VOLUME 11 ISSUE 1 2025

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 11, No. 1, 594-604 (2025)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Optimizing Water Quality and Management Practices for Sustainable *Litopenaeus vannamei* Culture in Parangipettai, Tamil Nadu, India

Naskar Bidesh[1], Harikrishnan S.[2], Parivallal M.[1], Dhinesh P.[3] and Sundaramanikam A.[1]*

[1]Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai, Tamil Nadu 608502, India
[2]Centre for Pollution Control and Environmental Engineering, School of Engineering and Technology, Pondicherry University, Kalapet, Puducherry, 605014, India
[3]Department of Aquatic Animal Health Management, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Dr. M.G.R Fisheries College and Research Institute, Ponneri, Tamil Nadu 601 204, India

**Corresponding Author*

Received: 2nd February, 2025; **Accepted:** 2nd April, 2025; **Published online:** 24th April, 2025

https://doi.org/10.33745/ijzi.2025.v11i01.062

Abstract: This study was conducted at a shrimp pond in Parangipettai, Cuddalore district, Tamil Nadu, India to assess the hydro-biological conditions and management practices for *Litopenaeus vannamei* culture. The experimental pond covered an area of 2960 m^2, with a water spread of 2300 m^2. Various pond preparation techniques, including soil treatment, pH stabilization, and water conditioning, were employed to optimize the culture environment. Water quality parameters such as temperature, dissolved oxygen, salinity, and pH were monitored regularly. The shrimp were stocked at a density of $20/m^2$, and feeding practices were carefully managed. The study found that the pond was highly productive, with stable water quality parameters conducive to shrimp growth. Harvesting results indicated an FCR of 1:1, demonstrating effective feed utilization. The study also identified key constraints such as seepage, predatory fish infestation, and insufficient water pumping. The findings suggest that improving infrastructure, such as using a 10 HP pump and implementing protective fencing, can enhance sustainability. This research contributes to better management strategies for shrimp farming, ensuring higher productivity and profitability.

Keywords: *Litopenaeus vannamei*, pH, Temperature, Dissolved oxygen, FCR

Citation: Naskar Bidesh, Harikrishnan S., Parivallal M., Dhinesh P., Sundaramanikam A.: Optimizing water quality and management practices for sustainable *Litopenaeus vannamei* culture in Parangipettai, Tamil Nadu, India. Intern. J. Zool. Invest. 11(1): 594-604, 2025.

https://doi.org/10.33745/ijzi.2025.v11i01.062

Introduction

The culture of *Litopenaeus vannamei*, a globally significant shrimp species, in Parangipettai, Tamil Nadu, India necessitates a comprehensive approach to water quality management and the adoption of sustainable practices to ensure long-term viability (Mishra *et al.*, 2017). Traditional shrimp farming methods often exhibit inefficiencies in labor and cost-effectiveness, highlighting the urgent need for technological integration to enhance real-time monitoring and objective data acquisition in aquaculture systems (Intan *et al.*, 2020). Furthermore, the indiscriminate expansion of aquaculture can encroach upon sensitive ecosystems like mangrove forests, underscoring the importance of responsible spatial planning and the adoption of environmentally sound aquaculture technologies (Ferdiansyah *et al.*, 2022). The transformation of shrimp farming from a traditional activity to a highly commercial enterprise in India within a few decades stands as a remarkable achievement in aquaculture, primarily propelled by technological advancements in shrimp seed production and culture technologies (Durai *et al.*, 2020).

Maintaining optimal water quality is paramount for successful *L. vannamei* culture, requiring continuous monitoring and precise control of various parameters. With the expansion of aquaculture activities, the aquatic environment has deteriorated, further making cultured animals susceptible to pathogens (Mishra *et al.*, 2017). Factors such as pH, salinity, temperature, dissolved oxygen, ammonia, nitrite, and nitrate play crucial roles in shrimp health and productivity (Deepti *et al.*, 2024). Dissolved oxygen is especially critical, with levels below 4 mg/l causing stress and mortality in *L. vannamei*, which necessitates the use of aeration devices to maintain adequate DO levels, particularly in densely stocked ponds (Mishra *et al.*, 2017). Moreover, water temperature significantly influences shrimp metabolism and growth rates, with optimal temperatures typically ranging from 28°C to 32°C. Salinity, another critical parameter, affects the osmotic balance of shrimp, with *L. vannamei* exhibiting a wide tolerance range but generally thriving in salinities between 15 ppt and 25 ppt. Regular monitoring and adjustment of salinity levels are crucial, especially in areas with fluctuating freshwater inputs.

Effective management practices are essential to mitigating the environmental impacts of shrimp farming and ensuring the sustainability of *L. vannamei* culture. This includes the implementation of closed-loop systems or recirculating aquaculture systems to minimize water usage and discharge of pollutants. The aquaculture sector has witnessed remarkable growth in both fish and shrimp production, this progress has been accompanied by unwarranted activities that impact both the species and the environment (Mishra *et al.*, 2017). Additionally, the use of probiotics and biofloc technology can improve water quality by promoting beneficial microbial communities that consume organic waste and reduce the accumulation of harmful substances like ammonia and nitrite. The integration of industry, university, and research has guided scientific research institutes to closely integrate with enterprises, like the establishment of the first joint breeding center of *L. vannamei* in China (Tian *et al.*, 2024). Furthermore, the judicious use of antibiotics and chemicals is necessary to prevent the emergence of antibiotic-resistant bacteria and minimize the risk of environmental contamination.

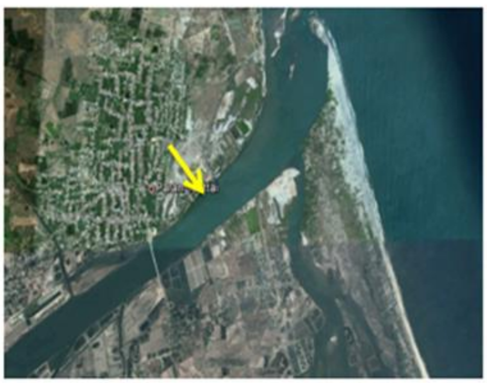
Disease prevention and control are critical aspects of sustainable *L. vannamei* culture, with viral diseases like white spot syndrome virus posing a significant threat to shrimp production. The development of hatchery breeding technologies was matured *Penaeus monodon* brood stocks were collected from wild and used for the production of Post Larvae and raided for stocking. Implementing stringent biosecurity measures, such as disinfection of rearing water and selection of pathogen-free broodstock, is essential to minimize the risk of disease outbreaks (Yoshimizu, 2009). Vaccination and immunostimulants can also enhance the disease resistance of *L. vannamei*, reducing the reliance on antibiotics and other chemotherapeutic agents. The use of appropriate water quality parameters, stocking densities, and feed management practices are important in minimizing the occurrence and spread of diseases in shrimp farms. By implementing these strategies, the *Litopenaeus vannamei* culture in Parangipettai can achieve enhanced sustainability.

The intricate balance between host, pathogen, and environment is critical in aquaculture, and its disruption can lead to disease outbreaks, emphasizing the need for better management practices to prevent production losses (Suguna, 2020). The increasing emergence of diseases in fish and shrimp is primarily driven by anthropogenic activities, including the increasing loads of pollutants, contaminants and toxins in aquatic habitats that threaten the health and disease-resistance of both native and farmed fish populations (Mishra *et al.*, 2017). The application of Best Aquaculture Technologies, such as advanced water treatment systems and water management tools, are essential for disease identification, minimization, and mitigation (Drillet *et al.*, 2014). Developing more effective strate-gies to manage water quality and prevent and control fish diseases requires more information to elucidate host-pathogen environment interactions.

Farmers commonly use probiotics, drugs, chemicals, antimicrobials, sanitizers, anti-parasitic drugs, and antibiotics as preventive and control measures in fish culture systems, highlighting the importance of understanding disease prevalence and indigenous prevention technologies (Suguna, 2020). Furthermore, integrated approaches like disease surveillance, pathogen zoning, and disease forecasting are vital for implementing preventive and control measures (Mishra *et al.*, 2017). The parasitic diseases such as dactylogyrosis, paradac-tylogyrosis and argulosis are observed to be very frequent in occurrence and bring out heavy economic loss, which also coincides with the reports of Suguna (2020). Water quality deterioration, leading to stress in cultured animals, can trigger infections by opportunistic pathogens, making knowledge of fish health management crucial for preventing economic losses (Suguna, 2020). Addressing these issues requires a multifaceted approach that integrates scientific research, technological innovation, and responsible management practices to ensure the long-term sustainability of aquaculture (Ahne *et al.*, 1989; Faisal *et al.*, 2017; Mishra *et al.*, 2017; Raman, 2017). Plant-derived medicines are known to have very high therapeutic value and have been used from time immemorial in the treatment of various ailments in humans and livestock (Raman, 2017). Recently, there has been a growing interest in the use of medicinal plants and their bioactive compounds to control diseases in fish farming, offering a potentially cheaper and more effective alternative to chemotherapy (Tavares-Dias, 2018). The advantage of using medicinal herbs is that they are easily available, biodegradable and have fewer side effects (Valladão *et al.*, 2015; Rukisah *et al.*, 2019; Hoseinifar *et al.*, 2020). Several studies have demonstrated that medicinal plants have significant antibacterial, antifungal, antiparasitic and antiviral activities against various fish pathogens (Pandey, 2013). Medicinal plants also act as immunostimulants, conferring early activation to the non-specific defense mechanisms of fish and elevating the specific immune response (Pandey, 2013). A number of medicinal herbs, including garlic, ginger, turmeric, neem and holy basil, have shown promise in controlling ecto-parasitic infections in fish (Pandey, 2013).

The use of antibiotics in aquaculture has come under scrutiny due to the emergence of antibiotic-resistant bacterial strains, accumulation of residual antibiotics in edible tissues, and depression of immune systems (Carbone and Faggio, 2016; Kumar and Roy, 2017). Nutritional approaches, such as providing better nutrition to improve health, are essential to alleviate diseases among farmed aquatic animals, as nutritional imbalances, especially during larval and juvenile stages, can profoundly affect growth, disease resistance, and survival (Kiron, 2012). The integration of probiotics, prebiotics, and synbiotics into aquafeeds is also a promising strategy to improve the functionality of aquafeeds, upgrade growth, reproduction, immunity, and disease resistance in fish (Rohani *et al.*, 2021). The use of herbal-based immunostimulants in aqua-

Fig.1: *Litopenaeus vannamei*.



Site	Parangipettai
District	Cuddalore
State	Tamilnadu
Latitude	11°29'25.55"N
Longitude	79°45'38.62"E

Fig. 2: Study area.

culture has opened a new vista in fish health protection, proving to be an effective means of increasing immunopotency of fish (Raman, 2017).

This study was conducted at a shrimp pond in Parangipettai, Cuddalore district, Tamil Nadu, to assess the hydro-biological conditions and management practices for *Litopenaeus vannamei* (Fig. 1) culture.

Materials and Methods

The present study was undertaken at shrimp pond (11.490, 79.765) in Parangipettai, Cuddalore district, Tamil Nadu, India. Total size of the experimental pond was about 2960 m^2 and water spread area was 2300 m^2 (Fig. 2). Parangipettai is situated on the Southeast coast of India, towed with a variety of biotopes and with rich biodiversity. Vellar estuary is a positive estuary as it has connection with the adjoining sea throughout the year. This estuarine environment serves as a good nursery area for many commercially important marine organisms and also supports many aquaculture farms on both banks of the estuary. The mangroves were planted on the southern banks of Vellar estuary in March 1994. The vegetation has an area of 402.8 m^2 with 26.5 m length and 15.2 m breath. Thus existing mangrove species are *Avicennia marina*, *Rhizophora apiculata* and *R. mucronata* with a total number of 1800 with a density of plants 4.4 m^2.

Pond Preparation

The pond bottom was allowed to dry and crack to

Fig. 3: Seed stocking.

promote the capacity of the hydrogen sulphide. and to eradicate the micro or macro-organisms and other predators. The scraping of pond bottom was made up to 3-4 inches and special in zone of high organic black soil areas by using traditional plougher. The scraping black soils were removed and thrown away from the pond side. Then the pond bottom was thoroughly ploughed at a depth of 30 cm to remove the obnoxious gases existing in the soil. The pond bottom was treated with lime as well as bleaching powders.

From the Vellar estuary the saline water was allowed to enter the pond through pumping after fine filtration systems up to 2-3 ft water level. The filled water was left for one week. The pond water has conditioned with minerals, probiotic, yeasts, local prepared organic juice etc. before stocking.

pH (Hydrogen Ion Concentration)

The pH of the pond was measured using an electronic pH pen. The average pH of the soil was measured with the help of pH meter. The lime was applied to maintain the pH at 7.8 and above. In the morning time the pH was 7.8 and in evening time pH was 8.2

Temperature

Water temperature was measured in the pond itself using a standard centigrade thermometer.

Dissolved Oxygen

The dissolved oxygen was determined using the modified Winkler's method, following the procedure outlined by Strickland and Parsons (1972).

Transparency

Transparency was quantified in terms of the light penetration, using a Secchi disc.

Water Quality Parameters

The major water parameters were measured and recorded weekly by the help of field testing instruments and test kits. The major water quality parameters like salinity, dissolved oxygen, pH, temperature and total ammonia nitrogen (TAN) are monitored at regular intervals. The major water parameters of pond were in following range.

Stocking

The stocking of *L. vannamei* post larvae PL10 were procured from the J.J Shrimp Hatchery in Marakkanam after quality and PCR tests. The shrimp post larvae were transported from hatchery to culture pond by road. The stocking of post larvae are undertaken after proper acclimitzation process (Fig. 3).

Stocking Density

The pond was initially stocked with 45000 seeds which was mostly in the stage of PL9-PL10. Density of stocking was as low as 20/m^2

Feeding

Formulated commercial pellet feed of Royal

Fig. 4: Feeding.

Fig. 5: Check tray feeding.

Dragon (DTI 311) was initially started. This feed was fed for 30 days @8% body weight and then started with (DTI 312) @ 6% of the body weight. Generally feeding has been done twice a day (Fig. 4).

Check Tray Monitoring

Feeding trays are typically used to avoid overfeeding in aquaculture production systems. They are sometimes used to deliver 100% of the feed and other times to evaluate broadcast feeding efficiency with a small number of trays. They are credited with reducing feed cost per unit of production, but there is seldom mention of their effects on overall crop profitability (Fig. 5).

Rainfall

The rainfall data was obtained from the Meteorological records from Centre of Advanced Study in Marine Biology at Parangipettai. Since the pond was a rain fed pond hence, water from rainfall was harvested for 6 months (August-January) and the culture was carried out in the harvested rainwater.

It was seen that, the maximum rainfall was obtained in the month of November (687 cm) while the minimum amount of rainfall was received in the month of January (32 cm) which is why harvesting was done during these months (Fig. 6).

Application of the Probiotics

Probiotics defined as micro-organisms that have a beneficial effect on the host intestinal microbial balance. Probitics organisms are live organisms

Fig. 6: Monthly rainfall.

Fig.7: Harvesting by drag net.

thought to be beneficial to the host organisms. Two of the most well-known probiotic bacteria include *Lactobacillus* and *Bifidobacteria*.

Harvesting

Harvesting was done at morning by using drag net. All the cultured animals were harvested from the pond and sold to local market. The length and weight of the harvested animals were monitored and recorded (Fig. 7).

Results and Discussion

pH (*Hydrogen Ion Concentration*)

The pH varied between 7.5 - 8.9. The maximum pH was found during the month of November when the DOC was 15 days and the minimum was observed during month ends i.e. on 30 DOC. The pH values did not show a great fluctuation and it was always on the alkaline side which is the ideal condition for shrimp culture. The lower pH values

Table1: Water Quality Parameters

Water Parameters	Value Ranged
pH	7.2-8.6
Salinity (ppt)	25-32
Dissolve Oxygen (ppm)	3.6-6.1
Ammonia (ppm)	0.1-1.5
Temperature ^{0}C	25-34

Table 2: Physio-chemical feature of water during the culture of *Litopenaeu svannamei*

S. No.	Parameters	Minimum	Maximum
1.	Salinity (ppt)	25	33
2.	pH (Hydrogen Ion concentration)	7.2	8.3
3.	Temperature (^{o}C)	27	32
4.	Dissolved Oxygen (ml/L)	6	8
5.	Transparency (cm)	22	65

Table 3: Details of the culture

D.O.C.	Total pond area		Total seed stocked	Stocking density	Survival	Total feed	A.B.W	A.D.G	Total harvested biomass
87	Length (65.51m)	Breadth (43.75m)	45,000	16/m^2	6% (2,700 animals)	80 kg	30 g	0.2 g	80 kg

in the pond during the month ends might be due to the decomposition of organic matter associated with the influx of rainwater.

The hydro-biological regime is a highly complex factor in shrimp farming due to the slow movement of water, shallow depth, intensive stocking of shrimps, algal development, and accumulation of organic matter. Variations in dissolved oxygen, temperature, salinity, and productivity rates are key factors in the culture system, playing a significant role in maintaining the prawns in good condition (Shigueno, 1972). Salinity fluctuations in tropical countries are primarily influenced by freshwater runoff or monsoon months. In the culture pond, the initial salinity was 25 ppt, gradually increasing to 33 ppt through regular pumping of estuarine water for three hours. Maximum salinity was recorded in April, while the minimum was observed in May. Harvesting was conducted at 31 ppt salinity. The pond temperature varied between 27-32°C, with the highest temperature recorded in May (DOC 80) and the lowest at the beginning of the month (DOC 30). Initially, the temperature was low due to the fresh introduction of water but gradually increased over time. The oxygen level in the water ranged from 6-8 ml/l. The highest dissolved oxygen (DO) levels were recorded at the start of the culture period due to the influx of natural waters from rainfall. Over time, DO levels gradually decreased, likely due to the accumulation of organic matter, which increased oxygen demand. Fluctuations in DO levels in the culture pond were also influenced by the respiration of organisms. At night, DO levels were lower. Maintaining adequate dissolved oxygen in the pond is crucial for shrimp health, as it is a key element in their survival and growth (Tables 1, 2).

Water transparency ranged from 22 to 65 cm. Maintaining stable water color (phytoplankton bloom) is a key factor in ensuring good water quality. The color of the pond water reflects the type of plankton present, with phytoplankton density measured using a Secchi disc. The recommended Secchi disc reading for optimal shrimp culture is between 30-40 cm. Phytoplankton and zooplankton standing stocks significantly influence water turbidity. Secchi disc depth measurements provide a rough estimate of chlorophyll concentration and algal population density, making them a useful tool for characterizing water quality parameters. Comparing these results to previous studies, it has been observed that similar temperature fluctuations and dissolved oxygen levels were reported by Boyd and Tucker (1998), who stated that shrimp survival rates significantly decline when DO drops below 4 mg/L. Additionally, Alam *et al.* (2019) found that maintaining a stable salinity between 25-35 ppt results in higher growth rates and survival in *L. vannamei*. Our findings align with these studies, reinforcing the importance of maintaining optimal environmental conditions.

The present observations indicate that the pond was highly productive and suitable for shrimp culture. Favorable environmental conditions and high organic production supported shrimp growth and the maintenance of a high biomass in the pond ecosystem (Table 3).

Key culture parameters

- Total harvested biomass: Number of shrimps/count
- Count: 1000/ABW
- Feed Conversion Ratio (FCR)**:** Total feed given/total biomass harvested = 80/80 = 1:1

Challenges and Solutions

Seepage was a major issue in the culture pond due to creeks in the bund. Other constraints included predatory fish infestation, insufficient water inflow (due to the availability of only a 5 HP motor), and poaching by local fishermen. These issues can be mitigated by using a 10 HP pump with a 4-inch diameter PVC pipe to maintain appropriate water levels, installing fencing with area lighting to prevent poaching, and conducting repair works in Pond 2 to support sustainable shrimp farming.

The Pacific white-legged shrimp (*Litopenaeus vannamei*) dominates shrimp culture in India, accounting for 90% of total shrimp production. It exhibits a fast growth rate, and its culture period is significantly shorter than that of *Penaeus monodon*, making it a preferred alternative.

Rao *et al.* (2014) reported studied the effect of endemic viral diseases on *L. vannamei* in India and emphasized the importance of SPF broodstock, high-health post-larvae production, and strict quarantine measures**.** Srinivas Rayaprolu (2014) examined running mortality syndrome (RMS), attributing it to poor pond management, including low post-larvae quality, overfeeding, and stocking beyond the pond's carrying capacity. Gunalan *et al.* (2010) presented findings on freshwater *L. vannamei* culture, outlining essential farm management practices. Laramore *et al.* (2001) studied the impact of low salinity on the growth and survival of post-larval and juvenile *L. vannamei*.

In the present study, a stocking density of 16 animals per m^2 was found to be unsuitable when water depth was below 40 cm and temperature exceeded 30°C. Farmers can experiment with this stocking density per m^2 using 10 HP pumps, but certain conditions must be maintained: water depth above 2.5 ft, absence of predators, proper feeding, regular water pumping, and routine sampling. Additionally, shrimp seeds were stocked at 27 ppt salinity, and growth rates were found to be satisfactory under these conditions.

Conclusion

The present study highlights the importance of water quality management and best aquaculture practices in *L. vannamei* culture. The hydro-biological conditions of the pond were found to be suitable for shrimp growth, with stable pH, salinity, and dissolved oxygen levels. The study confirmed that the Pacific white shrimp exhibited optimal growth when stocked at appropriate densities and provided with regular monitoring and management.

Ethical Statement

The authors confirm that all ethical issues have been dealt with the research ethics guidelines provided by the Department of Aquatic Animal Health Management, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Dr. M.G.R Fisheries College and Research Institute, Ponneri, Tamil Nadu 601 204, India

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Acknowledgements

The author gratefully thanks Annamalai University, Tamil Nadu, India for providing lab facilities.

Conflict of Interest

The authors declare no conflicts of interest.

References

Ahne W, Winton J and Kimura T. (1989) prevention of infectious diseases in aquaculture. J Vet Med Series B 36: 561.

Carbone D and Faggio C. (2016) Importance of prebiotics in aquaculture as immunostimulants. Effects on immune system of *Sparus aurata* and *Dicentrarchus labrax.* Fish Shellfish Immunol. 54: 172.

Deepti M, Meinam M, Devi NC, Singh SK and Devi WM. (2024) Aquamimicry (Copefloc technology): an innovative approach for sustainable organic farming with special reference to shrimp aquaculture. Blue Biotechnol. 1: 5.

Drillet G, Chan N, Drillet Z, Foulsham AJ, Ducheyne A, Hans SE, Claire S, Benni WH and Rikke L. (2014) Opinions on the sustainable development of aquaculture. J Fisheries Livest Prod 2: 118.

Durai V, Alagappan M and Venkatesan M. (2020) Techno-economic analysis of Shrimp farming in Coastal districts of Tamilnadu. J Entomol Zool Stud. 8(4): 2193.

Faisal M, Samaha H and Loch TP. (2017) Planning a fish-health program. Elsevier BV, pp. 221.

Ferdiansyah D, Darmawan A, Wahyurini ET and Sugiono S. (2022) Shrimp pond suitability index (SPSI) in the north coast of Sumenep Regency. IOP Conference Series Earth and Environmental Science, 967(1): 12003. https://doi.org/10.1088/1755-1315/967/1/012003

Gunalan B, Soundarapandian P and Dinakaran GK. (2010) Effect of different stocking densities on the MBV infected seeds of black tiger shrimp, *Penaeus monodon* (Fabricius). Asian J Agricult Sci. 2(1): 5-8.

Hoseinifar SH, Sun Y, Zhou Z, Doan HV, Davies SJ Harikrishnan R. (2020) Boosting immune function and disease bio-control through environment-friendly and sustainable approaches in finfish aquaculture: Herbal therapy scenarios. Rev Fisheries Sci Aquacult. 28(3): 303.

Intan I, Nurlina N and Pangerang F. (2020) Water circulation monitoring system in the vanname shrimp cultivation based on internet of thing. Jurnal Pekommas 5(2): 203.

Kiron V. (2012) Fish immune system and its nutritional modulation for preventive health care. Animal Feed Sci Technol. 173: 111.

Kumar V and Roy S. (2017) Aquaculture drugs: Sources, active ingredients, pharmaceutic preparations and methods of administration. J Aquac Res Development 8: 510.

Laramore S, Laramore CR and Scarpa J. (2001) Effect of low salinity on growth and survival of postlarvae and juvenile *Litopenaeus vannamei*. J World Aquacult Soc. 32(4): 385-392.

Mishra S, Das R, Choudhary P, Debbarma J, Sahoo S, Giri B, Rathod R, Kumar A, Mishra C and Swain P. (2017) Present status of fisheries and impact of emerging diseases of fish and shellfish in Indian aquaculture. J Aquat Res Mar Sci. 5: 26.

Pandey G. (2013). Some medicinal plants to treat fish ectoparasitic infections. Int J Pharmaceut Res Sci. 2(2): 532-538.

Raman RP. (2017) Applicability, feasibility and efficacy of phytotherapy in aquatic animal health management. American J Plant Sci. 8(2): 257.

Rao ER, Venkatrayulu CH and Venkateswarlu V. (2017) Effect of herbal feed supplement Phytozoi on Running Mortality Syndrome in white leg shrimp *Litopenaeus vannamei* (Boone, 1931) farming. Int J Fisheries Aquat Stud. 5(3): 365-368.

Rohani MF, Islam SM, Hossain MK, Ferdous Z, Siddik MAB, Nuruzzaman M, Padeniya U, Brown CL and Shahjahan M. (2021) Probiotics, prebiotics and synbiotics improved the functionality of aquafeed: Upgrading growth, reproduction, immunity and disease resistance in fish. Fish Shellfish Immunol. 120: 569.

Rukisah R, Maulianawati D and Cahyadi J. (2019) In vitro antibacterial efficacy of leaves extract of *Centela asiatica* against *Vibrio harveyi* and *Aeromonas hydrophila.* Indonesian Aquacult J. 14(2): 69.

Suguna T. (2020) Survey on occurrence of parasitic diseases in carp culture ponds of West Godavari, Andhra Pradesh. Int J Curr Microbiol Appl Sci. 9(10): 2306.

Tavares-Dias M. (2018) Current knowledge on use of essential oils as alternative treatment against fish parasites. Aquat Living Resources 31: 13.

Tian J, Wu W, Li J, Wan X, Zhao Z, Xi R, Hu X, Pan M, Xue Y and Yu W. (2024) Development dilemma of *Litopenaeus vannamei* industry in China, current countermeasures taken and its implications for the world shrimp aquaculture industry. Israeli J Aquacult Bamidgeh 76(3): 106-116.

Valladão GMR, Gallani SU and Pilarski F. (2015) Phytotherapy as an alternative for treating fish disease. J Vet Pharmacol Therapeut. 38(5): 417.

Yoshimizu M. (2009) Control strategy for viral diseases of salmonid fish, flounders and shrimp at hatchery and seed production facility in Japan. Fish Pathol. 44(1): 9.