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Growth Performance Cachama (*Colossoma macropomum*) Fished by Polyculture with Taiwan Kijing (*Anodonta woodiana*)

Performa Pertumbuhan Ikan Bawal Air Tawar (Colossoma macropomum) yang Dipelihara secara Polikultur dengan Kijing Taiwan (Anodonta woodiana)

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Abstract

Cachama (*Colossoma macropomum*) is a freshwater fishery commodity with high economic value, but water quality in cultivation is often an obstacle. The utilisation of natural biofilters, such as Taiwanese mussels (Anodonta woodiana), in a polyculture system is expected to improve water quality and increase fish growth performance. This study aims to evaluate the effect of different numbers of Taiwanese mussels in a polyculture system on the growth of Cachama. The study was conducted for 56 days using a completely randomised design (CRD) with four treatments: P0 (without biofilter), P1 (14 mussels), P2 (19 mussels), and P3 (24 mussels), with three replications for each treatment. The parameters observed include absolute weight growth, absolute length, specific growth rate, survival, and water quality. The results showed that the P3 treatment gave the best results with an absolute weight of 8.25 g, an absolute length of 4.78 cm, and a specific growth rate of 2.02% per day. The use of Taiwanese mussel biofilters significantly improved water quality and growth of cachama.

Keywords: Cachama, Polyculture, Biofilter, Taiwanese Mussel

Abstrak

Ikan bawal air tawar (*Colossoma macropomum*) merupakan komoditas perikanan air tawar yang bernilai ekonomis tinggi, namun kualitas air dalam budidaya sering menjadi kendala. Pemanfaatan biofilter alami seperti kijing Taiwan (*Anodonta woodiana*) dalam sistem polikultur diharapkan dapat memperbaiki kualitas air dan meningkatkan performa pertumbuhan ikan. Penelitian ini bertujuan untuk mengevaluasi pengaruh jumlah kijing Taiwan berbeda dalam sistem polikultur terhadap pertumbuhan ikan bawal air tawar. Penelitian dilaksanakan selama 56 hari menggunakan Rancangan Acak Lengkap (RAL) dengan empat perlakuan: P0 (tanpa biofilter), P1 (14 ekor kijing), P2 (19 ekor kijing), dan P3 (24 ekor kijing) dengan tiga kali ulangan. Parameter yang diamati meliputi pertumbuhan bobot mutlak, panjang mutlak, laju pertumbuhan spesifik, kelulushidupan, dan kualitas air. Hasil penelitian menunjukkan bahwa perlakuan P3 memberikan hasil terbaik dengan bobot mutlak 8,25 g, panjang mutlak 4,78 cm, dan laju pertumbuhan spesifik 2,02% per hari. Penggunaan biofilter kijing Taiwan meningkatkan kualitas air dan pertumbuhan ikan bawal air tawar secara signifikan.

Kata kunci: Bawal air tawar, Polikultur, Biofilter, Kijing Taiwan.

1. Introduction

Cachama (*Colossoma macropomum*) is a fishery commodity with high economic value, with a market price of around IDR 30,000 / kg. Cachama is currently in great demand as a consumption fish and is suitable for development as a potential freshwater fish farming business (Abrar et al., 2019). One way to increase cachama production is by improving the cultivation system through an optimal recirculation system (Nurhariati & Diniarti, 2021). High-density stocking of test fish can also affect water quality. The use of filters has provided many excellent benefits in aquaculture activities. The biological filter, which utilises filter-feeding organisms like clams, combined with a recirculation system, is efficient in water use (Sukendar et al., 2025).

The Taiwanese mussels (*Anodonta woodiana*) are known as filter feeders. According to Kadar (1997), the function of Anodonta can be used as a water purifier, overcoming water pollution due to pollutants, including heavy metals; mussels can also utilize food scraps that fish do not have time to eat and can filter particles between 0.1 - 50.0 µm from water bodies, then at particle sizes> 4.0 µm can filter up to 100%. A biofilter is a water treatment system using microorganisms to decompose organic and inorganic substances (Said & Hartaja, 2018).

Cachama and Taiwanese mussels biofilters can minimise high ammonia and maintain water quality in a single container. Maintenance. The type of anadonta mussel can filter water up to 40 L / day. It can extract colloidal materials and both suspended and particulate organic matter, reducing the content of organic matter in waters to an average of 99.5% (Karnaukhov, 1979).

This fish farming polyculture system aims to analyse the growth performance of cachama in a Taiwanese mussel polyculture system compared to non-polyculture cultivation. Because research on the maintenance of cachama with a polyculture system using Taiwanese mussels has never been done, this research needs to be done to find out how biofilters affect the growth of cachama.

2. Material and Method

2.1. Time and Place

This research was conducted from April to May 2024 at the Laboratory of Aquaculture Technology (TBD), Faculty of Fisheries and Marine, Universitas Riau, Riau Province.

2.2. Methods

The method used in this research is an experimental method with a completely randomised design (CRD) with four levels of treatment and three replicates. This treatment refers to research conducted by Putra et al. (2016), which found the highest absolute growth in treating 200 individual Taiwanese mussels with varying amounts of biofilters. The treatment levels used in this study are P0 (control), P1 (number of biofilters 14 individuals/m^3), P2 (number of biofilters 19 individuals/m^3), P3 (number of biofilters 24 individuals/m^3) and the same fish stocking density, namely, 150 fish/m^3 (Firnanda, 2021).

2.3. Procedures

2.3.1. Rearing Container Preparation

The container used is an aquarium with 100 litres and up to 12 units. Next, the container is filled with 90 L of water and then allowed to stand for 42 hours. A water pump with a power of 18 watts is used to continuously flow water into the aquarium media to increase oxygen levels (Figure 1).

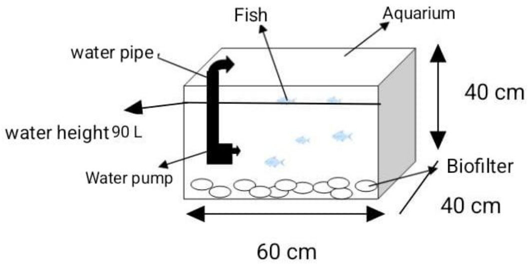

Figure 1. Research container design

2.3.2. Polyculture and Fish Preparation

The natural biofilter used in this study is the Taiwanese mussels, which are 7-8 cm in size. Mussels are adapted for 7 days in a separate container before being placed in the maintenance media. Four treatments were prepared: P0 without a biofilter, P1 with 14 mussels, P2 with 19 mussels, and P3 with 24 mussels, to test the effect of the number of mussels on water quality and the growth of cachama. Cachama fry measuring 3-5 cm were used as test fish. Before stocking, the fish were acclimatised for 30 minutes to 1 hour to adjust to the environmental temperature. After acclimatization, the initial weight and length of the fish were measured, and then the fish were stocked at a density of 14 fish per aquarium containing 90 L of water.

2.3.3. Feed Preparation and Feeding

The feed used in this study is PF 1000 MS PRIMA FEED, with a protein content of 39%. The feed was given three times a day at 08.00, 12.00, and 16.00 WIB using the ad satiation method, which involves feeding until the fish are full by sprinkling the feed evenly on the water's surface, ensuring all fish have the same opportunity to eat.

2.3.4. Fish and Media Maintenance

Fish rearing lasted for 56 days. Every 14 days, sampling was done by measuring the length and weight of the fish. Fish body length was measured using graph paper, while fish weight was measured using analytical scales. In addition, the number of dead fish was recorded daily to calculate the survival rate. Water quality in the aquarium was also monitored regularly to ensure that the rearing medium remained optimal to support fish growth.

2.4. Parameters Measured

2.4.1. Absolute Weight Growth

Absolute weight growth was calculated using the formula of Zonneveld et al. (1991) as follows:

$$Wm = Wt - Wo$$

Description:

Wm = Absolute weight growth (g)
Wt = Average weight at the end of the study (g)
Wo = Average weight at the beginning of the study (g)

2.4.2. Absolute Length Growth

Absolute length growth was calculated using the formula from Zonneveld et al. (1991), which is as follows:

$$L = Lt - Lo$$

Description:

L = Absolute length growth (cm)
Lo = Average length of fish at the beginning of the study (cm/fish)
Lt = Average length of fish at the end of the study (cm/fish)

2.4.3. Specific Growth Rate

The specific growth rate was calculated by the formula of Zonneveld et al. (1991) as follows:

$$LPS = \frac{(\text{Ln Wt} - \text{Ln Wo})}{\text{t}} \; x\ 100\%$$

Description:

LPS = Specific growth rate (%)
Wt = Average weight of test fish at the end of the study (g)
Wo = Average weight of test fish at the beginning of the study (g)
t = Duration of study (days)

2.4.4. Survival Rate

Cachama survival rate was calculated using the formula proposed by Effendie (1979) as follows:

$$SR = \frac{\text{Nt}}{\text{No}} \text{ x } 100\%$$

Description:

SR = Survival (%)
Nt = number of fish at the end of rearing
No = Number of fish at the beginning of rearing

2.4.5. Water quality

Water quality parameters in this study will be measured in terms of temperature, pH, dissolved oxygen levels (DO), and ammonia. Temperature and pH measurements are carried out twice daily in the morning, while measurements of dissolved oxygen levels (DO) and ammonia are taken in the afternoon. Performed three times, namely the beginning, middle, and end

2.5. Data Analysis

The research data were tabulated and analysed using the SPSS application, which included Analysis of Variance (ANOVA) to determine whether the treatment level had a significant effect on the number of Taiwanese mussels, the absolute weight growth of seeds (g), and the absolute length growth of seeds (cm). The specific growth rate of seeds (%/day), seed survival (%), and the effect of mussels on water quality are measured using parameters such as pH, temperature, DO, and ammonia.

3. Result and Discussion

3.1. Growth

Table 1 shows the results of measuring the absolute weight of cachama during the study, conducted every 14 days across all treatments.

Table 1. Absolute weight growth of cachama

Treatment	Sampling day-					Absolute Weight
	0	14	28	42	56	(g)
P_0	3.41	6.72	9.3	8.18	7.7	4.28 ± 0.10^a
P_1	3.48	6.31	9.32	9.55	10.33	6.85 ± 0.28^b
P_2	3.30	7.00	9.43	9,69	10.36	7.06 ± 0.43^b
P_3	3.24	7.89	9.48	9,83	11.5	8.25 ± 0.06^c

Table 1 shows that the growth of cachama fish increased differently in each treatment. The highest average weight growth was obtained in P3, with a weight of 8.25 g, while the lowest average weight was in P0, with a weight of 4.28 g. The P0 (control) treatment produced the lowest absolute weight of 4.28 ± 0.10 g, indicating that fish growth is not optimal in a monoculture system without additional biological intervention. This is likely due to the accumulation of organic matter and the deterioration of water quality over time, which adversely affects the fish's appetite and overall health. Zonneveld et al. (1991) stated that growth occurs due to excess energy derived from feed after deducting metabolized energy and energy contained in faeces.

The P1 and P2 treatments showed an increase in absolute weight to 6.85±0.28 g and 7.06±0.43 g, respectively. This suggests that using Taiwanese mussels in the culture system increases the filtration of suspended particles and organic compounds, thereby promoting improved water quality (Ghaisani, 2024). The P3 treatment showed the most considerable absolute weight, 8.25±0.06 g, and significant differences from the other treatments. The success of this polyculture system is highly dependent on factors such as stocking density. In a high stocking density culture system, the presence of mussels as a natural biofilter contributes to maintaining stable water quality. Mussels can filter phytoplankton, detritus, and other suspended matter, reducing water quality fluctuations and supporting fish survival and growth more stably (Adharani et al., 2024).

Table 2 shows the results of measuring the absolute length of cachama during the study, conducted every 14 days across all treatments.

Table 2. Absolute length growth of cachama

Treatment	Sampling day-					Absolute Length
	0	14	28	42	56	(cm)
P_0	5.44	6.46	7.15	7.37	7.53	2.08 ± 0.18
P_1	5.47	6.06	7.49	7.68	8.33	2.65 ± 0.31
P_2	5.19	6.53	7.60	8.28	9.26	3.91 ± 0.48
P_3	5.18	7.02	8.12	9.21	9.96	4.78 ± 0.18

Table 4 shows the average length of cachama in each treatment. The best length growth was found in P3, with an average length of 9.96 cm, while the lowest average growth was found in P0 (Control). Absolute growth is the change or growth of body size maintained in units of time (Effendie, 1979). Internal and external factors can influence the difference in average length in fish. One of the internal factors is age and body resistance. External factors are water quality, food and stocking density (Azima, 2023). Fish growth is a complex biological process with many factors that can affect it. One of the influencing factors is the amount of feed, along with the temperature and water level in the container. P3 stabilises the water quality in the container to increase long growth in cachama

Based on 56 days of research, the specific growth rate of cachama can be seen in Table 3.

Table 3. Specific growth rate of cachama

Treatment	Specific Growth Rate (%)
P0	1.40 ± 0.08^a
P1	1.94 ± 0.11^b
P2	2.04 ± 0.09^b
P3	2.26 ± 0.00^c

The growth rate is the percentage of fish weight gain every day. In Table 7, it is stated that the specific growth rate results in P3, which has an average length of 9.96 cm, while the lowest growth rate is found in P0 (Control). Maharani et al. (2023) explained that the growth and specific growth rates are closely related to body weight gain from consumed feed. Water quality is also very influential on fish growth. With the addition of Taiwanese mussels, water quality in the container can be maintained. According to Putra et al. (2016), the mussels used in the recirculation system effectively filter suspended particles and reduce ammonia levels, which harm fish. The results of the measurement of Taiwanese Mussels during the study, conducted every 14 days in all treatments, are shown in Table 4.

Table 4. Specific growth rate of Taiwanese mussels

Treatment	Absolute weight (g)	Absolute length (cm)	Absolute width (cm)	Absolute Thickness (cm)
P1	4.07 ± 0.20	0.28 ± 0.05	0.28 ± 0.02	0.21 ± 0.03
P2	4.20 ± 0.21	0.26 ± 0.07	0.22 ± 0.01	0.20 ± 0.00
P3	3.17 ± 0.12	0.28 ± 0.04	0.21 ± 0.03	0.19 ± 0.03

Based on the observations, Taiwanese mussels' highest absolute weight growth was achieved in the P2 treatment at 4.20 ± 0.21 g / individual, followed by P1 at 4.07 ± 0.20 g / individual. In comparison, the lowest weight growth occurred in P3 with 3.17 ± 0.12 g / individual. This shows that smaller mussels in one container make individual weight growth more optimal because competition for space and food is lower. According to Palinussa et al. (2021), a stocking density that is too high can reduce the efficiency of food absorption and cause individual growth to be slower due to increased competition between mussels.

For absolute length growth, the highest value was found in the P1 and P3 treatments, both at 0.28 cm, while the lowest value was obtained in P2 at 0.26 cm. This shows that although the individual weight in P2 is higher, the length growth is less significant than in P1 and P3. This is the opinion of Prihartini (1999), which states that the growth of Taiwanese mussels can vary between weight growth and physical dimensions, such as length, depending on environmental conditions and nutrient availability.

Regarding absolute width, mussels in the P1 treatment showed the highest growth of 0.28 cm, followed by P2 at 0.22 cm, and the lowest at P3 at 0.21 cm. This reinforces the notion that at a lower density (P1), mussels have more adequate space and resources to grow optimally. According to Kadar (1997), biofilters such as mussels need sufficient space to maximize water filtration activities and the growth of their body tissues. Meanwhile, in absolute thickness growth, the highest value was again found in the P1 treatment at 0.21 cm, followed by P2 at 0.20 cm and the lowest in P3 at 0.19 cm. These results show a similar pattern to absolute width growth, where a lower stocking density provides a growth advantage in the mussel's body dimensions.

Overall, this study's results indicate that Taiwanese mussels' growth will be more optimal at a density that is not too high. Too much stocking density, as in the P3 treatment, reduces individual growth because competition for space and food increases. This aligns with the research results by Putra et al. (2016), which state that the effectiveness of mussel biofilters in water recirculation systems decreases if the density is too high, thereby affecting the physiological performance and growth of individual mussels.

In addition, Palinussa (2010) also reported that the performance of mussels in improving water quality through filtering organic and inorganic particles would be optimal at moderate to low stocking densities. Thus, the recommendation for biofilter-based polyculture is to maintain a moderate biofilter density to maximise the growth of both the fish and the biofilter itself.

3.2. Survival Rate

One indicator of the success or failure of a fish farm is the survival rate of the fish being reared, which is crucial for achieving maximum production. Observations of the survival rate of Cachama are presented in Table 5.

Table 5. Survival rate of cachama during the study

Repeat	Survival rate (%)			
	P_0	P_1	P_2	P_3
1	85	92	100	100
2	85	100	92	100
3	78	92	100	100
Total	165	284	292	300
Average	83± 4.04 ^{a}	94 ± 4.61 ^{a}	97 ± 4.61 ^{a}	100 ± 0.00 ^{a}

Table 5 shows that the highest survival rate of cachama is found in the P3 treatment (100%), while the lowest is in P0 (83%). The P1 and P2 treatments also showed high survival rates of 94% and 97%, respectively, but these were still lower than that of P3. In general, all treatments showed a survival rate above 50%, which, according to Andrila et al. (2019), is categorised as good because it exceeds the minimum threshold for viable survival in aquaculture activities. The high survival rate, particularly in P3, is strongly suspected to be influenced by the optimal role of Taiwanese mussels as a natural biofilter, which can filter suspended particles and reduce excess concentrations of ammonia, nitrite, and organic matter. In addition, a recirculation and aeration system significantly contributes to maintaining the stability of dissolved oxygen (DO) levels in the water column, which is crucial for pomfret metabolism and endurance.

3.3. Water Quality

Water is a crucial factor in supporting the growth and survival of fish and serves as a medium for fish farming. Water quality parameters measured during the research period include temperature, pH, DO, and ammonia, as shown in Table 6.

Table 6. Water quality

Treatment	pH	Temperature	Dissolved Oxygen (DO)	Ammonia
P0	6.11 ± 0.07	27.43 ± 0.20	4.97 ± 0.02	0.71 ± 0.07
P1	7.54 ± 0.15	27.60 ± 0.28	5.85 ± 0.01	0.08 ± 0.01
P2	7.62 ± 0.09	28.04 ± 0.34	5.92 ± 0.11	0.08 ± 0.01
P3	7.68 ± 0.23	27.66 ± 0.26	5.92 ± 0.10	0.07 ± 0.00

Water's degree of acidity (pH) can affect cachama's growth and survival. The pH value obtained during the study ranged from 6.5 to 8.5, while the optimal pH value for cachama seed growth was 5-8.5. According to Yustiati et al. (2020), this pH range is sufficient to support the growth of cachama. Cachama cannot tolerate cold temperatures. Temperatures that are too low can cause fish to experience stress, inhibiting growth and metabolism. The optimal temperature for growth ranges from 26 to 30°C, so optimum growth will be achieved if maintained at that temperature. The container temperature during the study period ranged from 26.8 to 29.7^{0}C. Water temperature can directly affect the life of aquatic biota through its influence on oxygen solubility.

Dissolved oxygen is a factor in the success of aquaculture efforts. Breathing will be disrupted if oxygen is lacking in the water. The higher the water temperature, the lower the solubility of oxygen. Dissolved oxygen content in the container during the study ranged from 4.5 to 6.9 mg/L. The oxygen content in the media is considered ideal for the development of organisms. Some fish can survive if oxygen is below 4 mg /L, but their appetite declines (Sarif et al., 2019). Ammonia is the final product of nitrogen metabolism and can harm aquatic organisms. The presence of ammonia in water needs to be monitored and controlled. During the measurement, the ammonia concentration fluctuated. The highest concentration was found in P0. Ammonia (NH^3) is a nitrogen compound that can be harmful as it can interfere with the growth of cachama. Ammonia results from protein breakdown in faeces and the rest of the cachama feed, which, if left for a long time, will accumulate and become toxic to cachama.

4. Conclusions

The results of this study indicate that the difference in stocking density of Taiwanese mussels as a biofilter in a polyculture system affects the growth in weight, length, and specific growth rate of cachama. The best treatment was found in the P3 stocking density treatment, namely 14 heads / 24 individuals m^3, which gave a significant difference (P≤0.05): absolute weight of 11.5 g, absolute length of 9.96 cm, and specific growth rate of 2.26%. Different stocking densities do not significantly affect (P≤0.05) the survival rate of cachama. The value of water quality parameters during the study was still categorized as supportive in the life and growth of cachama. The best water quality was obtained in P3 with a specific pH level.7.03/90 L, Temperature 27.1/90 L, Do 6.8/90 L, Ammonia 0.1490/90 L.

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