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Production Performance and Economic Viability of an Intensive *Litopenaeus vannamei* Nursery System

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Abstract

Shrimp nursery systems play an important role in modern aquaculture by improving the survival, uniformity, and early growth of shrimp before stocking in grow-out ponds. This study evaluated the production performance and economic profitability of a commercial *Litopenaeus vannamei* nursery system operated under intensive tank-based conditions in Camarines Sur, Philippines. Production data were collected from a 23-day nursery culture cycle in a circular tank stocked with PL10 shrimp at a density of 2 individuals L^{-1}. Growth performance, survival, and feed utilization were evaluated, and a cost–return analysis was conducted to assess economic viability. Water quality parameters were regularly monitored to ensure optimal conditions for shrimp growth.

Results indicated strong production performance, with shrimp reaching an average body weight of 0.55 g and achieving a survival rate of 95%. Feed utilization was efficient with a feed conversion ratio (FCR) of 1.03, indicating effective feeding management and culture conditions. Economic analysis showed that the operation generated USD 595.20 net profit per cycle, with a benefit–cost ratio (BCR) of 1.30 and a return on investment (ROI) of 30%, indicating favorable financial returns.

Overall, the findings demonstrate that intensive tank-based nursery systems can effectively produce high-quality *L. vannamei* juveniles while maintaining efficient feed use and positive economic outcomes. The adoption of well-managed nursery systems can therefore enhance production efficiency and provide a practical strategy for improving the profitability of commercial shrimp farming operations.

Keywords: shrimp nursery, *Litopenaeus vannamei*, production performance, aquaculture economics, feed conversion ratio, survival rate, nursery culture system.

INTRODUCTION

Aquaculture is one of the fastest-growing food production sectors globally and plays a vital role in food security and livelihood generation, particularly in coastal regions (FAO, 2024; Guerrero III et al., 2022). Among cultured aquatic species, shrimp farming is one of the most economically important sectors due to its high market demand and export value. The Pacific white shrimp, *Litopenaeus vannamei*, has become the dominant cultured species worldwide because of its rapid growth, environmental tolerance, and adaptability to intensive farming systems (Durai & Alagappan, 2020). Advances in hatchery production, feed development, and culture management have further supported the expansion of shrimp aquaculture.

Despite this growth, shrimp farming continues to face major challenges, including disease outbreaks, environmental degradation, and increasing production costs. Poor water quality and viral diseases have caused substantial production losses, prompting the adoption of more controlled and biosecure culture systems (Mishra et al., 2008; Rodríguez-Olague et al., 2021). Consequently, intensive and technology-driven production strategies are increasingly employed to improve survival, productivity, and overall system efficiency.

One important development in modern shrimp aquaculture is the adoption of a two-phase culture system consisting of a nursery phase followed by grow-out. In this approach, post larvae (PL) are reared to larger juveniles under controlled conditions prior to pond stocking (Correia et al., 2014). The nursery phase enables better control of feeding, water quality, and health management, resulting in improved growth, survival, and size uniformity. Previous studies have shown that nursery integration can enhance production efficiency and overall farm performance (Mishra et al., 2008; Moss & Moss, 2004).

Nursery systems are typically operated at high stocking densities with intensive feeding and close monitoring of water quality to promote rapid growth and minimize mortality (Mohammadi et al., 2023). Effective management during this stage is critical, as the quality of juveniles directly affects their performance during grow-out (Katturi et al., 2023). In addition, nursery systems provide operational advantages such as improved stock control, reduced predation, shorter grow-out periods, and increased production cycles, all of which contribute to higher efficiency and profitability (Zelaya et al., 2004).

From an economic perspective, the nursery phase plays a crucial role in determining production success. Efficient nursery management can reduce risks, improve survival, and enhance profitability. While previous studies have demonstrated the biological benefits of shrimp nursery systems, economic outcomes remain dependent on input costs such as feed, seed, labor, and energy (Durai & Alagappan, 2020; Rodríguez-Olague et al., 2021).

However, despite the increasing adoption of nursery-based production strategies, there is still limited research that simultaneously evaluates both production performance and economic viability under commercial-scale conditions. This gap is particularly evident in the Philippines, where shrimp farming is a key aquaculture industry, but empirical data on the operational efficiency and profitability of intensive nursery systems remain scarce.

Therefore, this study evaluates the production performance and economic viability of a commercial *L. vannamei* nursery system in the Philippines, focusing on growth, survival, biomass production, and economic returns.

MATERIALS AND METHODS

Location and Culture System

Production data used in this study were obtained from a commercial shrimp nursery facility located in Camarines Sur, Philippines. This production cycle represented the initial operational run of the nursery system, serving as a pilot test to evaluate the production performance and economic viability of the system for rearing Pacific white shrimp (*L. vannamei*) from the post-larval stage to early juvenile size prior to stocking in grow-out ponds.

The nursery system consisted of two circular tanks, each with a working volume of 102 m^3. The nursery tank was lined with high-density polyethylene (HDPE) to prevent seepage and facilitate improved biosecurity and maintenance. One tank functioned as the shrimp rearing tank, while the other served as a treatment tank used for water conditioning and preparation before being introduced into the culture system. Adequate aeration was provided throughout the culture period to maintain suitable dissolved oxygen levels and ensure proper water circulation**.**

Research Design

This study employed an exploratory case study design based on production data obtained from a commercial shrimp nursery facility. The research focused on evaluating the production performance and economic viability of an intensive tank-based *L. vannamei* nursery system during a single operational production cycle. Biological performance indicators and economic metrics were analyzed to assess the operational efficiency of the nursery system under actual farm conditions.

Stocking and Culture Management

Pacific white shrimp (*L. vannamei*) post larvae at the PL10 stage were stocked in the nursery tank at a density of 2 individuals per liter, equivalent to 200,000 post larvae in the 102 m^3 culture tank. Before stocking, the tank was prepared following standard nursery management procedures to ensure suitable environmental conditions for shrimp survival and growth.

The shrimp were reared in the nursery system for 23 days, during which they were cultured from the post-larval stage to the juvenile stage. Culture management practices included continuous aeration and routine monitoring of shrimp condition to support optimal growth and survival.

Feeding Management

Shrimp were fed a commercially formulated diet containing 35% crude protein, 5% crude fat, 4% crude fiber, 12% moisture, and 16% ash. Feeding was conducted eight times daily at 2.5-hour intervals from 06:00 to 23:30 to ensure continuous nutrient availability and minimize feed wastage.

During the initial culture period, blind feeding was applied at a rate of 1 kg of feed per 100,000 post larvae. As shrimp biomass increased, the amount of feed provided was adjusted daily based on observed feeding response using a bottom drag method. Approximately 30 minutes prior to the next scheduled feeding, the tank bottom was gently dragged using a scoop net to assess uneaten feed.

Adjustments in the amount of feed were based on the estimated proportion of uneaten feed as follows: when approximately 10% of feed remained, the amount of feed was maintained; when uneaten feed exceeded 30%, the amount of feed was reduced; and when no uneaten feed was observed, the amount of feed was increased by approximately 30%. This approach enabled dynamic adjustment of feed input based on shrimp consumption and improved feed utilization efficiency.

Water Quality Management

Water quality parameters were monitored throughout the culture period to ensure suitable conditions for shrimp growth and survival. Temperature was measured using a glass thermometer, salinity was determined using a handheld refractometer, and pH was measured using a commercially available pH test kit (CPF India Private Limited). Other parameters, including alkalinity, dissolved oxygen, ammonia, nitrite, calcium, and magnesium, were analyzed using commercially available water quality test kits (Advance Pharma Co., Ltd.). Measurements were conducted twice daily at 06:00 and 15:00.

Water exchange was conducted twice daily with a target of 50% total daily water exchange, depending on the observed water quality parameters. In addition, probiotics were applied to the culture water twice per week to help maintain water quality and promote a beneficial microbial community in the culture system. Regular monitoring of these parameters was conducted to maintain stable environmental conditions within the nursery system and to allow timely management interventions when necessary.

Harvest and Transfer Procedure

Prior to harvest, a stress test was conducted to assess the robustness and physiological condition of the nursery-reared shrimp. The stress test consisted of air exposure for 5 minutes, followed by immersion in freshwater for 30 minutes, and subsequent return of the shrimp to their original culture water for a 30-minute recovery period. After recovery, the number of surviving shrimp was counted to evaluate their tolerance to handling and environmental stress.

Stress tests are widely used in shrimp hatchery and nursery operations as a rapid method to assess post-larvae quality and predict survival performance during grow-out (Álvarez et al., 2004). The inclusion of this procedure in the present study provides an additional indicator of juvenile robustness under handling and environmental stress conditions.

Following the stress test, feeding was temporarily withheld to reduce stress and maintain water quality during handling. The culture tank was gradually drained, and shrimp were carefully concentrated and harvested using fine mesh nets. The harvested juveniles were then transferred to holding containers with aerated water prior to transport to grow-out ponds.

Growth and Production Performance Assessment

At harvest, approximately 100 shrimp were randomly collected from the culture tank, and three replicate samples were taken to determine the average body weight (ABW) of the population. Growth and production performance indicators were calculated using the following formulas:

(a) Average Body Weight (ABW) = Total weight of sampled shrimp (g) / Number of shrimp sampled
(b) Average Daily Gain (ADG) = (Final weight − Initial weight) / Culture days
(c) Survival Rate (SR %) = (Number of shrimp harvested / Number of shrimp stocked) × 100
(d) Yield per Unit Volume = Total harvest weight (kg) / Tank volume (m^3)

Feed utilization efficiency was determined using the feed conversion ratio:

(a) Feed Conversion Ratio (FCR) = Total feed consumed (kg) / Total harvest weight (kg)

The growth performance indicators used in this study, including average body weight, survival rate, and feed conversion ratio, were calculated using standard aquaculture performance equations commonly applied in shrimp culture studies (Ratti & Kunda, 2025)

Economic Analysis

A cost–return analysis was conducted to determine the economic profitability of the nursery operation. Production costs were categorized into major components, including shrimp post larvae (seed), feed, energy, labor, disinfectants, probiotics, and mineral supplements. Fixed cost in the form of equipment depreciation was also included in the total production cost. The following economic indicators were calculated:

(a) Total Cost (TC) = Total Operating Cost + Depreciation Cost
(b) Gross Revenue (GR) = Total juveniles sold × Selling price per juvenile

(c) Net Profit (NP) = Gross revenue − Total production cost
(d) Benefit–Cost Ratio (BCR) = Gross revenue / Total production cost
(e) Return on Investment (ROI %) = (Net profit / Total production cost) × 100

Additional economic indicators were also calculated to evaluate the production efficiency of the nursery system:

(a) Cost per juvenile = Total production cost / Total juveniles sold
(b) Profit per juvenile = Net profit / Total juveniles sold
(c) Cost per kg = Total production cost / Total harvest weight
(d) Profit per kg = Net profit / Total harvest weight
(e) Profit per m^3 = Net profit / Tank volume

The economic indicators used in this study were adapted from standard aquaculture cost–benefit analysis methods commonly applied in aquaculture economic studies (Aheto et al., 2019; Hasan, 2008). Monetary values were converted from Philippine Peso (PHP) to United States Dollar (USD) using the average exchange rate during the study period applied at the transaction level. Minor differences between reported unit values and aggregated totals may arise from currency conversion and rounding procedures and do not affect the accuracy of the economic analysis.

Data Analysis

Descriptive statistics were used to summarize growth performance, production indicators, and economic parameters of the shrimp nursery operation during the 23-day culture period. The calculated indicators were presented using tabular summaries to describe the production performance and economic profitability of the nursery system.

Given that the study was based on a single production cycle under commercial conditions, inferential statistical analyses were not applied. Therefore, the results are presented as descriptive outcomes and should be interpreted as indicative of system performance under specific operational conditions rather than as statistically generalizable findings.

RESULTS AND DISCUSSION

Results

Production Performance

The production performance of *L. vannamei* nursery culture over 23 days is presented in Table 1. A total of 200,000 post larvae (PL10) were stocked in the nursery tank, and 190,000 juveniles were harvested at the end of the culture period, corresponding to a survival rate of 95%. The shrimp reached a final average body weight of 0.55 g. The total yield obtained from the nursery system was 104.5 kg, equivalent to a yield of 1.02 kg m^{-3}. The feed conversion ratio (FCR) recorded during the culture period was 1.03. The stress test conducted before harvest resulted in a post-stress survival rate of 96%.

Table 1. Production performance of *L. vannamei* nursery culture over a 23-day production cycle.

Production Parameter	Value
Initial Stocking (pcs)	200,000
Final ABW (g)	0.55
Survival Rate (%)	95%
Total Juveniles Produced	190,000
Yield (kg)	104.5
Yield (kg m^{-3})	1.02
FCR	1.03
Post-stress survival (%)	96

Production Cost Structure

The production cost structure of the shrimp nursery system is shown in Table 2, while the percentage distribution of operating costs is presented in Figure 1. The total operating cost for one production cycle was USD 1805.32. Seed cost accounted for 68% of the total operating cost, followed by energy at 14%, feed at 7%, labor at 5%, disinfectants at 4%, probiotics at 2%, and minerals at 1%. A fixed cost of USD 176.62 was recorded as depreciation of infrastructure and equipment. The total cost per cycle, including operating and fixed costs, was USD 1,981.94.

Table 2. Production cost structure of the shrimp nursery system.

Cost Category	Cost (USD)
Operating Cost	
Seed	1,220.75
Feed	122.89
Energy	244.37
Labor	84.77
Disinfectants	78.00
Probiotics	30.00
Minerals	24.54
Total Operating Cost	1,805.32
Fixed Cost	
Depreciation	176.62
Total Cost	1,981.94

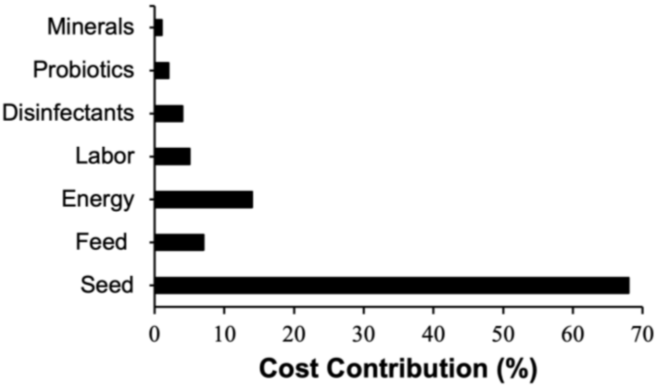

Figure 1. Percentage distribution of operating cost components in the shrimp nursery system.

Economic Performance of the Nursery System

The economic performance of the shrimp nursery production cycle is summarized in Table 3. The juveniles were sold at a price of USD 0.014 per piece. The sale of 190,000 juveniles generated a gross revenue of USD 2,577.14. After deducting the total cost of USD 1,981.94, the net profit per production cycle was USD 595.20. The calculated benefit–cost ratio (BCR) was 1.30, while the return on investment (ROI) was 30%. The total duration of approximately 30 days allows 12 production cycles per year, resulting in an estimated annual income of USD 7,142.40.

Additional economic indicators are presented in Table 4. The cost per juvenile produced was USD 0.010 per piece, and the profit per juvenile was USD 0.003 per piece. The cost per kilogram of shrimp produced was USD 18.97, while the profit per kilogram was USD 5.70. The profit per cubic meter of tank volume was calculated at USD 5.84.

Table 3. Economic performance of the shrimp nursery production cycle

Economic Parameter	Value
Selling Price (USD piece^{-1}	0.0135
Total Juveniles Sold (pcs)	190,000
Gross Revenue (USD)	2,577.14
Total Cost (USD)	1,981.94

Net Profit (USD)	595.20
Annual Cycles	12
Annual Profit (USD year^{-1})	7,142.40
Benefit-Cost Ratio	1.30
Return on Investment (%)	30%

Table 4. Additional economic indicators for shrimp nursery production

Indicator	Value
Cost per juvenile (USD piece^{-1})	0.010
Profit per juvenile (USD piece^{-1})	0.003
Cost per kg (USD kg^{-1})	18.97
Profit per kg (USD kg^{-1})	5.70
Profit per m^3 (USD m^{-3})	5.84

Water Quality Parameters During Nursery Culture

Table 5 summarizes the mean (± SD) water quality parameters recorded during the nursery culture of *L. vannamei*. Temperature, dissolved oxygen, salinity, pH, ammonia, nitrite, alkalinity, calcium, and magnesium remained relatively stable throughout the culture period.

Table 5. Mean (± SD) water quality parameters recorded during the nursery culture of *L. vannamei* .

Parameter	Value
Temperature (°C)	30 ± 0.8
Dissolved oxygen (mg L^{-1})	5.5 ± 0.5
Salinity (ppt)	31 ± 0.5
pH	8.2 ± 0.1
Ammonia (mg L^{-1})	0.50 ± 0.17
Nitrite (mg L^{-1})	<0.01
Alkalinity (mg L^{-1})	189 ± 16.0
Calcium (mg L^{-1})	332 ± 6.0
Magnesium (mg L^{-1})	894 ± 50.0

*Values represent mean ± standard deviation

Discussion

The present study demonstrates that a tank-based nursery system can effectively produce robust *L. vannamei* juveniles with high survival and favorable economic returns under commercial conditions. The survival rate of 95% observed in this study indicates that the culture environment and management practices were highly suitable for shrimp development during the nursery phase. This high survival can be attributed to stable water quality conditions, continuous aeration, and the controlled tank-based environment, which minimized environmental fluctuations and physiological stress. Maintaining adequate dissolved oxygen levels and stable pH likely supported metabolic efficiency and reduced stress-related mortality. In addition, the frequent feeding schedule ensured consistent nutrient availability and reduced competition among individuals, contributing to improved survival and uniform growth. Similar high survival rates have been reported in intensive nursery systems when environmental conditions and feeding practices are properly managed (Mishra et al., 2008; Samocha et al., 2004).

The shrimp reached an average body weight of 0.55 g after 23 days of culture, which falls within the recommended size range for transfer to grow-out systems. The nursery phase typically aims to produce juveniles of sufficient size to improve survival and performance after stocking. According to FAO guidelines, shrimp are commonly nursed to approximately 0.2–0.5 g prior to transfer (Briggs, 2006). The slightly higher final weight observed in this study suggests that the culture conditions supported efficient growth. This performance can be attributed to the combination of controlled environmental conditions and intensive feeding management, which enhanced nutrient assimilation and reduced energy loss due to stress.

Feed utilization in this study was highly efficient, as indicated by the feed conversion ratio (FCR) of 1.03. This low FCR reflects effective feeding management and minimal feed wastage. The adaptive feeding strategy employed, where feed input was adjusted based on feeding response, likely contributed to improved feed efficiency by preventing overfeeding and maintaining water quality. Stable environmental conditions also play a critical role in enhancing digestion and feed utilization efficiency in shrimp. Comparable FCR values have been reported in intensive nursery systems under controlled conditions (Mishra et al., 2008), supporting the effectiveness of the management approach used in this study.

The stress test conducted prior to harvest resulted in a post-stress survival rate of 96%, indicating that the juveniles produced were physiologically robust. Stress tolerance is an important indicator of shrimp quality, as it reflects the ability of juveniles to withstand handling, transport, and environmental changes during stocking. Previous studies have shown that higher survival during stress tests is associated with improved performance in grow-out systems (Álvarez et al., 2004). This suggests that the nursery system not only supported growth and survival but also contributed to the production of high-quality juveniles.

The strong biological performance observed in this study directly influenced the economic outcomes of the nursery operation. The high survival rate (95%) increased the total number of juveniles available for sale, thereby maximizing gross revenue. In addition, the low feed conversion ratio (1.03) reduced feed consumption relative to biomass production, lowering feed costs and improving cost efficiency. Efficient growth, reflected in the attainment of an average body weight of 0.55 g within 23 days, further contributed to economic performance by enabling shorter production cycles and increasing the number of cycles that can be completed annually. These biological outcomes were supported by stable water quality conditions and effective management practices, which collectively enhanced shrimp health, feeding efficiency, and overall productivity. Among these factors, survival rate and feed efficiency can be considered the primary drivers of profitability in this system, as they simultaneously increase production output and reduce operational costs.

The cost structure analysis revealed that seed cost accounted for the largest proportion of operating expenses (68%), consistent with previous findings that identify seed as a major cost component in shrimp nursery production (Durai & Alagappan, 2020). The relatively high seed cost in this study may be attributed to the procurement of high-quality and disease-free post larvae, which likely contributed to improved survival and growth performance. This indicates that investment in high-quality seed can be economically justified when it results in enhanced production efficiency. Energy was the second largest cost component, reflecting the continuous aeration and water management required in intensive systems. While these inputs increase operational costs, they are essential for maintaining stable environmental conditions that support optimal shrimp performance (Shinji et al., 2019). Feed costs accounted for a relatively small proportion of total expenses (7%), which can be attributed to both the short culture duration and efficient feed utilization.

The economic analysis confirmed that the nursery system was financially viable, with a benefit–cost ratio of 1.30 and a return on investment of 30%. A benefit–cost ratio greater than one indicates that the benefits exceed production costs, confirming economic feasibility (Huirne & Dijkhuizen, 1997). Similar profitability indicators have been reported in shrimp nursery systems, demonstrating that well-managed operations can generate favorable financial returns (Durai & Alagappan, 2020; Gammanpila, 2015). The estimated annual profit further highlights the advantage of intensive systems, where shorter production cycles allow for increased production frequency and improved utilization of infrastructure (Shinji et al., 2019). These findings reinforce that optimizing biological performance, particularly survival and feed efficiency, is fundamental to achieving economic sustainability in shrimp nursery operations.

Water quality parameters recorded during the study remained within ranges suitable for *L. vannamei* culture and likely contributed to the observed production performance. Stable temperature, salinity, dissolved oxygen, and pH conditions support physiological processes such as growth, molting, and metabolism (De Oliveira Lobato et al., 2020; Do et al., 2024; Patang, 2023; Srinivasan et al., 2025). Although ammonia levels were slightly elevated, they remained within tolerable limits and did not adversely affect shrimp performance. Maintaining stable water quality is particularly important in intensive systems, where high stocking densities can increase the risk of environmental stress (Han et al., 2017; Do et al., 2024).

Despite the strong biological and economic performance observed, this study was based on a single production cycle conducted under specific commercial conditions. As such, the findings should be interpreted as indicative of system performance rather than broadly generalizable outcomes. Variability in environmental conditions, input costs, and management practices across production cycles may influence both biological and economic performance. Future studies involving multiple production cycles and seasonal variation are recommended to provide a more comprehensive evaluation of system stability and long-term profitability.

The results demonstrate that intensive tank-based nursery systems can effectively produce high-quality *L. vannamei* juveniles while achieving favorable economic returns. The findings highlight the importance of integrated management strategies, where biological performance and economic efficiency are closely linked, and reinforce the role of nursery systems as a key component of sustainable and profitable shrimp aquaculture.

Conclusion

This study evaluated the production performance and economic viability of a commercial *Litopenaeus vannamei* nursery system under intensive tank-based conditions in the Philippines. The results show that the system can produce high-quality juveniles with high survival, efficient feed utilization, and positive economic returns. These findings help address the limited empirical data on commercial-scale nursery systems in the Philippines and highlight the importance of biological performance, particularly survival and feed efficiency, in determining profitability.

However, the study was based on a single production cycle without replication; therefore, the results should be interpreted as indicative rather than broadly generalizable. Future studies involving multiple production cycles and varying production conditions are recommended to validate and expand these findings.

Overall, intensive nursery systems show strong potential to improve production efficiency and support profitable shrimp farming when properly managed.

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