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Review Article

ECONOMIC CHALLENGES AND ANTIMICROBIAL RESISTANCE IN VIBRIO-INDUCED DISEASES OF SHRIMP

Bharathi A

PG & Research Department of Advanced Zoology and Biotechnology, Sir Theagaraya College, Chennai - 600 021, Tamil Nadu

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ABSTRACT

Shrimp aquaculture is essential to the world's seafood output, bacterial infections, especially those brought on by Vibrio species, have a serious negative impact on the industry. High mortality, stunted growth, decreased feed efficiency, and significant financial losses are the outcomes of these illnesses. Antimicrobial-resistant (AMR) bacteria have emerged as a result of widespread antibiotic use, which has decreased treatment efficacy and raised issues with food and environmental safety. In order to promote sustainable shrimp aquaculture, this review addresses the economic significance of bacterial diseases, the emergence and effects of antimicrobial resistance in Vibrio species, and sustainable disease management strategies like biosecurity, probiotics, bacteriophage therapy, and responsible antibiotic use.

Keywords: Shrimp aquaculture, *Vibrio harveyi,* Antimicrobial resistance, Economic impact, Bacterial diseases.

INTRODUCTION

Shrimp aquaculture is one of the fastest-growing sectors of global aquaculture, contributing significantly to food security, employment generation, international trade, and rural economic development. According to the Food and Agriculture Organization (FAO, 2024), shrimp production has expanded rapidly worldwide; however, disease outbreaks remain one of the major constraints limiting sustainable production. Among various pathogens affecting shrimp, bacterial diseases, particularly those caused by Vibrio species, represent a serious economic challenge due to their ability to cause rapid mortality, reduced growth performance, and severe production losses. Bacterial pathogens such as *Vibrio harveyi*, *Vibrio parahaemolyticus*, and *Vibrio alginolyticus* are frequently associated with disease outbreaks in shrimp hatcheries and grow-out systems. Lightner (1996) reported that bacterial infections contribute significantly to mortality in penaeid shrimp culture, especially during larval and post-larval stages when immune defense mechanisms are poorly developed. Similarly, Karunasagar *et al.,* (1994) documented mass mortality of *Penaeus monodon* larvae caused by antibiotic-resistant Vibrio harveyi, highlighting the severe economic consequences of bacterial infections in hatchery production.

The economic impact of bacterial diseases is not restricted to direct mortality but also includes reduced growth, poor feed utilization, increased management costs, and delayed harvesting. Infected shrimp often exhibit reduced appetite, impaired digestion, hepatopancreatic damage, and decreased nutrient absorption, resulting in poor biomass production. Adams (1991) demonstrated that exposure of penaeid shrimp to pathogenic Vibrio species significantly affected physiological performance and immune responses, ultimately reducing production efficiency. Disease outbreaks also increase operational costs due to additional expenditure on probiotics, immunostimulants, diagnostic tests, pond treatment, water quality management, and biosecurity measures. According to Selvin *et al.,* (2009), effective shrimp disease management requires continuous monitoring and preventive health strategies, which increase production expenses. Furthermore, bacterial infections negatively affect hatchery operations by reducing larval survival, lowering post-larval quality, and limiting seed availability for grow-out farms (Lightner *et al.,* 1992). The international shrimp trade is also influenced by bacterial disease problems because importing countries have strict regulations regarding food safety and antibiotic residues. The presence of antimicrobial residues in shrimp products

*Corresponding Author: Bharathi A, Associate Professor and Research Supervisor, PG & Research Department of Advanced Zoology and Biotechnology, Sir Theagaraya College, Chennai - 600 021, Tamil Nadu. Email: bharathia@stcchennai.edu.in.

may result in rejection of export consignments, economic penalties, and loss of consumer confidence. Holmström *et al.,* (2003) emphasized that inappropriate antibiotic use in shrimp farming creates concerns related to environmental contamination, food safety, and international trade restrictions.

Direct Economic Losses

Direct economic losses mainly occur due to mortality during hatchery, nursery, and grow-out stages. Acute bacterial infections caused by pathogenic Vibrio species can rapidly destroy entire shrimp populations within a short period. De Schryver *et al.,* (2014) reported that microbial imbalance and pathogenic bacterial proliferation are major factors associated with early mortality syndrome (EMS) outbreaks in shrimp farming. Acute hepatopancreatic necrosis disease (AHPND), caused by toxin-producing strains of Vibrio parahaemolyticus, has caused severe economic losses in major shrimp-producing countries. The disease results in hepatopancreatic destruction, reduced feeding activity, rapid mortality, and complete crop failure in affected farms. Defoirdt *et al.,* (2007) highlighted that bacterial diseases such as luminous vibriosis significantly affect shrimp production and emphasized the importance of alternative disease control strategies.

Indirect Economic Losses

Indirect losses associated with bacterial infections include reduced growth rate, poor feed conversion ratio (FCR), increased production cycles, additional disease monitoring expenses, and higher operational costs. Continuous disease outbreaks require farmers to invest in laboratory diagnosis, water treatment, probiotics, and biosecurity programs. According to Watts *et al.,* (2017), antimicrobial resistance and recurring bacterial infections increase production costs by reducing treatment efficiency and requiring improved disease management practices. Export restrictions due to antibiotic residues further contribute to economic losses by affecting market accessibility and consumer acceptance.

Antimicrobial resistance in Vibrio species

Antimicrobial resistance (AMR) has become a major global concern in shrimp aquaculture due to the extensive and sometimes inappropriate use of antibiotics for disease prevention and treatment. Antibiotics such as oxytetracycline, chloramphenicol, florfenicol, enrofloxacin, ciprofloxacin, erythromycin, and sulfonamides have historically been used against bacterial pathogens in aquaculture systems. Cabello (2006) reported that excessive use of antibiotics in aquaculture contributes to the emergence of resistant bacterial populations and creates risks to environmental and human health. Resistant strains of *Vibrio harveyi, Vibrio parahaemolyticus,* and *Vibrio alginolyticus* have been detected in shrimp farming regions worldwide, reducing the effectiveness of conventional antimicrobial treatments. The development of antimicrobial resistance occurs through several genetic mechanisms, including spontaneous mutation, plasmid-mediated resistance, transposons, integrons, and horizontal gene transfer. Watts *et al.,* (2017) explained that aquatic environments act as reservoirs for antimicrobial resistance genes, facilitating their transfer among bacterial populations. The persistence of antibiotic residues in shrimp tissues, pond sediments, and surrounding aquatic ecosystems further increases ecological risks. According to the World Health Organization (WHO, 2023), antimicrobial resistance threatens both animal and human health because resistant bacteria may enter the food chain through contaminated seafood products.

Mechanisms of Antimicrobial Resistance

Pathogenic Vibrio species develop resistance through multiple physiological and molecular mechanisms. One important mechanism involves the production of antibiotic-degrading enzymes such as β-lactamases, which inactivate antimicrobial compounds before they reach their cellular targets. Resistant bacteria can also modify antibiotic target sites, reducing drug-binding efficiency and preventing antimicrobial action. Another important resistance mechanism is reduced membrane permeability, which limits antibiotic entry into bacterial cells. Additionally, Vibrio species possess active efflux pump systems that remove antimicrobial compounds from bacterial cells, allowing survival under antibiotic exposure. Biofilm formation is another major resistance strategy. Bacteria within biofilms are protected by extracellular polymeric substances that reduce antibiotic penetration and protect bacterial communities from environmental stress. Cano-Gómez *et al.,* (2009) reported that biofilm formation contributes significantly to the persistence and pathogenicity of *Vibrio harveyi* in aquaculture environments. Horizontal gene transfer through plasmids, transposons, integrons, and bacteriophages accelerates the spread of resistance genes among bacterial populations. These mechanisms contribute to the emergence of multidrug-resistant Vibrio strains, making disease management increasingly difficult.

Consequences of Antimicrobial Resistance

The emergence of antimicrobial-resistant bacteria has serious consequences for shrimp production, environmental sustainability, and public health. Resistant infections reduce the effectiveness of available antibiotics, resulting in repeated disease outbreaks, increased mortality, and reduced farm profitability. According to Cabello (2006), antibiotic misuse in aquaculture contributes to environmental contamination and increases the risk of transferring resistance genes to human-associated bacteria. Resistant bacteria present in aquatic environments may persist in sediments and spread through water exchange systems. Economically, antimicrobial resistance increases production costs due to repeated treatment attempts, disease monitoring, and implementation of advanced biosecurity practices. Shrimp products containing antibiotic residues may face international trade barriers, reducing export opportunities (Holmstrom *et al.*, 2003). The World Organisation for Animal Health (WOAH, 2023) emphasized the importance of responsible antimicrobial use and encouraged sustainable alternatives such as probiotics, bacteriophage therapy, immunostimulants, biofloc technology, and improved farm management practices. Therefore, controlling bacterial diseases and reducing antimicrobial resistance are essential for sustainable shrimp aquaculture. Integrated approaches combining preventive health management, functional feeds, microbial control strategies, and environmentally friendly technologies are required to ensure long-term productivity and global food security.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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