

Impacts of Coronavirus on Farm, Pet, and Zoo Animals

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Abstract: Coronaviruses are positive sense RNA virus belonging to the Coronaviridae family, which are further subdivided into four genera: Alpha, Beta, Gamma, and Delta Coronaviruses. Infectious bronchitis virus and SARS-CoV belong to Beta Coronaviridae family. Infectious bronchitis virus causes respiratory and nephritic signs that includes tracheal rales, urate crystals, lethargy and nasal discharge. In livestock and pets, the Coronavirus infection causes mostly gastrointestinal lesions, which may be prevented through vaccination and biosecurity. Recent infections of SARS-CoV-2 (also known as COVID-19) on farm, pet, and zoo animals were summarized in this study. Although the damage of COVID-19 has not been reported in commercial livestock and poultry, the transmission mechanism of COVID-19 among group animals and farms are not still clear. The impact of Coronavirus on animals and potential prevention strategies, such as vaccine development and farm biosecurity measures, were discussed. Before the right vaccine is successfully marketed, biosecurity measures (e.g., conventional disinfection strategies and innovated technologies) may play roles in preventing potential airborne transmission.

Keywords: Coronavirus, SARS-CoV-2, animals; nephritic, vaccination, biosecurity measures

1. Introduction

Coronaviruses are positive sense RNA virus named for solar corona like appearance (meaning crown) with helical nucleocapsid measuring 80 to 160 nm. It consists of glycoproteins on the surface of envelope appearing as club shaped projections that measure 20 nm in length and 5-11 nm inn width [1]. Coronaviruses (CoVs) are the largest group of viruses belonging to the Nidovirales order, which includes Coronaviridae, Arteriviridae, Mesoniviridae, and Roniviridae families. The Coronavirinae comprise one of two subfamilies in the Coronaviridae family, with the other being the Torovirinae [2]. The Coronavirinae are further subdivided into four genera: the alpha, beta, gamma, and delta coronaviruses. The viruses were initially sorted into these genera based on serology but are now divided by phylogenetic clustering [3].

Table 1. Coronavirus Groups, Target Tissues, and Diseases [4,5]

Genetic Group	Virus	Host	Infection site
Alpha	HCoV-229E	Human	Upper respiratory tract
Alpha	TGEV PRCV PEDV	Pig	Upper respiratory tract, Small intestine, Upper Respiratory tract, lungs, Viremia
Alpha	FIPV FCoV	Cat	Upper Respiratory tract, enteric and systemic signs Small intestine
Alpha	CCoV	Dog	Small Intestine
Alpha	RaCoV	Rabbit	Systemic signs
Beta	HCoV-OC43	Human	Upper respiratory tract
Beta	NUN	Mouse	Hepatitis, CNS, systemic signs
Beta	RCoV	Rat	Salivary glands, eye
Beta	BEV	Pig	Respiratory tract

Beta	BcoV	Cattle	Lungs, colon
Beta	SARS-CoV	Human	Upper respiratory tract, lungs, viremia, kidney
Beta	SARS-CoV-2	Human	Lower respiratory tract
Beta	Civet cat CoV	Himalayan palm civet	Subclinical?
Beta	Raccoon dog CoV	Raccoon dog	Subclinical?
Gamma	IBV	Chicken	Upper respiratory tract, lungs,
Gamma	TCoV (TECoV)	Turkey	Small intestine
Delta	HKU12 HKU13	Mammals, Birds, Pigs	Gastrointestinal tract

Note: ? = Unknown, CNS = Central Nervous System.

2. Coronaviruses in Farm Animals and Pets

Infectious bronchitis is an acute, highly contagious disease of poultry characterized by tracheal rales, coughing and sneezing [6]. It is caused by IBV virus, a member of Coronaviridae family which is single stranded RNA virus. Chicken is naturally infected though susceptibility varies among breeds and strain of chicken [6]. It is horizontally transmitted via aerosol route. The virus may also be transmitted through contaminated feed and equipment [7]. Birds of all ages are susceptible, but chicks of 1-4 weeks of age are most severely affected. After invasion virus localizes in the respiratory system, following which a viremia occurs and the virus is distributed in the body and affect reproductive and urinary system and replicates up to 1-8 days post infection. Incubation period is about 18-30 hours. Symptoms includes respiratory and nephritic form. Common clinical signs are tracheal rales, sneezing, nasal discharge, depression, ruffled feathers, wet droppings and urolithiasis [8]. Post mortem lesions include cloudy air sacs, catarrhal tracheal exudates [9]. Pneumonia may also be seen. Kidneys are pale swollen with tubules and ureters are often distended with urates. Diagnosis can be done according to clinical signs, PM lesions, virus isolation in chick embryo serological tests [10]. Treatment is non-specific and antimicrobial therapy is recommended. Prevention is done by vaccination of birds with strict isolation procedure for affected birds and disinfection of the poultry house [11]. In general, it is recommended to allow two weeks between two live IB

vaccinations and obtain a good booster effect of the inactivated vaccines, preferably 4–6 weeks should elapse between the last live vaccination and the application of the inactivated vaccine [12].

It is highly contagious disease of domestic animals, specially of canine and bovine of young age group, characterized by gastroenteritis [13]. Canine population is the main host of this viral infection causing Canine Corona Virus (CCV) disease [14]. Transmissible Gastroenteritis (TGE) causes profuse diarrhea and vomiting in pigs, it results in serious atrophy of intestinal villi [15]. Transmission is mainly through fecal contamination and vomitus [16]. The virus invades the small intestine, damage the intestinal villi resulting in profuse diarrhea [17]. Clinical signs include depression, anorexia, lethargy, vomiting, prolonged diarrhea (7-10) days with yellow orange colored fecal materials with occasional mucus or blood. Cat may also show vomiting and diarrhea accompanied by fever [18]. The intestinal villi are atrophied and desquamated [19]. Serological tests like AGID, ELISA and PCR can also be done [20]. This disease is often confused with canine parvo virus due to similar clinical signs [21]. Symptomatic treatment to control diarrhea along with fluid therapy is recommended [21]. Vaccination is most effective method for prevention of this disease [20].

3. Animals with SARS-COV-2 (COVID-19)

It is suggested that SARS CoV may also have a broad host range besides humans. Genetically similar CoVs were isolated from civet cats and raccoon dogs [22]. In experimental studies, the SARS CoV infected and caused disease in macaques and ferrets and cats' sub clinically [4]. COVID-19 is caused by SARS-CoV-2 (Severe acute respiratory syndrome coronavirus 2). This disease was firstly reported in Wuhan, China in December 2019 [23]. It was thought to be originated from bats though the intermediate animal sources of virus are still unknown [24]. SARS-CoV-2 replicates poorly in canine, swine and poultry but ferrets and cats are permissive to infection [25]. Bats, civets, and camels have been the recent animal carriers of human CoV infections [26]. Bats and pangolins are considered to be the probable sources of origin of SARS-CoV-2 [27,28]. Cats has been found to be the asymptomatic carrier of COVID-19 [29].

Pets cats in Hongkong, Tigers in Zoo and Mink on farms in Netherlands were reported cases of coronaviruses with several species, including pet dogs and cats, captive lions and tigers are susceptible to the virus [30]. A veterinary virologist at Kansas State University, indicated that farmed mink, mink, weasels, badgers, martens and wolverines could be susceptible [30]. Pigs, ducks and chickens are found to be non-susceptible after experiments, but there have been no studies of other livestock animals, such as cows, sheep and horses [31]. There have been only two reported cases of animals both mink passing the virus SARS-CoV-2 to people, which is proved after genomic analysis from mink and people [32].

Table 2 shows the summarized information regarding impacts of COVID-19 on pets and farm animals.

Farm Animals/Pets/Others	Animal type	Country/Remarks	Date	Source
Pets	Dogs	Hong Kong, China	Feb, 2020	[33]
Farm Animals	Mink	Netherlands	April, 2020	[34]
Pets	Cats	Belgium	March, 2020	[35]
Pets	Cats	Hong Kong, China	March, 2020	[36]
Others	Cats & Ferrets	China	March, 2020	[31]
Pets	Dogs	Hong Kong, China	March, 2020	[37]
Others	Tiger	India	April, 2020	[38]
Pets	Cats	USA	April, 2020	[39]
Others	Tiger, Lion	USA	April, 2020	[40]
Pets	Cats	Netherlands	May, 2020	[41]
Pets	Cats	Experimental/ Japan	May, 2020	[42]
Pets	Cats	Germany	May, 2020	[43]
Pets	Cats	France	May, 2020	[44]
Farm animals	Mink	Netherlands	May, 2020	[32]

4. Coronavirus Prevention on Animal Farms

COVID-19 has yet caused disaster infection in commercial livestock and poultry as what the Highly Pathogenic Avian Influenza (HPAI) or African Swine Fever (ASF) has led. But the transmission mechanism

of COVID-19 among group animals and farms are not well studied yet. Vaccination is the most efficient for stopping the spread of COVID-19, but the commercial canine coronavirus vaccine that is available will not provide cross protection as it is effective for enteric coronavirus only [45]. Before the right vaccine is successfully developed and marketed, conventional and emerging measures of on-farm biosecurity may help prevent transmission of COVID-19 among farm animals. Conventional farm biosecurity measures include vehicles disinfection with liquid spraying, ultraviolet light, and shower-in and show-out for all farm staff and visitors. Emerging biosecurity measures such as heat treatment and electrostatic air filtration have been tested in the US in recent years. Scientists have developed a heat treatment method (i.e., heat room temperature to 60°C over hours) for disinfecting egg transportation tools during outbreak of HPAI in Midwest [46]. Besides, an electrostatic air filtration system was tested for filtering the airborne dust at the inlet of poultry housing ventilation system to prevent potential airborne transmission of HPAI between farms or between animal houses on the same farm [47,48]. Those conventional and innovated biosecurity measures may be considered by producers if there are any outbreak of COVID-19 in farm animals.

5. Summary

The primary coronavirus groups, target tissues, and diseases in farm animals and pets are systematically summarized to present the correlation between coronavirus and some other relevant diseases. Being as viral disease, the treatment of the condition is non-specific and antibiotic therapy is done for secondary bacterial infections.

The outbreak/infections of COVID-19 among farm, pet, and zoo animals were summarized in this study. Increasing positive COVID-19 cases have been reported in cats and farm minks. It is necessary to test both the animals and individuals that can be in close contact with each other in order to find out cross transmission and potential infections.

Vaccination of animals is the prophylactic measure for the control and prevention of Coronavirus. However, an efficient vaccine has been yet developed. Prior to the development of a successful vaccine, on-farm

biosecurity strategies (e.g., conventional disinfection measures and innovative engineering technologies of electrostatic air filtration and heat treatment method) may play a role in preventing the spread of COVID-19 between commercial farms or animals.

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