Enhancement of production and quality of *Moina* sp. through the utilization of pond water effluent from intensive cultivation of freshwater shrimp *Penaeus vannamei*

[1]Maya Meiyana, [1]Siti Murniasih, [1]Adang Saputra, [2]Lusi H. Suryaningrum, [3]Rita Rostika, [1]Taukhid Taukhid, [1]Abidin Nur, [1]Edy B. Kholidin, [1]Yohanna R. Widyastuti, [1]Lisa Ruliaty, [4]Arief R. Rivaie, [1]Tri H. Prihadi, [1]Brata Pantjara, [1]Endhay K. M. Kontara

[1] Research Center for Freshwater Aquaculture, National Research and Innovation Agency (NRIA), Cibinong, Indonesia; [2] Research Center for Applied Zoology, National Research and Innovation Agency (NRIA), Cibinong, Indonesia; [3] Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Sumedang, Indonesia; [4] Research Center for Marine Aquaculture, National Research and Innovation Agency (NRIA), Cibinong, Indonesia. Corresponding author: S. Murniasih, siti098@brin.go.id

Abstract. The rapid development of intensive freshwater *Penaeus vannamei* culture technology has led to environmental quality degradation and the emergence of problems related to wastewater discharge containing organic matter and nutrients. Nutrient-rich shrimp pond effluent has potential as an eco-friendly alternative feed source. One approach to address this issue is to use wastewater from intensive freshwater *P. vannamei* culture as a medium for the cultivation of mixotrophic aquatic organisms such as *Moina* sp. However, *Moina* sp. culture is still constrained by issues of quality, productivity, and sustainability. An alternative solution is the use of nutrient-rich wastewater from intensive freshwater shrimp farming to support the quality and productivity of *Moina sp.*, which serves as an initial feed for fish larvae growth. The objective of this study was to evaluate the effectiveness of nutrient and solid contents from intensive freshwater *P. vannamei* culture wastewater on the production and quality of *Moina* sp. Four concentrations of shrimp pond wastewater were tested as culture media under laboratory conditions: P1 (*Moina* sp. cultured with 100% shrimp wastewater), P2 (75% shrimp wastewater + 25% clean water), P3 (50% shrimp wastewater + 50% clean water), and P4 (25% shrimp wastewater + 75% clean water). The results showed that phytoplankton abundance was dominated by *Golenkinia* and *Oocystis*, with diversity and evenness index greater than others on the second day after inoculation. The highest *Moina* sp. population was obtained in the 100% shrimp wastewater treatment, reaching 237,526 individuals each container, which was significantly higher than other treatments ($p<0.05$). The nutritional composition of *Moina* sp. was also significantly higher ($p<0.05$) in the 100% wastewater treatment, particularly in protein, carbohydrate, and lipid content, while essential and non-essential amino acids were below the detection limit in the 75, 50, and 25% wastewater treatments. Therefore, culturing *Moina sp.* using wastewater from 100% *P. vannamei* freshwater intensive culture provides optimal growth performance and nutritional quality, especially on the second day after initial stocking.
Keywords: aquaculture wastewater, *Moina* sp., nutritional quality, production.

Introduction. The rapid advancement of intensive freshwater *P. vannamei* aquaculture technology has considerably enhanced shrimp production efficiency. However, it also contributes to environmental degradation if wastewater is not properly managed. Intensive freshwater shrimp farming commonly employs high stocking densities. According to Renitasari & Musa (2020), increasing stocking density requires a proportional increase in feed input. Suwoyo et al (2015) further stated that higher feed input elevates nutrient concentrations in pond water, leading to an increased organic load in the surrounding aquatic ecosystem. The excessive discharge of organic and nutrient-rich effluents into aquatic environments can result in severe ecological consequences, including water pollution, biodiversity loss, disease outbreaks, and habitat degradation (Ni et al 2021; Nur 2021).

Nutrients originating from shrimp farming activities also influence the abundance and composition of microalgae within ponds and their effluent discharge areas (Prasetiyono et al 2024). The accumulation of nutrients and organic matter in receiving waters leads to a decline in environmental quality around aquaculture sites. Nitrogen and organic compounds are decomposed into nitrite and ammonia, thereby increasing total ammonia nitrogen (TAN) concentrations in the water (Chen et al 2023). When TAN concentrations exceed the optimal threshold, they can cause mortality in aquatic organisms and trigger algal blooms (Pratiwi et al 2017). Elevated organic matter further promotes excessive phytoplankton proliferation, which intensifies competition for dissolved oxygen among aquatic biota.

To address the problem of excess nutrients and organic matter from intensive freshwater shrimp culture, several studies have explored their utilization as growth media for aquatic organisms, including *Moina* sp. (Sabilu et al 2020). *Moina* sp. is a small mixotrophic zooplankton capable of utilizing phytoplankton and organic detritus as nutritional sources (Baidya et al 2021; Tangguda & Prasetia 2019). It is widely recognized as a superior live feed for fish and shrimp larvae because of its high nutritional value and suitable particle size for larval ingestion. According to Rottmann et al (2018), *Moina* sp. contains approximately 60% crude protein and 20–27% lipid on a dry weight basis. Similarly, Mtaki et al (2025) reported that *Moina sp.* has a crude protein content of 64.1%, which is significantly higher than that of *Artemia* (44.0%). In addition to its high protein content, *Moina* sp. produces digestive enzymes such as amylase, protease, and lipase that function as extracellular enzymes within fish larvae intestines, facilitating nutrient absorption and digestion (Sontakke et al 2019). *Moina* sp. also exhibits a high reproductive rate, rapid growth, and can be cultured using various organic waste sources from fisheries, animal farming, and food industries (Nugroho et al 2021). Moreover, the effluent from intensive freshwater *P. vannamei* culture not only contains organic matter and nutrients but also essential amino acids derived from microbial consortia, such as valine, lysine, leucine, phenylalanine, threonine, and methionine (Ekasari et al 2014). This composition suggests that shrimp aquaculture wastewater has great potential to serve as an alternative nutrient source for *Moina* sp., potentially enhancing its nutritional quality. Therefore, the reuse of nutrient-rich and microbially active shrimp culture effluent represents a sustainable and low-cost approach for *Moina* sp. production while simultaneously reducing the environmental burden of aquaculture waste.

Despite this potential, there is currently limited information and scientific data on the utilization of intensive freshwater *P. vannamei* aquaculture effluent as a culture medium for *Moina* sp. Hence, this study aimed to evaluate the effectiveness of the nutrient and microbial composition of intensive freshwater *P. vannamei* culture effluent on the production performance and nutritional quality of *Moina* sp.

Material and Method

Wastewater source. The wastewater used in this study was obtained from an intensive freshwater *P. vannamei* culture system in Bandar Lampung City, Lampung Province, Indonesia. Sampling was conducted in August 2025. The wastewater was collected from the outlet channel of a shrimp pond after 87 days of the culture period. The collected wastewater was stored in white plastic jerry cans and used as the culture medium for *Moina* sp. For plankton identification and abundance analysis, wastewater samples were collected from the outlet using a 300 μm plankton net. The samples were then transferred into white sampling bottles for further laboratory analyses. These analyses included the determination of organic matter content specifically nitrate (NO_3^-), nitrite (NO_2^-), ammonia (NH_3), and phosphate (PO_4^{3-}) and the identification and quantification of plankton species present in the wastewater.

Experimental containers. The experiment was conducted using plastic boxes with dimensions of 54.5 × 37 × 30 cm^3, each filled with 15 L of effective water volume. A total of 12 units were prepared. Each container was aerated continuously using an air pump connected to air stones. The containers were placed in an outdoor hatchery area on a metal rack and covered with plastic lids to prevent rainwater contamination. Throughout the experimental period, no water exchange or cleaning was performed to maintain consistent environmental conditions.

Experimental design. A Completely Randomized Design (CRD) was applied, consisting of four treatments with three replicates each. The treatments represented different concentrations of intensive freshwater shrimp culture wastewater diluted with clean water, as follows: P1: 100% shrimp-culture wastewater; P2: 75% shrimp-culture wastewater + 25% clean water; P3: 50% shrimp-culture wastewater + 50% clean water and P4: 25% shrimp-culture wastewater + 75% clean water. *Moina* sp. was introduced one day after the experimental containers were filled according to the treatment concentrations. The number of starters *Moina* sp. stocked in each experimental container was 16 ind L^{-1} (an average of 1,613 ind $container^{-1}$), referring to Mirza et al (2025). Furthermore, the calculation of the density of *Moina* sp. was carried out every day at 07.00-09.00 PM. During the 7-day experimental period, *Moina* sp. was not provided with any supplemental feed; the available nutrients were solely derived from phytoplankton and organic matter present in the wastewater.

Observed parameters. Several parameters were evaluated in this study. The plankton community structure was assessed based on species composition, abundance, diversity, and evenness. *Moina* sp. population dynamics was monitored for 7 days, followed by a nutritional composition analysis at the end of the culture. Water quality (temperature, DO, pH, and TDS) was measured daily *in situ* using a portable multiparameter device (AZ860351). Additionally, initial concentrations of ammonia-N, nitrite, nitrate, and phosphate were analyzed using test kits. Quantitative assessments of the experimental parameters were also performed. Plankton abundance was determined according to the method described by APHA (2005) as follows:

$$N = \frac{Oi}{Op} x \frac{Vr}{Vo} x \frac{i}{Vs} x \frac{n}{p}$$

Where:
N - plankton abundance (individuals L^{-1});
Oi - area of the cover glass (mm^2);
Op - area of one field of view (mm^2);
Vr - volume of filtered water (mL);
Vo - volume of observed water sample (mL);
Vs - volume of water filtered (L);
n - total number of plankton observed in all fields of view (individuals);
p - number of fields of view observed.

The plankton diversity index was determined according to Prawiradilaga et al (2003), as follows:

$$H' = -\sum_{N=f}^{S} Pi\ Ln\ Pi$$

Where:
H' - species diversity index;
S - number species observed;
N - total number of individuals;
Pi - ni/N (proportion of the ith species).

The plankton evenness index was determined according to Krebs (1985):

$$E = \frac{H'}{H'max}$$

Where:
E - species evenness index;
H' - species diversity index;
H'max - maximum diversity index.

The population of *Moina* sp. was determined following the method of Yunda et al (2016) using a sampling technique by counting the number of *Moina* sp. individuals present in a 100 mL sample of the culture medium. During sampling, aeration was applied to ensure an even distribution of *Moina* sp. throughout the container. The counts were performed in Petri dishes for each experimental unit with three replicates, and the results were averaged. Population counts of *Moina* sp. were conducted daily for seven consecutive days of the culture period. The population growth rate of *Moina* sp. was calculated according to the formula described by Fogg (1975). The population growth rate of *Moina* sp. was calculated using the formula described by Fogg (1975) as follows:

$$K = (\ln N_t - \ln N_o)/t$$

Where:
K - population growth rate of *Moina* sp. per day;
Nt - population of *Moina* sp. after t days;
No - initial population of Moina sp.;
t - observation period (days).

Proximate analysis of Moina sp. The nutritional quality analysis of *Moina* sp. included proximate composition analysis covering ash, moisture, lipid, carbohydrate, and protein contents, as well as amino acid composition. The proximate analysis was conducted following the procedures of AOAC (1990).

Data analysis. The data were analyzed using analysis of variance (ANOVA), and when significant differences were observed, Duncan's multiple range test was applied to determine specific treatment differences. Data processing was performed using Microsoft Excel 2010 and SPSS software version 28.0. Water quality parameters such as temperature, dissolved oxygen, and pH were analyzed descriptively.

Results

Phytoplankton abundance. The identification and enumeration of plankton species present in the wastewater from intensive freshwater *P. vannamei* culture revealed a total of 13 plankton species, consisting of eleven phytoplankton species and two zooplankton species. Phytoplankton abundance in the wastewater was dominated by green algae (Chlorophyta). *Golenkinia* was the most prevalent species, reaching an abundance of 172,132 cells L^{-1}. In contrast, *Chorococcus*, *Chlorococcum*, *Palmella*, *Rhizolenia* recorded the lowest abundances, with only 789 cells L^{-1}.

Zooplankton abundance dominated by *Daphnia* with 1,579 cells L^{-1}, whereas *Fronotoniella* showed the lowest abundances 789 cells L^{-1}. The quantitative results of phytoplankton and zooplankton abundance are presented in Table 1, while the species richness and relative distribution were evaluated using the plankton diversity and evenness index, the results of which are shown in Table 2.

Table 1
Species composition and abundance of plankton in wastewater from intensive freshwater *Penaeus vannamei* culture

Number	*Phytoplankton species*	*Population (cells L^{-1})*	*Zooplankton species*	*Population (cells L^{-1})*
1	*Asterococcus*	72,643	*Daphnia*	1,579
2	*Chlorococcum*	789	*Frontoniella*	789
3	*Chodatella*	1,579	-	-
4	*Chorococcus*	789	-	-
5	*Golenkinia*	172,132	-	-
6	*Nitzschia*	90,803	-	-
7	*Nostoc*	15,791	-	-
8	*Oocystis*	26,849	-	-
9	*Palmella*	789	-	-
10	*Rhizolenia*	789	-	-
11	*Scenedesmus*	5,527	-	-

Table 2
Diversity and evenness index of plankton in wastewater from intensive freshwater *Penaeus vannamei* culture

Indices	*Value*
H' Plankton	1.49
H' Phytoplankton	1.45
H’ Zooplankton	0.03
E (Evenness index)	0.97

Moina sp. population. The population dynamics of *Moina* sp. cultured in wastewater from intensive *P. vannamei* farming at different concentrations (100%, 75%, 50%, and 25%) are presented in Figure 1.

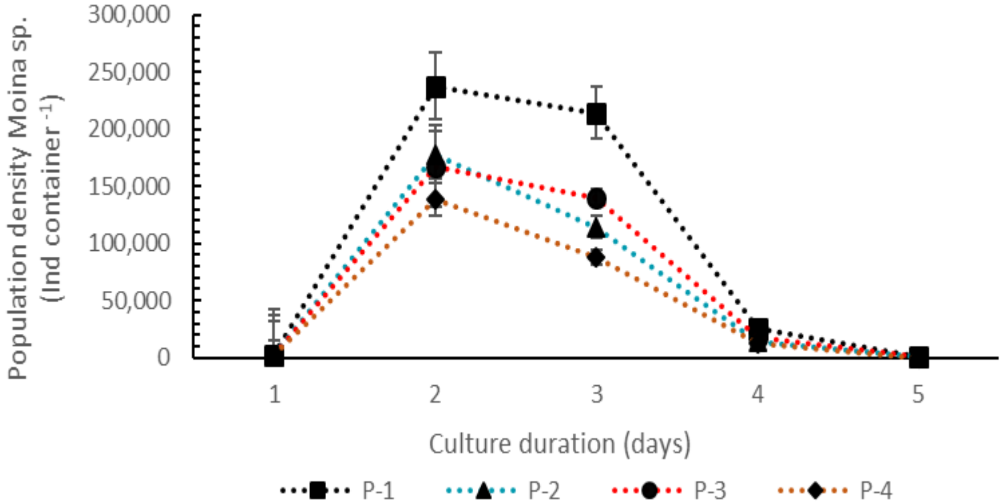

Figure 1. Population density (ind container^{-1}) of *Moina* sp. at different concentrations of wastewater from intensive freshwater *Penaeus vannamei* culture.

Following inoculation, *Moina* sp. exhibited a lag phase before showing optimal growth in the medium containing 100% shrimp-culture wastewater (P1), followed by treatments with 75% (P2), 50% (P3), and 25% (P4) wastewater concentrations. The initial stocking density of *Moina* sp. was 1,613 ind per container, and after two days of culture, the population increased significantly ($p<0.05$) to 237,526 individuals per container in the 100% wastewater treatment (P1), which was notably higher than in the 75, 50, and 25%

treatments. From day 2 to day 4, the population of *Moina* sp. remained above the initial inoculation density. However, beginning of day 5, a sharp population decline occurred, dropping below the initial density. While the observation was originally intended for a 7-day period, the data for days 6 and 7 were excluded from the analysis as the population had reached near-zero levels across all treatments, indicating the end of the productive culture cycle. These results indicate that the effective culture period for *Moina* sp. in shrimp-culture wastewater was three days, with the population peak occurring on day two of the culture period.

Water quality. The water quality parameters measured during the culture of *Moina* sp. in wastewater from intensive freshwater *P. vannamei* culture included temperature, pH, dissolved oxygen (DO), and total dissolved solids (TDS). The results showed that the temperature of the culture medium across all treatments ranged from 25.40 to 29.20°C, pH ranged from 6.68 to 8.19, DO ranged from 7.30 to 13.20 mg L^{-1}, and TDS ranged from 161 to 550 mg L^{-1}. The detailed results of water quality measurements are presented in Table 3.

Table 3
Profile of water quality parameters including temperature, pH, dissolved oxygen (DO), and total dissolved solids (TDS) in *Moina* sp. culture using wastewater from intensive freshwater *Penaeus vannamei* farming

Treatments	*Water quality parameters*			
	Temperature (°C)	pH	DO (mg L^{-1})	TDS (mg L^{-1})
P-1	25.60–28.70	7.00–8.19	10.00–13.90	406.00–550.00
P-2	25.40–27.60	7.01–7.83	7.30–13.40	245.00–317.00
P-3	25.50–28.60	6.73–7.80	9.60–13.20	196.00–296.00
P-4	25.70–29.20	6.68–7.63	10.10–12.20	142.00–161.00

Laboratory analyses of organic compounds are presented in Table 4. The results showed not significant differences ($p>0.05$) in NO_2^-, NO_3^-, NH_3, and PO_4^{3-} concentrations in all treatments. These findings indicate that variations in wastewater concentration from intensive freshwater *P. vannamei* culture did not cause water quality deterioration or organic pollution that could negatively affect the *Moina* sp. production medium.

Table 4
Organic matter content in *Moina* sp. culture using wastewater from intensive freshwater *Penaeus vannamei* farming

Parameters	*Unit*	*Waste water source*	*Treatments*			
			P-1	*P-2*	*P-3*	*P-4*
Nitrite (NO_2^-)	mg L^{-1}	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrate (NO_3^-)	mg L^{-1}	0.360±0.02	0.20±0.02^a	0.22±0.01^a	0.22±0.03^a	0.24±0.02^a
Ammonia (NH_3)	mg L^{-1}	0.100±0.00	0.02±0.00^a	0.03±0.00^a	0.04±0.00^a	0.04±0.00^a
Phosphate (PO_4^{3-})	mg L^{-1}	0.430±0.02	0.20±0.02^a	0.21±0.02^a	0.22±0.02^a	0.21±0.02^a

Nutrient composition of Moina sp. The proximate analysis of *Moina* sp. cultured in wastewater from intensive freshwater *P. vannamei* farming showed that the carbohydrate content in the 100% wastewater treatment reached 14.36±0.007%, which was significantly higher ($p<0.05$) than in other treatments, with the lowest value observed in the 75% wastewater treatment. The highest lipid content was recorded in the 75% wastewater treatment (6.91±0.007%), which was significantly different ($p<0.05$) from the other treatments, while the lowest lipid content was found in the 100% treatment (5.63±0.007%). The highest protein content was observed in *Moina* sp. cultured in 100% wastewater, reaching 67.65±0.056%, and was significantly different ($p<0.05$) from the 75%, 50%, and 25% treatments (Table 5). These results indicate that 100% intensive freshwater shrimp-culture wastewater provided the most favorable nutrient composition in *Moina* sp., making it a promising feed organism for early fish larvae.

Table 5
Proximate and amino acid profile of *Moina* sp. cultured in wastewater from intensive freshwater *Penaeus vannamei* farming

Composition	*Treatments*			
	P-1	*P-2*	*P-3*	*P-4*
	Proximate (%)			
Ash	0.11±0.007[a]	0.11±0.006[a]	0.12±0.005[a]	0.12±0.005[a]
Carbohydrate	14.36±0.007[a]	7.55±0.007[d]	10.22±0.049[b]	7.97±0.015[c]
Lipid	5.63±0.007[d]	6.91±0.007[a]	6.59±0.098[b]	6.38±0.049[c]
Protein	67.65±0.056[a]	65.74±0.028[c]	67.23±0.034[b]	64.21±0.044[d]
Nitrogen free extract	12.25±0.01[d]	19.69±0.02[a]	15.84±0.02[b]	19.32±0.01[c]
	Essential amino acids (%)			
L-Leucine	0.078±0.0014	-	-	-
L-Arginine	0.20±0.001	-	-	
L-Lysine	<0.07	-	-	-
L-Valine	0.070±0.001	-	-	-
L-Phenylalanine	0.062±0.001[a]	0.020±0.001[d]	0.089±0.001[b]	0.071±0.001[c]
L-Threonine	0.010±0.007	-	-	-
L-Isoleucine	0.049±0.001	-	-	-
	Non-essential amino acids (%)			
Glycine	0.067±0.001	<0.02	-	
L- Glutamic Acid	0.0795±0.0007[a]	0.0355±0.0001[c]	-	0.091±0.001[b]
L-Serine	0.021±0.001[a]	<0.01	<0.01	<0.01
L-Alanine	0.335±0.001[a]	0.020±0.001[b]	<0.01	
L-Tyrosine	<0.06	-	-	-
L-Proline	0.083±0.001[c]	0.020±0.01[d]	0.10±0.01[b]	0.11±0.01[a]

The analysis of amino acid composition revealed the presence of essential amino acids such as leucine, arginine, lysine, valine, phenylalanine, threonine, and isoleucine, and non-essential amino acids including glycine, glutamic acid, serine, alanine, tyrosine, and proline. In general, the 100% wastewater treatment contained a wider range of both essential and non-essential amino acids compared to the 75, 50, and 25% treatments, where only phenylalanine was detected among the essential amino acids. The amino acid profile analysis confirms that culturing *Moina* sp. in 100% intensive freshwater *P. vannamei* wastewater yields the best nutritional quality for use as live feed in aquaculture hatcheries.

Discussion. The analysis of wastewater from intensive freshwater whiteleg shrimp (*L. vannamei*) culture revealed the presence of various phytoplankton and zooplankton taxa. The phytoplankton community was dominated by green algae (Chlorophyta), particularly from the genera *Golenkinia*, *Asterococcus*, *Oocytis*, *Scenedesmus*, *Chodatella*, and *Chlorococcum.* In addition, *Nitzschia*, a member of Bacillariophyceae (diatoms), represented chromophytic algae, while *Nostoc* belonged to the Cyanobacteria group, commonly known as blue-green algae. All identified green algae genera are components of phytoplankton that serve as primary producers and a vital food source for zooplankton such as *Moina* sp. The zooplankton assemblage found in the shrimp wastewater was dominated by *Daphnia* sp., a freshwater crustacean, with an abundance of 1,579 ind mL^{-1}. The natural occurrence of *Daphnia* sp. in intensive freshwater shrimp wastewater indicates suitable environmental conditions to support *Moina* sp. (Rottmann et al 2018). Therefore, the effluent from intensive freshwater shrimp farming provides a highly favorable medium for *Moina* sp. culture.

The plankton diversity index (H’) of the wastewater was categorized as moderate (H’=1–3), as proposed by Prawiradilaga et al (2003). When H’ values range between 1 and 3, the aquatic community is considered stable (Siregar et al 2014). Plankton diversity is strongly influenced by water quality and particularly the availability of organic matter in the aquatic environment (Pagoray et al 2015). The evenness index (E) of plankton in the wastewater was high (E>0.6) according to Krebs (1985), indicating a balanced community without dominance of any single species (Khaeriyah & Burhanuddin 2015). The population dynamics of *Moina* sp. cultured in shrimp wastewater at varying concentrations demonstrated a progressive increase in abundance over time, following a typical sigmoid growth curve consisting of lag, exponential (log), stationary, and death phases (Figure 1). *Moina* sp. reached its maximum population density and exponential phase after 24 hours (day 2). Population growth began to decline during the stationary phase on days 4–5 (Table 3), likely due to nutrient depletion in the medium, followed by mortality on day 6. The stationary phase represents equilibrium between cell division and mortality, which occurs when nutrients become limiting (Krishnan et al 2015).

Cultures supplemented with 100% shrimp wastewater supported the highest *Moina* sp. population from days 2 to 5 compared to other treatments. This result reflects the nutrient richness of the wastewater medium. Both the quality and quantity of feed are major factors determining *Moina* biomass production (Rasdi et al 2020; Rasdi et al 2024; Sipaúba-Tavares et al 2014). Similar findings were reported by Hena et al (2024), who stated that green algae are among the best natural food sources for *Moina* sp. As a non-selective filter feeder, *Moina* sp. consumes unicellular algae and detrital organic matter, and its growth rate increases with higher phytoplankton abundance (Rasdi et al 2024). In addition to nutrient availability, water quality parameters also influence *Moina* sp. performance. Temperature is one of the key factors affecting metabolism and growth (Suprimantoro et al 2016). During the experiment, temperature ranged from 25.4–29.2°C in the morning and 27.6–29.2°C in the afternoon, with low fluctuation due to frequent rainfall. These conditions remained within the optimal range for *Moina* sp. survival and reproduction.

Moina sp. is known to tolerate poor water quality, including low oxygen environments (Rottmann et al 2018). Dissolved oxygen (DO) serves as an indicator of photosynthetic activity by microalgae. Low DO concentrations often indicate reduced algal photosynthesis or high oxygen consumption by heterotrophic microorganisms (Morales et al 2018). According to Rosyadi (2013), DO concentration in culture water is influenced by the presence of phytoplankton, which contribute oxygen through photosynthesis. Mubarak (2009) further noted that *Moina* sp. density can affect DO concentration in the medium. In this study, DO levels ranged between 7.30–14.20 mg L^{-1}, which are considered high, likely due to relatively low *Moina* density and respiration rate. A temporary decrease in DO following *Moina* sp. inoculation indicated active respiration (Murakami et al 2020). The pH values observed during the experiment ranged from 6.68–8.19, which is within the tolerable range for *Moina* sp. (7.0–8.0), supporting its survival and reproduction. Pennak (1978) and Leung (2009) reported similar findings, stating that *Moina* sp. thrives best in pH 6.5–8.0, with an optimum range between 7.0 and 8.0. Nutrient analysis of the shrimp wastewater, including nitrite (NO_2^-), nitrate (NO_3^-), ammonia (NH_3), and phosphate (PO_4^{3-}), revealed concentrations below the freshwater and aquaculture effluent discharge limits (Table 4). Nitrite originates from ammonia oxidation by *Nitrosomonas* bacteria and phytoplankton excretion. According to Saputra et al (2024), phytoplankton require organic nutrients such as nitrogen (N), phosphorus (P), potassium (K), and silicate (Si) for their growth. Aquaculture effluents typically contain 10–20% of the total feed-derived nitrogen and phosphorus (Kibria et al 2001; Mubarak et al 2017), which serve as essential nutrients for both phytoplankton and zooplankton development.

Moina sp. cultured in 100% shrimp wastewater exhibited superior performance, as indicated by its proximate composition. Elevated protein levels indicate strong potential for *Moina* to serve as a live feed for fish larvae. Protein plays a vital role as an energy source and structural component supporting tissue development and growth (Ouli 2012; Herawati et al 2020). Carbohydrate content in *Moina* sp. cultured with 100% wastewater was also higher than in the 75, 50, and 25% treatments. Elevated carbohydrate levels contribute to energy supply for fish larvae. Zhang et al (2025) reported that balanced protein and carbohydrate intake accelerates larval development. Lipid content, another essential macronutrient, was also notably high, providing a dense energy source that supports metabolism and growth (Herawati et al 2020). In addition to the favorable proximate composition, *Moina* sp. cultured in 100% shrimp wastewater showed a complete amino acid profile, including both essential and non-essential amino acids (Table 5). According to Casiraghi et al (2025), amino acid enrichment significantly enhances fish larval growth. Efatpanah et al (2024) highlighted that amino acids such as arginine, histidine, isoleucine, methionine, and serine are crucial for larval development, while Hăbeanu et al (2024) emphasized their role in organ formation. Thus, the present study confirms that *Moina sp.* cultured in 100% intensive freshwater shrimp wastewater provides an excellent nutritional profile, making it a highly promising live feed for early fish larvae.

Conclusions. Intensive freshwater *P. vannamei* wastewater is a highly effective medium for producing high quality *Moina* sp. biomass. The 100% wastewater concentration (P1) yielded the best results, reaching a peak population of 237,526 individuals per container and superior nutritional content on the second day. However, the population declines rapidly after the fourth day as the culture cycle ends. Therefore, to maximize productivity and nutrient quality for fish larvae feed, harvesting is recommended on the second day of cultivation. This approach provides a sustainable solution for shrimp farm waste management while supporting live feed production.

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Conflict of Interest. The authors declare that there is no conflict of interest.

Data Availability. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Authors:
Maya Meiyana (MM), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: maya012@brin.go.id
Siti Murniasih (SM), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: siti098@brin.go.id
Adang Saputra (AS), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: adan004@brin.go.id
Lusi Herawati Suryaningrum (LHS), National Research and Innovation Agency (NRIA), Research Center for Applied Zoology, Indonesia, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: lusi006@brin.go.id
Rita Rostika (RR), Universitas Padjadjaran, Faculty of Fisheries and Marine Sciences, Department of Fisheries, Jl. Raya Bandung- Sumedang KM 21, Jatinangor 45363, Sumedang, Indonesia, e-mail: rita.rostika@unpad.ac.id
Taukhid Taukhid (TT), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: tauk001@brin.go.id
Abidin Nur (AN), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: abid006@brin.go.id
Edy Barkat (EB), Kholidin National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: edyb001@brin.go.id
Yohanna Retnaning Widyastuti (YRW), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: yoha016@brin.go.id
Lisa Ruliaty (LR), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: lisa005@brin.go.id
Arief Rahman Rivaie (ARR), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: arie060@brin.go.id
Tri Heru Prihadi (THP), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: trih016@brin.go.id
Brata Pantjara (BP), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: brat001@brin.go.id
Endhay Kusnendar Muljana Kontara (EKMK), National Research and Innovation Agency (NRIA), Research Center for Freshwater Aquaculture, Jl. Raya Jakarta-Bogor KM 46, Cibinong 16911, Bogor, Indonesia, e-mail: endh001@brin.go.id

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