

Disease: A Major Stumbling Block in the Growth of Aquaculture

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Abstract

*Aquaculture plays a crucial role in ensuring food security, fostering economic development, and providing recreational opportunities worldwide. However, the intensification of aquaculture practices has led to a surge in environmental challenges, including water pollution, soil acidification, eutrophication, chemical contamination, and the spread of diseases. Among these, diseases caused by bacteria, viruses, fungi, and parasites pose significant threats to the sustainability of global aquaculture. Despite the implementation of various diagnostic methods and control measures, the success rate in managing these diseases remains low due to asymptomatic infections and the lack of effective therapeutics. Viral diseases, in particular, present formidable challenges due to their rapid spread, high morbidity rates, and limited understanding of aquatic animal immune responses. Current strategies such as selective breeding for resistance and vaccination have shown limited success in controlling viral outbreaks. Bacterial infections also pose significant obstacles to aquaculture, with common pathogens such as *Aeromonas* spp. and *Vibrio* spp. causing widespread diseases. Parasitic infections, although less common, can have devastating ecological and economic consequences if left untreated. In the face of these challenges, there is a growing need for sustainable control measures to mitigate the risks associated with disease outbreaks. Vaccination, probiotics, and biotechnological advances such as gene therapy and genetically modified species offer promising avenues for disease prevention and management. Additionally, integrating immunomodulators, metal nanoparticles, herbal products, and biofilm vaccination into aquaculture practices shows potential for enhancing disease resistance. Overall, adopting sound management practices and strict biosecurity measures is essential for minimizing the impact of pathogens on fish and aquaculture systems, thereby ensuring the long-term sustainability of this vital industry.*

Keywords: Aquaculture, bacterial diseases, viral diseases, fungal and parasitic diseases

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INTRODUCTION

In the present fisheries set-up, aquaculture brings a huge contribution to human food security, economic development and recreation. There is a strong need to maintain this contribution for the forthcoming generations. With the aim of achieving this goal, the culture systems have been scientifically intensified for various species of fish, crustaceans and mollusks. However, with the good there comes a bad; as there is increase in the intensification in the rearing techniques, so do the problems associated with it. Water pollution, acidification of the soil, eutrophication, chemical contamination, antibiotic residues, spreading of diseases and destruction of natural ecosystem by introduction of exotic species are the negative impacts imposed on the environment. Among all the problems, diseases are the major factor worthy of studying [1,2].

Several emerging diseases caused by various causative agents like bacteria, virus, fungi, parasites etc. have limited the expansion of aquaculture. Bacteria are the most common causative agents in aquaculture, followed by viruses, parasites and fungi. Numerous diagnostic methods have been introduced into the industry, but the success rate is very much low when compared to the other farming sectors like veterinary, poultry etc. The central reason behind this is the asymptomatic infections of fish pathogens. Generally, antibiotics are used to address majority of the bacterial diseases, various vaccination methods have been used to control viral diseases and chemical treatments have been used against parasitic and fungal diseases. Even though there are different controlling measures for almost all of the fish pathogens, preventive measures are the best to curb the infectious diseases in culture systems [3].

Although the survival rate for most viral pathogens is limited in aquatic environments, viral diseases are one of the major challenges that threaten sustainable growth of global aquaculture. Viral infections take place through various modes (injuries, water, faeces, etc.) and spread rapidly with high level of morbidity. Viral diseases are most difficult to control due to the higher susceptibility rate of aquatic animals, lack of therapeutics and limited knowledge regarding antiviral mechanism of aquatic animals. Even the immune system of the aquatic animals is not well developed to tackle the severity of viral disease. In attempts to improve profitability of fish farming, several strategies that were successfully implemented for terrestrial farm animals were employed in the fish farms including selective breeding for increasing resistance and vaccination. In spite of these measures, viruses set in as sudden outbreaks creating enormous economic losses in fish farming. Currently, viruses belonging to the families *Iridoviridae*, *Herpesviridae*, *Nodaviridae*, *Birnaviridae* and *Rhabdoviridae* are creating a havoc in the aquaculture industry [4,5].

Bacteria is ubiquitous in aquatic environment and can independently survive well outside the host, this makes the bacteria as an important obstacle to aquaculture. Fishes are always surrounded by common pathogenic bacteria and are likely to get infected when the pathogenic bacteria get into high densities. Motile aeromonad septicemia (MAS) caused by *Aeromonas* spp. is the most common fish disease in freshwater aquatic systems. In addition to MAS, Vibriosis caused by *Vibrio* spp. are commonly seen in marine water systems. Other obligate bacterial pathogens include, gram negative bacteria like *Edwardsiella*, *Flavobacterium*, *Francisella*, *Photobacterium*, *Piscirickettsia*, *Pseudomonas* and *Yersinia*; gram positive bacteria like *Streptococcus*, *Renibacterium* and *Lactococcus*. There are many cases of bacterial infection along with the fungal infections. Epizootic ulcerative syndrome (EUS) caused by *Aphanomyces invadens* is the best example where bacteria have been isolated along with the fungus. Further, fungal diseases caused by *Saprolegnia* spp., *Lagenidium*, *Branchiomyces*, *Achyla* sp., *Ichthyophonus*, *Basidiobolus* and *Aspergillus* are capable of causing chronic diseases in culture animals.

Besides viral and bacterial diseases, parasitic diseases also tend to have a little affect on fish production. If the parasitic infection is not treated in a proper way, it can be devastating with serious ecological and economic consequences. Losses due to parasites can be directly through mortality of the stock or by increased costs of removing parasites, reduced growth and feed conversion ratios. Parasites with direct life cycles tend to dominate the parasitic infections. Parasites like *Argulus*, *Lernaea*, *Ergasilus*, *Gyrodactylus*, *Dactylogyrus*, Digenetic trematodes, *Ichthyophthirius multifiliis*, *Chilodonella*, *Epistylis*, *Trichodina*, *Hexamita*, *Ichtyobodo* and *Henneguya* are reported to have lethal effects on fish.

Even though, a number of innovative technologies, methods and equipment were routinely used to monitor and control the aquatic animal diseases, there is always a risk of break through of a pathogen in culture systems. However, the risk of antibiotic resistance development and the transfer of antibiotic resistance genes to other animal pathogens, as well as concerns for environmental impact and consumer safety, have stimulated the need for new sustainable control measures. Vaccination is a sustainable control measure, but various viral and bacterial fish diseases, and more specifically fungal and oomycete

diseases, cannot yet be controlled by vaccination. Hence, the usage of probiotics has been raised over the decade in aquaculture. Biotechnological advances like gene therapy, gene editing, genetically modified species etc., will help in avoiding majority of viral diseases. Other than probiotics, bacterial diseases are tackled by incorporating immunomodulators in the feed, using metal nanoparticle to increase the immunity of the species, addition of herbal products in the feed, biofilm vaccination and sometimes combinations of two or more methods rather shows promising results. To conclude with, all the pathogens related to fish and aquaculture can be avoided by following good management practices and strict biosecurity measures [6].

Viral Diseases: A Major Threat

Viral diseases pose a significant threat to the sustainability of aquaculture, spreading rapidly among aquatic species through various transmission modes such as direct contact and waterborne routes. The challenges in controlling these diseases are exacerbated by the high susceptibility of aquatic animals to viral infections and the lack of effective therapeutics tailored for them. While selective breeding and vaccination have been employed as strategies for disease management, they are hindered by limitations such as slow progress and the need for effective vaccine delivery methods. Despite ongoing efforts, including exploring antiviral treatments and enhancing biosecurity measures, the economic losses and productivity impacts caused by viral outbreaks continue to pose major obstacles to the growth of global aquaculture. Addressing these challenges requires urgent research and implementation of effective control measures to safeguard the future sustainability of aquaculture industries worldwide [7].

Bacterial Diseases: Ubiquitous and Challenging

Bacterial diseases present pervasive challenges in aquaculture, with pathogens ubiquitous in aquatic environments exerting a significant impact on fish health. The prevalence of bacterial pathogens contributes to the susceptibility of fish to various infections, leading to widespread disease outbreaks and economic losses within aquaculture systems. Common bacterial diseases such as Motile Aeromonad Septicemia (MAS) and Vibriosis exemplify the severity of bacterial infections, causing significant morbidity and mortality among cultured fish populations, particularly in freshwater and marine environments, respectively. To combat these challenges, innovative approaches to bacterial disease management are being explored. These include the use of immunomodulators to bolster fish immunity, metal nanoparticles to enhance disease resistance, and herbal products with antimicrobial properties to inhibit bacterial growth. Such strategies hold promise in providing alternative and sustainable solutions for controlling bacterial diseases in aquaculture, thereby contributing to the long-term health and productivity of aquatic organisms and the sustainability of the aquaculture industry as a whole [8].

Fungal and Parasitic Diseases: Underestimated Threats

Fungal and parasitic diseases represent underestimated threats to aquaculture, with significant ecological and economic implications. Fungal diseases pose chronic challenges to cultured animals, causing long-term health issues and decreased productivity. These infections can affect various aquatic species, leading to reduced growth rates, increased mortality, and compromised immune systems. On the other hand, parasitic infections present complex ecological and economic consequences, impacting both wild and cultured fish populations. The presence of parasites can directly result in mortality, increased production costs, and reduced growth rates, ultimately affecting the overall profitability of aquaculture operations. Certain parasitic species, such as Argulus, Lernaea, and Ichthyophthirius multifiliis, exhibit lethal effects on fish, further exacerbating the challenges in disease management. Despite efforts to treat and prevent these infections, challenges persist, including limited effective treatment options and the complexity of parasite life cycles. Addressing fungal and parasitic diseases requires comprehensive strategies that prioritize disease prevention, innovative treatment methods, and enhanced biosecurity measures to mitigate their impact on aquaculture sustainability [9].

Sustainable Control Measures

Implementing sustainable control measures is crucial for mitigating the challenges associated with disease management in aquaculture. Current efforts face significant hurdles, including the emergence

of antibiotic resistance and growing environmental concerns regarding their use. Vaccination plays a pivotal role in disease prevention; however, its effectiveness is limited, particularly in controlling viral, bacterial, fungal, and oomycete diseases. To address these limitations, alternative approaches such as probiotics, gene therapy, gene editing, and genetically modified species are being explored. Probiotics offer promising avenues for enhancing disease resistance, while gene-based interventions hold potential for targeted disease control and prevention. Moreover, emphasizing the adoption of good management practices and implementing strict biosecurity measures are essential components of disease prevention strategies. By integrating these sustainable control measures, aquaculture stakeholders can effectively mitigate disease risks and promote the long-term health and resilience of aquatic ecosystems and the aquaculture industry as a whole [10–12].

CONCLUSION

In conclusion, this review lecture has highlighted the significant challenges posed by diseases in aquaculture and the urgent need for sustainable disease management practices. Key points discussed include the pervasive threat of viral, bacterial, fungal, and parasitic infections to aquaculture sustainability, as well as the limitations of current control measures such as vaccination and antibiotic use. Alternative approaches such as probiotics, gene therapy, and strict biosecurity measures have been identified as promising avenues for mitigating disease risks. Moving forward, there is a critical call to action for the adoption of these sustainable disease management practices in aquaculture to ensure future growth and sustainability. By implementing these measures, stakeholders can enhance the resilience of aquaculture systems, protect aquatic biodiversity, and safeguard the long-term viability of the industry.

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