)
Fact sheet
December 2022

Key points

- There have been **no** detections of SARS-CoV-2 or closely related viruses in Australian wildlife
- There is **no** evidence to suggest that any animals in Australia might be a source of SARS-CoV-2
- It is safest to assume that any mammalian wildlife species **may** have the potential to be infected with SARS-CoV-2, following close exposure with an infected human (similar situations to those described as risky for human-to-human transmission)
- Appropriate precautions are always recommended before, during and after contact with animals (see COVID-19 and Australian wildlife: Biosecurity information for people working with wildlife and the National Wildlife Biosecurity Guidelines)
- People who are sick or under medical attention for COVID-19 should not have any contact with Australian wildlife
- If you care for wildlife, you should have a plan in place for the animals in your care in the event you become sick or have to self-isolate
- Further information on COVID-19 and animals can be found at:
    - Australian Department of Agriculture, Fisheries and Forestry (www.agriculture.gov.au/coronavirus/animals)
    - Australian Veterinary Association (www.ava.com.au/coronavirus)
    - WOAH (www.woah.org/en/what-we-offer/emergency-and-resilience/covid-19/#ui-id-4)
    - WHA – COVID-19 and Australian wildlife: Biosecurity information (https://wildlifehealthaustralia.com.au/Portals/0/Documents/ProgramProjects/COVID-19_Biosecurity_Aust_Wildlife.pdf).

Introduction

Coronaviruses are the cause of several recently emerged diseases which cause significant respiratory symptoms in humans, including Severe Acute Respiratory Syndrome (SARS-CoV-1), Middle East Respiratory Syndrome (MERS-CoV) and COVID-19 (SARS-CoV-2). Evidence suggests bats are the maintenance hosts for both SARS and MERS coronaviruses. None of these viruses have been found in Australian wildlife (see WHA fact sheet “Coronaviruses in Australian Bats”).

In December 2019 a novel coronavirus disease, named COVID-19, emerged in humans in China, and spread through the global human population. WHO declared COVID-19 a "Public Health Emergency of International Concern" (WHO 2020c). A range of animal species are susceptible to infection acquired from humans shedding the virus. Farmed mink in Europe acquired the virus from humans and appear to have spread infection back to close-contact humans (Munnink et al. 2020).

Public health concerns

COVID-19 is spread by human-to-human transmission. See WHO (www.who.int/emergencies/diseases/novel-coronavirus-2019) and the Australian government Department of Health (www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert) for information on COVID-19 in humans.

SARS-CoV-2 infection in animals

There is **no** evidence that Australian animals carry the SARS-CoV-2 virus and no evidence that they can be a source of infection for humans.

All reported positive cases of SARS-CoV-2 in animals globally are considered to be a result of recent contact with an infected human.

Significance of animal infections: There are concerns about the possible establishment of SARS-CoV-2 reservoirs in wild or domestic animals, which could pose risks to animal and public health. Although mink and white-tailed deer have been infected at the population level there is **no evidence that an animal reservoir has been established** (WOAH 2022a).

There are reports globally of SARS-CoV-2 in felids, mustelids, non-human primates, white-tailed deer, dogs and other carnivores, and a small number of other mammalian species. See www.woah.org/en/what-we-offer/emergency-and-resilience/covid-19/#ui-id-3 and www.aphis.usda.gov/aphis/dashboards/tableau/sars-dashboard for regularly updated information on SARS-CoV-2 in domestic and wild animals.

In domestic settings, transmission between animals is self-limiting. In high density settings, such as farmed mink, there may be ongoing transmission between animals (Hobbs and Reid 2020). The only evidence of transmission from infected animals to humans is in farmed mink (Munnink et al. 2020).

Felids: domestic cats have been infected with SARS-CoV-2after close contact with infected humans. Clinical signs include diarrhoea, vomiting and breathing difficulty however some confirmed virus-positive cats did not show signs (Chini 2020; Government of Hong Kong 2020a). Similar reports have been received from a range of countries. A study found that cats in Wuhan showed signs of previous infection (antibodies) after the start of the outbreak in humans, whereas no cats sampled before the outbreak had antibodies, indicating cats had been infected during the outbreak (Zhang Q et al. 2020).

A tiger at Bronx Zoo tested positive for SARS-CoV-2 in April 2020 and several other tigers and lions at the zoo showed signs of respiratory illness. It is thought an asymptomatically infected zookeeper may have been passed on the infection. The big cats had a dry cough, wheezing and some loss of appetite but were not severely affected. All affected big cats, and one asymptomatic tiger sharing the enclosure, subsequently tested positive to PCR on faecal samples. All cats appeared to recover uneventfully from the infection (USDA 2020; WCS 2020a, 2020b). Other tigers, lions, cougar, fishing cat, lynx and snow leopards in zoos around the world have tested positive to SARS-CoV-2 after contact with infected humans (Dawson 2020; APHIS 2021d, 2022; WOAH 2022b). Three snow leopards in a zoo in the US are reported to have died of Covid-19 disease (AP News 2021).

Mustelids: large numbers of farmed mink (Mustelidae, in the same taxonomic family as ferrets and weasels) across several countries in Europe and in the USA have become infected following exposure from infected humans (Hobbs and Reid 2020; Oreshkova et al. 2020). There is evidence that farmed mink can act as a reservoir of SARS-CoV-2, passing the virus between themselves, and also pose a risk for virus spillover from mink to humans (Munnink et al. 2020; WHO 2020b; Hammer et al. 2021). In mid-December 2020, the USDA reported SARS-CoV-2 in a free-ranging, wild mink sampled in Utah; the wild mink was sampled close to an infected mink farm. There is no evidence that SARS-CoV-2 is circulating or has been established in wild populations surrounding the infected mink farms. Several other wildlife species were sampled, but all others tested negative. (DeLiberto 2020). WOAH has published guidance on working with farm animal species susceptible to SARS-CoV-2 infection (www.woah.org/app/uploads/2021/12/en-oie-guidance-farmed-animals-.pdf) and the FAO has published recommendations for the epidemiological investigation of SARS-CoV-2 in exposed (farm) animals (FAO 2021).

Ferrets have been infected in the USA and Slovenia (APHIS 2021b). Infected Asiatic small-clawed otters (*Aonyx cinereus*) in a US zoo had mild clinical signs as seen in other mammals and humans (APHIS 2021e).

Canids: domestic dogs may become infected with SARS-CoV-2 after close contact with infected humans, but typically have no signs of disease (Government of Hong Kong 2020b; Hobbs and Reid 2020).

Non-human primates: In January 2021, western lowland gorillas at San Diego Zoo Safari Park tested positive for SARS-CoV-2. Signs included cough, nasal discharge, congestion and lethargy. Infection is believed to have been acquired from an asymptomatically infected staff member, despite use of PPE and compliance with other recommended transmission risk management practices (San Diego Zoo Global 2021a). One male gorilla had pneumonia and heart disease confirmed under anaesthesia and was treated with monoclonal antibody therapy for COVID-19 along with other medications. The gorillas appeared to recover slowly over a period of a few weeks (San Diego Zoo Global 2021b). Non-human primates are known to be susceptible to SARS-CoV-1 and were assumed to be susceptible to SARS-CoV-2 infection. More information can be found in the IUCN “Statement on great apes, COVID-19 and SARS-CoV-2” (IUCN 2020).

Deer: In the USA, wild white-tailed deer (*Odocoileus virginianus*) were found to be infected with SARS-CoV-2. Earlier studies found that white-tailed deer can be experimentally infected with the virus and that some in wild white-tailed deer had antibodies to the virus. Infected deer can spread the virus to other deer in close contact. Clinical signs have not been seen in infected deer. There is no evidence that deer play a significant role in spreading the virus to humans however multiple spillover events from humans to deer appear to have occurred (APHIS 2021f; Kuchipudi et al. 2021).

Other mammals: Binturong (*Arctictis binturong*), a spotted hyena (*Crocuta crocuta*) and coatimundi (*Nasua nasua*) in US zoos have tested positive to SARS-CoV-2 (APHIS 2021d, 2021a, 2021c). Farmed beavers (*Castor fiber*) in Mongolia tested positive for SARS-CoV-2 and two animals died (XinHuaNet 2021). Two common hippos (*Hippopotamus amphibius*) in a zoo in Belgium tested positive for SARS-CoV-2. They had mild clinical signs (Zoo Antwerpen 2021).

Infection trials: early results from laboratory-based infection trials with SARS-CoV-2 suggested ferrets and cats are more susceptible to infection than dogs, and that pigs and poultry are not susceptible. Cats may be able to pass the infection on to other cats. These studies do not necessarily reflect the situation outside a laboratory setting (Hobbs and Reid 2020; PROMED 2020; Shi et al. 2020).

A laboratory study with intranasal inoculation of Egyptian fruit bats (*Rousettus aegyptiacus*) (n=9) resulted in a transient respiratory infection and virus replication. Infected animals did not show any clinical signs. Virus was also detected in one of three in contact bats, which were not directly inoculated. The infected bats shed virus orally and in faeces. Viral RNA was found in respiratory tissues and other body organs. Infectious virus was only isolated from one bat in tracheal and nasal samples, 4 days after inoculation. Low levels of neutralising antibodies were found in infected bats. The infection in this species of bat appeared to be primarily intranasal (PROMED 2020; Schlottau et al. 2020).

Australia: There are published studies of other coronaviruses in Australian animals, with a focus on bats (see WHA fact sheet "Coronaviruses in Australian Bats"). Although some coronaviruses have been found in a variety of Australian bat species, there have been **no** detections to date of SARS-CoV-1, MERS-CoV, SARS-CoV-2 or closely related viruses in Australian bats or other wildlife. Serological evidence of exposure to a coronavirus antigenically related to SARS-CoV-1 ("SARS-CoV-1-like") has been found in various bat species (Smith et al. 2016b; Prada et al. 2019; Boardman et al. 2020; Peel et al. 2020).

SARS-CoV-2 is not closely related to any known Australian bat coronaviruses and there is no suggestion that SARS-CoV-2 is present in Australian wildlife, although further surveillance and studies are recommended to better understand endemic coronaviruses of Australian wildlife.

Further studies are needed to understand if and how different animals could be affected by SARS-CoV-2.

There is no evidence to support restrictions to movement or trade of animals (WOAH 2022a).

Vaccination of zoo animals: there is increasing use of vaccination to protect zoo animals from SARS-CoV-2 infection (Burns 2021), including in Australia (ZAA 2022).

Testing of animals for SARS-CoV-2

WOAH has published considerations for sampling, testing and reporting of SARS-CoV-2 in animals (www.woah.org/en/document/monitoringsarsanimals) which includes advice for wildlife and zoo animals, as well as livestock and companion animals.

Australia's Animal Health Committee (www.agriculture.gov.au/animal/health/committees/ahc) advises that diagnostic testing and surveillance in Australian animals for COVID-19 is only recommended on the advice of human and animal health authorities. If testing is undertaken, confirmatory testing should be performed at the CSIRO Australian Centre for Disease Preparedness (the former Australian Animal Health Laboratory). Veterinarians considering testing their patients for SARS-CoV-2 must consult with their state or territory animal health authorities in the first instance (Animal Health Committee 2022).

Precautions when in contact with Australian wildlife

There is no evidence to suggest that any animals (livestock, pets or wildlife) in Australia might be a source of infection of SARS-CoV-2.

Evidence suggests a wide range of distantly-related mammals are likely susceptible to SARS-CoV-2. Until more is known, it is safest to assume that any mammal wildlife species may have the potential to be infected with SARS-CoV-2, from close exposure to an infected human [similar situations to those described as risky for human-to-human transmission](Gryseels et al. 2021). Appropriate precautions are always recommended before, during and after contact with animals (including wildlife) and their food, supplies and excreta. This includes, for example washing hands and cleaning of equipment, clothing and boots and maintaining "physical distance" (minimum of 1.5 m) wherever possible (Animal Health Committee 2022).

See the WHA document "COVID-19 and Australian wildlife: Biosecurity information for people working or interacting with wildlife (https://wildlifehealthaustralia.com.au/Portals/0/Documents/ProgramProjects/COVID-19_Biosecurity_Aust_Wildlife.pdf) and the National Wildlife Biosecurity Guidelines for more information.

People who are unwell, including those with COVID-19 like symptoms, should avoid contact with wildlife, wherever possible. If you care for wildlife, you should have a plan in place for the animals in your care in the event you become sick or have to self-isolate. Wherever possible, apply the same precautions recommended for prevention of human-to-human transmission to your interactions with wildlife.

If an animal tests positive for SARS-CoV-2, it should be kept away from unexposed susceptible animals and contact with the infected animal should be avoided (WOAH 2022a).

There is no justification in taking measures against animals which may compromise their welfare (WOAH 2022a).

Wildlife Health Australia has undertaken a rapid, qualitative **risk assessment** to assess the risk of SARS-CoV-2 establishing in an **Australian bat population** following human-to-bat transmission. The risk was assessed to be low, but with a high level of uncertainty around the estimate due to information gaps and variability across bat populations and human activities. As the risk will vary with individual circumstances, case-by-case assessments are recommended and restricting, postponing or cancelling activities may be advisable for higher risk situations. The risk assessment may need to be revisited if COVID-19 prevalence increases in Australia (Cox-Witton et al. 2021).

Aetiology and possible origin

Coronaviruses are single stranded, enveloped RNA viruses, 75-160 nm in diameter in the family *Coronaviridae*. The subfamily *Coronavirinae* is further divided into four genera: alpha-, beta-, gamma-, and deltacoronavirus. SARS and MERS coronaviruses belong to the betacoronavirus genus and all coronaviruses detected in bats are either alpha- or betacoronaviruses (Drexler et al. 2014). Coronaviruses have been shown to have the potential for cross-species transmission and an ability to evolve relatively rapidly, which makes them of interest as potential emerging infectious diseases (Peel et al. 2020).

Only some coronaviruses are considered to be zoonotic (passed from animals to humans) (WHO 2020a). While coronaviruses infect a wide range of bird and mammal species, bats appear to be the natural hosts of many coronaviruses. There is evidence to suggest that all coronaviruses recognised in other species originally derived from bats (Vijaykrishna et al. 2007), although others suggest that alpha- and betacoronaviruses originated in bats and gamma- and deltacoronviruses originate in birds (Wong et al. 2019). Previous emerging betacoronaviruses causing respiratory disease in humans (SARS-CoV-1, MERS-CoV) have been shown to have recently moved from a bat host, via an intermediate animal host, to humans.

The virus responsible for COVID-19 (SARS-CoV-2), is also a betacoronavirus and is presumed to have transferred to humans from an (as yet) unidentified animal host.

Many experts consider bats to be the most plausible and probable original host of SARS-CoV-2. SARS-CoV-2 is closely related to a known bat coronavirus (96% genome homology) and is less closely related to SARS-CoV-1 (~80% homology) (e.g. Lu et al. 2020; Zhou et al. 2020). A possible snake origin based on viral genetics was quickly refuted by other virologists (Ji et al. 2020; Lu et al. 2020; Luan et al. 2020; Robertson 2020; Zhou et al. 2020). Many scientists believe an intermediate host has likely been involved in the original movement of the virus from bats into humans. Pangolins were proposed as a possible intermediate host from bats to humans (e.g. Cyranoski 2020; Zhang T et al. 2020) but this has been questioned by others (Frutos et al. 2020; e.g. Lee et al. 2020;

Liu et al. 2020). Others suggest that Bovidae and Cricetidae (New World rodents) should be considered as possible intermediate hosts for SARS-CoV-2, based on genetic studies (Luan et al. 2020). Rodents in Australia, including introduced house mice, black and brown rats, and native rodents fall in the Old-World rodent group, and are not Cricetidae.

Routes of transmission between bats, and from bats to other hosts, including humans, are yet to be confirmed for coronaviruses (Smith et al. 2016a).

Epidemiology

Although coronaviruses appear to have a relatively narrow host range, one bat species may be infected with multiple different coronaviruses. This potential mixing of viral species, along with their high mutation rate, permits significant genetic recombination allowing coronaviruses to change and evolve relatively rapidly (Woo et al. 2007).

There is no clear evidence of how SARS-CoV-2 moved from bats into humans and whether an intermediate host species was involved in transmission of the emergent disease in humans, as was shown to be the case for both SARS-CoV-1 (civets) and MERS-CoV (camels) (Peel et al. 2020).

Conclusion

SARS-CoV-2 has most likely moved from a natural bat host into humans, possibly via an unidentified intermediate animal host. There have been no detections of SARS-CoV-2 or closely related viruses in Australian wildlife although there is evidence from overseas that animals can become infected when exposed to an infected human. Good hygiene and infection control practices are always recommended when interacting with animals.

Acknowledgements

We are extremely grateful to the many people who had input into this fact sheet including Dr Hume Field, Dr Craig Smith and Dr Sam Hamilton. Without their ongoing support production of these fact sheets would not be possible.

Updated: December 2022

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To provide feedback on this fact sheet

Wildlife Health Australia would be very grateful for any feedback on this fact sheet. Please provide detailed comments or suggestions to admin@wildlifehealthaustralia.com.au. We would also like to hear from you if you have a particular area of expertise and would like to produce a fact sheet (or sheets) for the network (or update current sheets). A small amount of funding is available to facilitate this.

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