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Effect of physicochemical parameters on growth performance of marine prawn *Litopenaeus vannamei*

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ABSTRACT
Since nearly three decades ago, brackish water aquaculture has been practiced extensively in India to meet the demand for seafood in the country and to expand exports. Furthermore, it assists in curbing the overexploitation of natural resources. However, aquaculture industry issues have become evident in terms of deterioration of natural water quality. To ensure the health status of natural resources (coastal, estuary, backwaters, creeks, etc.) it is necessary to monitor the water quality parameters regularly. Various physicochemical parameters, feeding rate, water exchange rate, influence of stocking density, and growth rate of *Litopenaeus vannamei* were investigated *invivo* (direct field) over 45 days in three ponds. The first stage juveniles of *L. vannamei* were planted at varying densities in each pond and harvested on a regular basis for routine analysis. Comparatively, the pH and ammonia were high in P1 and lower in P2 and P3 during the culture. After 45 days of culture, the average stocking density of shrimps reared in P3 was greater up to 336715 counts and lower up to 296474 counts in pond 1. Furthermore, the survival rate of shrimps in the P3 pond was up to 92% followed by P2 (81%), whereas the rate in the P1 pond was only up to 60%. Based on these findings, it is recommended to use a stocking density similar to that of pond P2 and P3 for the culture of *L. vannamei* in the Velankanni area of Tamil Nadu, South India, under these specific field conditions.
Keywords: *Litopenaeus vannamei,* physico-chemical parameters, Growth parameters*,* Velankanni

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INTRODUCTION
Global aquaculture production has demonstrated tremendous growth over the past few years as more species of aquatic animals, particularly fish, shellfish, and seaweed, are cultivated in freshwater or marine environments for food production (1, 2). Among all food-producing industries, aquaculture has seen the best growth over the past few years. China is the world's leading aquaculture producer (67%), followed by India (6%), and Vietnam (3%) (3). According to The latest estimates from the Food and Agriculture Organisation (FAO) show that global aquaculture fish production has been growing at a rate of approximately 10% per year. This has resulted in an increase from about 10 million metric tonnes (MT) in 1984 to over 39 million tonnes in 1998. In contrast, the production from capture fisheries has only increased by less than 1% to reach 87 million tons in 1998 (4). Total global aquaculture production in 2004 was 59.4 million tonnes, valued at $70.3 billion (5). Although aquaculture has been practiced for millennia, the majority of its growth has occurred in the previous three decades. Between 1980 and 2004, total global aquaculture production increased approximately ninefold (6). Aquaculture output in 2012 is expected to be around 66.5 million tonnes. FAO has collected complete global statistics on aquaculture production, and the results will be released in early March 2014 (7).
The use of antibiotics in aquaculture has led to the emergence of resistant strains, making antibiotics less effective. A recent study by NOAA suggests that aquaculture has a minimal impact on the environment (8). The effects of aquaculture are usually localized and temporary, and in some cases, it can even have positive environmental benefits (9). For example, when filter feeding shellfish like oysters are cultured in their natural habitat, it can improve water quality in ponds and lakes. Despite some known issues, government agencies view aquaculture as a viable and sustainable solution for the declining wild marine fish populations worldwide (10). Land-based fish farms, similar to large aquariums, need to regularly change the dirty water in order to maintain the quality of the fish culture. Depending on the setup of the system, this can lead to the release of significant amounts of wastewater into the environment, which contains

feces, nutrients, and chemicals. The presence of nutrients can cause the growth of algae, leading to a decrease in oxygen levels in the water or eutrophication (11), which can be harmful to aquatic animals. Additionally, chemicals like antibiotics and water treatment agents are commonly used in the aquaculture industry (12). To prevent this problem, it is necessary to treat the wastewater from aquaculture before it is discharged.

Shrimp production is a component of aquaculture. Asia accounts for the vast bulk of worldwide prawn aquaculture production (13). In the 1980s, significant funding was allocated to aquaculture projects in Asia and Latin America, which helped establish the industry by providing the necessary capital. The size and extent of these investments, along with the presence of suitable land and a readily available workforce, gave Asian and Latin American countries a competitive edge (14). Asian and Latin American countries have gained a competitive advantage in aquaculture due to their significant investments, available land, and abundant labor force. In 1998, Asia alone produced over 90% of the global quantity and more than 80% of the value of aquaculture, with China being the leading producer accounting for over 75% of Asia's total production. Other significant producers include India, the Philippines, and Indonesia. Shrimp cultivation in brackish water conditions is common, and the introduction of *L. vannamei* shrimp in Asia for commercial purposes in 1996 has been widely practiced. In India, *L. vannamei* shrimp culture has expanded beyond Gujarat, Andhra Pradesh, and Tamil Nadu to various parts of the country due to its rapid growth in both brackish water and freshwater and the need for freshwater is greatly increasing at the same time

Hence, this study was conducted in *in-vivo* at RAF (Dr. Ravikumar Aqua farm), Velankanni, Nagapattinam District, Tamil Nadu, India (Lat. 10.6814° N; Long. 79.8504° E). Experiments were conducted during August 2022 to October 2022. Over all study deals with the effect of stocking density of shrimp species (*L. vannamei*) in three ponds on physicochemical analysis, shrimp weight, biomass and survival rate.

Material and Methods

Study area

Study area is Velankanni coastal village (Lat. 10.6814° N; Long. 79.8504° E). The study area was selected based on its coastal agro-ecosystem, issues related to soil and water salinization, and conversion of substantial agricultural land into aquaculture farms. More than 25 hectares of this uncultivated agricultural land has been used for aquaculture. Location was used as the study area and the satellite image was shown in Figure 1a & b.

Fig 1: Location and Collection site

Pond preparation

The surface of the pond was scraped to a depth of 2-3 inches and then tilled with a tractor. The pond was then left to dry for about a week. After the week, sea water was pumped directly from the sea into the dried pond, filling it up to a height of 150 cm. Sodium hypochlorite powder at a concentration of 10ppm was added to each pond. The water was left to sit for 3 days to remove any odor. Lime powder was then added to the pond and left for one day. Probiotics were applied to the pond to promote the growth of algae. Once the algae had developed, *L. vannamei* seeds were introduced into the pond (Fig 2 a-d). The pH, dissolved oxygen, ammonia, salinity, and feed consumption were regularly monitored. Care was taken to maintain the salinity of the pond water at a level of 15 to 25 ppt.

Fig 2: Pond Preparation and Shrimp Collection

Shrimp and experimental conditions

Juveniles of *L. vannamei* were obtained from the hatchery at Marakkanam, Villupuram District, Tamilnadu, India. Prior to start the experiment, the shrimps were acclimated to the culture environment for 3 weeks and fed with a commercial diet. The experiments were conducted after 15 days of the pond preparation and P1, P2 and P3 ponds covers (0.66 hec) with initial stocking density of 353000, 371000 and 351000 Sp (Shrimp pieces) of similar size with rough body weight 0.30g were randomly distributed, respectively. Each pond was regularly fed with appropriate diet in same interval. All groups of shrimps were fed to apparent satiation four times daily. Feed were put in a 25 x 25 cm feeding tray that was placed at the bottom of each pond after feeding time 2 hour to check the feeding tray to find out the consumption any uneaten feeds were collected by siphoning, then dried, weighed and used to calculate feed intake.

Physico-chemical parameters were analyzed using water analysis kit and APHA 196516 at 5 days interval after introduction of shrimp seed. The water exchange treatment process was also started after 20 days of culture period and maintained for three pond (P1, P2 and P3) and water pH, salinity and Ammonia were recorded. The ammonia (Method: Colorimetric 200 determinations) was estimated using test kits (Aqua and Aqua Purchased from Advanced Pharma Co., Ltd, Thailand). The pH and salinity were determined using pH meter/pH paper and refractometer, respectively. Water quality parameters were monitored in 5 days once at the laboratory.

Experimental diet analysis

Commercially available probiotic, Zymetin (ZY) was used in this study. Two hundred milliliter of the ZY with rice bran, tapioca flour, sugar and yeast were added to 200 L of freshwater and left overnight with vigorous aeration. After fermentation, the slurry was applied evenly in the ponds. Diets were then stored in clean plastic bags at 4°C until use.

Periodic survey of shrimp survival analysis

After a culture period of 45 days, the feed consumption, survival, weight and biomass of shrimp were measured on 10 days once and recorded as averages. If the growth was found to be decreasing, a water treatment process would be implemented to enhance shrimp growth and production. At the end of the 45th day, the fully grown shrimps were harvested. A square meter of net was placed in the pond water and 25 shrimp individuals were analyzed and the survival rate of the shrimp was calculated using a specific formula (1).

$$\text{Survival (\%)} = \frac{\text{Number of shrimp species}}{\text{Initial shrimp species}} \quad X\ 100$$

Data Collection

After 45 days all shrimp species from each pondweresampledrandomlycollectedat10 days interval to assess shrimp body weight and total biomass. The total biomass was estimated using following formula (2).

$$\text{Bodyweight(gm)} = \frac{\text{kg}}{\text{No.of shrimp pieces}}$$

$$\text{Total biomass (kg)} = \frac{\text{No.of Shrimp pieces 'x Bodyweight}}{1000}$$

RESULTS AND DISCUSSION

Diet consumption

Figure 3 depicts the rate of food consumption by shrimps with described diet composition for each pond on each day. For the entire study period, shrimps in pond P2 dank more feed (9488.3 Kg), while shrimps in pond P1 ingested less feed (8948.9 Kg). However, at P3 (9325.3 Kg), feed consumption was moderate. This component could be caused by changes in several pond environmental conditions. According to Table 1, the disturbed pond environment, such as pH, ammonia and salinity, may have an impact on low and high feed consumption. Furthermore, unstudied characteristics such as CO_2, temperature, NO^-, hardness, H_2S, and BOD could be the root cause of the imbalanced feed intake (15,16).

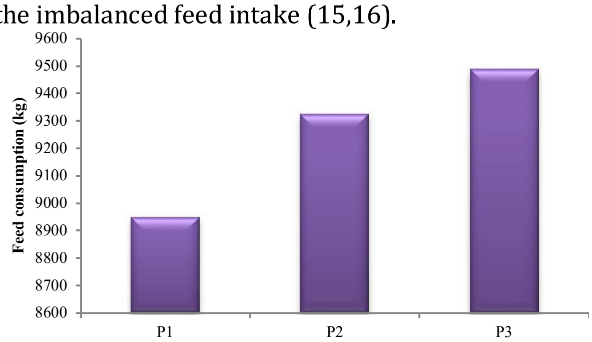


Fig 3 —Diet consumption of shrimp in each pond

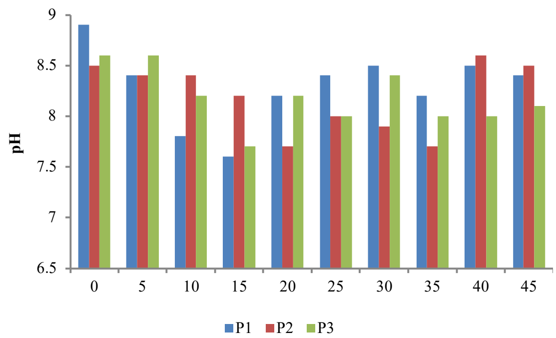
Water quality analysis

The pH, salinity, and ammonia levels were regularly monitored in the culture ponds with continuous aeration. The results are presented in Table 1 and graphically represented in Figure 4a and 4b. The pH levels in all ponds ranged from 8.18 to 8.29 on average. Pond 1 had consistently higher pH levels compared to the other ponds throughout the shrimp growth period (Figure 4a). Salinity values fluctuated between 11.6 and 15.8 in all ponds, with the highest salinity recorded in pond P2 and the lowest in pond P3 (Figure 4b). Whenever there was a significant decrease in salinity, it was necessary to drain the water and replace it with new seawater to maintain the desired salinity level (17).

The ammonia levels in all the ponds ranged from 0.25 ppm to 0.75 ppm, with the highest concentration observed in pond P1 and the lowest in pond P3. It was observed that the percentage of ammonia increased only during the middle of the shrimp growth period, which coincided with high mortality rates in all three ponds. These fluctuations in ammonia levels were attributed to the disturbed environmental conditions and physico-chemical parameters of the ponds. To prevent further disturbances caused by increased ammonia levels, a water exchange treatment was implemented for all three ponds.

Fig 4a: pH of three ponds in different days

Fig 4b: Salinity of three ponds in different days



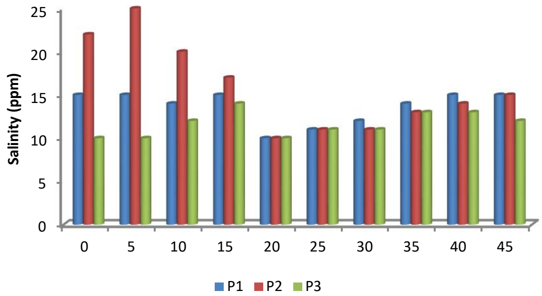


Table.1— The level of Ammonia of three ponds in different days

	Ammonia (ppm)		
	P1	P2	P3
0	0.00	0.00	0.00
5	0.00	0.25	0.00
10	0.25	0.25	0.00
15	0.50	0.25	0.25
20	0.25	0.50	0.25
25	0.00	0.00	0.00
30	0.25	0.25	0.00
35	0.50	0.25	0.25
40	0.75	0.25	0.25
45	0.25	0.25	0.25

Average survival analysis of shrimp in each pond

Table 2 shows the various stocking densities and the resulting shrimp production, survival rate, body weight, and total biomass. Throughout the culture period, there was a mortality rate of 8 to 40% due to factors such as de-molding, high ammonia levels, and low dissolved oxygen. The analysis of shrimp body weight and biomass was conducted on the 45th day. Pond P2 had the highest average shrimp weight at 25.5 grams, while pond P3 had the lowest at 20 grams. Pond P1 had the highest mortality rate at 40%, while P3 had the lowest at 8%. The growth rate of the shrimp decreased with higher stocking densities, but increased exponentially with water exchange.

Table.2—Total Shrimp survival and different stocking density in three pond

Pond	Area (sq.m)	Initial stocking	Final harvest	Day of culture	Avg body wt	Total biomass (kg)	Survival (%)
P1	8127	430,000	258,920	101	25	5853	60
P2	6700	300,000	242,385	97	25.6	6215	81
P3	7785	350,000	323,100	99	20	6199	92

CONCLUSION

The physico-chemical parameters were consistently maintained in three ponds, but the level of ammonia fluctuated due to shrimp consuming food for growth during the middle of the culture period, leading to a high mortality rate. Therefore, it is important to consider the amount of ammonia in the pond in order to reduce the mortality rate. The diet was carefully managed to increase the shrimp's body weight and growth rate, which was successful in the final stage. Among the three ponds, pond P2 had the highest weight and growth rate, with a survival rate of 81% and a production of 6215 Kg. Pond 3 had a high survival rate but moderate production. In conclusion, the culture of *L. vannamei* shrimp had the best results in pond P2 and P3, with successful use of sea water and a direct correlation between growth and lower stocking density. This study provides valuable insights for shrimp farmers to improve production and predict yields.

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