ISSN: 0116-6514
E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2020.33.1.009

Viewpoint: SARS-CoV-2 (The Cause of COVID-19 in Humans) is Not Known to Infect Aquatic Food Animals nor Contaminate Their Products

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Abstract

This paper was prepared in response to the need for clear communication regarding the risk of transmission of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that causes COVID-19 in humans and the general societal concern of potential contamination of aquatic animals used as food or their products with the virus. SARS-CoV-2 belongs to the family *Coronaviridae* and genus *Betacoronavirus*. Betacoronaviruses are only reported to infect mammals. Currently, there is no evidence to suggest that SARS-CoV-2 can infect aquatic food animals (e.g. finfish, crustaceans, molluscs, amphibians) and therefore these animals do not play an epidemiological role in spreading COVID-19 to humans. Aquatic food animals and their products, like any other surface, may potentially become contaminated with SARS-CoV-2, especially when handled by people who are infected with the virus. Nevertheless, with proper food handling and sanitation, the likelihood of contamination of aquatic animals or their products with SARS-CoV-2 should be negligible. The COVID-19 pandemic may indirectly affect livelihoods, food security and nutrition for populations that rely on aquatic animals as a source of food or income. However, COVID-19 outbreaks may also lead to an increase in local community consumption and/or utilisation of aquatic food animals or their products due to limited transportation and trade away from the fishing and harvesting communities or limited supplies of alternative sources of animal proteins.

Keywords: COVID-19, SARS-CoV-2, coronavirus, fish, aquatic food animals, public health

Introduction

Concerns have been raised regarding aquatic animals used as food being a transmitter of coronavirus disease (COVID-19) to humans. These animals include finfish (e.g. carp, catfish, grouper, salmon, etc.), crustaceans (e.g. crab, freshwater prawn, shrimp, etc.) and molluscs (e.g. abalone, oyster, etc.)[1]; amphibians (e.g. frog) are also included in this discussion. Earlier reports indicated that COVID-19 originated from a live animal and seafood market in Wuhan, China (Jiang et al., 2020). Decreased consumption of aquatic food animals has been reported in some countries, in part due to misconceptions regarding the risk of viral transmission. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the causative agent of COVID-19 in humans (WHO, 2020). This paper presents the output from a group of aquatic animal health, aquaculture, fisheries, food safety and veterinary specialists who engaged in a discussion to understand the risk of SARS-CoV-2 to the health of aquatic food animals and safety of their products.

Zoonotic Diseases Associated with Aquatic Food Animals

Zoonotic diseases of aquatic food animals are caused by bacteria or parasites (Boylan, 2011; Haenen et al., 2013). Diseases in humans are mainly food-borne illnesses, such as salmonellosis and vibriosis, occurring via ingestion of raw or undercooked fish tissue. Some bacterial pathogens associated with fish, however, are opportunistic and can be transmitted to humans (especially those with immunosuppression) through contact with skin wounds (e.g. *Mycobacterium marinum, Vibrio vulnificus*) or ingestion of contaminated water (e.g. *Vibrio cholerae*). Over 50 species of zoonotic helminths in fish have been reported to infect humans (Deardorff, 1991; Shamsi, 2019). So far, no viruses that infect fish have been reported to pose a risk to human health (Boylan, 2011; Woolhouse et al., 2012).

Viruses are submicroscopic infectious agents that replicate only inside the living cells of their host. When not inside an infected cell nor in the process of infecting a cell, viruses exist in the form of independent particles, or virions. These virions, which are complete, infective forms of a virus outside a host cell, consist of: (1) the genetic material – these are molecules of DNA or RNA that encode the structure of the proteins by which the virus acts; and (ii) the capsid – the protein cell of the virus that surrounds and protects the genetic material. Some viruses are also covered by a lipid membrane (viral envelope), generally derived from host cell membranes.

SARS-CoV-2 and Aquatic Food Animals

SARS-CoV-2 belongs to the family *Coronaviridae* and genus *Betacoronavirus* (WHO, 2020). All five genera of the coronavirus family infect only birds and mammals (Hemida and Ba Abduallah, 2020). Specifically, betacoronaviruses are only reported to infect mammals. Viruses affecting major aquatic food animals are very diverse and belong to multiple genera within more than 20 virus families (see Table 1); none of which belongs to the *Coronaviridae* family. The World Organisation for Animal Health (OIE) has standardized criteria for assessing whether an aquatic animal species is susceptible to infection with a specific pathogen (OIE, 2019a).

SARS-CoV-2 primarily targets the upper and lower respiratory tract with the pathology of most consequence in the lung. Fish do not have lungs, with the exception of lungfish[2], and are therefore not susceptible to the virus. Fish breathe through gills that extract dissolved oxygen from water.

The host specificity of SARS-CoV-2 and similar coronaviruses is largely determined by the use of specific cellular receptors governing entry to cells. In the viral life cycle, the earliest stage of infection is viral entry, where the virus comes into contact with a targeted host cell and introduces viral material into the cell. Prior to entry, a virus must attach to a host cell. Attachment is achieved when specific proteins on the viral capsid or viral envelope bind to specific proteins called receptor proteins on the cell membrane of the target cell.

The angiotensin-converting enzyme 2 (ACE2), found in human cells, is the receptor protein that serves as the main entry point for coronaviruses, including SARS-CoV-2, to enter the host cell. ACE2 is widely expressed in the animal kingdom and its structure is highly conserved, i.e. relatively unchanged in the phylogenetic tree.

Comparison of human ACE2 receptor with that of a finfish, for example, showed amino acid sequence identity of only 59 % (Chen et al., 2020). The very low genetic similarity of ACE2 receptors, therefore, negates the possibility of the virus infecting aquatic food animals. SARS-CoV-2 would need to undergo mutations to be able to attach to cells in these animals.

In addition, aquatic food animals do not have the required host conditions to support replication of SARS-CoV-2. For example, assuming the virus attached to and entered a fish cell, this virus is not optimised to use the machinery of fish cells (i.e.

[1] These animals are grouped in FAO's terminology as "fish".

[2] There are six extant species of lungfish.

Table 1. Major viruses of important aquatic food animals, including those listed by the OIE (OIE, 2019).

Viruses of finfishes (e.g. carp, catfish, grouper, salmon, tilapia)	Genus
Carp edema virus (CEV)*	Unassigned; Family *Poxviridae*
Channel catfish virus (CCV)	*Ictalurivirus*
Epizootic haematopoietic necrosis virus (EHNV)	*Ranavirus*
Grouper iridovirus (GIV)*	*Ranavirus*
Infectious pancreatic necrosis virus (IPNV)	*Aquabirnavirus*
Infectious haematopoietic necrosis virus (IHNV)	*Novirhabdovirus*
Infectious salmon anaemia virus (ISAV)	*Isavirus*
Infectious spleen and kidney virus (ISKNV)	*Megalocytivirus*
Koi herpesvirus (KHV)	*Cyprinivirus*
Salmonid alphavirus (SAV)	*Alphavirus*
Spring viraemia of carp (SVC)	*Sprivivirus*
Tilapia lake virus (TiLV)*	*Tilapinevirus*
Viral nervous necrosis (VNN)*	*Betanodavirus*

Viruses of crustaceans (e.g. crab, freshwater prawn, shrimp)	Genus
Covert mortality nodavirus (CMNV)*	Unassigned; Family *Nodaviridae*
Decapod iridescent virus 1 (DIV1)*	*Decapodiridovirus*
Infectious hypodermal and haematopoietic necrosis virus (IHHNV)	*Penstyldensovirus*
Infectious myonecrosis virus (IMNV)	Unassigned; Family *Totiviridae*
Macrobrachium rosenbergii nodavirus (MrNV)	Unassigned; Family *Nodaviridae*
Taura syndrome virus (TSV)	*Aparavirus*
White spot syndrome virus (WSSV)	*Whispovirus*
Yellow head virus (YHV)	*Okavirus*

Viruses of molluscs (e.g. abalone, oyster)	Genus
Ostreid herpesvirus 1 (OSHV-1)*	*Ostreavirus*
Abalone herpesvirus (AbHV)	*Aurivirus*

Viruses of amphibians (e.g. frog)	Genus
Ambystoma tigrinum virus (ATV)	*Ranavirus*
Frog virus 3 (FV3)	*Ranavirus*
Bohle iridovirus (BIV)	*Ranavirus*

*The diseases caused by these viruses are considered to be regionally important by the Network of Aquaculture Centres in Asia-Pacific and are included in the Quarterly Aquatic Animal Disease reporting system.

transcription and translation enzymes, factors, etc.) to replicate and assemble. Also, the virus has evolved to circumvent the innate defences of mammals, which are different from that of fish, and any potential infection would be shut down by the defences of aquatic animals.

Currently, there is no evidence to suggest that the novel coronavirus SARS-CoV-2 can infect aquatic food animals. Aquatic food animals, therefore, do not play an epidemiological role in spreading COVID-19 to humans.

Surface Contamination with SARS-CoV-2

SARS-CoV-2 is transmitted between humans by infectious droplets containing the virus (WHO, 2020). The virus can be spread via contact with viral aerosols or contaminated surfaces (fomites), such as doorknobs and light switches. Aquatic food animals and their products may, as with other surfaces, potentially become contaminated with SARS-CoV-2 when handled by people who are infected and actively shedding the virus.

Current data suggests the number of viral particles exposed to an individual (viral dose) or present in an individual (viral load) may be related to severity of the disease (Auwaerter, 2020; Heneghan et al., 2020). The shedding rate of SARS-CoV-2 may vary considerably between infected carriers. For example, viral titres are highest during the early stages of infection.

The survival time for a virus outside a living host may vary from hours to many days depending on the type of virus, surface and environmental conditions. While some early information has been published regarding SARS-CoV-2 survival (van Doremalen et al., 2020), these data are still under development. No data are available regarding the survival of the virus on the surfaces of seafood. Nevertheless, with proper food handling and sanitation, the likelihood of contamination of aquatic animals and their products with SARS-CoV-2 should be negligible.

Even if fish or fish products become contaminated with droplets from an infected handler, coronaviruses are thermolabile and do not withstand normal cooking temperatures (>70 °C) (FAO, 2020b). Hence, these animals and their products are safe to eat as long as they are prepared and served under standard hygiene and food safety measures (Codex Alimentarius, 2020). General hygiene measures following the World Health Organization (WHO) recommendations (WHO, 2020) include handwashing with soap and water after touching animals and their products.

COVID-19 and Fishery and Aquaculture Food Systems

The COVID-19 pandemic may indirectly impact global fishery and aquaculture food systems through changing consumer demands, market access or logistical problems (i.e. transportation, border restrictions) (FAO, 2020a). This may lead to adverse effects on livelihoods, food security and nutrition of populations that rely on fish and their products as a source of food or income.

Conclusions and Take-home Messages

Based on current knowledge and supporting evidence, it can be concluded that:

- SARS-CoV-2, the cause of coronavirus disease (COVID-19) in humans, is not known to infect aquatic animals used as food nor contaminate their products.
- Aquatic food animals do not play an epidemiological role in spreading COVID-19 to humans; thus, there is an additional benefit to their consumption, as they are known to be a healthy source of animal protein. This should be communicated to all stakeholders and the public to clear up any misconceptions regarding this virus.
- As with any surface, aquatic food animals and their products may potentially become contaminated with SARS-CoV-2 when handled by people who are infected and actively shedding the virus. While the actual risk of contact with contaminated products is unknown, seafood is safe to consume, as long as it is prepared and served in accordance with recommended hygiene and food safety measures.
- The COVID-19 pandemic may indirectly affect livelihoods, food security and nutrition for populations that rely on aquatic animals as a source of food or income, due to lockdown measures. However, it may also lead to an increase in local community consumption and/or utilisation of aquatic food animals due to limited transportation and trade away from the fishing and harvesting communities or limited supplies of alternative sources of animal proteins.
- The health of humans is interrelated with the health of animals and the environment, a concept known as "One Health"; therefore, the health of all living organisms is of paramount importance. Good aquaculture practices and biosecurity allow the production of a healthy source of aquatic animal protein.
- To date, there are many unknowns regarding SARS-CoV-2. As new information becomes available through peer-reviewed studies, we should continuously improve our understanding of the virus and assess any potential risks to fishery and aquaculture food systems that may arise.

Acknowledgements

We acknowledge the following experts for their encouragement and comments on earlier drafts of this paper: Vera Agostini, Richard Arthur, Katinka de Balogh, Matthias Halwart, Stian Johnsen, Mark Lawrence, Audun Lem, Ana Menezes, Julio Pinto, Eran Raizman, Andy Shinn and Huan Ung.

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