

Marine Zoonotic Diseases and You

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Warning, this article contains graphic images.

"The fact that marine organisms can now be successfully collected and cultivated in aquaria also means that people no longer have to venture into the natural habitat of these creatures to be scratched, stung, bitten, or envenomated, but can now suffer these hazards in the privacy of their own home or place of work." – D.W. Tong, 1996.

Introduction

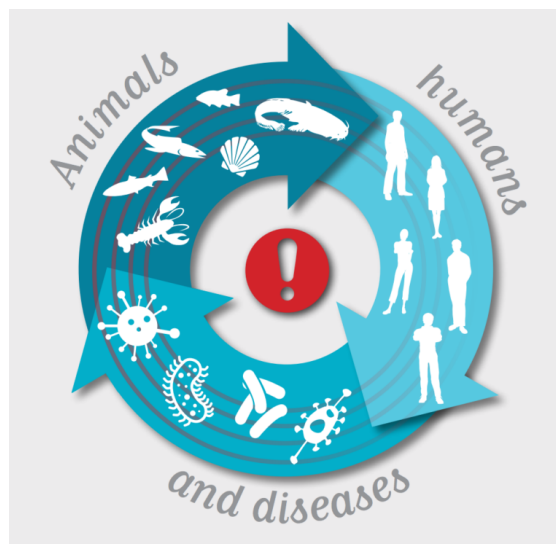
What is a zoonotic disease? A zoonotic disease, or zoonosis, is one that can be transmitted from animals, either wild or domesticated, to humans (Haenan et al., 2013). You are most likely aware of some of the most common zoonotic diseases, such as malaria, which is transmitted to humans after being bitten by an infected mosquito. However, you may be less aware of the risk of zoonotic diseases from household pets, including animals you may be keeping in your marine aquarium.

Zoonotic diseases associated with pet ownership are an increasing health issue as the definition of a pet changes to include new and exotic animals (Smith and Whitfield, 2012). Marine aquaria have become increasingly popular over the past 15 years (Rhyne and Tlustý, 2012) with 1 billion ornamental fish, comprising of both freshwater and marine species, traded annually around the globe (Chomel, 2015).

Historically, zoonotic infections primarily affected fishermen and those handling fish in processing plants, however, as the number of fish hobbyists has grown, there has been an increase in the number of published cases of zoonoses related to fish (Boylan, 2011). Pathogens (organisms causing disease), which can cause infection, are not only present in aquatic animals but also in the water in which the animals live (DeTolla et al., 1996). Zoonotic diseases are health risks which need to be recognized when owning and maintaining marine aquaria.

Transmission of zoonotic diseases

Zoonotic pathogens can be transmitted to humans from fish in two ways. The first route of transmission is through contact with aquatic animals, their products, or the water they are kept in (Haenan et al., 2013). The second route of transmission is primarily through ingestion of raw or undercooked products (Lowry and Smith, 2007; Haenan et al., 2013). Although a large body of work exists on zoonoses of fish being transmitted through ingestion, this article will focus only on those that can be transmitted through contact, as these zoonotic diseases are the ones which you are most likely to be affected by if you own marine aquaria.



Animals, humans and diseases. OIE, 2015. [<http://web.oie.int/download/press/2015/leaflet.pdf>]

Transmission of zoonotic pathogens between fish and humans is complex. Many pathogens that can be transmitted to humans do not result in disease in aquatic animals (Lowry and Smith, 2007). Consequently, contact with seemingly healthy aquatic animals can still result in an infection. On the other hand, coming into contact with a sick aquatic animal or the water they are kept in will not always result in an infection. Several factors determine a pathogen's effect. For example, the virulence of a pathogen and the susceptibility of the host (e.g. you) will determine the severity of the infection (DeTolla et al., 1996). Additionally, pathogens are opportunistic and frequently require a host to be compromised in order for an infection to become established (Roberts et al., 2009). A host may be compromised for a number of reasons. It could be because of a weakened immune system, for example as a result of illness or medication (Geraci, 1991; Haenan et al., 2013), or may simply be due to the presence of an abrasion, cut or open wound (Lowry and Smith, 2007; Boylan, 2011; Haenan et al., 2013), like bites and scratches received while handling aquatic animals (Lowry and Smith, 2007; Boylan, 2011).

Common zoonotic diseases

Zoonotic diseases of aquatic animals fall into four categories; bacterial, parasitic, viral, and fungal. Bacterial infections are the primary zoonoses transmitted to humans from fish through contact (Lehane and Rawlin, 2000; Lowry and Smith, 2007; Evans et al., 2009; Boylan, 2011; Haenan et al., 2013; Chomel et al., 2015). There are no parasitic, viral, or fungal zoonoses reported as being transmitted through contact (Lowry and Smith, 2007; Evans et al., 2009; Chomel et al., 2015).

The main zoonotic bacteria transmitted by contact from fish, shellfish and crustaceans of concern to marine aquarium owners are: *Mycobacterium marinum*, *Vibrio vulnificus*, *Edwardsiella tarda*, *Erysipelothrix rhusiopathiae*, and *Streptococcus iniae*.

Mycobacterium species

Mycobacterial infections are among the most common bacterial infections transmitted by fish (Prearo et al., 2004; Souza, 2009; Boylan, 2011; Gauthier, 2015), and are increasingly affecting aquarium owners (Novotny et al., 2004; Chomel et al., 2015). *Mycobacterium* are abundant in water (Roberts

et al., 2009; Boylan, 2011), affecting fish species from freshwater, brackish and marine environments (Chinabut, 1999; Evans et al., 2009; Haenan et al., 2013; Novotny et al., 2004; Prearo et al., 2004). The most common *Mycobacterium* species are *Mycobacterium marinum*, *M. fortuitum*, and *M. chelonae* (Beran et al., 2006; Novotny et al., 2004; Roberts et al., 2009; Chomel et al., 2015). Currently over 167 different fish species, from 40 different families, have been identified as being susceptible to *Mycobacterium* species (Chinabut, 1999; Jacobs et al., 2009; Haenan et al., 2013). Of the *Mycobacterium* species, *M. marinum* is the main bacteria associated with mycobacterial infections in marine fish, especially tropical aquarium fish (Roberts et al., 2009). *M. marinum* is also the most common bacteria transmitted from fish to humans (Jacobs et al., 2009).



Mycobacterium marinum infection of the arm of a fish-tank worker. Pier-simoni and Scarparo, 2009. [http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2819852/pdf/08-1259_finalSCME.pdf]

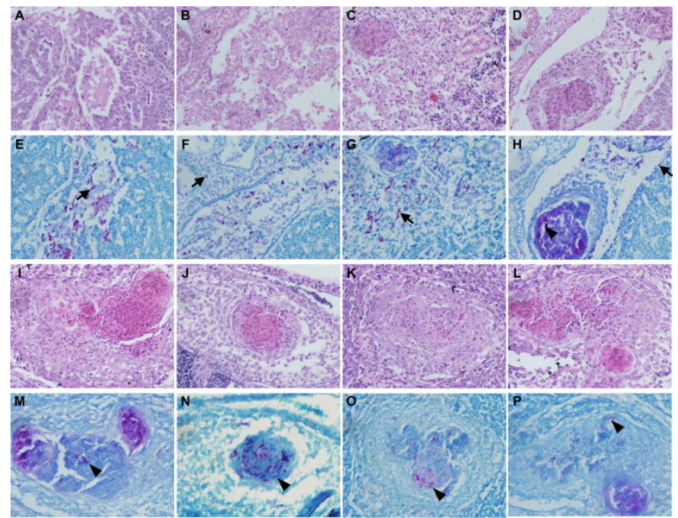
Mycobacterium marinum

While you may not be aware of the scientific name of this bacterial disease, you may have heard of its more common names such as “fish handler’s disease”, “fish fancier’s disease”, “fish tank granuloma”, “swimming pool granuloma” or “fish TB” (Beran et al., 2006; Lowry and Smith, 2007; Evans et al., 2009; Souza, 2009; Boylan, 2011; Haenan et al., 2013).

In fish, *M. marinum* is chronic and progressive (Novotny et al., 2004; Lowry and Smith, 2007; Roberts et al., 2009; Haenan et al., 2013) and individuals can be long-time carriers before any physical signs appear (Gauthier and Rhodes, 2009; Souza, 2009). Although, there are no *Mycobacterium* infection specific symptoms (Jacobs et al., 2009), signs can include

skin ulcerations, loss of normal coloration, emaciation, anorexia, exophthalmia ("pop-eye"), fin erosion, lethargy and a swollen abdomen (Beran et al., 2006; Lowry and Smith, 2007; Gauthier and Rhodes, 2009; Jacobs et al., 2009; Roberts et al., 2009; Souza, 2009; Haenan et al., 2013). Often however, there are no apparent signs and only upon examination after death can the diagnosis be made when, for example, granulomas are observed on the liver, kidneys and spleen (Gauthier and Rhodes, 2009; Jacobs et al., 2009; Roberts et al., 2009; Souza, 2009). *M. marinum* has an optimum growth temperature of 30°C and transmission between fish is generally considered to be oral, via ingestion of infected feces or tissue (Lowry and Smith, 2007; Roberts et al., 2009). Overcrowding and poor water quality are the main causes of mycobacterial infections in aquarium fish (Rao et al., 2013). Although antibiotics are available, there is currently no effective treatment for *Mycobacterium* infections in fish, as once the course of antibiotics is completed symptoms often return (Francis-Floyd, 2011). As a result, it is recommended that infected fish should be destroyed and the tank disinfected (Jacobs et al., 2009; Roberts et al., 2009; Chomel et al., 2015). There are a variety of options for humanely euthanizing and properly disposing of them; talk to your veterinarian to determine the best option for you. Never flush diseased or dying fish down the toilet, as this is a highly inhumane method of euthanasia. Whether infection is apparent or not, infected fish are shedding *Mycobacterium* into the surrounding water through feces, tissue, and skin ulcerations (Souza, 2009). Therefore, infection is concern when owning a marine aquarium.

In humans, *M. marinum* results in lesions which appear as ulcers or granulomas and are generally restricted to extremities of limbs such as hands and fingers (Lewbart, 2001; Lowry and Smith, 2007; Souza, 2009; Boylan, 2011; Gauthier, 2015). In people with weakened immune systems, infection may involve deeper tissue such as tendon and bone (Lahay, 2003; Haenan et al., 2013; Chomel et al., 2015; Gauthier, 2015). Exposure to *M. marinum* generally occurs after forearms are placed into tanks and bacteria enter through open wounds (Souza, 2009). In fact, between 1993 and 1996, there were 653 cases of *M. marinum* in the USA. Of the 193 cases where the exposure source was known, 49% of infections were associated with aquarium exposure, 27% be-



Histopathologies of zebrafish infected by WT *M. marinum* (A to H) and PPE38 mutant strain 05B1 (I to P). Arrows indicate bacteria outside granulomas, while arrowheads show bacteria inside granulomas. Magnifications, $\times 64$ for all sections. Dandan Dong et al., 2012. [ia.asm.org/content/80/1/43/F7.expansion.html]

cause of injury inflicted by aquarium fish and only 9% were associated with injury while swimming in seawater (Novotny et al., 2004). Diagnosis of *M. marinum* is difficult and treatment is often delayed as a result. Symptoms can take several weeks to appear (Boylan, 2011; Chomel et al., 2015) and it is important to inform your doctor as soon as infection is suspected that you have been in contact with tank water, so that *M. marinum* infection can be considered quickly. Treatment involves a course of antibiotics which can last many months (Oliver, 2005; Boylan, 2011), although surgical debridement (removal of infected tissue) is occasionally required in more severe cases (Gauthier and Rhodes, 2009).



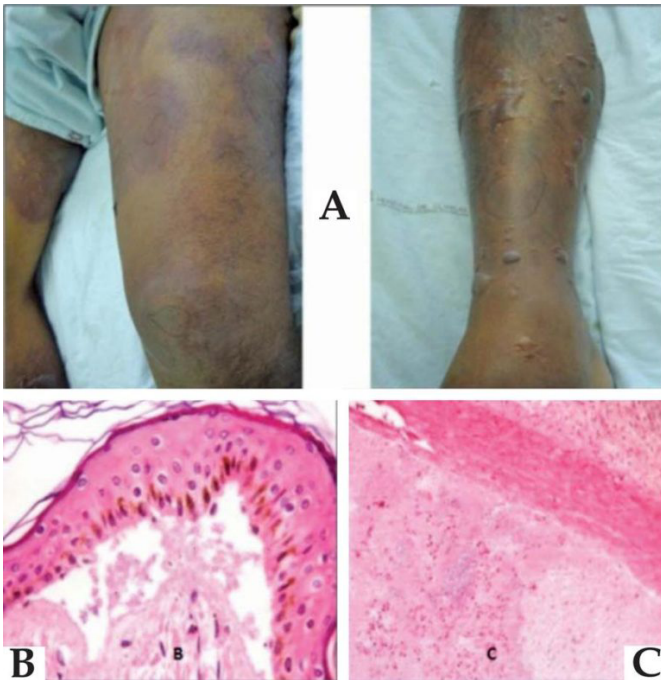
35-year-old man with a chronic ulceration on his right hand in whom an infection with *Mycobacterium marinum* was diagnosed. Salik & Del Marmol, 2011. [goo.gl/xQ36vg]

Vibrio species

Vibrio bacterial species are widespread in the marine environment (Roberts et al., 2009). The species mostly associated with human infections are *Vibrio vulnificus*, *V. parahaemolyticus*, *V. cholerae* (Austin, 2010) and *V. damsela* (Haenan et al., 2013). *V. vulnificus* is the most common *Vibrio* infection transmitted to humans from fish (Lowry and Smith, 2007), and *V. vulnificus* infections are notifiable to the Centers for Disease Control and Prevention (CDC) in the USA (Haenan et al., 2013).

Vibrio vulnificus

In fish, signs of infection can include anorexia, skin ulcers, lethargy, exophthalmia (pop-eye), reddening of skin and hemorrhaging (Lowry and Smith, 2007; Roberts et al., 2009; Boylan, 2011). Numbers of *V. vulnificus* increase rapidly in warm water (Lewbart, 2001; Lowry and Smith, 2007), while salinities of 10 – 25 parts per thousand (ppt) are normal for growth (Strom and Paranjpye, 2000).



A) Pictures of skin lesions, multiple tense bullae and intense edema, with about twelve hours of evolution. Histopathological findings from leg and spleen. (B) Presence of gram-negative bacilli in the subepidermal space. (C) Presence of gram-negative bacilli inside the splenic small vessels. (H&E, 400X). Was later identified as *Vibrio vulnificus*. França et al., 2013. [goo.gl/9M8M2T]

Fish can have *V. vulnificus* bacteria but show no signs until stressful environmental conditions (e.g. overcrowding) produce disease (Roberts et al., 2009; Boylan, 2011). The lack of signs of disease fur-

ther compounds and increases the risk of infection to marine aquarium owners. Affected fish can be treated with antimicrobial compounds (Lewbart, 2001).

V. vulnificus infection in humans is generally because of ingestion; however, infection can result from contact with open wounds (Boylan, 2011). *V. vulnificus* thrives in temperatures greater than 20°C (68°F) (Bross et al., 2007). It is reported that around 25% of *V. vulnificus* infections are because of direct exposure of an open wound to warm seawater containing the bacteria (Bross et al., 2007). Typically, water activities such as swimming and fishing expose individuals to the bacteria, however, it has been linked to marine wildlife (Bross et al., 2007). *V. vulnificus* has short incubation times (Chiang and Chuang, 2003), with most symptoms appearing after 24 hours (Oliver, 2005).

In humans, signs of infection include fluid collecting around and swelling in the immediate area of the wound (Lowry and Smith, 2007). The severity of wound infection is variable. It can be mild, or lead to cellulitis and fasciitis necroticans (also commonly known as “flesh-eating”). In some instances, it can be fatal (Oliver, 2005; Haenan et al., 2013; Chomel et al., 2015). Dependent on how bad the infection is, treatment can range from antibiotics to surgical debridement, limb amputation (Chiang and Chuang, 2003; Oliver, 2005; Bross et al., 2007), and worst scenario, death (Bross et al., 2007). Again, people with immune system problems are more at risk of developing limb or life threatening infection, as are individuals with underlying medical conditions (Oliver, 2005; Bross et al., 2007).

Edwardsiella tarda

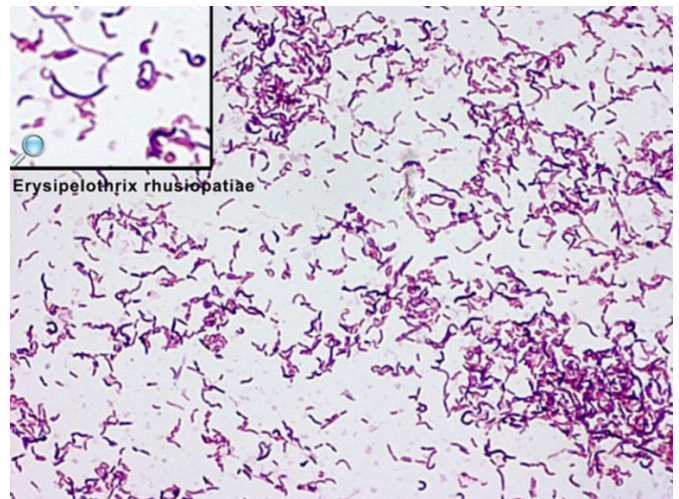
Edwardsiella tarda is a zoonotic bacteria which has a wide geographic distribution and is found in many freshwater and marine fish (Roberts et al., 2009; Park et al., 2012; Rowe et al., 2014). Fish which have been infected by *E. tarda* exhibit abnormal swimming behavior, including floating near the surface of the water (Park et al., 2012) and moving in a spiral (Mohanty and Sahoo, 2007; Lowry and Smith, 2007; Park et al., 2012). Signs in fish also include loss of normal coloration, exophthalmia (“pop-eye”), swelling of the abdomen, clouding of the eye and haemorrhaging in the fins and skin (Park et al., 2012). High temperatures, poor water quality and nutrient loading are among the main causes of *E. tarda* infections in

aquarium fish (Mohanty and Sahoo, 2007; Park et al., 2012). Much like *M. marinum* and *V. vulnificus*, ornamental aquarium fish can also be carriers of *E. tarda* but exhibit no obvious signs of infection (Lewbart, 2001). Antibiotics are commonly used to treat *E. tarda* infections in fish (Roberts et al., 2009), and there are vaccines available (Mohanty and Sahoo, 2007).

In humans, *E. tarda* infections are most commonly associated with the ingestion of food or water, leading to gastroenteritis (stomach flu) which causes diarrhea and vomiting (Janda and Abbott, 1993; Boylan, 2011; Leung et al., 2012). However, there are instances of *E. tarda* infections resulting from contact with open wounds (Boylan, 2011) and *E. tarda* has been linked to freshwater ornamental fish (Vandepitte et al., 1983). *E. tarda* infections can also result from wounds received while handling fish. For example, puncture wounds caused by the spines of a catfish have been shown to cause infections of *E. tarda* (Hargraves and Lucey, 1990; Crosby et al., 2013). Necrotic skin lesions can result from *E. tarda* infection (Lowry and Smith, 2007), whilst people with suppressed immune systems or underlying medical conditions can suffer from cellulitis, myonecrosis (death of muscle tissue) and sepsis (blood poisoning) (Janda and Abbott, 1993; Novotny et al., 2004; Boylan, 2011; Leung et al., 2012). Infection can be localized to the point of entry or it can affect limbs or the whole body (Lowry and Smith, 2007), resulting in meningitis (Lowry and Smith, 2007; Leung et al., 2012; Gauthier, 2015). A broad spectrum of antibiotics can be used to treat *E. tarda* in humans (Park et al., 2012; Diaz, 2014), although dependent on the severity of the infection, other surgical treatment options (e.g. drainage and removal of infected tissue) may need to be explored (Janda and Abbott, 1993).

Erysipelothrix rhusiopathiae

You may be aware of the bacteria *Erysipelothrix rhusiopathiae*, more commonly known as “fish handler’s disease”, “seal finger”, “fish poisoning”, and “fish hand” among others (Brooke and Riley, 1999). *E. rhusiopathiae* is abundant in soil, freshwater and marine environments (Lowry and Smith, 2007). *E. rhusiopathiae* is commonly found in the mucus of fish (Robson et al., 1998; Lowry and Smith, 2007; Boylan, 2011; Gauthier, 2015), but does not cause disease in fish (Robson et al., 1998; Boylan, 2011; Gauthier, 2015).



Erysipelothrix rhusiopathiae gram stain. Versalovic et al., 2011. [<http://www.asmscience.org/content/book/10.1128/9781555816728.chap25>]

In humans, *E. rhusiopathiae* infection can occur after handling or preparing fish for consumption (Romney et al., 2001; Novotny et al., 2004; Diaz, 2014). Frequently, existing wounds, or injuries sustained while handling aquatic animals, are points of entry for *E. rhusiopathiae* (Lowry and Smith, 2007; Boylan, 2011; Diaz, 2014). The incubation period is approximately 1 – 2 days (Diaz, 2014). There are three forms of *E. rhusiopathiae* infection (Lowry and Smith, 2007). The first results in a localized infection, generally associated with an existing wound, and primarily affects hands and fingers, while the second involves spreading of a localized infection to surrounding tissue. The third form of infection is more severe, involving the whole body and affecting the heart valves and heart function (Brooke and Riley, 1999; Romney et al., 2001; Lowry and Smith, 2007; Diaz, 2014). Antibiotics can be used to effectively treat infections of *E. rhusiopathiae* (Brooke and Riley, 1999).



Erysipelothrix rhusiopathiae. Left: purplish red, indurated skin lesions on fingers or hands. Right: treated with penicillin. [goo.gl/nByk8a]

Reports of *E. rhusiopathiae* being transmitted by aquarium fish are rare. A case reported by Robson et al. (1998), involved an individual who had sustained a minor cut to his finger prior to cleaning his home freshwater aquarium without protective gloves. However, the individual concerned handled frozen bait for fishing afterwards and therefore transmission from the home aquarium could not be confirmed. Despite the case mentioned not being transmitted by marine aquarium fish, it does highlight the fact that *E. rhusiopathiae* should still be a zoonotic disease of concern for aquarium owners.

Streptococcus iniae

Although *Streptococcus iniae* bacteria is common in both freshwater and marine fishes (Haenan et al., 2013), it is not commonly reported in ornamental aquarium fish (Lewbart, 2001). It is included here because it is a known fish zoonosis and can be transmitted by handling infected fish (Baiano and Barnes, 2009; Boylan, 2011). However, there are few reported cases of transmission by contact and those primarily affected appear to have been infected through ingestion of raw fish (Russo et al., 2006). The risk of *S. iniae* infections for marine aquarium owners appears to be low, with mostly freshwater ornamental fish (Lewbart, 2001; Yanong and Francis-Floyd, 2002; Russo et al., 2006), and cultured marine fish species (Roberts et al., 2009) affected.

How do you know if your fish are infected with a zoonotic disease?

How do you know if your aquarium has these bacteria present or your fish are infected? The easiest way would be because your fish are displaying any of the symptoms of one of the bacteria listed in this article. However, because many of the symptoms listed are common to all of these bacteria, it is very difficult without expert consultation and lab results to identify which bacteria you are dealing with. Ultimately, you know your aquarium and you know your fish. If something seems off the best practice is to review your system, check your water quality, assess the diet and generally practice good husbandry. If none of these steps help, consult your veterinarian to determine the best course of action rather than administering any antimicrobial products yourself. If you do not

have or do not know how to find a fish veterinarian, view <http://www.aquavetmed.info/index.cfm?PID=6>.

Prevention

Of the zoonotic diseases mentioned above which can be transmitted by contact from aquatic animals to humans, there is a common theme regarding the method of transmission. All zoonotic diseases referred to in this article can be contracted through pre-existing abrasions, cuts or open wounds. The most effective way to prevent contracting a zoonotic disease is to keep your hands out of the tank water and use appropriate tools for the task that you are trying to complete within the tank (Lowry and Smith, 2007) such as nets, magnet cleaners, brushes or algae scrapers.

When contact cannot be avoided, it is advisable to use a pair of gloves (Haenan et al., 2013). This is especially important if you are aware of any existing abrasions, cuts, sores or wounds on your hands or forearms which could make you susceptible to infection. Heavy waterproof gloves are of high importance for marine aquarium owners who have weakened immune systems (Haenan et al., 2013), as such individuals are more at risk of zoonotic diseases than healthy individuals (Lowry and Smith, 2007). Boylan (2011) suggests applying tissue glue, Vaseline or topical ointments to any known cuts or wounds prior to contact with water, but emphasizes that disposable gloves should still be used. In addition to the use of tools and/or gloves, it is important to follow basic hygiene practices after contact with your aquarium water or animals (Lowry and Smith, 2007). Thorough hand washing should be carried out after any contact, even if gloves have been worn.

These precautions are crucial, as fish do not always show signs of disease but may still be carriers, shedding bacteria into the surrounding water without your knowledge. Any existing wounds, or wounds received during contact with anything in the tank should be monitored as some zoonotic diseases, such as *M. marinum*, can take several weeks to show signs of infection. Additionally, many of the signs of those zoonotic diseases mentioned in this article are similar which makes it impossible to know exactly which disease your fish may have without professional diagnosis or which disease you may risk contracting. If any wound, especially on hands or fingers, shows signs of infection after contact

with your marine aquarium, you should seek medical advice/treatment and inform your doctor of contact with fish or tank water. This ensures that zoonotic diseases associated with fish can be tested for, and the correct treatment administered quickly to avoid any infection progressing or spreading.

In addition to open wounds, it would be advisable to prevent ingestion of tank water when siphoning your tank in order to reduce the risk of zoonotic diseases being contracted. When sucking on the end of the tube to start your siphon cleaner, tank water can sometimes be accidentally ingested. It would be advisable to invest in a siphon cleaner which can be started by shaking or comes equipped with a pump to begin the suction. These are readily available for many tank sizes and price points.

If you own multiple tanks, you also need to take appropriate precautions to avoid transferring any bacteria from tank to tank. Because there is no way to be certain if your tools are fully cleaned, the best practice is to maintain dedicated tools and gloves for each tank, and to be sure you are using proper hand washing procedures (washing your hands with soap and warm water for 30-60 seconds and thoroughly drying them).

Finally, if you have fish with a suspected bacterial disease in your quarantine tank you need to clean and disinfect your tank after use. All water, any filter media, and all other decorations/equipment must be removed. Filter media should be disposed of and replaced, while everything else should be disinfected with bleach and rinsed with warm water. This should ensure that your tank can be safely used for new fish again. An additional note must be included with regard to the disinfection of tanks or equipment having been, or suspected to have been, in contact with *Mycobacterium*. Francis-Floyd (2011) notes that *Mycobacterium* is more resistant to disinfection protocols than other bacteria, including when using bleach alone. As a result, they suggest using

a mycobacteriocidal agent such as Lysol (1% benzyl-4-chlorophenol-2-phenylphenol) or ethyl alcohol at 50% or 70% concentrations even after following a standard disinfection protocol using bleach.

Ultimately, on a personal note, your risk of contracting a zoonotic disease from your marine aquarium is low, but the good husbandry practices outlined above can help to ensure that you can continue to enjoy your aquarium without incident.

Summary for aquarists

Though the likelihood of contracting one of the 5 common zoonotic diseases discussed in this article is quite low, it is advisable for the aquarist to practice the following steps to minimize the risk even further.

- Never transfer fish, equipment, decorations, or tools between tanks.
- Do not attempt to treat a fish with antibiotics immediately as it is very difficult to identify what type of bacteria with which you are dealing. Clean your system, and practice good husbandry first. Consult your veterinarian second.
- Always use gloves when you are dealing with your tank.
- Make sure to use good hand washing procedures to protect yourself and do not stick your hands into a tank if you have any cuts.
- Never suck on the siphon cleaner tube to get suction started. Instead invest in a pump for this purpose.
- If you suspect a zoonotic disease in your tank, consult your veterinarian to determine the best course of action rather than administering any antimicrobial products yourself.

References

References can be found on the web article:

<http://masna.org/masna-education/zoonotic-diseases/>