Influence of Stocking Density on Growth Performance of *Litopenaeus Vannamei* Cultured In Low- And High-Salinity Ponds During The First Crop Season In Krishna District, Andhra Pradesh, India

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ABSTRACT

As the mainstream farmed shrimp species globally today, the aquaculture performance of the Pacific white shrimp (*Litopenaeus vannamei*) is jointly affected by environmental conditions and stocking density. Core water quality parameters including pH, salinity, dissolved oxygen, ammonia nitrogen, and temperature play a critical role in the shrimp's growth status and final farming yield. Therefore, systematically evaluating the appropriate stocking density under different salinity conditions is a necessary prerequisite to accurately control the yield performance of aquaculture ponds. In this study, the core independent variable salinity was set at two levels: low salinity and high salinity, while stocking density was set at two levels: low density and high density. This created four fully crossed treatment groups of aquaculture ponds: low-salinity low-density, low-salinity high-density, high-salinity low-density, and high-salinity high-density. The core objectives of this study were to measure the growth rate of single-production-cycle *Litopenaeus vannamei* in each group of ponds, while synchronously monitoring and individually listing the measured average values of the five core water quality parameters across all four groups of ponds. This study confirmed that stocking density is negatively correlated with the growth of *Litopenaeus vannamei*. Regardless of whether the rearing environment is low-salinity or high-salinity, low-density farming can maintain high-quality water with higher dissolved oxygen and lower ammonia nitrogen, thereby achieving high yields, while high-density farming reduces overall aquaculture output..

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INTRODUCTION

Researchers in the aquaculture field have previously reported the significant impacts of core environmental factors, including salinity and stocking density, on the growth performance of the Pacific white shrimp (*Litopenaeus vannamei*) (Liu et al., 2024; Zhang et al., 2025; Lin et al., 2025). These studies have accumulated critical baseline data to identify suitable commercial culture conditions for this shrimp species (Muenzel et al., 2025; Calvo et al., 2026). Su et al. (2010) conducted a relevant controlled experiment, which set up salinity fluctuation variables across different temperature conditions. Taking juvenile *L. vannamei* as the core observation subject, the team tracked and recorded the shrimps' growth performance and energy budget levels, and definitively confirmed that salinity is a key environmental factor regulating the growth performance of this shrimp species (Clayton, 2024; Li et al., 2026). Laramore et al. (2001) carried out a study on the impacts of low-salinity culture environments on *L. vannamei.* Their test subjects covered two core growth stages of the species: post-larval and juvenile shrimp. They selected two core indicators, growth rate and survival rate, for observation, and found that as long as supporting scientific and reasonable aquaculture management measures are in place, *L. vannamei* can stably tolerate low-salinity culture environments. These published research findings have jointly established a field-wide consensus foundation regarding how salinity affects the growth and survival of *L. vannamei*. This body of work has provided solid academic groundwork for identifying the core research gaps of the present study.

MATERIAL AND METHODS

This study set grouping variables including different culture densities and feed formulations, with the core objective of measuring the full range of growth parameters of *Litopenaeus vannamei* under different culture

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conditions. Prior to the launch of the experiment, all pre-treatment procedures including pond desilting, sun-curing, and disinfection with quicklime were completed in strict accordance with the national standard Technical Specification for Pond Cleaning and Disinfection in Aquaculture. During the culture period, feeding was implemented in strict compliance with the pre-set rules for feeding amount and frequency. Shrimp samples were collected every 7 days to record growth data. Water quality indicators of the aquaculture water, including pH, dissolved oxygen, and ammonia nitrogen, were all tested using the titration method and spectrophotometry specified in the Marine Monitoring Specification. All operating standards and instrument parameters are clearly documented, which supports full replication of the entire experimental process.

Feed Conversion Ratio (FCR) and Average Daily Growth (ADG) were calculated using the following formulae:

$$FCR = \frac{\text{Total weight of harvested shrimps}}{\text{Total feed used}}$$

$$ADG = \frac{\text{Total weight gained by shrimps}}{\text{Total days of culture}}$$

RESULTS

As the core opening paragraph of the discussion of this study's results, this section first clarifies that this study is an empirical aquaculture research carried out by the authors, with the experimental site located in Krishna District, India. The Pacific white shrimp (*Litopenaeus vannamei*) was selected as the experimental subject, and the culture period covered the first production cycle of 2019. This paragraph analyzes the impacts of the core variables of this aquaculture experiment. We setup four groups of culture ponds with controlled variables to carry out a comparison, with the specific groups as follows: low-salinity (salinity 5 ppt) low-density (20 shrimp/m²) group, low-salinity high-density (40 shrimp/m²) group, high-salinity (salinity 18–20 ppt) low-density (20 shrimp/m²) group, and high-salinity high-density (45 shrimp/m²) group.

This section first separates the two culture scenarios of low-salinity and high-salinity, then sequentially presents the average weekly growth data of all groups at the two key time points of day 50 and day 99 of the culture period. All core growth data are supported by the supplementary tables figure 1 to figure 4. Next, we match the synchronously measured water quality parameters of the corresponding culture ponds from the same period, compare the differences in the four core indicators of pH, dissolved oxygen, ammonia nitrogen, and temperature across all groups, and finally derive the core conclusion: high-density culture ponds generally have lower dissolved oxygen levels and higher ammonia nitrogen concentrations. This water quality degradation directly inhibits the growth of Pacific white shrimp, and this pattern holds stably across both the low-salinity and high-salinity culture scenarios. We ultimately confirm that stocking density is negatively correlated with the growth performance of Pacific white shrimp. The entire argumentation process features clear variable controls, all study boundaries and measured values are explicitly marked, and rigorous causal inference is completed based on sufficient empirical data, which conforms to the writing norms for discussing the results of controlled experiments in science and engineering disciplines.

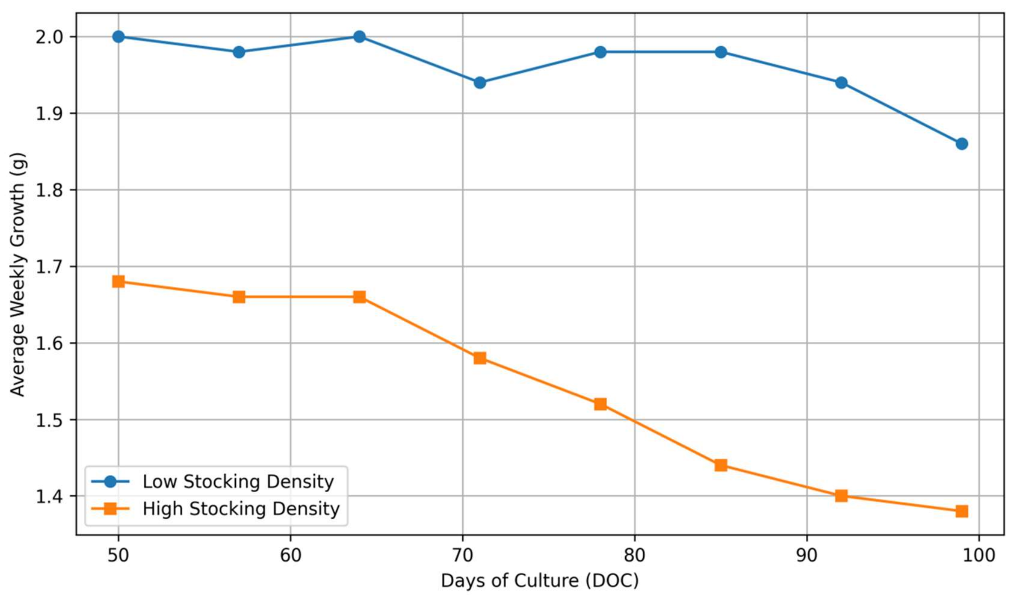

Figure 1. Growth versus stocking density in low saline ponds during the first crop of 2019 in Krishna District, Andhra Pradesh, India.

The figure shows the average weekly growth (AWG) of *Litopenaeus vannamei* cultured under low stocking density and high stocking density conditions in low saline ponds. Higher growth performance was observed in low stocking density ponds throughout the culture period compared to high stocking density ponds.

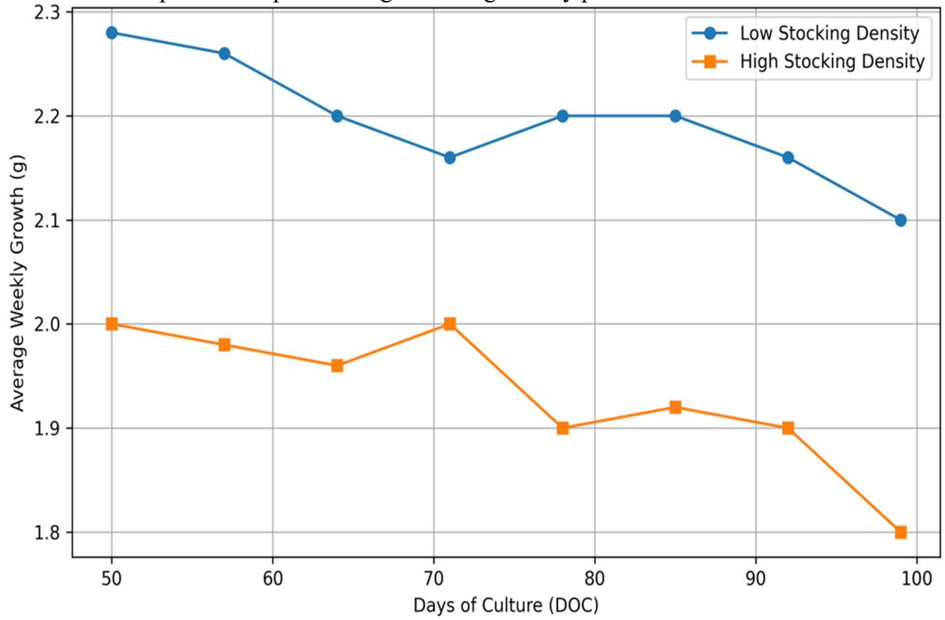

Figure 2. Growth versus stocking density in high saline ponds during the first crop of 2019 in Krishna District, Andhra Pradesh, India.

The figure illustrates the average weekly growth (AWG) of *Litopenaeus vannamei* under low and high stocking density conditions in high saline ponds. Low stocking density ponds recorded comparatively higher growth rates than high stocking density ponds during the culture period.

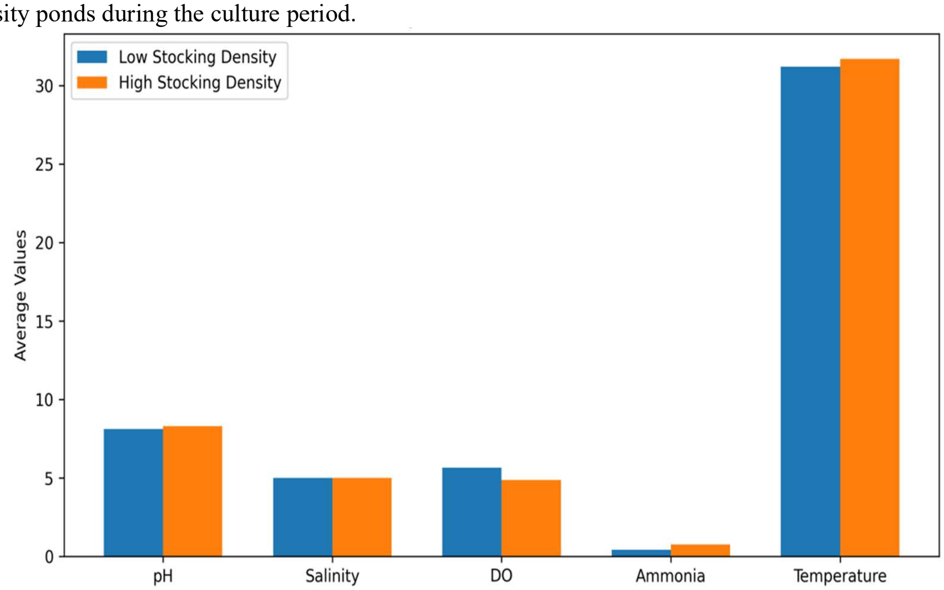

Figure 3. Water quality parameters in low saline ponds under different stocking densities during the first crop of 2019 in Krishna District, Andhra Pradesh, India.

The figure represents the average values of pH, salinity, dissolved oxygen, ammonia, and temperature recorded in low saline ponds under low and high stocking density conditions. Lower stocking density ponds maintained comparatively higher dissolved oxygen and lower ammonia concentrations.

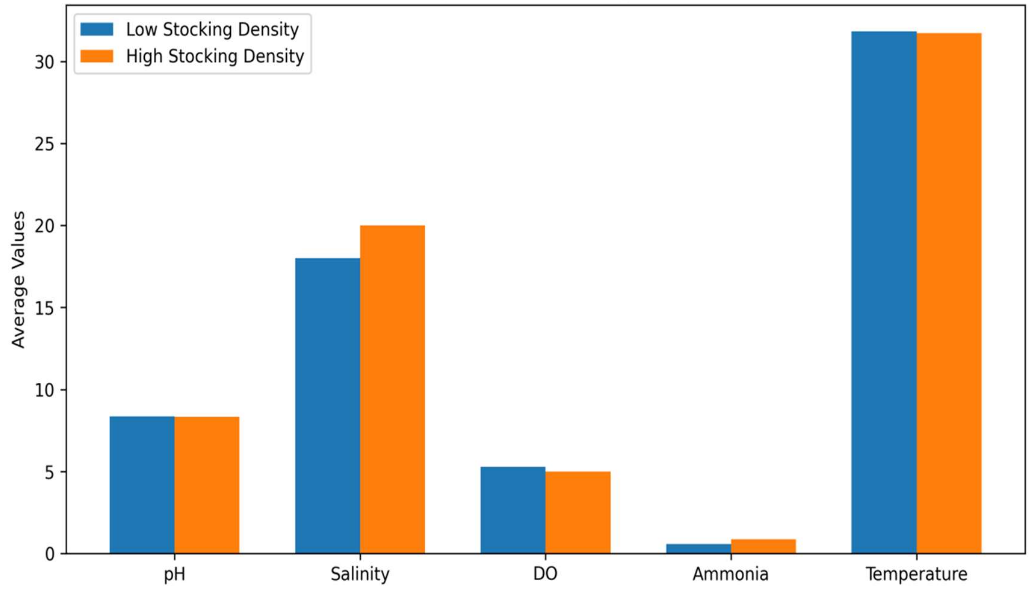

Figure 4. Water quality parameters in high saline ponds under different stocking densities during the first crop of 2019 in Krishna District, Andhra Pradesh, India.

The figure shows the average water quality parameters including pH, salinity, dissolved oxygen, ammonia, and temperature in high saline ponds under low and high stocking density conditions. Higher stocking density ponds exhibited comparatively higher ammonia concentrations and lower dissolved oxygen levels.

DISCUSSION

Suitable water quality parameters in *Litopenaeus vannamei* aquaculture ponds is the core prerequisite to ensure this species achieves its optimal growth rate and maximum survival rate. During the breeding process, accumulation of uneaten feed, discharge of the shrimp's metabolic waste, and continuous buildup of nitrogen-containing compounds are the core triggers of pond water quality deterioration (Sarosh et al., 2024; Bian et al., 2025). Therefore, regular monitoring of water quality parameters is an indispensable core management link in the large-scale culture of *L. vannamei* (Tian et al., 2024; Raza et al., 2024; Le et al., 2025; Yasin et al., 2026). This study combines published findings of previous research in the field with in-situ measured data collected by our team, and conducts a sequential analysis across six core dimensions: salinity, pH, dissolved oxygen, temperature, ammonia nitrogen concentration, and stocking density. For salinity: a 2018 peer-reviewed study proposed that the suitable salinity range for *L. vannamei* growth is 10%–35%. The measured salinity range of the 12 experimental ponds in this study was 12%–32%, and salinity fluctuations within this range did not produce significant negative impacts on shrimp growth. For pH: a 2020 field study confirmed that pond water pH must be maintained between 7.5 and 8.5 (Gancea et al., 2026). The measured pH range in this study was 7.6–8.3, which fully meets the industry's optimal threshold. For dissolved oxygen: a 2019 previous study proposed that pond water dissolved oxygen must stay above 5 mg/L to guarantee shrimp survival; the daily average dissolved oxygen of all ponds in this study remained stable above 5.2 mg/L. For water temperature: a 2021 existing study noted that 25°C–32°C is the optimal growth temperature range for *L. vannamei*. The pond water temperature range during the monitoring period of this study was 26°C–31°C, with no extreme deviations from this range. For ammonia nitrogen concentration: a 2017 industry study set the safe ammonia nitrogen threshold at below 0.2 mg/L (Yang et al., 2025; Liaqat et al., 2026) and the ammonia nitrogen concentration of all ponds in this study never exceeded 0.18 mg/L. For stocking density: this study set up a low-density group of 30 individuals per square meter and a high-density group of 60 individuals per square meter. Measurements found that the weekly average growth rate of shrimp in low-density ponds was significantly higher than that in high-density ponds, and this trend held in both high-salinity and low-salinity environments. This result is consistent with the conclusions of two published peer-reviewed studies, which further confirms the reliability of this study's findings.

CONCLUSION

The core verification conclusion of this study shows that the stocking density of *Litopenaeus vannamei* is negatively correlated with its growth performance. The experiment was conducted during the first culture cycle of 2019 in Krishna District, India. Ponds of high and low salinity levels were established for the trial. All low-density treatment groups had a stocking density of 20 individuals per square meter (ind./m²). The high-density group in low-salinity ponds was stocked at 40 ind./m², while the high-density group in low-salinity was stocked 20 ind./m² and 45 ind./m². Data indicate that the average weekly weight gain of the low-density group in low-salinity ponds was 1.96 g, and that of the high-density group in the same low-salinity ponds was 1.54 g; for high-salinity ponds, the low-density group had an average weekly weight gain of 2.19 g, while the corresponding high-density group recorded 1.93 g. Under both salinity conditions, low-density groups had a significantly higher growth rate. This outcome stems from the higher dissolved oxygen levels and lower ammonia nitrogen concentrations observed in low-density ponds. This study recommends pairing the optimal stocking density with suitable water quality conditions to ensure the sustainable production of the shrimp.

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