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The Effect of Water Quality on the Performance Growth of Vannamei Shrimp (*Litopenaeus vannamei*) at the Center for Brackish Aquaculture Fisheries

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Abstract

The Vannamei shrimp (*Litopenaeus vannamei*) is a key species in global aquaculture, with its growth influenced by various environmental factors and nutritional quality. This study aimed to analyze water quality parameters and phytoplankton density, as well as assess the growth of juvenile Vannamei shrimp in circular ponds with low salinity (5-6 ppt). Shrimp were stocked at a density of 80 individuals per square meter in 5-ton capacity tanks and fed four times daily over a 30-day period. Water quality parameters, including temperature, dissolved oxygen, pH, and light intensity, were monitored bi-daily, revealing fluctuations that impacted shrimp health. Notably, plankton density assessments showed Cyclotella present on day 14 but absent on day 28, while Microcystis and Rhizosolenia were detected on day 28, indicating shifts in the phytoplankton community. The specific growth rate (SGR) of shrimp was measured at 18.69% per day, with initial and final weights recorded at 0.01 ± 0.00 g and 2.72 ± 0.23 g, respectively. This study highlights the importance of maintaining optimal water quality and understanding phytoplankton dynamics for enhancing shrimp growth. Additionally, it explores the potential benefits of alginate supplementation and the effects of low salinity on the growth of juvenile Vannamei shrimp, contributing valuable insights for sustainable aquaculture practices

1. Introduction

Litopenaeus vannamei, also known as the Pacific white shrimp, is one of the most popular shrimp species in the global aquaculture industry (Liao and Chien, 2011). The life cycle of the *L. vannamei* consists of several stages, including larval, juvenile, and adult phases (Rojo-Arreola *et al.*, 2020). Nutrition and environmental quality greatly influence growth and development during these phases. Therefore, pond managers must ensure optimal environmental conditions, such as water temperature, salinity, dissolved oxygen, and pH, to support healthy growth. Additionally, providing a balanced diet is crucial to meet the nutritional needs of *L. vannamei* at each growth stage. *L. vannamei* shrimp aquaculture industry continues to grow with the increasing global demand for seafood products. The advancement of technology and sustainable farming practices is a key focus to maintain pond productivity and environmental sustainability (Abdelrahman *et al.*, 2019; Ariadi *et al.*, 2019; Menon *et al.*, 2023; Mugwanya *et al.*, 2022).

The juvenile stage in the shrimp's life cycle is crucial, as this is when rapid growth and the development of major anatomy occur (Laramore *et al.*, 2001; Lemos and Weissman, 2021; Seidman and Lawrence, 1985). During this stage, shrimp are more vulnerable to environmental changes and pond conditions, so careful maintenance and management are essential to ensure optimal growth and survival. Feed and nutrition are the main factors influencing the growth of juvenile shrimp (Jaffer *et al.*, 2020; Rodríguez-Olague *et al.*, 2021; Wyban *et al.*, 1995; Yu *et al.*, 2020). High-quality feed is vital to meet the nutritional requirements at this stage.

Phytoplankton, which consists of unicellular algae and cyanobacteria, are the primary producers in aquatic ecosystems (Zohary *et al.*, 2014). They convert solar energy into chemical energy through photosynthesis, making them an important food source for zooplankton and shrimp.

Furthermore, phytoplankton plays a significant role in the global biogeochemical cycle by absorbing carbon dioxide (CO_2) from the atmosphere and converting it into organic carbon, helping regulate CO_2 concentrations and potentially influencing climate change (Jahan, 2023; Naselli-Flores and Padisák, 2023). However, some species of phytoplankton can produce toxins that are harmful to aquatic organisms and humans if they accumulate in contaminated seafood. Environmental conditions such as temperature, light, and nutrients affect the abundance and composition of phytoplankton in ecosystems (Jia *et al.*, 2022; Lee *et al.*, 2019; Pradhan *et al.*, 2022).

Water quality and aquatic parameters, such as temperature, pH, dissolved oxygen, salinity, and nutrient content, are crucial factors in maintaining a healthy aquatic ecosystem (Banerjee *et al.*, 2019; Boyd and Pillai, 1985; Menon *et al.*, 2023). Poor water quality can affect the ecosystem's balance and the survival of aquatic organisms, including shrimp and fish. For example, an increase in water temperature can reduce dissolved oxygen levels, while drastic pH changes can cause stress in aquatic organisms (Boyd, 2015; Boyd, 2019; Boyd and McNevin, 2015; Yusoff *et al.*, 2024). Therefore, monitoring water quality is essential to maintain the health of aquatic ecosystems. The purpose of this study is to measure and analyze water quality parameters, calculate and identify the phytoplankton community, and measure the growth of juvenile Vannamei shrimp in round ponds with low salinity.

2. Material and methods

2.1 Materials

The shrimp utilized in this study had an average weight of around 0.01 ± 0.00 g. They were cultured in circular tanks with a 5-ton capacity, stocked at a density of 80 shrimp per square meter for a period of 30 days. During the experiment, the water salinity was consistently maintained at a low range of 5-6 ppt.

2.2 Methods

2.2.1 Experimental Design

The shrimp used in the study were sourced from the CV Hadid Mukti Karya hatchery. They were introduced into circular ponds with a diameter of 3 meters and a water depth of 1 meter (total depth of 1.2 meters) at a stocking density of 80 shrimp per square meter. Prior to stocking, the shrimp were acclimated by floating their transport bags in the ponds, allowing them to gradually adapt to the pond water temperature. Feeding was conducted four times daily at 07:00, 10:00, 13:00, and 16:00.

2.2.2 Water Quality Sampling Procedure

Water quality parameters, such as temperature, salinity, pH, dissolved oxygen (DO), and light intensity, were monitored twice a day at 8:00 AM and 4:00 PM using standardized instruments.

2.2.3 Plankton Density

Plankton density was assessed using a hemocytometer under a microscope. The magnification varied according to the size of the plankton: larger specimens were counted at low magnification, while smaller or more challenging forms were observed at higher magnifications, sometimes with the use of immersion oil for improved precision. When plankton density was low, the entire bottom of the chamber was analyzed to ensure accuracy. In cases of higher density, only specific sections of the chamber bottom, such as several diagonal fields, were counted to account for irregular distributions while maintaining representativeness in the data. This adaptable approach allowed for precise estimation of plankton density based on the characteristics of the sample (LeGresley and McDermott, 2010; Willén, 1976). Identification of phytoplankton species adhered to the guidelines established by Genkal (2012), Kilham and Hecky (1988) and Reynolds (1984)

2.2.5 Specific Growth Rate

Shrimp were randomly chosen from the population, and their weights were measured on day 0 and day 30 of the rearing period with a precision scale. The specific growth rate (SGR) was subsequently calculated using the following formula (Ario and Nursani, 2024; Ridlo *et al.*, 2024):

$$\text{SGR (\%/day)} = \frac{\ln W_t - \ln W_0}{t} \times 100$$

where Wt is the final weight, W_0 is the initial weight, and t is the time in days.

3. Results

3.1 Water quality parameters

The water quality parameters recorded at 8:00 AM and 4:00 PM exhibited variations (Figure 1). At 8:00 AM, dissolved oxygen levels ranged from 5.66 to 9.26 mg L^{-1} (Figure 1a), pH levels varied from 7.82 to 8.39 (Figure 1b), temperatures were between 27.7 and 29.8°C (Figure 1c), light intensity ranged from 20,700 to 67,200 Lux (Figure 1d), and salinity was maintained at 5 to 6 ppt (Figure 1e). By 4:00 PM, dissolved oxygen levels ranged from 4.59 to 9.54 mg L^{-1} (Figure 1a), pH levels varied from 7.6 to 9.3 (Figure 1b), temperatures increased to between 30.1 and 32.5°C (Figure 1c), light intensity ranged from 1,506 to 27,400 Lux (Figure 1d), and salinity remained at 5 to 6 ppt (Figure 1e). These results highlight the fluctuations in water quality parameters throughout the day, offering insights into the dynamic characteristics of the aquatic environment.

3.2 Plankton identification and density

Base on Table 1, the plankton density measurements over 14 and 28 days showed that Cyclotella appeared only on day 14 with 750.00 ± 23.6 (x 10^3 cell mL^{-1}) and not showed on day 28. On the other hand, day 28 showed Microcystis (11.11 x 10^3 cell mL^{-1}), Cyclotella (529.93 x x 10^3 cell mL^{-1}) and Rhizosolenia (11.11 x x 10^3 cell mL^{-1}).

3.3 Specific Growth Rate (SGR)

As shown in Table 2, the initial and final weights were 0.01 ± 0.00 and 2.72 ± 0.23, respectively. The specific growth rate was measured at 18.69% per day.

4. Discussion

Analyzing the relationship between water quality parameters is a crucial aspect of this study on the growth of juvenile vannamei shrimp. Parameters such as temperature, dissolved oxygen, pH, light intensity, and salinity can have a significant impact on the health and growth of shrimp (Azizah and Samaadan, 2024). Maintaining optimal water quality is essential to create a suitable environment for the growth of vannamei shrimp.

The phytoplankton community in the pond plays a vital role in the growth of vannamei shrimp. Phytoplankton serves as the primary natural food source for shrimp, and variations in the type and quantity of phytoplankton can influence the availability of nutrients (Lyu *et al.*, 2021; Mustika *et al.*, 2023). For instance, Cyclotella, a genus of diatoms, is known for its high nutritional content, particularly omega-3 fatty acids, which can enhance shrimp health and growth (Abdel-Moez *et al.*, 2024; Nieri *et al.*, 2023). Rhizosolenia, another genus of diatoms, also contributes to the nutritional value of the pond ecosystem, as it is rich in essential fatty acids and serves as a high-quality food source (Damsté *et al.*, 2000; Rowland *et al.*, 2001; Villareal, 1988;

Yun *et al.*, 2011; Yung *et al.*, 1988). These diatoms can provide significant benefits to shrimp health and growth when present in sufficient quantities.

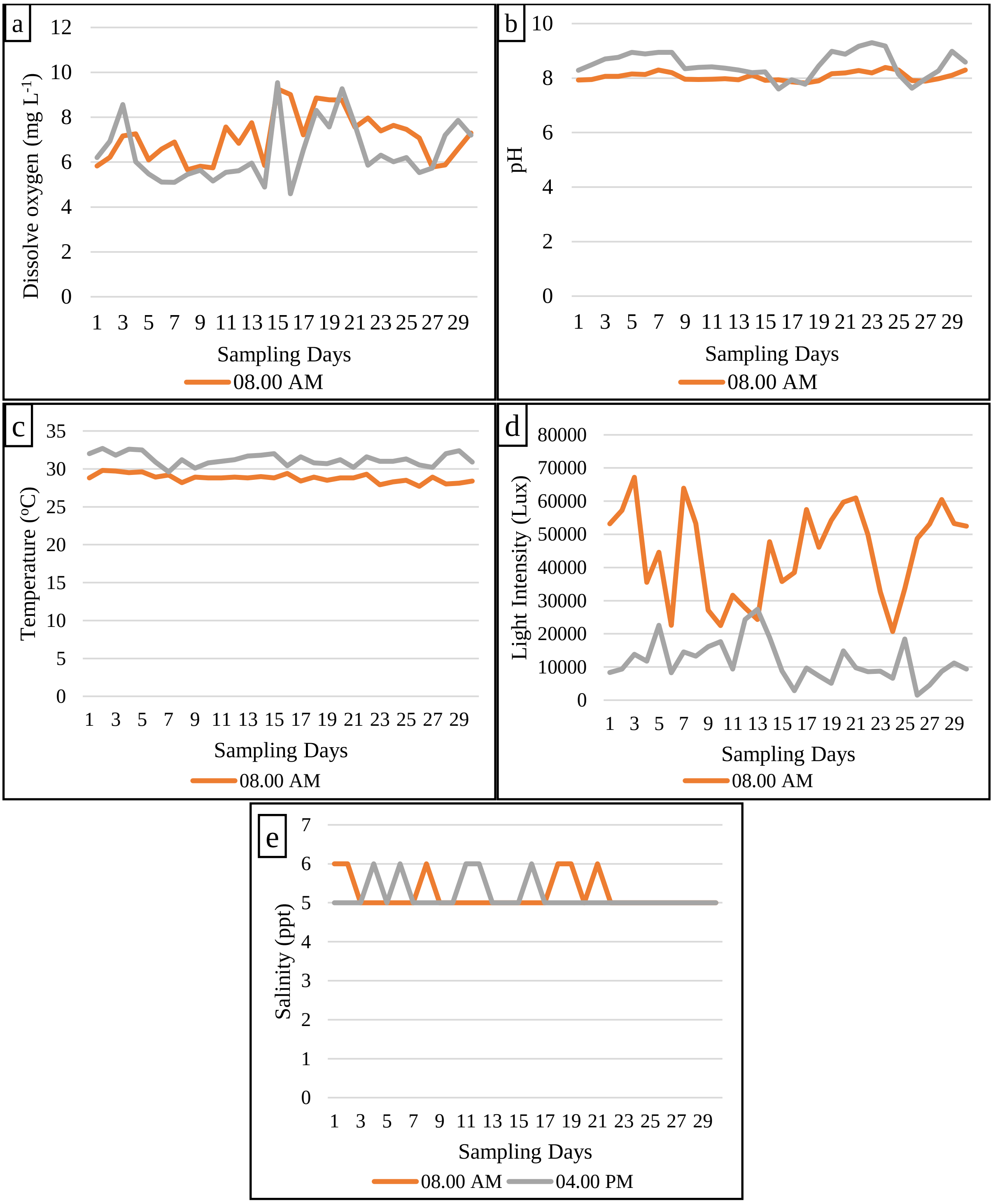

Figure 1. The water quality parameters. a). dissolved oxygen levels; b) pH levels; c) temperatures were ; d) light intensity; e) salinity.

Tabel 1. Plankton Identification and Density on 14 days and 28 days of rearing

Days	the plankton density (x 10^3 cell mL^{-1})			
	Cyclotella	Microcystis	Cyclotella	Rhizosolenia
14	750.00 ± 23.6	ND	ND	ND
28	ND	11.11 ± 0.00	529.93 ± 66.97	11.11 ± 0.00

ND : Not detected

Table 2. Weight of *Litopaneus vannamei*

Initial weight (gr)	Final weight (gr)	SGR(%)

0,01±00	2.72 ± 0.23	18.69%

On the other hand, Microcystis, a genus of cyanobacteria, can have a different impact on shrimp growth. While some cyanobacteria can be beneficial in the food web, Microcystis is often associated with harmful algal blooms (HABs) that produce toxins such as microcystins, which can be detrimental to shrimp health (Lad *et al.*, 2022; Le Manach *et al.*, 2019; Le *et al.*, 2023; Wilhelm *et al.*, 2020). The presence of Microcystis in the pond environment can affect water quality and potentially inhibit the growth of vannamei shrimp, especially if the population density becomes excessive.

This study will investigate how variations in the phytoplankton community, particularly the presence of Microcystis, Cyclotella, and Rhizosolenia, affect the growth of vannamei shrimp and how these species relate to changes in water quality parameters.

The use of alginate as a supplement in vannamei shrimp farming is another focus of this study. Alginate is a compound known to enhance feed efficiency and improve shrimp health (Azhar and Yudiati, 2023; Chen *et al.*, 2022; Yudiati *et al.*, 2016; Yudiati *et al.*, 2019). This research will evaluate the extent to which alginate supplementation can promote the growth of juvenile vannamei shrimp in circular ponds. The findings will provide valuable insights into the potential application of alginate in improving vannamei shrimp aquaculture.

This study will also analyze how low salinity affects the growth and health of vannamei shrimp. Understanding its impact is essential for effective pond management and ensuring the optimal growth of juvenile vannamei shrimp.

This study demonstrates that water quality and phytoplankton community dynamics significantly impact the growth of Vannamei shrimp (*Litopenaeus vannamei*). Fluctuations in water quality parameters, such as temperature, dissolved oxygen, pH, and light intensity, influence the health and growth of shrimp during the juvenile phase. The measurements indicate that the presence of Cyclotella, Microcystis, and Rhizosolenia within the pond ecosystem contributes to the variability in available nutrition for the shrimp. The recorded specific growth rate (SGR) of 18.69% per day highlights the potential for substantial growth under well-managed conditions.

Additionally, the study underscores the importance of regular water quality monitoring and phytoplankton management to ensure optimal growth environments for shrimp. The implementation of alginate supplementation could serve as a promising strategy to enhance shrimp health and feed efficiency. These findings provide valuable insights for sustainable aquaculture practices, particularly in managing low salinity levels in ponds. Effective management of these environmental factors is crucial for achieving maximum productivity and sustainability within the aquaculture industry.

3 Conclusions

This study demonstrates that water quality and phytoplankton dynamics significantly influence the growth of Vannamei shrimp (*Litopenaeus vannamei*). Key factors such as temperature, dissolved oxygen, pH, and light intensity affect shrimp health, while the presence of Cyclotella, Microcystis, and Rhizosolenia impacts nutritional availability. With a specific growth rate (SGR) of 18.69% per day, optimal conditions are crucial for strong growth.

Ethics approval

No permits were required.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author contributions

MBI is doing research ideas, sample image collection, water quality sampling collection, EH and CAS are supervising and writing

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Declaration of competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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