

Zoonosis Update

Aquatic zoonoses associated with food, bait, ornamental, and tropical fish

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Fish medicine has been a relatively small discipline of veterinary attention in the past because of many factors, the most important of which is the perceived value of pet and ornamental fish. As more people invest in expensive species, such as koi and various reef species, the demand to provide a higher level of care for these animals is increasing. This trend is also evident in the commercial food and bait fish industry, where aquaculture producers are expecting improved standards of care for populations of fish that are worth millions of dollars. With increasing numbers of pet and production fish operations, veterinarians will be expected to have the abilities and knowledge to diagnose and treat aquatic species and provide a standard of care commensurate with other commonly treated animal species. As their caseloads of aquatic species increase, veterinarians will come into contact with zoonotic diseases specific to aquatic species that have been of little concern when dealing with terrestrial animals. Certain pathogens pose a specific potential threat to veterinarians, pet owners, and producers working with finfish species. Although there is an extensive list of pathogens that are communicable to humans from aquatic species via consumption, pathogens can also be encountered during examination, handling, and treatment of aquatic species. It is important for veterinarians to be aware of the clinical signs that are associated with these specific zoonoses and ways to minimize risk of exposure to the causative organisms.

Transmission of Pathogens

The interaction of pathogens between humans and aquatic species is complex because of the various routes of transmission coupled with the fact that many of the zoonotic pathogens do not cause disease in aquatic organisms. Thus, as unaffected carriers, seemingly healthy fish have the potential to transmit pathogens to humans. It is also possible for commensal organisms that typically cause few problems for aquatic species to become a zoonotic pathogen of humans. As a further complication associated with pathogen diagnosis in fish, many clinical signs of the disease in aquatic species have little relevance to the clinical signs that develop in affected humans.

With regard to infections acquired through handling of aquatic organisms, there are no reported parasitic, viral, or fungal zoonoses that are derived from aquatic species exclusively through a contact route. Bacteria are the primary causative agents for zoonotic infections that develop from such contacts. The diversity of bacterial species associated with aquatic organisms is vast and is largely attributable to the aquatic environment. Although most fish pathogens are gram-negative bacteria, both gram-positive and gram-negative bacteria are among the potential zoonotic pathogens that can be found in association with aquatic animals. Aquatic animals live in a wide range of conditions, thereby influencing the particular bacterial species that are associated with certain species. *Aeromonas* spp, for example, are more commonly associated with freshwater species, whereas *Vibrio* spp are generally associated with marine species of aquatic organisms. The bacteria that a veterinarian may encounter are generally considered to infect humans opportunistically, and diseases caused by these bacteria develop sporadically or in immunocompromised individuals.

Specific Bacterial Disease Agents

Aeromonas spp compose a large portion of the bacterial flora among freshwater aquatic organisms that are maintained in a wide range of water temperatures. *Aeromonas* organisms are gram-negative, motile, facultative anaerobic rods that are ubiquitous in the aquatic and terrestrial environments. *Aeromonas hydrophila*, *Aeromonas caviae*, *Aeromonas sobria*, and *Aeromonas schubertii* have all been implicated in human disease and are found in association with aquatic finfish and crustaceans.¹ These aeromonads frequently cause disease in cultured and pet fish. Clinical signs of *Aeromonas* infections in fish are seldom specific and include ulcerative lesions of the skin around the base of the fins and anus, raised scales, abdominal distension, and exophthalmia, all of which are signs that commonly develop with other bacterial infections. Depending on the severity of infection, anemia, hepatomegaly, and ascites may develop in affected fish. Aeromonad infections in fish are often secondary to other stressors such as a suboptimal environment, poor water quality, parasitism, and nutritional deficiencies. The primary route for transmission to a clinician or persons handling fish is contact with mucus and tissues from infected or carrier fish. Cuts and abrasions that are already present on the hands of the handler, as well as wounds caused by

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handling fish directly, are possible routes of infection. Human infections with *Aeromonas* spp often develop in immunocompromised persons for whom the bacteremia can prove life threatening.^{2,3} In healthy individuals, the most common signs of an *Aeromonas* spp infection include localized wound swelling and gastroenteritis.^{4,5} *Aeromonas salmonicida* is another important member of this group and is responsible for large economic losses in cultured salmonid populations through what is commonly called furunculosis. An atypical strain of *A salmonicida* can also cause so-called goldfish ulcer disease in goldfish and erythrodermatitis in carp. However, to our knowledge, there are no reported cases of human infection with *A salmonicida* despite the prevalence and severity of disease among salmonids and cyprinids.

Vibrio spp are gram-negative, facultative anaerobic rods of the family Vibrionaceae. The species most commonly identified in aquatic environments and species are *Vibrio vulnificus*, *Vibrio parahaemolyticus*, and *Vibrio cholera*. These bacteria are often associated with marine and brackish environments because of the bacteria's preference for waters of high salinity. *Vibrio* spp can also be occasionally isolated from freshwater fish despite being more prevalent in saltwater environments. *Vibrio* spp typically proliferate in warm water and are often more abundant during the warmer months.⁶ *Vibrio* spp can also be cultured from the skin and gastrointestinal tracts of fish that appear clinically normal; however, in fish hosts under stressful conditions, these bacteria can cause disease.⁷ Clinical signs in fish infected with *Vibrio* spp are similar to those of other bacterial infections and cannot be relied on for diagnostic purposes. These clinical signs include anorexia, lethargy, skin ulcers, exophthalmia, and erythema around the anus and bases of fins. In humans, *Vibrio vulnificus* infection is the most common fish-derived *Vibrio* infection, and the major route of exposure has been reported to be through puncture wounds and ingestion.⁸ Clinical signs of such infections in humans are necrotizing fasciitis, edema, and swelling in the immediate area of the puncture wound.⁹ Septicemia after ingestion of *V vulnificus* (typically in shellfish) results in death in 50% to 60% of clinically affected humans.¹⁰

The Enterobacteriaceae family includes several genera of bacteria that have zoonotic potential. These bacteria include *Edwardsiella*, *Escherichia*, *Salmonella*, and *Klebsiella* spp.⁴ This group of bacteria contain gram-negative, facultative anaerobic rods that are directly associated with fish species or freshwater aquatic environments. Of these bacteria, *Edwardsiella ictaluri* and *Edwardsiella tarda* are the only important primary pathogens to fish, and both cause major losses in the commercial food-fish industry. *Edwardsiella ictaluri* is the etiologic agent of enteric septicemia of catfish¹¹; clinical signs associated with *E ictaluri* infection include circular areas of hyperemic skin, blood at the fin bases, raised reddish lesions on the top of the head that are often ulcerated, exophthalmia, abdominal distention, anorexia, and swirling behavior.¹² The highest potential for infection to a human is through a puncture wound received during handling or examination of fish, followed by contamination of existing cuts and abra-

sions. *Edwardsiella tarda* infection in catfish has been termed emphysematous putrefactive disease.¹³ In fish, this infection induces nonspecific clinical signs that may include petechiae and ulcerations of the skin and excessive mucus production. The disease can progress, and fish may develop large gas-filled abscesses that appear as raised areas of skin. As a result of lesions that destroy muscle tissue, catfish in advanced stages of disease are often unable to swim. Humans infected with *E tarda* via a wound or ingestion may develop necrotic skin lesions and gastroenteritis.^{14,15} Infections with any of these bacteria can remain localized at the point of entry or can become systemic and result in severe cases of meningitis.^{16,17}

There are also important gram-positive species of bacteria of aquatic organisms that are associated with zoonotic infections in humans. *Mycobacterium* spp are gram-positive, nonmotile, acid-fast rods and are considered part of the nontubercular group of mycobacterial pathogens. As a group, these bacteria are generally slow growing and often difficult to culture. Three major species are commonly cultured from a diverse variety of freshwater, brackish, and marine species of fish: *Mycobacterium marinum*, *Mycobacterium fortuitum*, and *Mycobacterium chelonae*. In addition, *Mycobacterium ulcerans*, *Mycobacterium chesapaeki*, *Mycobacterium shottsii*, and *Mycobacterium pseudoshottsii* have also been isolated from various fish species.¹⁸⁻²³ All of these aquatic *Mycobacterium* spp can cause acute to chronic disease in fish, which may be associated with multiple and varied clinical signs. The most common clinical signs of the chronic form of infection are exophthalmia, lethargy, scale loss, abdominal distention, pigment changes, poor body condition, and skin ulcers.²² To complicate determination of the diagnosis, many fish are long-time carriers of the disease before any clinical signs of illness are detected grossly.^{21,24} Infected fish may act as reservoirs and transmit the infection to other fish in an aquarium, tank, or pond. The most likely route of transmission among fish is generally regarded as oral, largely via ingestion of infected feces or tissues.²² However, release of infectious organisms from infected gill tissue or ulcerated skin lesions may also be a route through which *Mycobacterium* spp spread within water.²² In humans, *Mycobacterium* spp often affect people who handle or work with fish, and the resultant infections have been called fish handlers' disease or fish tank granuloma. In affected humans, lesions typically develop on the extremities and are either ulcerative or raised granulomatous nodules.²⁵⁻²⁷ Most infections in humans are limited to the extremities because of the preference of aquatic *Mycobacterium* spp for lower temperatures (< 30°C [$< 86^{\circ}\text{F}$]). However, a few rare cases of systemic mycobacteriosis in humans have been reported^{28,29}; these generally develop in immunocompromised individuals and result in symptoms of respiratory tract disease.

Streptococcus iniae is another bacterium of major concern because of the serious clinical signs that develop in infected humans. These organisms are gram-positive, nonmotile cocci that cause multiple clinical signs in freshwater and marine fish including abdominal distention, petechial hemorrhage of the dermis, exophthalmia, and death.³⁰⁻³² Tilapia (*Oreochromis* spp,

Sarotherodon spp, and *Tilapia* spp), striped bass (*Morone saxatilis*), and their respective hybrids are reported to be predisposed to infection with *S iniae* and may be chronic carriers of the bacterium, although many other food and tropical species can also harbor the pathogen.^{31,33,34} Humans infected with *S inae* develop cellulitis, systemic arthritis, endocarditis, and meningitis and may die as a result.³³ Most humans have been infected via an existing wound or a fresh puncture wound during handling of live or dead fish.

Erysipelothrix rhusiopathiae is a gram-positive rod that is ubiquitous in its distribution in soil and fresh and marine water. Although the bacterium has no apparent pathologic effect in fish, it is often associated with fish skin and mucus.³⁵ Human infections with *E rhusiopathiae* are typically obtained during contact or handling of animal tissues; an existing wound or injury sustained during animal handling is the point of entry.^{36,37} The disease in humans has 3 forms, 1 of which is a localized skin infection that is generally associated with a wound, cut, or abrasion. This localized form is typically associated with the extremities, primarily the hands and fingers. The disease also has a diffuse cutaneous form, which is a progression of a localized infection to surrounding tissues. The third form is systemic infection in which the heart and heart valves are targeted, resulting in endocarditis. The disease in humans is rare; however, on the basis of available data, 22% of infected humans contract the disease from fish or shellfish, and 38% are likely to die.⁴

Of the bacteria that may be encountered when handling fish during an examination, several species are not generally considered transmissible through contact but rather through ingestion. These bacteria would be less likely to cause infection via the oral route of transmission in a clinical setting, but are included to provide more complete information regarding fish-borne bacteria. They are almost all ubiquitous in the environment, can be cultured from numerous sources, and are not considered specific to aquatic environments or fish. *Staphylococcus* spp are gram-positive cocci that cause disease in many species of animals. However, in fish, this bacterium is rarely a primary cause of disease, but can be cultured from samples of aquarium and pond water. The greatest source for illness associated with *Staphylococcus* spp is ingestion of enterotoxin produced by the bacteria during improper food handling and preparation.³⁸ *Clostridium* spp (gram-positive rods) contribute to the resident intestinal bacteria in many fish species and rarely cause disease in fish.³⁹ For humans, the primary risk of illness associated with *Clostridium* organisms from fish species is through ingestion of preformed toxin produced by vegetative cells in improperly handled fish products. Following ingestion, *Clostridium perfringens* toxins can cause gastroenteritis and often result in diarrhea of ≥ 24 hours' duration.⁴⁰ Compared with the effects of toxins from other *Clostridium* spp, *Clostridium botulinum* toxins can have effects that are much more severe, including generalized muscle paralysis that may result in death from respiratory system collapse. *Plesiomonas shigelloides* is a gram-negative bacterium that is not specific for aquatic species but is widely distributed in water and soil in

temperate and tropical regions. This organism causes disease in humans generally through ingestion of improperly cooked seafoods. Human disease caused by *P shigelloides* is characterized by 3 forms of gastroenteritis: secretory, invasive, and cholera-like. Occupations that are reported to be at high risk for this infection are fish handlers, aquaculturists, veterinarians, zoo keepers, and water sports performers.⁴¹ *Campylobacter* spp are gram-negative rods that are associated with water contaminated with fecal material. Low numbers of infections in relation to shellfish consumption have been reported.⁴² *Salmonella* spp (also gram-negative rods) have commonly been isolated from contaminated aquarium and tanks and polluted ponds and salt water. *Salmonella* spp are not known to be pathogenic to fish but can be associated with human disease.^{43,44}

Pathogen Detection

Samples that are obtained from fish for diagnostic purposes are frequently sent to laboratories outside of veterinary clinics and need to be collected and shipped properly. Techniques for collection of samples from aquatic animals are the same as techniques for collection of samples from mammals—aseptic collection procedures are required to ensure appropriate and representative results of diagnostic testing. Most bacterial pathogens can be cultured from samples of the caudal kidney of a fish, and this is the most common sample submitted. However, some bacterial pathogens may be better isolated from other tissues; *S inae*, for example, is cultured most successfully from specimens of brain tissue. The veterinary clinician and diagnostic laboratory should also be aware that most fish pathogens should be cultured from specimens at room temperature (20° to 22°C [68.0° to 71.6°F]) rather than at the typical bacterial culture temperature for mammalian specimens of 37°C (98.6°F).

Preventative Measures

Aquatic medicine is similar to other areas of veterinary medicine in that prevention is a much more economical and effective way of avoiding zoonotic diseases than response to existing infections. Thus, discussion of biosecurity principles with clients and implementation of an appropriate biosecurity plan for aquaculture facilities are paramount to diminishing the introduction and minimizing the spread of a pathogen in an animal population. There are several measures that can be recommended by veterinarians to clients for reduction of the risk of zoonotic pathogen introduction into established aquatic animal populations. One is to establish a quarantine area or tanks that are separate from existing populations in which new fish can be held. This is helpful in preventing zoonotic pathogens and also other disease agents (ie, viral, bacterial, parasitic, and fungal) from entering the clients' fish populations. Typically, new fish should be held in quarantine for 30 to 45 days to allow observation of behavior, feeding response, and development of any clinical signs. This period is generally sufficient to detect the presence of most active pathogens in newly acquired fish, although chronic infections with pathogens such as *Mycobacte-*

rium spp may not be evident. The quarantine area or facility should be treated as a separate area and should be equipped with nets, feed, water supply, and tank-cleaning supplies designated for use solely in that area to prevent contamination of existing populations of fish.

It is also advisable to have clients seek veterinary guidance prior to purchasing fish and arrange pre-purchase examinations by a veterinarian when large numbers or expensive fish are involved. Unfortunately, it can be difficult to impossible to determine whether a fish is persistently infected or a carrier of disease. This is especially true with diseases such as mycobacteriosis. In addition, inspection of facilities and assessment of the health status of existing fish populations can both provide indications of zoonotic risk. To further reduce the potential transmission of zoonotic pathogens, clients should be advised to deal with fish and feed suppliers that have a reputable history and provide veterinary certificates of health for purchased fish.

In production facilities that accommodate large populations of food, bait, or ornamental fish, large numbers of fish will be entering and leaving a facility throughout a production cycle. Any one of the incoming fish has the potential to introduce a new disease that may or may not have zoonotic potential. Recommendations to clients to implement an all-in-all out production cycle can decrease the quarantine requirements and help prevent the spread of some infections within a facility. The period between production cycles should be sufficiently long to allow thorough disinfection of the facilities, thereby removing viable bacterial and viral pathogens and interrupting the life cycles of parasites.

A veterinarian-client-patient relationship is also important for identification of control points for disease. By advising clients to have regularly scheduled appointments for fish examinations or site visits, clinicians may identify and prevent many problems that contribute to introduction of pathogens in a fish population.

As for veterinarians who work with mammals, clinicians who work with finfish also need to be aware of possible zoonotic diseases and use standard safety practices. Gloves should be worn at all times during handling and examination to protect the clinician as well as the fish. Abrasive skin and oils on bare hands can remove the delicate external mucus layer and predispose the fish to opportunistic bacterial infections. Similar to mammalian practice, gloves should be changed between examinations of fish in different tanks or populations to prevent the spread of pathogens.

The list of pathogens that can infect humans as a result of eating undercooked fish and other aquatic species is quite extensive. Review of food-borne pathogens is beyond the scope of this article, which has focused on diseases that a clinician or client could encounter during routine handling, care, or diagnostic assessment of aquatic animals. Information regarding food-borne illnesses in relation to handling and processing of fish and seafood is widely available.⁴⁵⁻⁴⁷ It is important for veterinarians to be able to not only diagnose and treat diseases in fish but also inform clients of health risks associated with handling and caring for those

animals. This is not unlike the veterinarians' responsibilities when dealing with public health issues in pet animals and domesticated livestock; however, this area of client information is often overlooked when dealing with aquatic species. The most important information that clinicians can give clients is reassurance that with proper husbandry and care, fish are safe to keep and maintain as pets or aquatic livestock. Avoidance of contact with the fish and water would be the single most effective way to prevent infection; however, to provide proper care for fish in home aquariums or aquaculture tanks, some contact with the water, fish, or both will occur. Basic hygiene and thorough hand washing after contact with fish or water that contains fish are good preventative protocols. The extent of this contact can be decreased by use of gloves when working with the fish or tank, thereby reducing exposure via cuts obtained from equipment, ornaments, coral, or fins. Also, whenever possible, use of a brush, tubing, or other means of cleaning a tank instead of hands is recommended. Open sores, cuts, or scrapes are easy routes of entry for many of the pathogens found in aquariums or tanks. Contact of open wounds with aquarium water during cleaning or water changes should be prevented. Clients should be cautioned that immunocompromised individuals are at greater risk for infection with a zoonotic pathogen, and their contact with aquarium water and fish should be more strictly limited. Clients seeking advice regarding zoonotic diseases should also be advised to talk with their personal physicians and should inform those physicians that they have contact with aquariums and fish because certain infections can become severe if not diagnosed and treated properly.

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