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Optimization of Different Stocking Densities on Growth and Survival Rate of Bonylip Barb (*Osteochilus vittatus*) Larvae

Optimalisasi Padat Tebar yang Berbeda Terhadap Pertumbuhan dan Kelangsungan Hidup Larva Ikan Nilem (*Osteochilus vittatus*)

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Abstract

This study aimed to determine the optimal stocking density on growth and survival rate of bonylip barb larvae. This study applied a completely random design experimental method with three treatments, namely 5 fish/L, 15 fish/L and 25 fish/L, in triplicates. Parameters obtained were composed of weight gain (WG), length gain (LG), survival rate (SR), and feed intake (FI). All data were analyzed using an analysis of variance (ANOVA) to determine the significance condition. If there were any significant difference on the data, a further analysis was conducted using the DMRT (Duncan's Multiple Range Test). The results showed that the optimal stocking density for bonylip barb fish larvae is 5 fish/L, due to showing the best treatment on WG, SR, and FI ($p<0.05$), although having no significant difference in LG among different treatments ($p>0.05$). This study concludes that different stocking densities can affect the growth and survival of bonylip barb larvae, with the best results observed at a density of 5 fish/L.

Keywords: Bonylip barb, density, growth, survival rate

Abstrak

Penelitian ini bertujuan untuk mengetahui padat tebar yang optimal bagi larva ikan nilem dan untuk mengetahui pengaruh padat tebar terhadap pertumbuhandan kelangsungan hidup larva ikan ni. Metode yang digunakan dalam penelitian ini yaitu eksperimen dengan Rancangan Acak Lengkap (RAL) yang terdiri dari tiga perlakuan (5 ekor/L, 15 ekor/L dan 25 ekor/L) dengan tiga kali ulangan. Parameter yang diambil pada penelitian ini meliputi berat mutlak (WG), panjang mutlak (LG), kelangsungan hidup (SR), dan jumlah konsumsi pakan (FI). Data dari parameter dianalisis menggunakan metode analisis sidik ragam (ANOVA) untuk mengetahui pengaruh data. Apabila ada pengaruh kemudian dilakukan uji lanjut DMRT (*Duncan's Multiple Range Test*). Hasil penelitian menunjukkan padat tebar yang optimal untuk larva ikan nilem yaitu 5 ekor/L, karena menunjukkan perlakuan terbaik pada nilai WG, SR, dan FI ($p<0,05$), meskipun tidak menunjukkan adanya perbedaan nyata pada nilai LG terhadap perlakuan lain ($p>0,05$). Penelitian ini menyimpulkan, bahwa padat tebar yang berbeda mampu mempengaruhi pertumbuhan dan kelangsungan hidup larva ikan nilem dengan perlakuan padat tebar terbaik ditunjukkan pada 5 ekor/L.

Kata Kunci : *Kepadatan, Nilem, Pertumbuhan,* kelangsungan hidup

1. Introduction

The nilem fish (*Osteochilus vittatus*) is a freshwater fish native to Indonesia found across various islands such as Java, Kalimantan, Sumatra, and other regions. Nilem fish are quite popular among the public due to their savory taste and firm flesh; additionally, the nutritional content of nilem fish is quite comprehensive, including protein, omega-3, vitamin D, and minerals (Syamsuri et al., 2018). The market potential for nilem fish is quite extensive; not only within Indonesia, but this fish is also exported to several regions in Asia, such as Southeast Asia and East Asia. The selling price of nilem fish in the international market can be higher than in the local market, which can be a significant advantage for farmers in enhancing economic value. The high market demand for this fish has a positive impact on efforts to develop freshwater aquaculture commodities (Molen, 2021).

The availability of low-quality fry is one of the challenges in tilapia farming. The limited number of sustainable tilapia hatcheries often makes it difficult for farmers to obtain sufficient quantities of high-quality juvenile (Mumpuni and Wahyudin, 2023). The quality of the juvenile produced is also low, characterized by slow and uneven growth as well as high

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mortality rates. As a result of these issues, the production value of tilapia has experienced a significant decline. Nile tilapia production has declined year over year; for instance, in 2018, Nile tilapia production was only 54,825 fingerlings (Azharul et al., 2024). Nile tilapia productivity needs to be improved to meet the increasingly high market demand, boost community economic value and national foreign exchange earnings, and increase fish populations.

Stocking density is a crucial factor in fish farming, including for tilapia. According to Majhi et al. (2023), stocking density is closely related to growth rate, survival, and feed conversion ratio, all of which contribute to increased production. Inappropriate stocking density can lead to various problems such as increased feed consumption, deteriorating water quality, and the spread of disease, which can result in production failure. Budi et al. (2020) explained that a stocking density of 10 fish/L for wader pari (*Rasbora argyrotaenia)* larvae yielded the best growth and survival rates. Motta et al. (2020) also noted that carp (*Cyprinus carpio*) larvae stocked at a density of 5 individuals/L exhibited the best growth and survival rates, while the lowest growth and survival rates were observed at stocking densities of 35 and 40 individuals/L.

However, research on stocking densities for nilem fish larvae has not been previously reported, given the lack of available recommendations for optimal stocking densities in the rearing of nilem fish larvae. This is the rationale behind this study on the optimization of different stocking densities regarding the growth and survival of nilem fish larvae (*Osteochillus vittatus*). This study aims to provide information on the appropriate stocking density for nilem fish culture.

2. Materials and Methods

2.1. Time and Location

This study was conducted from December 2024 to January 2025 at the Muntilan Fish Hatchery and Cultivation Center (PBI), Muntilan, Magelang, Central Java. The study was carried out at the Muntilan PBI Center, which serves as the primary supplier of nilem fish juvenile for the City and Regency of Magelang.

2.2. Materials and Equipment

The fish larvae used in this study were nilem fish larvae measuring 0.3–0.5 cm in length and 3 days old. A total of 1,350 larvae were used. The nilem fish larvae were obtained from semi-artificial spawning conducted by the Muntilan Fish Breeding and Cultivation Center (PBI). The equipment used in this study included 15-liter plastic containers, *millimeter blocks*, a digital scale, an aerator, a DO meter, and a pH meter. The materials used were nilem fish larvae, water, and an ammonia test kit.

2.3. Research Method

The plastic containers were sterilized using running water and dried for 24 hours. Then, 10 L of water was added. An aeration system was installed to supply additional oxygen to the rearing containers. The rearing containers were arranged according to the predetermined research design. The length and biomass weight of the nilem fish larvae were measured as baseline data for length and weight; the larvae were then stocked in the containers according to the predetermined quantities. The fish larvae were reared for 21 days, and during this period, they were fed D0 pellets using a feeding method until the fish stopped eating (*at satiation*). Feeding was conducted twice daily, in the morning (08:00 WIB) and in the afternoon (14:00 WIB).

Water quality is a critical factor in fish farming. The water used consists of groundwater and municipal water. The rearing tanks are cleaned once every seven days to remove debris from the tanks. Additionally, water changes are performed to maintain water quality within optimal limits. Cleaning is performed in the morning around 8:00 AM. Water quality parameters such as temperature, pH, and dissolved oxygen (DO) are checked daily in the morning and afternoon at 8:00 AM and 3:00 PM, while ammonia levels are measured once every seven days in the morning.

2.4. Research Design

The research design used in this study was a completely randomized design (CRD), with 3 treatments and 3 replicates. The treatments administered were: P1: 5 fish/L; P2: stocking density of 15 fish/L; and P3: stocking density of 25 fish/L. These stocking density treatments were based on studies by Budi et al. (2020) and Motta et al. (2020). A total of 9 experimental units were used in this study.

2.5 Parameters

The main parameters observed included absolute length (LG), absolute weight (WG), survival rate (SR), and feed intake rate (FI). The LG value can be calculated using the formula:

$$P = Lt - Lo$$

Explanation:
P: Length Growth (cm)
Lt: Final Length (cm)
Lo: Initial Length (cm)

The WG value can be calculated using the formula:

$$W = Wt - Wo$$

Notes:
W: Weight Gain (g)
Wt: Final Biomass Weight (g)
Wo: Initial Biomass Weight (g)

The SR value is calculated using the formula:

$$SR = \frac{N_t}{N_o} X\ 100\%$$

Notes:
SR: Survival Rate (%)
Nt: Number of Fish at the End of the Cultivation Period (individuals)
No: Initial Number of Fish (heads)

The FI value is calculated using the formula:

$$FI = F1 - F2$$

Notes:
FI: Total feed consumption (g)
F1: Initial feed amount (g)
F2: Final feed amount (g)

The supporting parameters observed were water quality data, namely temperature, pH, dissolved oxygen (DO), and ammonia. Water quality checks during fish larvae rearing were conducted in the morning and afternoon to ensure optimal water quality for the growth of nilem fish larvae.

2.6. Data analysis

Data analysis of the main parameters used in this study employed Analysis of Variance (ANOVA), followed by *Duncan's Multiple Range Test* (DMRT) to determine the differences between the various treatments. Data processing was conducted using *SPSS 24.0* to analyze the data obtained and the treatments administered. Data from supporting parameters were analyzed descriptively.

3. Results and Discussion

3.1. Absolute Length

The absolute length data for each treatment showed different average variations. The mean absolute length values for treatment P1 (5 fish/L) were 0.72 ± 0.03 cm, for P2 (15 fish/L) 0.70 ± 0.02 cm, and for P3 (25 fish/L) 0.67 ± 0.03 cm. P1 showed the highest mean absolute length, followed by P2, and the lowest was found in treatment P3, with a significant difference (p<0.05).

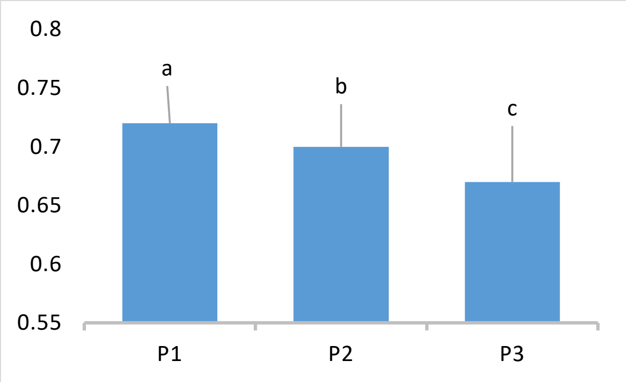

Figure 1. Absolute Length for Each Treatment (cm). Data are presented as mean ± SD. Different letters above the bars indicate significant differences (p < 0.05). Legend: P1 = stocking density 5 fish/L; P2 = stocking density 15 fish/L; P3 = stocking density 25 fish/L

The results of the analysis of variance indicate that stocking density has no significant effect on the absolute length of milkfish larvae (p<0.05). These results are consistent with the findings of Siri et al. (2023), who reported that the absolute length of milkfish (*Chanos chanos*) and Nile tilapia (*Oreochromis niloticus*) at different stocking densities showed no significant effect, as both species were able to utilize feed optimally. The study by Mile et al. (2023) also showed similar results, where different stocking densities in carp (*Cyprinus carpio*) juvenile did not result in a significant difference in length growth, but there were significant differences in weight gain and survival rates. The lack of significant difference in absolute length may be due to the fact that at high densities, most of the fish's energy is used to compete for swimming space, leading to energy depletion. Additionally, energy is redirected to maintain the immune system to reduce stress (Riana, 2021).

Length growth is generally linear and not highly sensitive to environmental changes. Fish length growth is influenced by both internal and external factors; however, in this case, length growth is likely more influenced by internal factors, as nilem fish larvae can utilize available residual energy and protein for their length growth. Energy and protein not used for vital activities such as respiration and movement are allocated to support the length growth process (Zulkhasyni et al., 2017). Genetic factors also play a significant role in regulating length growth, particularly in bone and tissue formation. According to Ariyanto and Utami (2006) as cited in Manunggal et al. (2018), fish growth conditions are highly influenced by genetic factors, kinship relationships, feed utilization efficiency, and population density.

3.2. *Absolute Weight*

The absolute weight data for treatments P1 (5 fish/L), P2 (15 fish/L), and P3 (25 fish/L) showed different values. The treatment with the highest absolute weight was P1, with an absolute weight of 0.068 ± 0.002 g, while the lowest absolute weight was found in treatment P3, with an average of 0.014 ± 0.001 g (p < 0.05). The weight gain of nilem fish larvae at lower stocking densities showed a higher growth rate compared to larvae reared at high densities.

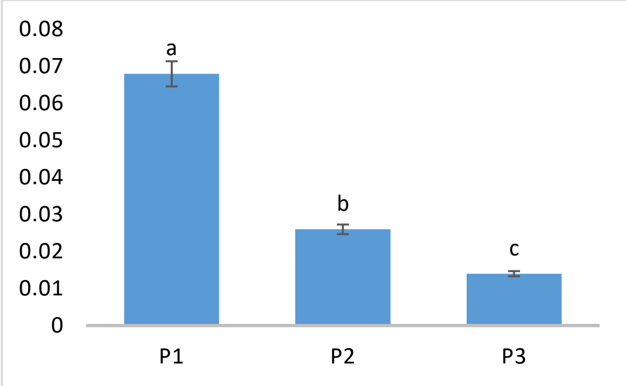

Figure 2. Absolute weight for each treatment (g). Data are presented as mean ± SD. Different letters above the bars indicate significant differences (p < 0.05). Legend: P1 = stocking density 5 fish/L; P2 = 15 fish/L; P3 = 25 fish/L

Data from the ANOVA analysis indicate that different stocking densities affect the absolute weight of nilem fish larvae. Results from the DMRT test show that treatment P1 produced the highest absolute weight, meaning that treatment P1 differs significantly from treatments P2 and P3, as indicated by different letter codes. Each treatment—P1, P2, and P3—exhibited different letter codes, indicating that different stocking densities affect the weight gain of nilem fish larvae. Stocking density P1 (5 fish/L) showed a high value and differed significantly from stocking densities P2 (15 fish/L) and P3 (25 fish/L). This occurs because P1 larvae can utilize feed optimally.

High stocking density can reduce the absolute weight gain of fish larvae, as high stocking density leads to intense competition for food and space, particularly during the larval phase when growth is rapid as they approach adulthood, thus requiring sufficient nutrients for their development. High stocking densities in larvae cause them to lose some of the energy that should be used for growth, as it is redirected to cope with stress and the struggle for survival (Suleman, 2024). This is further supported by Indriyani and Saselah (2025), who state that high stocking density in fish leads to the accumulation of metabolic waste, thereby degrading water quality. This, in turn, reduces energy efficiency, ultimately hindering fish growth.

The optimal stocking density for nilem fish larvae was found in treatment P1. The absolute weight gain at the stocking density in treatment P1 showed a high average value, indicating that at this density, the nilem fish larvae grew well and gained weight. The optimal stocking density for larvae provides sufficient space for movement, allowing them to move actively, forage for food, and reduce stress caused by high density. Sufficient space in the rearing tank enables larvae to access feed efficiently and reduces cannibalism among individuals. Pratama et al. (2021) also explained that a stocking density of 3 larvae/L for brek fish (*Systomus orphoides*) larvae showed the highest growth ( ) because at that density, the larvae had ample space to move freely; additionally, the low stocking density allowed for efficient feed utilization, enabling the larvae to grow well. This is further supported by Budi and Prayogo (2020), who found that a stocking density of 20 larvae per liter for wader pari fish (*Rasbora argyrotaenia*) resulted in the highest biomass, indicating good growth efficiency and survival rates, thereby offering economic benefits for wader pari fish (*Rasbora argyrotaenia*) aquaculture.

3.3. *Feed Intake Rate* (FI)

Based on the research results, the FI value for nilem fish larvae in treatment P1 (5 fish/L) was 7.3±0.4 g, in treatment P2 (15 fish/L) was 4.68±0.02 g, and in treatment P3 (25 fish/L) was 2.57±0.03 g. The highest FI value was found in treatment P1, and the lowest was found in treatment P3 (p<0.05).

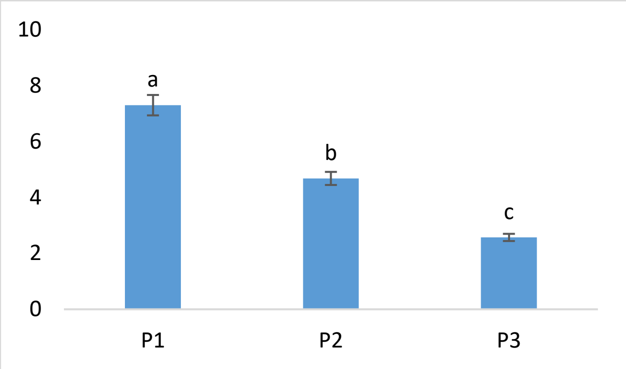

Figure 3. Feed intake levels for each treatment (g). Data are presented as mean ± SD. Different letters above the bars indicate significant differences ($p < 0.05$). Legend: P1 = stocking density 5 fish/L; P2 = stocking density 15 fish/L; P3 = stocking density 25 fish/L

The results of the ANOVA analysis indicate that different stocking densities have a significant effect on the feed intake rate (FIR) of nilem fish larvae. The results of the DMRT analysis indicate that each treatment received a different letter code, suggesting that stocking density significantly affects the feed intake rate of nilem fish larvae. Treatments P1, P2, and P3 were significantly different, as indicated by distinct letter codes. The highest FCR was observed in treatment P1 with a stocking density of 5 larvae/L. This indicates that at this stocking density, the nilem fish larvae were able to respond effectively and consume feed efficiently. This aligns with the study by Arisfa et al. (2021), where the optimal stocking density was found in treatment P1 (25 fish/125 L); a low stocking density in *Osteochillus kappeni* juvenile results in minimal feed competition, allowing the fish to access feed more easily. This is further supported by Hidayatullah et al. (2015), who noted that at low stocking densities, fish have better ability to utilize swimming space compared to those at high densities, as increased stocking density heightens competition among individuals, thereby disrupting growth and food acquisition.

Treatments P2 and P3 resulted in low feed intake but still showed significant differences. Excessively high density in fish larvae can potentially create competition among individuals for resources, particularly food; although feed availability was sufficient during the rearing period, access to food was limited due to competition for swimming space and varying swimming speeds. Larvae reared at high densities exhibit suboptimal feed utilization, leading to increased accumulation of metabolic waste (Fatmawati et al., 2022). The application of optimal stocking density allows each larva to have sufficient access to feed, so that feed can be efficiently converted into energy for growth. This is consistent with the statement by Aulianto et al. (2025) that low stocking density can make it easier for fish to obtain food and reduce competition, which can improve the ability to utilize nutrients in the feed.

3.4. *Survival Rate (SR)*

Based on the research results, the survival rates of nilem fish larvae were as follows: in treatment P1 (5 larvae/L) at 96.67±3.33%, P2 (15 larvae/L) at 52.66±5.34%, and P3 (25 larvae/L) at 33.87±0.13%. The highest larval survival rate was found in treatment P1, while the lowest survival rate of nilem fish larvae was found in treatment P3.

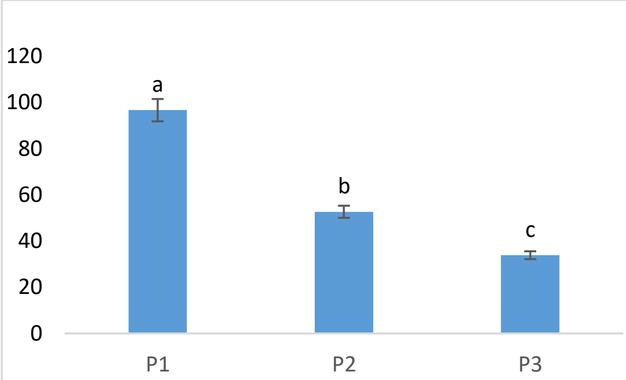

Figure 4. Survival rates for each treatment (%). Data are presented as mean ± SD. Different letters above the bars indicate significant differences ($p < 0.05$). Legend: P1 = stocking density of 5 fish/L; P2 = stocking density of 15 fish/L; P3 = stocking density of 25 fish/L

The results of the ANOVA test showed that different stocking densities had a significant effect on the survival rate of nilem fish larvae. The results of the DMRT SR test for nilem fish larvae showed that each treatment had a different notation, indicating that different stocking densities had a significant effect on the SR of nilem fish larvae. The best treatment was P1 with a mean value of 96.67±3.33%, followed by P2 at 52.66±5.34%, and the lowest was P3 at 33.87±0.13%. Treatment P1, with the highest value, indicates that a stocking density of 5 fish/L is the ideal condition for larval rearing. This suggests that the larvae have sufficient space to move, water quality is optimal, and feed management is effective. Tambunan et al. (2021) explained that the highest survival rate for tilapia (*Oreochromis niloticus*) juvenile was found in treatment A (18 fish) with an SR of 98.15%; the lower the fish density, the lower the metabolic waste output, allowing the fish to survive until the end of the rearing period.

Treatments P2 and P3 showed relatively low survival rates because nearly all, if not all, of the larvae died. This likely occurred due to high density, which made it difficult for the larvae to move; as the density in a rearing tank increases, the survival rate of fish larvae decreases. This is supported by the statement by Fitriani et al. (2015), that small rearing containers with high stocking densities ( ) cause fish to be crowded together, a condition that can trigger stress and mortality, thereby affecting fish survival rates.

High stocking density in nilem fish larvae increases competition among individuals for food and space, leading to physiological stress. This condition can trigger a stress response by elevating cortisol levels, which, if prolonged, suppresses the immune system. Individuals being too close together can also facilitate pathogen access into the fish's body. Susila (2016) explains that stress in fish leads to complex symptoms such as reduced responsiveness to feed, increased susceptibility to pathogen infection, and stress that ultimately results in death.

3.5. Water Quality

The water quality parameters measured include temperature, pH, dissolved oxygen (DO), and ammonia. The results of the water quality measurements are shown in Table 1.

Table 1
Water Quality During the Rearing of Nilem Fish Larvae

Parameter	Treatment		
	P1	**P2**	**P3**
Temperature (°C)	23.6 – 28	23.6 – 27.9	23.5 – 27.8
pH	6.57 – 7.77	6.61 – 7.83	6.52 – 8.36
DO (mg/L)	5 – 6.3	5 – 6.1	3.9 – 5.8

Ammonia (mg/L)	0	0 – 0.25	0 – 1.5

Based on water quality measurements, the temperature in treatment P1 ranged from 23.6–28°C, in P2 from 23.6–27.9°C, and in P3 from 23.5–27.8°C. pH in treatment P1 ranged from 6.57 to 7.77, in P2 from 6.61 to 7.83, and in P3 from 6.52 to 8.36. Dissolved oxygen levels in P1 ranged from 5 to 6.3 mg/L, in P2 from 5 to 6.1 mg/L, and in P3 from 3.9 to 5.8 mg/L. Ammonia levels in treatment P1 were 0 mg/L, P2 0–0.25 mg/L, and P3 0–1.5 mg/L. The temperature ranges in each treatment still indicated optimal values for the growth of nilem fish larvae. Generally, the ideal average temperature for nilem fish growth ranges from 18−28°C (Syamsuri et al., 2018). The optimal pH for fish growth ranges from 6.5–8 (Koniyo, 2020). The measured pH values remained within the optimal range for the growth of nilem fish larvae. Barus (2004) cited in Harsono (2015) stated that water conditions with suboptimal pH levels can threaten aquatic organisms because they increase the mobility of toxic metal compounds in the water, making them more readily available and potentially causing toxic effects on fish. The average dissolved oxygen (DO) in this study across all treatments ranged from 3.9 to 6.3 mg/L, a value that can be categorized as optimal. The optimal dissolved oxygen (DO) level for fish survival is >4 mg/L (Kevin and Putra, 2022).

Optimal ammonia concentrations were observed in treatment P1 (0 mg/L), whereas in P2 (0–0.25 mg/L) and P3 (0–1.5 mg/L), ammonia levels continued to rise as the duration of the experiment increased. Fish that live too long in excessively high ammonia concentrations will suffer impaired physiological functions and death (Wahyuningsih et al., 2020). The high ammonia levels in P2 and P3 are likely due to high stocking density, causing accumulated metabolic waste to decompose via microbial activity and release ammonia into the water. This aligns with Supono's (2015) statement that the accumulation of fish metabolic waste and uneaten feed increases ammonia concentration. Fanani et al. (2018) also noted that the higher the number of fish in a rearing tank, the more feces are produced, which can form ammonia. Fikri (2019) added that ammonia levels > 0.2 mg/L can be toxic, as they can affect water permeability in fish and reduce ion concentrations within the fish's body.

4. Conclusion

Based on the research results, it can be concluded that the stocking density of nilem fish larvae affects the growth and survival of nilem fish larvae. The optimal stocking density for the growth and survival of nilem fish larvae was found in the treatment of 5 individuals/L, with an absolute weight of 0.068 g, a survival rate of 96.67%, and a feed intake rate of 7.3 g.

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