Chronicle of Aquatic Science
Open Access Peer Reviewed Journal
Vol. 1, Issue 5
https://chronicleofaquaticscience.in/

OPEN ACCESS

Specific Pathogen-Free (SPF) Fish/Shellfish Stocks: Reducing Disease Risk in Aquaculture

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How to cite this article:

Pandit, N., Brahmchari, R. K., Nayak, S. K., Mogalekar, H. S. and Singh, M. K. 2023. Specific Pathogen-Free (SPF) Fish/Shellfish Stocks: Reducing Disease Risk in Aquaculture. *Chronicle of Aquatic Science* 1(5): 49-57.

ABSTRACT

Aquaculture has expanded significantly during the past few decades. As the demand for seafood rise continuously, aquaculture has become a realistic option to supplement wild-caught fish and meet world protein needs. However, the aquaculture sector too faces a number of challenges, including environmental issues and disease outbreaks that may result in huge financial losses. To overcome these problems, in recent years, specific pathogen-free (SPF) seeds have been developed and the success story of *Litopenaeus vannamei* is well known. Specific pathogen-free (SPF) fish and shellfish stocks are intentionally raised and bred to eliminate the detrimental pathogens responsible for causing significant morbidity or mortality. SPF is a promising solution to ensure the sustainability and productivity of aquaculture operations. This article explores the significance of SPF seeds and their potential to create a sustainable future for the aquaculture industry by reducing disease outbreak.

KEYWORDS

Fish/ Shellfish, Specific pathogen-free (SPF), Disease, Aquafarming, Biosecurity

Introduction

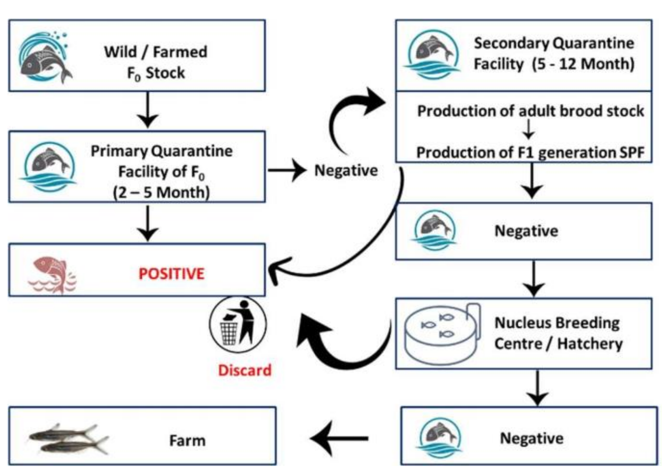
Aquaculture has grown remarkably, to meet the growing demand for seafood. With a large share of the world's seafood supply and a positive impact on food security, economic growth, and job creation, it has gained importance all over the world. The necessity for food security, environmental concerns, and the loss of fisheries resources have together contributed to the growth of the aquaculture industry. However, there are significant challenges to success due to the ever-present threat of a disease outbreak. According to the World Bank (2014), diseases impose an approximate annual economic impact of US$6 billion on the global aquaculture industry. Further, the economic losses resulting from parasitic infestations in global finfish aquaculture industry were estimated to be about US$1.05 to 9.58 billion (Shinn et al. 2015). Meanwhile, in the Asian shrimp aquaculture sector, the annual losses during 2009–2018 were reported to the tune of US$4 billion (Shinn et al. 2018). Similarly, a recent research study estimated that the annual economic losses attributed to shrimp diseases in India leading to an annual loss of 0.21 M ton shrimp amounting approximately US$1.02 billion (Patil et al. 2021). Therefore, for the sustainable growth and development of the aquaculture industry, the implementation of a biosecurity strategy specific for each facility, culture system and sanitary zone is required.

Specific Pathogen-Free (SPF) fish/shellfish stocks

SPF brood stocks or genetically selected stocks are aquatic organisms such as fish or shrimp populations that have been carefully selected for breeding and raised in sterile conditions to ensure that they are free of specific pathogens known to cause disease and improve the overall health and productivity of farmed fish (Barman *et al*. 2012). An animal classified as SPF should meet certain criteria: it originates from a population that has consistently tested negative for specific pathogens for a minimum of two years (with an established surveillance program), it is reared in highly bio secure facilities with appropriate water treatment and enclosed environments, and it is fed with bio secure feeds. Therefore, the SPF designation exclusively pertains to the animal's health history, the facility's sanitary status, and the controlled culture conditions in which it has been raised and maintained (Alday-Sanz, 2018).

Further, within the industry, various categories are established to classify farms based on their compliance with the testing criteria. SPF Category I farms adhere to stringent site requirements regarding water sourcing, prevention of wild fish and fish-eating birds, vehicle access and routes, and exclusively import fish and eggs from other Category I farms. On the other hand, SPF Category II farms have obtained at least two years of negative test results but do not fulfill the site requirements necessary to qualify as Category I (Murray et al., 2022). Fish that successfully complete the various testing procedures and showing that they are free of the targeted pathogens are then used to produce offspring with improved disease-resistance features. SPF seeds provide a healthy foundation for aquaculture operations and help to prevent the introduction and spread of diseases within farms. Selective breeding is a commonly used method to develop SPF seeds. By selectively mating individuals with desirable genetic characteristics such as immune system characteristics or behavioral traits for disease resistance, an aqua culturist can gradually enhance the resistance of the resulting offspring against specific pathogens. To obtain the desired level of disease resistance, this process may take several generations.

Figure 1: Steps to develop SPF Stocks as developed by the U.S. Marine Shrimp Farming Program (after Lightner 2011)



Global Scenario of SPF fish and shellfish stocks

Aquaculture production is increasing dramatically all around the world. But there are numerous viruses, bacteria, fungus, parasites, and other unidentified and developing pathogens continue to have a substantial impact on aquatic animal disease. According to the Food and Agriculture Organization (FAO), disease outbreaks cost the global aquaculture industry some US$6 billion per year and represent the major farm-level risk. Over the past few decades, diseases such as white spot syndrome caused by white spot virus (WSSV), yellow head disease caused by yellow head virus (YHV) and Taura syndrome caused by Taura virus (TSV), heavily impacted shrimp aquaculture in Asia and America leading to collapse the *Penaeus monodon* industry (Vijayan et al., 2015).

Since 2009, some major shrimp producer countries like China, Vietnam, Malaysia, and Thailand have suffered significant losses by a recently emerging diseases such an early mortality syndrome (EMS), also known as acute hepatopancreatic necrosis disease (AHPND). In 2013, AHPND was also found in Mexico with more than 80% mortality in around 50% of shrimp farms that were still in operation with a loss estimated to be $ 116.2 million (Vijayan et al., 2015). By developing SPF fish and shellfish seeds the loss of global aquaculture economy has been reduced up to some extent. Certain specific pathogen-free (SPF) seeds have been developed, including species such as zebra fish, sea bass, and *Litopenaeus vannamei*, as detailed in Table 1 and 2.

Table 1: SPF finfish species developed/under development for aqua farming

SPF fish variety	Resistant to pathogen	Type of pathogen	Developed by	Reference
Zebra fish	*Pseudoloma neurophilia*	Parasite (Microsporidia)	Sinnhuber aquatic resource laboratory, Oregon state university	Kent et al. 2011
Tilapia	Tilapia lake virus disease,	Virus	GenoMar group Central Luzon State	https://thefishsite.com/ articles/genomar-

	VER (viral encephalopathy and retinopathy)		University in the Philippines	secures-spf-status-for-tilapia-facility Machimbirike et al. 2019
Rainbow trout	IHNV(Infectious hematopoietic necrosis virus)	Virus	_	Zorriehzahra et al., 2019

Table 2: SPF shellfish species developed/under development for aqua farming

SPF shellfish spp.	**Resistant to pathogen**	**Type of pathogen**	**Reference**
Litopenaeous vannamei	WSSV (white spot syndrome virus)	Virus	Prochaska et al. 2022
	IMNV (infectious myonecrosis virus)	Virus	
	TSV (Taura syndrome virus)	Virus	
Penaeous monodon	WSSV (white spot syndrome virus)	Virus	Washim et al. 2016
Pacific oyster	Ostreid herpesvirus type 1	Virus	Delisle et al., 2018
Anadara tubetculosa	Bonamia spp., Perkinsus spp.	Parasite	Diringer et al., 2019
	Malaco–herpes virus	Virus	

Indian scenario of SPF shellfish stock

In India, the driving force behind the aquaculture industry is brackish water aquaculture, with a particular emphasis on shrimp farming, which has played a significant role in export revenues. Shrimp farming alone accounts for approximately 67.72% of India's seafood export earning, generating revenue worth Rs. 43,135 crores during 2022-23. The growth of tiger shrimp experienced a remarkable expansion in the early 1990s, but this growth was abruptly halted by the outbreak of the white spot disease (WSSV) pandemic in 1995.

However, since 2009, with the introduction of specifically pathogen-free (SPF) Pacific white shrimp, India's brackish water aquaculture has experienced resurgence. Therefore, India's long-term strategy likely involves the development of its own SPF shrimp stock. The Marine Products Export Development Authority (MPEDA) has already embarked on SPF development initiatives. Furthermore, the Andaman and Nicobar Islands have been identified as a suitable location for a nuclear breeding facility. Hatchery facilities at the Andhra Pradesh Shrimp Seed Production and Research Centre (TASPARC) and the Orissa Shrimp Seed Production Supply and Research Centre (OSSPARC) are involved in testing the SPF brood stock in a commercial production environment. The Aquatic Quarantine Facility at Chennai established in 2009, plays a crucial role in ensuring the SPF status of imported brood stock, particularly *Litopenaeus vannamei*, which is essential for mitigating the risks associated with continuous imports of *L. vannamei* broodstock. Further, the Coastal Aquaculture Authority (CAA) has approved a total of 314 SPF *L. vannamei* hatcheries and 183 Nauplii Rearing Hatcheries (NRH) located in coastal states. These facilities have a combined production capacity of approximately 80,000 million seeds, including NRH, for *L. vannamei* seed production, spanning the period from 2009 to December 2022. A detailed guideline has been laid down by Department of Animal Husbandry, Dairying and Fisheries, Government of India for regulating the establishment and operation of Specific Pathogen Free (SPF) Shrimp Broodstock Multiplication Centres in the coastal areas, especially for two species, Pacific White Shrimp - *Litopenaeus vannamei* and Black Tiger Shrimp - *Penaeus monodon*. In addition, recent efforts by ICAR-CIBA, Chennai, who initiated a Genetic Improvement Programme for *Penaeus indicus*, the Indian white shrimp. This program aims to diversify the shrimp farming sector and improve the genetic traits of this species.

Conclusion

Aquaculture has expanded significantly, offering a different and sustainable supply of fish. But the industry faces tough obstacles from disease outbreaks. The introduction of specific pathogen-free (SPF) seeds has revolutionized aquaculture by preventing the spread of diseases and improving production efficiency. Aqua culturists can encourage sustainable and responsible fish farming practices while ensuring the health and production of farmed fish by selectively breeding or genetically engineering fish populations with greater resistance to specific pathogens. Farmers can increase output, lessen dependency on wild populations, and maintain genetic diversity by starting with disease-free animals. For further development in aquaculture, this requires ongoing research, technological developments, and stakeholder cooperation.SPF seeds must continue to be developed and used in order for the aquaculture industry to be robust and environmentally sustainable.

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