The Rise of Phage - Based Disease Control in Revolutionizing Aquaculture

Gopi V [1], Balaji Guguloth[2]

[1]Associate Project Manager,
Foundation for Aquaculture Innovations and Technology Transfer (FAITT), Kumaran Kudil 4th Cross St., Thoraipakkam, Chennai, Tamilnadu
[2] Assistant Professor, College of Fishery science, P V Narsimha Rao Telangana Veterinary University, Pebbair, Wanaparthy, Telangana-509104

The Trouble Beneath the Surface

Aquaculture once hailed as the sustainable answer to the world's growing hunger for seafood is now facing a silent but deadly threat bacterial diseases. Fish and shrimp farms around the world lose billions of dollars each year to microbial infections that not only wipe out entire stocks but also force producers to rely on antibiotics just to survive. Vibriosis is one of the most common and economically significant bacterial diseases in aquaculture, caused by various species of the genus *Vibrio*. It affects a wide range of marine and brackish water organisms, including shrimp, fish, and mollusks.

But this heavy dependence on antibiotics has come at a steep cost. The rise of antibiotic-resistant bacteria is now threatening both aquatic life and human health. Pathogens like *Vibrio*, *Aeromonas*, and *Pseudomonas* have become increasingly difficult to control using traditional methods. Even worse, the excessive use of antibiotics leaves residues in seafood products and pollutes surrounding ecosystems. Just when the aquaculture industry seemed to be sinking under the weight of these issues, an old ally has resurfaced in a new light **bacteriophages therapy** or simply, **phages therapy**.

These naturally occurring viruses have been around for billions of years, silently preying on bacteria. Now, they're being enlisted as nature's precision tools to fight bacterial outbreaks in aquaculture, ushering in a new era of disease control.

Meet the Tiny Warriors

So, what exactly are phages?

Bacteriophages are viruses that infect and destroy specific types of bacteria, leaving other microbes unharmed. Unlike antibiotics, which indiscriminately kill both good and bad bacteria, phages act like guided missiles zeroing in only on their intended bacterial target.

This targeted approach is a game-changer for aquaculture. In shrimp hatcheries, for instance, where *Vibrio parahaemolyticus* and *Vibrio harveyi* were often wreaks havoc, phage treatments have been shown to reduce bacterial loads by up to 1,000 times. In fish farms, phages are being tested to combat common diseases like vibriosis with promising early results.

But it's not just about reducing disease. Phage therapy also contributes to environmental sustainability. Once a phage has eliminated its bacterial target, it naturally degrades leaving no harmful residues behind. It's as if nature built its own clean-up crew, tailored perfectly for the task.

Challenges and the Road Ahead

Despite the excitement, phage therapy in aquaculture is still in its early days. Several hurdles remain before it becomes a widespread solution.

Regulatory approval is one of the biggest barriers. Most countries still lack clear guidelines for using phage products in food systems, although this is beginning to change as governments recognize the urgency of antibiotic resistance.

Another challenge is the evolutionary arms race between bacteria and phages. Just as bacteria can become resistant to antibiotics, they can also develop resistance to phages. However, researchers are combating this by creating **phage cocktails** combinations of multiple phages that target the same bacteria in different ways, reducing the chance of resistance.

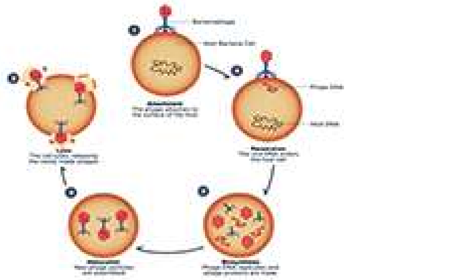

Fig 1. Phage action on Targeted Bacteria

Vibrio Species	Common Hosts	Disease Name / Syndrome	Key Symptoms
Vibrio harveyi	Shrimp, Groupers, Seabass	Luminous Vibriosis	Muscle necrosis, lethargy, glowing water, ulcers
Vibrio alginolyticus	Shrimp, Groupers, Seabream, Seabass	Tail Rot / Ulcerative Disease	Tail/fin erosion, red body parts, cloudy eyes
Vibrio parahaemolyticus	Shrimp	AHPND / EMS (Early Mortality Syndrome)	Hepatopancreas atrophy, lethargy, sloughing, high early mortality
Vibrio vulnificus	Fish (e.g., eels), Humans (zoonotic risk)	Hemorrhagic Septicemia	Ulcers, abdominal swelling, internal bleeding
Vibrio anguillarum	Marine Fish (Salmonids, Seabass)		

Table 1 : Types of Vibriosis in Aquaculture Ponds : Pathogens, Hosts, and Symptoms

A Viral Revolution

In a world desperate for sustainable solutions, phage therapy offers something rare: a method that is scientific, natural, and scalable. These microscopic viruses are redefining how we think about disease control not just in aquaculture, but potentially across all of agriculture and medicine.

As phages rise from obscurity to become frontline defenders of aquatic health, they bring with them the promise of a cleaner, healthier, and more resilient future for seafood.

Benefits

- Effective against Vibriosis, other Bacterial Infections.
- Effective in preventing Gut Infections and Feed improvement.
- Prevents sudden crop loss in pond
- Works as an alternative to antibiotics

Application

Finally, there's the matter of application. Should phages be added to feed? Sprayed into water? Injected? Different species, life stages, and diseases require different delivery strategies making continued research and field trials essential.

Still, the momentum is unmistakable. Startups and research labs around the world are racing to develop phage-based solutions, and some commercial products have already hit the market. With rising consumer demand for antibiotic-free seafood, the incentive for adoption is stronger than ever.

During mild to moderate symptoms of Vibriosis, a treatment regime recommended is pond application to hit the causative bacteria by more phage therapy approach and get faster results, thereby saving the fishes/shrimps. The Vibrio phages can be used in both growout ponds and hatcheries to control the Vibriosis infection.

Conclusion

As the aquaculture industry races to meet global seafood demand, the emergence of phage therapy marks a pivotal moment in disease management. With their precision, eco-friendliness, and adaptability, bacteriophages offer a natural solution to combat antibiotic-resistant pathogens and promote healthier aquatic systems. While challenges in regulation, formulation, and large-scale deployment remain, ongoing research and innovation are rapidly paving the way for phages to become mainstream tools in sustainable aquaculture. By embracing this microscopic ally, we not only safeguard aquatic livestock but also move one step closer to a resilient, antibiotic-free blue revolution.

References

Almeida A, et al. (2009). *Phage therapy in aquaculture: bacterial control by bacteriophages.* Aquaculture.

Jun JW, et al. (2016). *Bacteriophage application to control Vibrio infections in aquaculture: a review.* Frontiers in Microbiology.

Kalatzis PG, et al. (2018). *Bacteriophage therapy as an alternative to antibiotics in aquaculture.* Current Opinion in Microbiology.

Lara-Flores M, et al. (2023). *Field trial on phage use in shrimp farming in Ecuador.* Aquaculture Reports.

Nakai T, Park SC. (2002). *Bacteriophage therapy of infectious diseases in aquaculture.* Research in Microbiology.

Sulakvelidze A. (2011). *Phage therapy: an alternative approach to fighting drug-resistant bacteria.* Future Microbiology.