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Isopod and Vibrio Co-Infections in Fish: Effects and Mitigation Approaches

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Review Article

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Abstract

Infectious diseases in fish, particularly those involving multiple pathogens, pose a significant threat to wild fish populations and aquaculture industries. Co-infection by Isopod parasites and Vibrio bacteria significantly impacts fish health. This review focuses on these pathogens interactions and combined effects on various fish species. Isopod parasites attach externally to the host, causing physical trauma, stress, and increased vulnerability to secondary infections. In contrast, Vibrio species, known for causing Vibriosis, induce severe Septicemic infections leading to high mortality rates. The co-infection of fish by these pathogens results in compounded negative effects, including elevated morbidity and mortality, posing challenges for disease management and treatment. Our review highlights the complex interplay between isopod parasites and Vibrio bacteria, emphasizing the need for integrated disease control strategies that address the dual threat. Effective monitoring and management practices targeting both parasitic and bacterial infections are essential for improving fish health, aquaculture productivity, and the sustainability of aquatic ecosystems.

Keywords: *Isopod, vibrio, co-infections, mitigation, fish*

Introduction

In aquatic environments, pathogenic microorganisms significantly threaten economically important fish by causing secondary infections after primary parasitic infestations. Lesions from parasitic infections are often sites for subsequent microbial infections **Ravichandran *et al.*, (2008).** Disease risk in aquaculture is heightened by the presence of pathogens and poor living conditions, with insufficient disease monitoring and climate changes exacerbating the problem **Addo *et al.*, (2017).** Climate variations can influence parasites directly or indirectly by altering host traits such as distribution, physiology, behavior, and mortality **Lõhmus and Björklund, (2015).**

The order Isopoda, with over 10,300 species found from highland terrestrial environments to deep oceans, belongs to the phylum Arthropoda, subphylum Crustacea **Wilson, (2008).** Cyclothoid isopods, blood-feeding crustacean parasites, can severely harm fish by infesting their gill chambers or attaching to their surfaces **Eissa *et al.,* (2012).** Secondary microbial infections typically arise in lesions caused by parasites **Ravichandran *et al.,* (2008).** Bacterial diseases, such as those caused by Aeromonas, Pseudomonas, and various *Vibrio* species (*Vibrio alginolyticus, Vibrio cholerae, Vibrio vulnificus,* and *Vibrio anguillarum*) **Kayansamruaj *et al.,* (2017)**, pose significant threats to both wild and farmed fish populations **Elgendy *et al.,* (2022).** Vibriosis is a common disease that affects various species of farmed and wild fish, leading to substantial financial losses **Mohd Nor *et al.,* (2019).**

Isopod Parasites in Fish

1. Overview of Isopod Parasites:

Description:

Isopods are small crustaceans, typically ranging from 0.5 to 3.0 cm in length, with a distinctive dorsoventrally flattened body and no carapace **Montelli and Lewis, (2008**). Most parasitic isopods are ectoparasites, but some, like Cryptoniscoidea, are endoparasites of crustacean hosts **Williams and Boyko, (2012**). Manacae, the juvenile form of isopods, have large compound eyes, six pairs of legs (as opposed to seven in juveniles and adults), and strongly setose pleopods that allow them to swim very quickly.

Common Species:

Livoneca redmanii, Nerocila spp., *Cymothoa exigua*, Anilocra spp., and others.

Habitat:

Isopods include both free-living species found in various habitats and parasitic species, mostly affecting fish. Parasitic isopods are generally marine and prefer warmer seas **Lester, (2005).** In Egypt, they are found in Lake Qarun, Bitter Lakes, Lake Burullus, Lake Manzala, the Red Sea, and the Suez Canal **Saied *et al.,* (2024**). The main parasitic isopods in marine fish belong to the suborder Cymothoida, specifically the superfamily Cymothooidea. Some families within this group, like Aegidae, Corallanidae, Cymothoidae, and Gnathiidae, are known to parasitize fish at both immature and adult stages, though many are free-living. These isopods attach to the body surface, mouth, gills, or sometimes the nasal cavities of fish. Aegidae differ from Cymothoidae by having less modified pereopods, and Corallanidae are typically found in tropical and subtropical regions **Wtchariya and Apiruedee, (2020**).

Life cycle:

Gravid females use their ventral oostegites to form a brood pouch, or "marsupium," where they lay their eggs. The eggs hatch and undergo two or more moults before reaching the "manca" or "pullus II" stage. These young are sometimes expelled from the brood pouch simultaneously when the female contracts. The female then molts, feeds, digests food, and prepares to hatch another batch of eggs, often producing multiple batches **Williams and Bunkley-Williams, (2019)**. Some corallanid isopods, like Argathona macronema, parasitize fish, commonly found in the nasal passages of serranids and lutjanids on the Great Barrier Reef **Wtchariya and Apiruedee, (2020).** Cymothoids damage fish in various ways; their mancae (larval stage) feed aggressively, often killing fry and fingerlings due to the tissue damage they cause **Wtchariya and Apiruedee, (2020).**

2. Impact on Fish Health:

Cymothoidae isopods can attach to different parts of a fish's body depending on the species, commonly targeting the mouth, gills, fins, and skin **Hoffman, (2019).** These attachments can cause injuries and deformities, which may impair fish function **Ellis *et al.,* (2008)** and negatively impact fisheries' welfare and production efficiency **Huntingford *et al.*, (2006)**. Signs of isopod infestation include hypoxia, flaring opercula, and gasping mouths. Permanently attached adult isopods can hinder fish growth and reproduction. Those in the gill chamber can stunt gill development due to attachment-related injuries and pressure atrophy, and are often associated with anemia. Isopods in the mouth can alter oral structures, even completely replacing the tongue, as they feed on the host's blood, weakening the fish and making it more susceptible to fatal diseases and secondary bacterial infections **(Ghani, 2003)**.

Isopods exert pressure on the gill lamellae, causing them to shorten, rupture the epithelial layer, release blood, increase mucus production, and impair gas exchange **Helal and Yousef, (2018).** In some instances, isopods attach to the tongue in the buccal cavity, as observed in Carangoides malabaricus, where they firmly anchor to the tongue with their heads facing inward. These isopods occupy the floor of the lower jaw, causing large lesions and tiny pinholes in the tongue where their pereopods piercing claws penetrate host tissues **Rameshkumar and Ravichandran, (2014).** Infested fish gills exhibit varying degrees of degenerative pathological lesions, including destruction, detachment, hyperplasia, and fusion of primary and secondary gill lamellae. Additionally, hyperplasia of epithelial cells in the gill filament **Nadia and Ibrahim, (2018)**, lamellar epithelium, and mucous secreting cells, along with lifting of secondary lamellae and congested blood vessels, have been observed **Helal and Yousef, (2018).**

Vibrio Infections in Fish:

1. Overview of Vibrio Infections

Description: Vibrio species are gram-negative, non-spore-forming, rod-shaped bacteria with a single rigid curve. They are motile and have a single polar flagellum when cultured in broth **Noorlis *et al.*, (2011).**

Pathogenic Species: Common pathogenic species of Vibrio affecting fish include *Vibrio harveyi, V. vulnificus, V. alginolyticus,* and *V. parahaemolyticus*, all of which can lead to significant economic losses **Deng *et al.*, (2020).**

Vibriosis in fish:

Vibriosis is a major bacterial disease affecting fish, shellfish, and crustaceans worldwide **Mohamed and Abo-Esa, (2007).** Outbreaks occur when fish are exposed to infectious agents under stress from chemical, biological, or physical factors **Austin and Austin, (2012).** In Egypt, Vibriosis is primarily caused by *Vibrio* species, with *V. alginolyticus, V. vulnificus,* and *V. parahaemolyticus* being the most prevalent **Gobarah *et al.*, (2022).** Vibrio are gram-negative, curved bacteria that are mostly facultative anaerobes, preferring temperatures above 15°C. They are common in aquatic environments, especially in saltwater and brackish water, though *V. cholerae* can also be found in freshwater **Stephen, (2022)**. Harmful *Vibrio* species associated with saltwater include *V. anguillarum, V. parahaemolyticus,* and *V. vulnificus,* while in freshwater*, V. mimicus* and *V. cholerae* are more common **Fouz *et al.*, (2002)**.

Pathogenesis:

The development of Vibriosis depends on three main factors: the host, pathogen, and environment. The interaction between the host (various fish species) and the pathogen (different Vibrio species) greatly influences the severity of the disease. The infection starts with the bacterium binding to the host tissue, a process aided by various virulence factors. The bacteria then rapidly grow and spread to internal organs via the bloodstream. Although the immune system attempts to block the invasion using physical, cellular, and chemical defenses, environmental stress can tip the balance, allowing the disease to establish **Manchanayake *et al.,* (2023)**. Pathogenic Vibrio species possess virulence factors like membrane and secretory proteins, polysaccharide capsules, outer membrane components, siderophores, and biofilm-forming **Ina-Salwany *et al.,* (2019).**

2. Impact on Fish Health:

The pathology of Vibriosis varies significantly based on the host species, bacterial strain, infection dose, duration, and environmental conditions. Vibriosis, a septicemic illness, is a leading cause of mortality in marine and brackish water fish throughout the year **Roberts, (2012)**. Common clinical signs of Vibrio infection in fish include lethargy, reduced appetite, skin and fin ulcers, and changes in body coloration **Mohamad *et al.,* (2019).** Primary lesions typically start as skin erosion and ulceration, eventually extending to deeper muscle layers. These lesions are often accompanied by fin erosion, scale loss, exophthalmia, and a swollen abdomen **Xie *et al.,* (2020**). Naturally infected fish often show multiple hemorrhagic lesions in internal organs like the liver, kidney, intestines, and viscera, along with an increase in the size of visceral organs and ascites-induced abdominal swelling **Sumithra *et al.,* (2019**).

Liver examinations of fish infected with Vibrio species reveal a congested portal vein, bile pigment presence, hepatocyte necrosis, bile duct infiltration, and mononuclear cell infiltration. The gills show necrosis, blood vessel congestion, mononuclear cell infiltration, and thickened secondary lamellae. The spleen often exhibits significant fibrosis, hemosiderin accumulation, and hemorrhage. The kidneys typically show mononuclear cell infiltration around renal tubules, severe hemorrhage, congested glomerular capillaries, and degeneration and necrosis of renal tubular epithelium **El-Sharaby *et al.,* (2018**).

Isopod and Vibrio Co-infection:

A mixed infection occurs when multiple pathogens such as bacteria, parasites, viruses, or fungi infect the same fish either simultaneously or consecutively, leading to a secondary concurrent illness. These infections amplify the impact of pathogens, weaken disease resistance, and increase the risk of fish mortality **Abdel-Latif *et al.,* (2020).** Fish populations are particularly vulnerable to disease or death when predisposing factors, such as the presence of ectoparasites, are present **Moraes and Martins, (2004)**. Parasitic isopod wounds, for instance, can serve as entry points for microbial infections, allowing opportunistic bacterial and fungal diseases to take hold. The combination of parasite attachment and these microbial diseases severely affects the infected fish's physiology, often leading to death **Raja *et al.,* (2014).**

Fish with co-infections of bacteria and parasites have higher mortality rates due to the parasites weakening their immunity **Salama and Yousef, (2020).** Ectoparasite infestations can compromise a fish's natural immunity, making it more prone to bacterial and other infections **Kotob *et al.,* (2017).**

Additionally, parasites themselves may act as vectors for other harmful species **Horton and Okamura, (2001).** Pathogens can penetrate fish epithelial tissues through mechanical injuries caused by parasite invasion and movement **Xu *et al.,* (2012).** For example, the species *Stolephorus commersonii* can develop Vibriosis following isopod bites **Rajkumar *et al.,* (2007).** The association between the isopod *N. orbignyi* and bacterial infections, such as *Vibrio alginolyticus, Aeromonas sobria,* and *Staphylococcus aureus,* has been linked to significant mortality in *Tilapia zillii* and *Solea vulgaris* **Younes *et al.,* (2016).** While little is known about the host-parasite interaction in disease causation, a study by **El-kabany *et al.* (2023)** highlighted concurrent isopod infestation and Vibriosis in *Tilapia zillii and Solea aegyptiaca* and their impact on fish health. High salinity (30–35 ppt), high temperatures, parasite infestations, and mechanical damage are also associated with an increased risk of bacterial infections. In this context, *Vibrio alginolyticus* strains from *Tilapia zillii and Solea aegyptiaca* in Manzala Lake and Qaroun Lake may be transmitted by isopods.

Mitigation and Control Strategies:

1. Environmental Management:

- Quarantine is the first line of defense. Osmotic shock (freshwater or saltwater dips) can sometimes eliminate isopods, and mechanical removal with forceps is occasionally possible **Rameshkumar and Ravichandran, (2014).**

- A gradual decrease in water temperature elicits various responses from free-living isopods. At 26°C, they exhibit increased activity, but as the temperature drops, their activity progressively decreases, reaching complete dormancy at 15°C, where they lie motionless on the tank floor, appearing almost paralyzed **Saied *et al.*, (2024).**

- Maintaining optimal water conditions to reduce stress and pathogen load, along with regular cleaning and disinfection of aquaculture facilities, is essential. Studies suggest that pond design, water exchanges, draining, lime/ dolomite application, and periodic partial harvesting are effective methods for controlling Vibriosis. Variations in salinity and temperature enhance *Vibrio* spp. capabilities **Urquhart *et al.*, (2016).**

- The direct application of natural substances such as herbal extracts, probiotics, prebiotics, immunostimulants, and non-antibiotics in water can manage aquatic animals and improve defense against Vibrio infections without negative side effects. Maintaining high-quality water management through optimal conditions is essential. Filtration techniques using various mechanical and biological processes also provide an effective alternative for controlling aquaculture diseases in natural habitats. Combining previously researched methods, such as water changes, monitoring for fish infections, and using cage systems, is crucial for better outcomes. **Faria *et al.*, (2004).**

2. Chemical Treatments:

- Antibiotics: Antibiotics are commonly used in aquaculture to treat bacterial infections, with most Vibrio spp. being susceptible. These antibiotics are usually administered in baths or added to feed. Commonly used antibiotics for treating Vibriosis include oxytetracycline, tetracycline, quinolones, nitrofurans, potentiated sulfonamides, trimethoprim, sarafloxacin, flumequine, and oxolinic acid **Bondad-Reantaso *et al.,* (2023)**. Antibiotic treatments are generally employed at the onset of Vibriosis for prevention or urgent care **Xu *et al.,* (2023).**

- Parasiticides: Diflubenzuron is sometimes needed along with organophosphate treatments to control isopod infestations in water. Treating fish without addressing their environment may only provide temporary relief. It's also important to be aware of the risk of secondary infections that can arise from severe isopod infestations **Rameshkumar and Ravichandran, (2014).**

3. Biological Control:

- Cleaner Fish: Introduce species that naturally eliminate isopods.
- Probiotics: Improve fish health and infection resistance. Probiotics are live microbes that benefit the host by changing its microbial balance, enhancing feed value, and boosting immune responses to pathogens **El-Saadony *et al.*, (2021).** Vaccination is a safer and more effective method for preventing and managing Vibriosis in aquaculture compared to antibiotics. It reduces antibiotic use and stimulates a strong immune response **Delphino *et al.,* (2019)**.

Conclusion

Isopod parasites and Vibrio bacteria co-infection significantly threatens fish health in aquaculture. Managing this issue effectively involves improving water quality, enforcing biosecurity measures, and using targeted antimicrobial treatments. Regular monitoring and early detection are vital to prevent outbreaks. Ongoing research is needed to develop sustainable strategies to address these co-infections and maintain fish health and productivity.

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