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Effectiveness of probiotics on the growth and survival rate of catfish (*Clarias sp.*) in an aquaponics system

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ABSTRACT

Applying probiotics to the recirculation system can support successful catfish production by improving growth and survival rates. This study aims to apply an aquaponic cultivation method that combines catfish (Clarias sp.) and water spinach (Ipomoea aquatica) cultivation by adding Probio-7 probiotics as a digestive aid to accelerate growth and improve the survival rate of catfish. This study was carried out at UPR Doa Mandeh Ogan Ilir from August to September 2024, using the experimental design that compared the effects of probiotic application on aquaculture performance, and aimed to evaluate the effectiveness of weekly probiotics administration in a controlled aquaculture setting. Probiotics are introduced at the start of the maintenance period and reapplied weekly, following a 30% water loss, and promptly replaced with clean water. This routine was designed to maintain optimal water quality and microbial balance, supporting healthier aquatic life. The consistent probiotic treatment, aligned with systematic water management, highlights a practical approach to improving fish health and growth performance in sustainable aquaculture practices. The treatments used were without probiotics (P0) and the addition of probiotics at a rate of 0.25 mL L-1 water (P1). The results of the research activities in P1 showed absolute length growth of 16.71 cm, absolute weight of 16.44 g, feed efficiency of 84.3%, and fish survival rate of 79%. These values were higher than those in P0, which had an absolute length growth of 5 cm, absolute weight of 11.94 g, feed efficiency of 84.3%, and fish survival rate of 77%. Water quality during the study remained within the optimal range, supporting the growth and survival of catfish.

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INTRODUCTION

Catfish (*Clarias* sp.) is a key freshwater aquaculture commodity in Indonesia, valued for its rapid growth, ease of cultivation, and resilience in suboptimal environments (Yunus *et al.*, 2014; Prayogo *et al.*, 2012; Wulansari *et al.*, 2022). These characteristics make catfish an attractive species for both small- and large-scale aquaculture operations. However, the increasing demand for catfish has driven the expansion of aquaculture land and water use, raising sustainability concerns due to limited resources (Holmer, 2010; Polishchuk & Simon, 2023). According to the Indonesian Ministry of Marine Affairs and Fisheries (2022), national catfish production reached 347,511.48 tons in 2020, highlighting the significant scale of catfish production in Indonesia to meet consumer demand.

Furthermore, other problems arise from catfish farming, such as waste by-products that can contaminate the environment and disturb the surrounding community (Coppola *et al.*, 2021). These challenges can be addressed using an aquaponic system, which is efficient and eco-friendly by integrating fish farming with plant cultivation to optimize water use and reduce waste (Oladimeji *et al.*, 2020). The aquaponics system is a recirculation system that integrates plant and fish farming in a controlled environment (Yep and Zheng, 2019). Aquaponics combines aquaculture and hydroponics into a system with a symbiotic relationship that allows water and nutrients to be recirculated and reused (Liang *et al.*, 2013). Another advantage of aquaponics is its ability to maintain dissolved oxygen levels through effective water recirculation and nutrient uptake by aquatic plants, supporting better fish survival (Pratopo and Ahmad, 2021). The plants suitable for aquaponics cultivation include water spinach. Water spinach is used in catfish farming because it functions as a phytoremediation agent (Zulfahmi *et al.* 2021). The roots of water spinach plants can absorb nitrogen as a nutrient source, which comes from organic waste, uneaten feed residues, or inorganic waste produced by fish metabolism, thereby maintaining water quality in the cultivation medium (Effendi *et al.*, 2015). One method to support fish growth and survival is the addition of probiotics to the rearing medium, which helps improve water quality and enhances the fish's immune response. According to Reid *et al.* (2016), probiotics are microorganisms that, when added in appropriate amounts, provide benefits to their hosts. The addition of probiotics aimed at improving existing bacteria to assist in the digestive process within the digestive organs and accelerate fish metabolism, thereby resulting in more significant growth. Based on research by Primashita *et al.* (2017), the best treatment for catfish farming using probiotic B, which consists of *Lactobacillus*, *Nitrosomonas*, and *Bacillus* bacteria, resulted in the highest specific growth rate of 0.025% per day and the highest survival rate of 77.8%.

Unit Pembenihan Rakyat (UPR) Doa Mandeh, Ogan Ilir, is a place that specializes in catfish farming, particularly the provision of catfish larvae. UPR Doa Mandeh has adequate facilities to support aquaculture activities. Therefore, the author is confident enough to conduct research at UPR Doa Mandeh, Ogan Ilir.

METHOD

This research was conducted at UPR Doa Mandeh, Ogan Ilir, from August to September 2024. The study was conducted using a comparative experimental method comparing probiotic applications with non-probiotic treatment. The research utilized the following tools and materials: a box measuring 30x40x50 cm^3, a filter pump, PVC pipes, hoses, a digital scale, a thermometer, a pH meter, a net, a ruler, catfish measuring 5-7 cm, probiotics, commercial feed, rockwool, water spinach, and potassium permanganate. The procedure for this study was as follows: the container used during maintenance was a box measuring 30x40x50 cm^3. Washing and drying of the box was carried out at the beginning of preparation to remove dirt from the box. Then, fill the box with water until complete and apply potassium permanganate for 24 hours to eliminate pathogenic bacteria adhering to the box. Probiotic administration was performed at the start of maintenance and every week thereafter, following water replacement by siphoning 30% of the maintenance medium water and refilling with clean water equivalent to the volume removed. Two treatments are applied during the maintenance period: control treatment and treatment 1. Control treatment does not involve additional probiotics, while treatment 1 involves probiotics at a dose of 0.25 ml L^{-1} throughout the catfish maintenance period until harvest. The dose used is based on research by Primashita *et al.* (2017).

The aquaponics system is installed using PVC pipes with four holes drilled at a diameter of 5 cm. A pump is installed at the bottom of the box, where small pipes have been installed for water to circulate through the PVC pipes, forming a recirculation system. At the end of the PVC pipe, water will be discharged back into the pond. Planting water spinach plants measuring 5-10 cm in rockwool placed in the holes of the PVC pipe, which serves as the growing medium for the water spinach. This medium also functions as a filter to absorb organic matter in the water, thereby maintaining water quality.

Figure 1. Aquaponic system setup

The catfish were stocked on August 29, 2024, at 8:00 a.m. with a density of two fish per liter (Primashita *et al*., 2017). The catfish used were sourced from UPR Doa Mandeh. The catfish utilized were 5–7 cm in length and weighed 3–4 g. Acclimatization was conducted before stocking to allow the fish to adapt to the new environmental temperature, thereby reducing stress and mortality rates. The stocked catfish were sampled initially to determine their weight and length at the start of the rearing period. The catfish were reared for 30 days and fed using a feeding rate of 5% of the biomass of the reared fish, with a frequency of three times a day at 08:00, 12:00, and 16:00 WIB. The feed used was commercial feed with a protein content of 39-41%. During the rearing period, sampling of the catfish was conducted once a week to determine the amount of feed to be provided, calculate growth, and monitor the health of the catfish. Water quality measurements such as pH and temperature were conducted daily, and dissolved oxygen levels were measured once a week.

Catfish harvesting was carried out after a 30-day rearing period. This activity is carried out in the morning to prevent fish stress and mortality (Pang *et al*., 2016). Fish harvesting is done by measuring the weight and length of the fish to determine absolute weight growth and absolute length growth at the end of the rearing period. The parameters observed in this activity are absolute growth, feed efficiency, survival rate, and water quality as follows:

Calculation of absolute weight growth according to Effendi (2002), using the following formula:

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

Where W is absolute weight gain, Wt is the weight of fish at the end of the rearing period, and Wo is the weight of fish at the beginning of the rearing period.

Calculation of absolute length growth according to Effendi (2002), using the following formula:

$$L = Lt - L0 \quad (2)$$

Where L is absolute length gain, Lt is the length of fish at the end of the rearing period, and Lo is the length of fish at the beginning of the rearing period.

The feed efficiency calculation formula according to NRC (1977) is as follows:

$$FE = \frac{(Wt - W0)}{F} \times 100 \quad (3)$$

Where FE is feed efficiency, weight of fish at the end of the rearing period, and Wo is the weight of fish at the beginning of the rearing period

Calculation of fish survival rates according to Effendi (2002), using the following formula:

$$SR = \frac{Nt}{N0} \times 100 \quad (4)$$

Where SR is the survival rate, Nt is the number of individuals at the end of rearing, and No is the number of individuals at the beginning of rearing.

RESULTS AND DISCUSSION

The absolute growth and efficiency of catfish during the 30 days of research activities are presented in Table 1.

Table 1. Absolute growth, feed efficiency, and survival rate of catfish (*Clarias* sp.)

Treatments	Absolute length (cm)	Absolute weight (g)	Feed efficiency (%)	Survival rates (%)
P0	5,00	11,94	69,5	77
P1	6,71	16,44	84,3	79

The absolute growth results of catfish rearing for 30 days in Table 1 show that P1 was higher than P0. The absolute length growth of the probiotic treatment (P1) was 6.71 cm, and the absolute weight was 16.44 g, compared to the non-probiotic treatment (P0), which had an absolute length growth of 5 cm and an absolute weight of 11.94 g. The development of P1 is significantly higher, which is likely due to the presence of *Lactobacillus* bacteria in the probiotic that actively alter the feed composition and increase the secretion of proteolytic enzymes used to break down proteins in the feed into amino acids, making them easier to digest by the fish's intestines (Shah *et al*., 2024). Irianto and Austin (2002) also added that *Lactobacillus* bacteria could secrete protease and amylase enzymes to aid fish digestion. *Lactobacillus* can also produce lactic acid during fish metabolism, which can prevent pathogenic bacteria causing diseases (Dates *et al*., 2025).

Findings similar to those of Primashita *et al*. (2017) indicate that catfish reared with probiotics at a dose of 0.25 ml L^{-1} resulted in absolute length growth of 5.27 cm and absolute weight of 11.4 g. In comparison, this study obtained absolute weight growth of 16.44 g and absolute length growth of 6.71 cm. The higher absolute growth in this study is presumed to be due to water changes after sampling. In contrast, in the previous research, no water changes were performed, resulting in significantly better water quality. Additionally, the addition of probiotics supported catfish growth. Eliyani *et al*. (2015) stated that probiotics can improve water quality in aquaculture media and can act as agents that break down various elements such as NH_3, NO_3, NO_2, or other organic materials, and can inhibit the growth of blue-green algae. Providing probiotics will also suppress the growth of pathogenic bacteria in the culture medium (Hastuti *et al.*, 2019). Beneficial probiotics include lactic acid bacteria such as *Pseudomonas* and *Lactobacillus* (Sungsirin *et al.*, 2024). Irianto (2007) adds that bacteria in probiotics also aid digestion by facilitating the fish's processing of feed entering its digestive organs.

Feed efficiency describes the utilization of feed intake of fish concerning fish growth rates (Afriansyah *et al.*, 2023). Feed efficiency in Table 1 showed that the P1 value was higher than P0. The feed efficiency values of P0 and P1 were 69.5% and 84.3%, respectively. The higher feed efficiency in P1 is presumed due to optimal stocking density and the optimal functioning of bacteria in the probiotics. Digestible feed is utilized more efficiently due to nutrients in the diet being pre-processed by bacteria in the probiotics through accelerated metabolic processes in the digestive organs, producing enzymes that facilitate absorption by the fish's body (Bandari *et al.*, 2024). This finding was supported by (Hu *et al.*, 2008; Amin *et al.*, 2018) that bacteria found in probiotics could produce phytase enzymes, which break down phytic acid, an anti-nutritional factor in fish diets. The amount of protein in fish feed may also affect fish growth, as protein plays a role in muscle development, thereby promoting optimal growth outcomes (Putra, 2010).

The survival rates in Table 1 showed that P1 was higher than P0. The survival rate of catfish at the end of the rearing period was 77% for P0 and 79% for P1. The higher survival rate in P1 is suspected to be due to the activity and role of bacteria in the probiotic, which break down organic matter in the catfish rearing medium, thereby maintaining optimal water quality and preventing stress in the fish (Fachri *et al.*, 2024). Shija *et al.* (2023) additionally note the probiotic's role in the catfish's digestive system, as well as its role in enhancing the immune system and preventing the growth of pathogenic bacteria caused by diseases in the fish. In line with Gatlin and Peredo (2012), when probiotics are added, the probiotics can inhibit the growth of pathogenic bacteria, thus stimulating the immune response of fish. The survival rate was relatively high, allegedly due to optimal stocking density and adequate feeding, preventing food competition that could lead to size differences among fish, thereby avoiding cannibalism (Cahyanti *et al.*, 2015). The water spinach plants also help absorb organic matter that can't be processed by fish and improve the water quality of the rearing medium. That statement was supported by Andriyeni *et al.* (2017), who found that catfish waste contains macronutrients such as nitrogen, phosphorus, and potassium that plants can absorb as nutrients for their growth. Fitria (2012) explains that good water quality management and the availability of high-quality feed, which prevent stress or abnormal conditions in fish, influence fish survival rates.

The water quality data of catfish during 30 days of maintenance are presented in Table 2 as follows:

Table 2. Water quality during catfish rearing.

Treatments	Temperature (°C)	pH	Dissolve oxygen (mg L^{-1})
P0	26-34	6,94-8,75	6,9-7,2
P1	26,5-33,7	6,81-8,53	6,9-7,4

The water quality results in Table 2 indicate the results of water quality measurements during maintenance. The measurement results are within the optimal range. The temperature recorded during the maintenance period was relatively high at 26–34°C. In comparison to the statement from the Freshwater Aquaculture Development Center (Balai Besar Pengembangan Budidaya Air Tawar) (2005), which suggests that the optimal maintenance temperature for catfish should be within the range of 22–32°C, the recorded temperatures were indeed higher but still within the tolerable limits for catfish. Higher temperatures could also increase the catfish's feed intake, leading to faster metabolism and impacting growth rates.

The pH values obtained during maintenance ranged from 6.81 to 8.75. These values are still within the normal range and are sufficient for the survival and growth of catfish, as the optimal pH value according to SNI 01-6484.5 (2002) ranges from 6.5 to 8.5, and values above this range may cause fish mortality. When compared to the National Standards Agency (2014), the pH values obtained during the maintenance period are sufficient to support the growth of catfish.

The dissolved oxygen obtained during research was classified as good. Murhananto (2002) explained that the usual standard for dissolved oxygen was generally 4 mg L^{-1} and that oxygen levels of less than 20% could lead to the death of catfish. This opinion is also consistent with the standards outlined in Government Regulation No. 22 of 2021, which states that dissolved oxygen for freshwater fish farming should be greater than 4 mg L^{-1}. Dissolved oxygen itself plays a role in the respiration and metabolism of fish, which directly impacts catfish. Dissolved oxygen also plays a role in the photosynthesis process of plankton, bacteria, and water spinach plants, which helps stabilize water quality during maintenance.

CONCLUSION

The results of the experiment showed that the use of probiotics at a dose of 0.25 ml L^{-1} produced higher results with absolute length growth of 6.71 cm, absolute weight of 16.44 g, feed efficiency of 84.3%, and fish survival rate of 79%. Water quality in the study with a probiotic dose of 0.25mL L^{-1} was optimal, with a temperature range of 26-34°C, a pH range of 6.81-8.75, and dissolved oxygen levels in the range of 6.9-7.4.

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