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Original Article

Enhancing growth and survival rate of Asian Redtail Catfish *Hemibagrus nemurus* (Valenciennes 1840) Larvae through MinaPro probiotic soaking

Aprimoramento do crescimento e da taxa de sobrevivência das larvas do Bagre Asiático de Cauda Vermelha *Hemibagrus nemurus* (Valenciennes, 1840) através da imersão com o probiótico MinaPro

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Abstract

Asian redtail catfish (*Hemibagrus nemurus*) is a freshwater fish commodity with high economic value. However, the growth of the catfish larvae into fry is relatively slow. The administration of probiotics as a solution can increase the growth of fish larvae. Therefore, this research aimed to analyze the use of probiotics with a larval immersion method on the growth and survival of Asian redtail catfish larvae. A completely randomized design was adopted with four treatments and three replicates. Immersion treatment using probiotics consisted of P0 (control treatment without probiotic immersion), P1 (immersion treatment with a dose of 2.0 ml.L^{-1} of water), P2 (immersion treatment with a dose of 4.0 ml.L^{-1} of water), and P3 (immersion treatment with a dose of 6.0 ml.L^{-1} of water), with a stocking density of 50 fish/aquarium. The immersion was carried out every 10 days for 10 minutes in a basin container using 1 liter of water according to the specified dose. The results showed that the immersion larvae in probiotics significantly affected the biometric growth and survival ($p<0.05$). The highest biometric growth and survival was in P3- the group of immersion treatment with a dose of 6.0 ml.L^{-1} of water. This obtained absolute weight, length, and specific growth of 7.04 g, 8.81 cm, and 11.37% per day, as well as cannibalism type A and B of 8.00% and 0.00%, with cannibalism index, normal mortality, survival rate of 8.00%, 3.33%, and 88.67%, respectively.

Keywords: *Bacillus*, bacteria, cannibalism, growth performance, probiotic effectiveness.

Resumo

O bagre vermelho asiático (*Hemibagrus nemurus*) é um peixe de água doce com alto valor econômico. No entanto, o crescimento das larvas do bagre em alevinos é relativamente lento. A administração de probióticos como solução pode aumentar o crescimento das larvas de peixes. Portanto, esta pesquisa teve como objetivo analisar o uso de probióticos com um método de imersão larval no crescimento e na sobrevivência de larvas de bagre vermelho asiático. Foi adotado um delineamento inteiramente casualizado com quatro tratamentos e três repetições. O tratamento de imersão usando probióticos consistiu em P0 (tratamento controle sem imersão probiótica), P1 (tratamento de imersão com uma dose de 2,0 ml.L^{-1} de água), P2 (tratamento de imersão com uma dose de 4,0 ml.L^{-1} de água) e P3 (tratamento de imersão com uma dose de 6,0 ml.L^{-1} de água), com uma densidade de estocagem de 50 peixes/aquário. A imersão foi realizada a cada 10 dias por 10 minutos em um recipiente de bacia usando um litro de água de acordo com a dose especificada. Os resultados mostraram que as larvas de imersão em probióticos afetaram significativamente o crescimento biométrico e a sobrevivência ($p < 0,05$). O maior crescimento biométrico e sobrevivência foi em P3, o grupo de tratamento de imersão com uma dose de 6,0 ml.L^{-1} de água, no qual foram obtidos peso absoluto, comprimento e crescimento específico de 7,04 g, 8,81 cm e 11,37% ao dia, respectivamente, bem como canibalismo tipo A de 8,00% e tipo B de 0,00%, com índice de canibalismo, mortalidade normal e taxa de sobrevivência de 8,00%, 3,33% e 88,67%, respectivamente.

Palavras-chave: *Bacillus*, bactérias, canibalismo, desempenho de crescimento, eficácia dos probióticos.

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1. Introduction

Asian redtail catfish *Hemibagrus nemurus* (Valenciennes 1840) (Bagridae) is a freshwater fish serving as the mainstay of fishery commodities in Riau Province. This fish belongs to the 'Catfish' group and is among the 31 economically important fish species in the waters of Riau's Kampar River (Sukendi, 2014). The Asian redtail catfish business has grown rapidly in fish farming activities and the market demand continues to increase. This is because people prefer the fish processed into various dishes and culinary specialties of Riau. Due to the high market demand, the fish has become economically valuable. The selling price is quite high in the range of Rp 75,000-100,000/kg (Ikbal et al., 2022) but the provision of fry for aquaculture activities is an obstacle.

The problem of adhesive fish eggs has been overcome by soaking in a solution of natural plant extracts. Research conducted by Sukendi et al. (2023a) on the best type of natural plants to eliminate adhesiveness was found in kersen leaf plants at a dose of 4.0 ml/L water. Another problem in Asian redtail catfish farming is that the growth of fish larvae to reach fry size is relatively slow. According to Saputra et al. (2019), the problems faced in rearing larvae of Asian redtail catfish are low survival and slow growth. Therefore, an effort supporting the quality and quantity of larvae is to increase the growth and survival through the provision of probiotics. Probiotics are live microorganisms that may be used as dietary supplements to enhance fish performance and immunity (Hussain et al., 2021). The administration of probiotics can increase the survival and growth of larvae (Purba et al., 2021).

Probiotics are supplemental microbes with a beneficial effect on fish through nutrient utilization, enhancing immune response to disease, and improving environmental quality (Ali et al., 2020). The larvae are less susceptible to disease pathogens, and the appetite increases with the immune response. Probiotics are beneficial in regulating the microbial environment of the gut, blocking intestinal pathogens, and improving feed efficiency by releasing enzymes for food digestion (Mila and Mistina, 2022), contributing to increased larval survival during the early growth phase. Probiotics contain microorganisms and good bacteria that can improve the growth of fish larvae. Bacteria preventing disease and providing vitamins for fish include *Bacillus, Bifidobacteria, Pseudomonas, Lactobacillus*, and *Micrococcus* (Sidiq et al., 2023), as well as *Bacillus subtilis, Pseudomonas putida*, and *Bacillus licheniformis* (Suminto et al., 2019).

An important probiotic used in aquaculture is MinaPro, containing *Bacillus subtilis, Bacillus megatrium*, essential amino acids, skimmed milk, and molasses (Savara et al., 2023). The bacteria decompose useless and toxic organic materials and reduce total ammonia levels in the waters. In addition, the administration to the rearing medium can convert the remaining feed or feces through the biodegradation process to produce natural food (Beauty et al., 2012). Probiotics are also used to increase aquaculture production and profits due to improved growth and resistance to disease (Abadi et al., 2023).

The growth of Asian redtail catfish larvae produced without probiotics is low. This can be seen from research conducted by Sukendi et al. (2022) during 42 days where egg immersion using pineapple solution led to a length, weight, and specific growth of 4.74 cm, 1,315 g, and 13.8057%/day, respectively. Meanwhile, immersion using a kersen leaf solution led to a length, weight, and specific growth of 5.76 cm, 1,3222 g, and 14.5017%/day (Sukendi et al., 2023a), respectively. The growth of Asian redtail catfish larvae using Jamaican cherry leaf solution resulted in a length, weight, and specific growth of 5.54 cm, 1,2611 g, and 13.17%/day, respectively (Sukendi et al., 2023b).

The research on the use of probiotics administered in the maintenance medium was conducted by Saputra et al. (2019). The use of probiotics containing *Bacillus* sp. at a dose of 4.0 ml/L resulted in an absolute length increase of 5.36 cm in Asian redtail catfish, compared to 4.56 cm in the control treatment, with a growth difference of 0.8%. Additionally, the weight gain was 3.44 g, while the control treatment resulted in a weight gain of 2.58 g, showing a difference of 0.86%. Different types of probiotics are administered to fish but the effects in different doses of MinaPro probiotic remain unknown. Therefore, the effect of MinaPro probiotic immersion in increasing the growth and seed production of Asian redtail catfish larvae should be considered.

2. Materials and Methods

2.1. Time and place of research

This research was supported by the Institute for Research and Community Service (LPPM) at the Riau University, (Grant No. 15693/UN19.5.1.3/AL.04/2024). The collection and rearing of *Hemibagrus nemurus* larvae were approved by the Ethics Community Research and Community Service at Riau University, as documented in the grant letter No. 15693/UN19.5.1.3/AL.04/2024, dated May 15, 2024. Subsequently, the research was conducted in the Fish Hatchery and Breeding Laboratory within the Faculty of Fisheries and Marine, Riau University over 60 days from May to July 2024.

2.2. Research design

A completely randomized design was used with four treatments and three replicates. The treatment adopted was immersion of fish larvae using probiotics with the trade name MinaPro. The immersion dosage referred to Saputra et al. (2019), where the addition of *Bacillus* sp. bacteria in the maintenance medium of Asian redtail catfish was applied at a dosage of 4.0 ml/L. The duration for test fish larvae in the probiotic solution followed the research by Efendi et al. (2016), which was 10 minutes. Control treatment without probiotic immersion (P0), immersion treatment with a dose of 2.0 $ml.L^{-1}$ of water (P1), immersion treatment with a dose of 4.0 $ml.L^{-1}$ of water (P2), and immersion treatment with a dose of 6.0 $ml.L^{-1}$ of water (P3) were conducted to determine the effectiveness of the immersion dosage.

2.3. Preparation of Asian redtail catfish larvae

The larvae used were obtained from the artificial spawning of Asian redtail catfish broodstock. The number of broodstock was 2 pairs with fish weight ± 500 g injected twice with a time of 6 hours using the ovaprim branded hormone sGnRHa+Domperidone. The ovaprim used was packaged in a small 10 ml bottle produced by Syndell at a dose of 0.5 ml/kg and 0.3 for female and male brood stock. Stripping was carried out after 6-8 hours from the second injection. Eggs and sperm obtained were mixed in a bowl and stocked in an incubator container. The eggs were hatched in 22-24 hours and immersion in probiotics was performed after the yolk ran out or when the larvae were four - days old. The total number of fish was 600, consisting of 150 larvae per experimental group with an average length of 0.70 ± 0.00 cm. Each group was maintained in three aquarium units, measuring 30x30x30 cm, with a water volume of 20 liter per treatment. The treatment includes 50 fish per replicate, with a total of three replicates.

2.4. Preparation of larval immersion in probiotics

Before immersion, the probiotic solution was prepared in a clean environment with temperature adjustments around 28°C and pH of 7 to minimize the risk of stress from sudden environmental changes. The larvae were gradually introduced into the probiotic solution with adequate aeration, and the immersion time was 10 minutes to prevent stress, accompanied by careful monitoring. The probiotics used were first activated by the addition of condensed milk and water in a ratio of 2:1:100 (Imran et al., 2023), comprising 2 ml of probiotics, 1 ml of condensed milk, and 100 ml of water. All the ingredients were put into a measuring cup, then put into a glass bottle and stirred until homogeneous. Furthermore, the probiotic solution was inserted into the immersion container using a syringe with a predetermined dose with the duration of immersion of the test fish in the probiotic solution for 10 minutes (Efendi et al., 2016). The volume of probiotics used for soaking is adjusted according to the predetermined dosage. The larvae are soaked in a probiotic solution mixed with 1 liter of water. Larval immersion treatment in probiotic solution was carried out at 10.00 am, with a range of immersion every 10 days for 60 days of maintenance. During immersion, the immersion medium was aerated so that the fish larvae did not lack oxygen. After soaking, the fish larvae were stocked in the rearing medium with a stocking density of 5 individuals per liter.

2.5. Larval rearing

The test larvae were given natural food in the form of *Tubifex* sp. In this context, proper preparation was essential to ensure cleanliness and efficiency. The *Tubifex* was thoroughly rinsed under running water until clear and purged in clean, aerated water for 6–12 hours to eliminate ingested waste, with periodic changes. The daily feeding dosage was typically 5–10% of the body weight. The *Tubifex* sp. was cut into fine pieces using a knife to fit the mouth size of the larvae. The frequency of feeding was 4 times with an interval of 6 hours in 1 day at 07.00, 13.00, 19.00, and 01.00 WIB given ad libitum.

2.6. Research parameters

2.6.1. Absolute weight growth

Absolute weight growth (W) was observed every 10 days by weighing the fish biomass, and calculated using the Formula 1 (Wardoyo and Nasmia, 2021):

$$W = Wt - W0 \quad (1)$$

where: W = Weight growth (g); Wt = Average weight of fish at time t (g); W0 = Average weight of fish at the beginning of the research (g).

2.6.2. Absolute length growth

Absolute length growth was observed once every 10 days and calculated using the Formula 2 as follows (Asma et al., 2016):

$$Lm = Lt - Lo \quad (2)$$

where: Lm = Absolute length growth (cm); Lt = Larval length at the end of the research (cm); Lo = Larval length at the beginning of the research (cm).

2.6.3. Specific growth rate

The specific weight growth rate was observed once every 10 days and calculated using the Formula 3 according to Wardoyo and Nasmia (2021) namely:

$$SGR = \frac{\text{Ln Wt-Ln Wo}}{\text{t}} \text{ x } 100\% \quad (3)$$

where: SGR = Specific Growth Rate (%/day); Wt = Larval weight at the end of the research (g); Wo = Larval weight at the beginning of the research (g); t = rearing time (days).

2.6.4. Cannibalism Index

According to Heltonika et al. (2021), the cannibalism index is determined based on 2 types of cannibalism, namely types A and B. Type A is the incidence of cannibalistic death with loss of body parts due to predation while type B is the incidence of cannibalistic death without leaving carcasses or body remains. Both types of cannibalism are counted daily and will be accumulated at the end of rearing using the Equation 4:

$$\text{Cannibalism Index} = \frac{\text{Number of Dead Fish}}{\text{Number of Initial Fish}} \text{x} 100\% \quad (4)$$

2.6.5. Survival

Larval survival during 60 days of rearing can be calculated using the Formula 5 as follows (Wardoyo and Nasmia, 2021):

$$\text{SR} = \frac{\text{Nt}}{\text{No}} \text{x} 100\% \quad (5)$$

where: SR = Survival (%); Nt = Number of larvae at the end of the research (fish); No = Number of larvae at the beginning of the research (fish).

2.7. Data analysis

The data were tabulated and analyzed using SPSS version 22. Before conducting statistical tests, the assumptions of normality and homogeneity of variances were assessed. Normality was evaluated using the Kolmogorov-Smirnov test, and homogenity of variances was tested using Levene's test. For the main analysis, a one-way analysis of variance (ANOVA) was conducted to compare the treatment groups. Post hoc analysis was performed using the Student-Newman-Keuls (SNK) test to determine specific pairwise differences between treatments when significant differences were identified (P<0.05).

3. Results

Based on the research conducted during 60 days of rearing, the absolute weight and length growth of the Asian redtail catfish larvae showed an increase at each treatment. The treatment in P3 was given the highest value than others. The ANOVA showed that the treatment of larval immersion in probiotics with different doses had a significant effect (P<0.05) on the growth of absolute weight of Asian redtail catfish, as reported in Figure 1.

The absolute length growth at each treatment showed an increase. The analysis of the variance test reported significant effects (P<0.05) on the absolute length of Asian redtail catfish, as shown in Figure 2.

The specific growth and survival rate at each treatment showed an increase. The ANOVA reported the significant effect treatment of larval immersion in probiotics with different doses given (P<0.05) on the specific growth and survival rate, as shown in Figures 3 and 4.

The results of observations on the level of cannibalism of Asian redtail catfish larvae during 60 days of rearing reported a significant effect (P<0.05) on cannibalism type A, type B, cannibalism index, and normal mortality, as shown in Table 1.

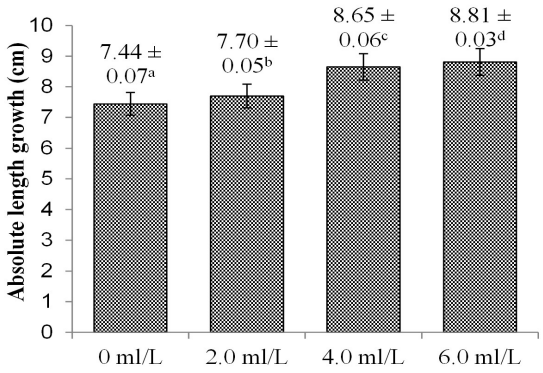

Figure 2. Absolute length growth of Asian redtail catfish and the data are expressed as mean ± SD. Different superscript letters above the bar chart for each probiotic dose indicated statistically significant differences (P<0.05).

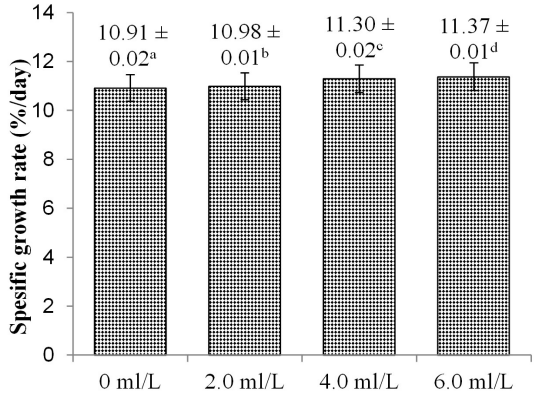

Figure 3. Spesific growth rate of Asian redtail catfish and the data are expressed as mean ± SD. Different superscript letters above the bar chart for each probiotic dose indicated statistically significant differences (P<0.05).

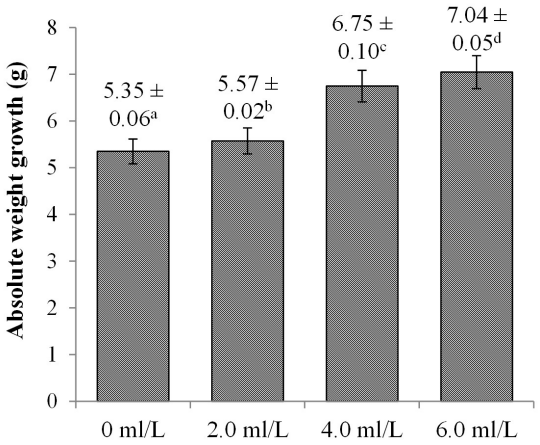

Figure 1. Absolute weight growth of Asian redtail catfish and the data expressed as mean ± SD. Different superscript letters above the bar chart for each probiotic dose indicated statistically significant differences (P<0.05).

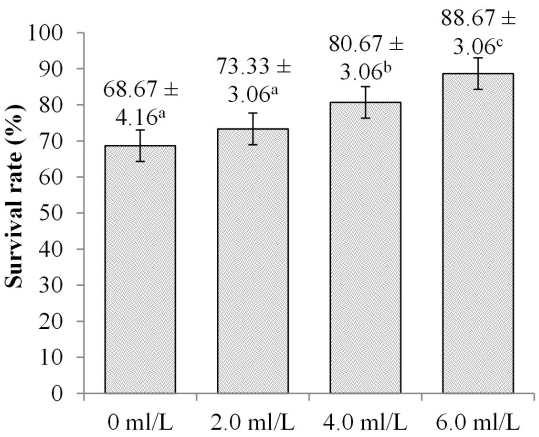

Figure 4. Survival rate of Asian redtail catfish and the data are expressed as mean ± SD. Different superscript letters above the bar chart for each probiotic dose indicated statistically significant differences (P<0.05).

Table 1. Cannibalism level of larvae of Asian redtail catfish (%).

Treatment	Cannibalism Type A	Cannibalism Type B	Index Cannibalism	Normal Mortality
P0	18.67±1.15^{c}	4.00±2.00^{b}	22.67±3.06^{c}	8.67±1.15^{c}
P1	16.67±1.15^{c}	3.33±1.15^{b}	20.00±2.00^{c}	6.67±1.15^{bc}
P2	12.67±1.15^{b}	1.33±1.15^{ab}	14.00±2.00^{b}	5.33±1.15^{ab}
P3	8.00±2.00^{a}	0.00±0.00^{a}	8.00±2.00^{a}	3.33±1.15^{a}

Different letters indicate differences based on statistical tests.

Remark: control treatment without probiotic immersion (P0); immersion treatment with a dose of 2.0 ml.L^{-1} of water (P1); immersion treatment with a dose of 4.0 ml.L^{-1} of water (P2); immersion treatment with a dose of 6.0 ml.L^{-1} of water (P3). Values were presented as the mean % ± SD based on triplicate measurements. Different superscripts for each probiotic dose indicated statistically significant differences ($P < 0.05$).

4. Discussion

The largest treatment for the value of absolute weight growth, absolute length growth, specific growth rate, and survival rate is the treatment P3 of 7.05 g, 8.81 cm, 11.37% / day, and 88.67%, respectively. This shows that the provision of probiotics with the immersion of fish larvae is preferable. The high growth in the P3 treatment is due to the number of bacteria induced into the digestive tract of fish larvae when the immersion process balances the microbes in the fish digestive tract. The ingredients in Mina Pro probiotics are *Bacillus subtilis, Bacillus megatrium*, essential amino acids, skimmed milk, and molasses (Savara et al., 2023). *Bacillus* sp. type can increase fish digestibility because these bacteria can compete in obtaining nutrients and surface space of the fish intestinal wall inhibiting the growth of pathogenic bacteria (Sitorus et al., 2019). *Bacillus* sp. contained in Mina Pro probiotics provide benefits to the absorption of feed due to the balance of microbes in the digestive tract (Sukoco et al., 2019).

Hanifa et al. (2022) stated that probiotics entered the digestive tract through the process of osmoregulation through the gills and blood vessels. During immersion, the number of bacteria that enter the digestive tract increases in line with the dose of probiotics given. The bacteria in the digestive tract will excrete enzymes such as amylase, lipase, and protease. The amount of enzymes secreted also increases according to the amount of probiotic dose given with the feed (Kesuma et al., 2019). The enzyme will help hydrolyze feed, such as breaking down carbohydrates, proteins, and fats into simpler molecules by facilitating the process of digestion and absorption in the fish digestive tract (Haryasakti et al., 2019). Probiotics can help the digestive process by increasing digestibility. In addition, digestibility of feed increases and feed will be more efficiently used by fish, because nutrients are easily absorbed by the body (Ezraneti et al., 2018).

Probiotics given through immersion in fish can help break down water and induce bacteria contained in the digestive tract to increase digestibility in fish. According to Malik et al. (2021), bacteria produce various enzymes for feed digestion, including amylase, protease and lipase. These enzymes assist in hydrolyzing stored feed nutrients (complex molecules), such as carbohydrates, proteins and fats into simpler molecules, thereby facilitating the digestion and absorption of feed in the digestive tract. The activity of *B. subtilis* bacteria contained in probiotics forms colonies and attaches to the intestines of fish and eventually urges pathogenic bacteria not to grow and not inhibit the digestive process of fish so as to increase digestibility (Kurniasih et al., 2021). Meanwhile, the bacteria used for the production of amylase enzyme is *Bacillus megaterium* (Istia'nah et al., 2020). *Bacillus megaterium* plays a role in improving the growth and immune response of fish (Hamka et al., 2021).

Consumption of probiotics provides health benefits for fish that can reach the digestive tract and remain alive to improve health (Adillah et al., 2023). These additional microbes possess beneficial effect on fish through nutrient utilization, increasing the immune response to disease and improving environmental quality (Ali et al., 2020). Susanti et al. (2017) stated that the survival of an organism was influenced by two factors, namely biotic and abiotic. Biotic factors include competitors, population density, age, and the ability of organisms with the environment, while abiotic factors comprise temperature, dissolved oxygen, pH and ammonia content.

The absolute weight growth of Asian redtail catfish reared without probiotics for 42 days reached a weight growth of 1.2611 g (Sukendi et al., 2023a). Research conducted by Efendi et al. (2016) on the difference in the period of immersion of selais larvae in probiotic solution resulted in the highest weight growth of 0.60 g. In addition, Nazar et al. (2019) also provided a statement that high fish length was consistent with increase in weight. There will be an increase in the length of the fish when the feed given can be used perfectly. The positive impact of probiotic supplements on fish intestinal health and immunity has been demonstrated in *Oncorhynchus mykiss* (Simakov et al., 2024), suggesting potential applications for other species, including larval fish.

Probiotics are feed additives that contain a range of microorganisms, providing beneficial effects on fish health by improving the balance of intestinal microflora. This leads to advantages such as enhanced protection against

diseases, improved digestion, and better feed utilization (Sedana and Sumadana, 2020). Fish larvae immersed in the solutions show a lower stress response compared to the control group. This is crucial, as fish larvae are often susceptible to environmental changes, including temperature fluctuations and high population density. With a stronger immune system and better resistance to stress, Asian redtail catfish larvae have a greater chance of survival (Hai, 2015).

Table 1 shows that the smallest cannibalism values of Asian redtail catfish larvae of cannibalism type A, type B, index cannibalism, and normal mortality in the treatment P3 are 8.00%, 0.00%, 8.00%, and 3.33%, respectively. Heltonika et al. (2021) reported that cannibalism index was determined based on types A and B. Type A cannibalism is the incidence of cannibalistic death with loss of body parts due to predation. Meanwhile, type B cannibalism is the incidence of cannibalistic death without leaving carcasses or body remains. Cannibalism in fish is caused by external and internal factors such as stocking density and hormonal activity (Peterson et al., 2013). Dead fish caused by cannibalism have characteristics obtained from preyed fish starting from the tail, head, and body (Mainisa et al., 2024). The absorption of fish nutrients is more optimal in the P3 treatment to suppress the level of cannibalism in larval Asian redtail catfish. Probiotics can improve digestion by absorbing nutrients and increasing the metabolic rate of fish.

MinaPro probiotics contain essential amino acids functioning to enhance growth performance and survival rates and improve fish immunity. Essential amino acids cannot be produced by the body and must be obtained from external sources (food). Tryptophan can reduce the occurrence of cannibalism and improve survival rates in Asian redtail catfish fry (Heltonika et al., 2022). This enzyme is converted by tryptophan hydroxylase into 5-hydroxytryptophan before transforming into serotonin by aromatic amino acid decarboxylase. Serotonin acts as a neurotransmitter in the brain to regulate behavioral changes, excessive movement, and food rejection (Mainisa et al., 2024). Probiotics work by enhancing gut health and the immune system, making larvae more resistant to disease and environmental stress. More feed is consumed when fish are healthy with increased appetite. Sobirin et al. (2017) stated that mortality occurred due to prolonged starvation and insufficient energy for growth and mobility.

The feed administered to the Asian redtail catfish larvae affects the response of fish larvae. The response of the larvae was very aggressive towards the feed and did not remain. The probiotic content can stimulate the formation of bacteria to produce enzymes in the digestive tract, affecting the digestibility and increasing the metabolic rate of the fish. In addition, silkworms have a distinctive aroma and high nutritional content to spur growth (Islama et al., 2019).

Based on the description above, probiotics reduces the reliance on antibiotics and other chemicals in fish farming, which is beneficial for the environment. These neurotransmitters improve gut health and reduce the risk of disease, leading to a decrease in the need for antibiotics by promoting healthy microbial populations in the digestive systems. The reduction mitigates the environmental pollution caused by antibiotic residues, which can negatively affect aquatic ecosystems and contribute to the development of antibiotic-resistant bacteria. Probiotics incur costs due to the purchase and addition of feed additives but the long-term benefits may outweigh the costs. Improved growth performance, better feed conversion ratios, and improved survival rates reduce overall production costs by minimizing losses due to disease and poor growth. In addition, healthier fish populations reduce the need for expensive medical treatments, such as antibiotics and other interventions. Probiotics enhance feed conversion efficiency and reduce the amount of waste entering the environment.

The larval immersion method using probiotics demonstrates significant advantages in enhancing larval health, survival, and growth rates, making it a promising approach for industrial-scale aquaculture. This method works through a more optimal bacterial colonization mechanism, where bacteria like *Bacillus sp.* directly interact with the larvae's body surface and digestive tract, enabling faster and more uniform colonization. This process plays a crucial role in boosting larval immunity by inhibiting the development of pathogenic bacteria through competition for space and nutrients while also stimulating the innate immune response. Additionally, probiotics produce digestive enzymes such as protease, amylase, and lipase, which improve digestion and nutrient absorption, thereby accelerating larval growth and strengthening their resistance to diseases and environmental stress. As a result, well-nourished larvae tend to exhibit lower levels of aggression, reducing the risk of cannibalism. By enhancing overall health and reducing reliance on antibiotics, this method supports sustainable aquaculture practices. Furthermore, the immersion technique is more cost-effective than administering probiotics through feed, as it ensures more even probiotic distribution and simplifies the application process. Its ease of implementation and effectiveness make this approach an economical and efficient solution for boosting large-scale fish hatchery productivity.

In addition to demonstrating the effectiveness of the probiotic immersion method in enhancing larval health and growth, it is essential to explore further research opportunities. Future studies should extend the duration of the experiment and investigate changes in gut microbiota to gain a deeper understanding of probiotic colonization. Examining interactions with different feeding regimes will also be crucial for optimizing feeding strategies. Moreover, increasing replication, expanding sample sizes, and conducting histological assessments of gut morphology will help improve the accuracy and generalization of these findings, making them more applicable to large-scale industrial aquaculture.

5. Conclusion

In conclusion, immersion increased the growth and survival of Asian redtail catfish larvae in probiotics with

different doses. The best dose was obtained in P3 where the probiotic immersion treatment was MinaPro with a dose of 6 ml.L^{-1}solution. The results obtained absolute weight, length, and specific growth of 7.04 g, 8.81 cm, and 11.37% per day, as well as cannibalism type A and B of 8.00% and 0.00%, with cannibalism index, normal mortality, survival rate of 8.00%, 3.33%, and 88.67%, respectively. The immersion of larvae using MinaPro probiotic solution was used as a reference to overcome problems in increasing the growth and survival of catfish larvae.

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