## Abstract

## SARS-CoV-2 infections in animals

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Epidemiologists face the daunting task of understanding what leads to the introduction of a new virus of animal origin, such as SARS CoV-2 the virus that caused coronavirus 19 (COVID-19), to the human population. Furthermore, unravelling how an infectious disease crosses the animal-human barrier, and vice-versa, is a major challenge. Although the risk of humans spreading COVID-19 to animals is considered rare, animals have been infected and more studies are needed on how different animals are affected by the virus. The aim of this study was to investigate reported cases of COVID-19 in animals. Although it is widely accepted that cats, dogs and other animals can be infected, scientist do not yet know the full range of animals that can be infected. Reports of animals being infected with the virus come from around the globe and multiple countries have reported that the virus has spread to animals and humans on mink farms. For example, there was a suspected case of mink to human transmission in the Netherlands. This study found that, as of November 20, 2020, there were 135 reported animal infection cases from 6 species, including dogs, cats, tigers, lions, puma and minks from 321 mink farms. In addition, 19 countries across 4 continents including Japan, the United Kingdom, the United States of America and South Africa reported COVID-19 animal infections. This study concluded that the main transmission routes were from human-to-animal infection where pets tested positive after a household was confirmed as COVID-19 positive. The dogs and cats on the mink farms were assumed to be infected from the minks. For tigers, lions and puma, it was assumed that the animals were infected by zoo personnel, and that minks were infected by humans. Due to the multiple cases of suspected human-to-animal transmission, continuous monitoring is needed to understand the types of animals that are infected with COVID-19, the forms of inter-animal transmission, and the patterns of transmission from animals to human. This study concluded that continued investigation and monitoring is critical to establishing a more complete understanding of human-to-animal virus transmission.

Keywords: COVID-19, animal, mink, dog, cat

Table	1 Country	and case	of COVID-	19 bv	animal type	(as i	of November	20	2020)
lable	1. Country	and case		10 Dy	anima type	(43)	or november	20,	2020)

Animals	Country (cases)	Total number of cases
Dog	<b>(8 countries)</b> Hong Kong (4), Japan (4), Denmark (1), USA (36), Netherlands (1), Italy (1), Canada (1), Argentina (4)	52
Cat	(13 countries) Hong Kong (6), Japan (2), Belgium (1), Russia (1), Germany (1), France (2), Spain (1), UK (1), Chile (3), Netherlands (3), USA (48), Brazil (1), Argentina (2)	72
Tiger	(1 country) USA (7)	7
Lion	(1 country) USA (3)	3
Puma	(1 country) South Africa (1)	1
Mink (on farms)	(7 countries) Spain (1), Netherlands (67), Denmark (216), Sweden (19), Italy (1), Greece (2), USA (15)	321



Figure 1. Countries reported COVID-19 animal infection (World Organization for Animal Health (OIE), November 19, 2020)

## Table 2. Major transmission route and symptoms in animals (as of November 20, 2020)

Animals	Source of the outbreaks (paths of infection)	Clinical symptoms		
Dog	<ul> <li>- (Breed) Pomeranian, Shepherd, bulldog</li> <li>- (Human ⇒ animal) The dogs tested positive after the households was confirmed.</li> <li>- (Mink farm's dog) The dogs were assumed to be infected from the minks.</li> </ul>	<ul> <li>No clinical signs, lethargy, respiratory signs, difficulty breathing, coughing, nasal secretion, wheezing</li> </ul>		
Cat	<ul> <li>- (Human ⇒ animal) The cats tested positive after the households were confirmed.</li> <li>- (Mink farm's cat) The cats were assumed to be infected from the minks.</li> </ul>	<ul> <li>No clinical signs, diarrhea, vomiting, difficulty breathing, wheezing, fever, oral lesions and ulcerations on the tongue, neurologic signs, inappetence</li> </ul>		
Tiger	– (Human $\Rightarrow$ animal) Being exposed to a zoo employee who was actively shedding the virus	- Dry cough, wheezing		
Lion	– (Human $\Rightarrow$ animal) Being exposed to a zoo employee who was actively shedding the virus	- Dry cough, wheezing		
Puma	– (Human $\Rightarrow$ animal) It was assumed that there was contact with infected handlers.	<ul> <li>Tested negative on a PCR test 8 weeks after infection</li> </ul>		
Mink*	<ul> <li>- (Human ⇒ animal) It was assumed that there was contact with infected humans.</li> <li>- (Netherlands**) The infection was notified through the early warning monitoring system in which animals are tested for the virus every week.</li> </ul>	<ul> <li>Runny noses, difficulty breathing, numbness, inappetence, epistaxis, sudden death</li> </ul>		

\* SARS-CoV-2 was officially designated in the Netherlands as an infectious animal disease (May 19, 2020)

\*\* Suspected cases of mink to human infection have occurred

Continent	Country	Animals	Total number of cases	Method of diagnosis	Other informations	
	Llenghang	Dog	4		A household with COVID-19	
A	Hongkong	Cat	6	PCR, VNI		
Asia	Japan	Dog	4		A household with COVID-19	
		Cat	2	PCR, VNI		
	Belgium	Cat	1	-	A week after its owner was confirmed, the cat presented symptoms	
	Russia	Cat	1	PCR	-	
	Germany	Cat	1	_	The owner died due to COVID-19	
	France	Cat	2	PCR	A household with COVID-19	
	<u> </u>	Cat	1	_	A household with COVID-19	
	Spain	Mink	1 (farm)	-	93,000 farmed mink were slaughtered	
	UK	Cat	1	PCR, VNT	A household with COVID-19	
Europe		Dog	1	-	A household with COVID-19, the dog had breathing problems and was euthanized	
	Netherlands	Cat	3	-	Mink farm	
		Mink	67 (farm)	-	Infection from mink to human	
		Dog	1	-	Mink farm	
	Denmark	Mink	216 (farm)	-	The farm was infected and all the mink were slaughtered	
	h-L-	Dog	1	PCR	A household with COVID-19	
	Italy	Mink	1 (farm)	-	-	
	Sweden	Mink	19 (farm)	PCR	-	
	Greece	Mink	2 (farm)	-	COVID-19 infection of farm owner	
		Dog	36	PCR, VNT	Mostly household infection	
		Cat	48	PCR, VNT	Mostly household infection	
	USA	Tiger	7	PCR	Zoo	
		Lion	3	PCR	Zoo	
A		Mink	15 (farm)	_	Mainly in the stare of Utah	
Americas	Chile	Cat	3	PCR	A household with COVID-19	
	Brazil	Cat	1	PCR	A household with COVID-19	
	Canada	Dog	1	PCR	A household with COVID-19	
	Argonting	Dog	4	PCR	Project of the diagnosis of pets living with	
	Argenuna	Cat	2	PCR	people affected by COVID-19	
Africa	South Africa	Puma	1	PCR	Zoo	

## Table 3. Current status of COVID-19 animal infection in countries (as of November 20, 2020)