**THE INFLUENCE OF DIFFERENT CULTURE METHODS ON THE GROWTH AND SURVIVAL OF KIJING MUSSELS (*Anadonta woodiana*)**

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ABSTRACT

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| This study aimed to analyze the influence of different culture methods and stocking density on the growth and survival of Kijing mussels (*Anadonta woodiana*). This research employed an experimental method with a factorial Randomized Block Design (RBD), consisting of two factors: culture method (B) with two levels (bottom and floating) and stocking density (P) with three levels (5, 10, and 15 individuals). Each treatment combination of culture method and stocking density was conducted in triplicate concrete ponds. The homogeneity of the ponds could not be guaranteed due to the inconsistent sunlight exposure across the land conditions. The total number of treatment units used in this study was 18 treatment units. The parameters measured were absolute weight, absolute length, specific growth rate, survival rate, and water quality. Data on absolute weight, absolute length, and specific growth rate were analyzed using Analysis of Variance (ANOVA) with a 95% confidence level via SPSS software to determine treatment effects, followed by Duncan’s multiple range test. Meanwhile, data on survival rate and water quality were analyzed using Microsoft Excel. The results showed that different culture methods significantly influenced the absolute weight of Kijing mussels (*A. woodiana*) during the 60-day rearing period, whereas stocking density and the interaction between stocking density and culture method did not significantly affect any of the measured parameters. The bottom culture method resulted in better growth of Kijing mussels compared to the floating method, increasing the absolute weight of mussels by 106.38 g, supported by an absolute length of 3.20 cm, a specific growth rate of 2.17%/day, and a 100% survival rate |

*Keywords: Floating, bottom, Randomized Block Design (RBD), Anadonta woodiana, Kijing mussels*

1. INTRODUCTION

The Kijing mussel (*Anadonta woodiana)* is a freshwater mussel species that inhabits aquatic environments as a benthic organism. These mussels play a crucial role in aquatic ecosystems as filter feeders, effectively reducing or recycling materials such as sediments, organic matter, bacteria, and plankton. According to Purnama *et al.* (2019),, *A. woodiana* is a keystone species in freshwater ecosystems, serving as a vital component in food chains and food webs, as well as a bioindicator for water quality monitoring. Furthermore, Kijing mussels possess ecological value in mitigating environmental pollution, particularly in reducing heavy metal contamination (Hamidah, 2013). This ecological significance underscores the dependence of other aquatic organisms on the existence of Kijing mussels in freshwater ecosystems. In aquaculture, Kijing mussels represent a novel protein source from freshwater fisheries commodities, boasting substantial edible flesh (Purnama *et al*., 2019; Chen *et al*., 2012). Additionally, these mussels are utilized as livestock feed (Andrzejewski *et al*., 2013), raw materials in accessory industries for items like buttons, necklaces, and earrings (Padwa *et al*., 2015), freshwater pearl production (Berni *et al*., 2004; Liu *et al*., 2014), and traditional medicine (Vaughn, 2018; Liu *et al*., 2008).

Given the promising potential of Kijing mussels, commercial cultivation efforts are warranted to investigate their bioecology, anatomy, environmental factors, and culture techniques through sustained scientific inquiry. Previous studies on Kijing mussel cultivation have demonstrated that different culture methods influence growth and survival. For instance, off-bottom culture methods have been shown to increase shell length by approximately 0.48 cm and shell width by 0.24 cm during the rearing period (Rahayu *et al*., 2015). Padwa *et al*. (2015) examined the growth of Taiwanese Kijing mussels using various substrates, including sandy mud, rock, sand, and mud, revealing that sandy mud substrates yielded superior length and weight growth, although substrate differences did not significantly affect growth statistically.

Sahusilawane *et al.* (2015) also investigated the survival of Kijing mussels using sand, mud, and mixed sand-mud substrates, finding that mixed sand-mud substrates provided the highest survival rate of 81.48 ± 17.37%. Fertilization in ponds plays a significant role in determining food availability for Kijing mussels by enhancing water fertility and promoting the growth of plankton, a natural food source. Kijing mussels typically inhabit substrates and filter plankton for sustenance, with a preference for *Chlorophyta* and *Cyanophyta* species (Rahayu & Rachman, 2015). These prior research findings highlight the potential for developing technological innovations in Kijing mussel aquaculture to enhance growth and survival. However, there has been no study of stocking density in previous research. Consequently, this study aims to analyze the influence of different culture methods on the growth and survival of Kijing mussels

2. material and methods

**2.1 Equipment and Materials**

The equipment used in the research includes a pH meter, thermometer, ruler, scale, aquarium, and writing instruments. The materials utilized in this study include the species *A. woodiana* as the test organism, with an average size of 3-4 cm, as well as baskets and nets used as the maintenance media.

**2.2 Research Method**

This research was carried out in October – December 2023 at the Balai Budidaya Ikan, Lombok Timur, Indonesia. This study employs an experimental method with a Factorial Randomized Block Design (RAK), which consists of three factors: cultivation method (M), with two levels, and stocking density (P), with three levels, as follows:

1. Cultivation Method (B)

B1 : Bottom

B2 : Hanging

1. Density (P)

P1 : 5 Kijing mussels

P2 : 10 Kijing mussels

P3 : 15 Kijing mussels

Each treatment combination of cultivation method and stocking density was applied to three concrete ponds. The homogeneity of the ponds could not be guaranteed due to uneven sunlight exposure. The total number of experimental units used in this study was 18, calculated as 2 x 3 x 3 = 18 experimental units. A schematic representation of the experimental design is shown in Figure 1.

POND 3

B2.P3

B2.P2

B2.P1

B1.P1

B1.P3

B1.P2

B2.P1

B2.P3

B2.P2

B2.P3

B2.P2

B2.P1

B1.P3

B1.P2

B1.P1

B1.P2

B1.P1

B1.P3

POND 2

POND 1

**Fig 1. Illustration of Treatment Placement**

### 2.3 Preparation and Maintenance of Seedlings(*A. woodiana*)

The seedlings used in this study ranged in size from 3 to 5 cm. Prior to maintenance, they were selected by inspecting their shells for any signs of damage. Before transferring them to the cultivation ponds, their weight, length, and width were measured. The mussels were then placed into the ponds according to the designated treatments. The maintenance of *A. woodiana* seedlings lasted for 60 days. During this period, they were fed natural plankton available in the pond.

### 2.4 Observation of Growth and Water Quality

During the cultivation period, daily monitoring was conducted. The growth of the Kijing mussels was observed every two weeks by weighing the mussels using a scale and measuring their length and width using a ruler. Water quality checks, including temperature, dissolved oxygen (DO), and pH, were conducted once a week

### Harvesting of Kijing Mussels (*A. woodiana)*

Harvesting of the Kijing mussels was carried out after 60 days of cultivation by removing and draining the mussels from the bags. The harvested mussels were then placed in a container for weighing using an analytical scale, and their length and width were measured with a ruler to document growth development.

2.6 Research Parameters

**2.6.1. Absolute Weight and Absolute Length**

Absolute weight (g) and absolute length (cm) of the Kijing mussels were calculated using the following equations (Padwa *et al*., 2015):

∆W = wt – 𝑊o

Where:

wt : Final weight of the mussel at the end of the study (g)

𝑊o : Initial weight of the mussel at the start of the study (g)

∆L =Lt – Lo

Where:

L = Absolute growth (cm)

Lt = Average length of the mussel at the end of the study (cm)

Lo = Average length of the mussel at the beginning of the study (cm)

**2.6.2. Specific Growth Rate (SGR)**

The specific growth rate was calculated using the equation from Safaringga *et al*. (2017) as follows:

 SGR = (Ln Wt-Ln Wo)/t x 100%

Where :

SGR = specific growth rate (%/day)

Wt = Average weight at the end of the study (g)

Wo = Average weight at the beginning of the study (g)

T = Cultivation period (days)

**2.6.3. Survival Rate**

The survival rate of the Kijing mussels was calculated using the equation from Safaringga et al. (2017) as follows:

SR = Nt\No x 100%

Where:

SR = Survival rate

Nt = Number of live mussels at the end of the study (individuals)

No = Number of live mussels at the beginning of the study (individuals)

### 2.6.4. Water Quality

Water quality parameters, including temperature, were measured using a thermometer, dissolved oxygen (DO) was measured using a DO meter, and pH was measured using a pH meter.

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**2.7. Data Analysis**

Data on absolute weight, absolute length, and specific growth rate were analyzed using Analysis of Variance (ANOVA) with a 95% confidence level through the SPSS software to assess the effects of the treatments. If the treatments showed significant effects, a Duncan test was conducted. Data on survival rate and water quality were analyzed using Microsoft Excel and presented descriptively

3. results

### 3.1 Absolute Weight

The results from the 60-day cultivation period showed that the absolute weight of the Kijing mussels increased in line with the increased stocking density in the cultivation using the bottom method. Conversely, in the floating method cultivation, there was a decrease in the absolute weight of the Kijing mussels as the stocking density of the mussels increased (Figure 2).

Figure 2. Absolute Weight of Kijing Mussels *(A. woodiana*)

The average absolute weight of the Kijing mussels ranged from 38.45 to 106.81 g, with the highest absolute weight recorded in the treatment using the bottom method at a stocking density of 15 mussels (P3 B1), which was 106.81 g. Conversely, the lowest weight was found in the treatment using the floating medium at a stocking density of 15 mussels (P3 B2), which was 38.45 g.

The analysis using One Way Anova (p < 0.05) showed that the single treatment with different cultivation methods had a significant effect on the increase in the absolute weight of the Kijing mussels (*A. woodiana*). However, the single treatment with different stocking densities, as well as the interaction between stocking density and cultivation methods, did not show a significant effect on the increase in the absolute weight of the Kijing mussels (*A. woodiana*). Duncan’s test indicated that the treatment using the bottom method resulted in the best absolute weight of the Kijing mussels.

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### 3.2. Absolute Length

The results of the cultivation over 60 days showed that the absolute length of the Kijing mussels decreased as the stocking density increased in the cultivation using the floating method. In contrast, the cultivation using the bottom method resulted in varying absolute lengths of the Kijing mussels, in line with the increased stocking density (Figure 3).

The average absolute length of the Kijing mussels ranged from 1.58 to 3.76 cm, with the highest absolute length recorded in the treatment using the floating method at a stocking density of 5 mussels (P1 B2), which was 3.76 cm. Meanwhile, the lowest absolute length was found in the treatment using the floating medium at a stocking density of 15 mussels (P3 B2), which was 1.58 cm

Figure 3. Absolute Length of Kijing Mussels *(A. woodiana)*

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The analysis using ne Way Anova (p < 0.05) showed that the single treatment with different cultivation methods, different stocking densities, and the interaction between cultivation methods and stocking densities did not have a significant effect on the absolute length of the Kijing mussels (*A. woodiana*).

### 3.3. Specific Growth Rate (SGR)

The results of the cultivation over 60 days showed that the specific growth rate of the Kijing mussels decreased as the stocking density increased in the cultivation using the floating method. Meanwhile, the cultivation using the bottom method resulted in varying specific growth rates of the Kijing mussels in line with the increased stocking density (Figure 4).

Figure 4. Specific Growth Rate (SGR) of Kijing Mussels *(A. woodiana)*

The average specific growth rate of the Kijing mussels ranged from 1.37 to 3.85 %/day, with the highest specific growth rate recorded in the treatment using the floating method at a stocking density of 5 mussels (P1 B2), which was 3.85 %/day. The lowest specific growth rate was observed in the treatment using the floating medium at a stocking density of 15 mussels (P3 B2), which was 1.37 %/day.

The analysis using One Way Anova (p < 0.05) showed that the single treatment with different cultivation methods, different stocking densities, and the interaction between cultivation methods and stocking densities did not have a significant effect on the specific growth rate of the Kijing mussels (*A. woodiana*).

### 3.4. Survival Rate (SR)

The results of the cultivation over 60 days showed that the survival rate of the Kijing mussels (*A. woodiana*) was 100% in all treatments (Figure 5).

Figure 5. Survival Rate of Kijing Mussels (*A. woodiana*)

### 3.5. Water Quality Parameters

The results of the water quality measurements, including DO, pH, and temperature, during the 60-day cultivation period showed that the water quality remained optimal for the cultivation of Kijing mussels across all treatments (Table 1).

Table 1. Water Quality Parameters

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| Parameter | Value | Literature (Hastuti *et al.,*2012) |
| DO | 3 – 7 mg/L | 3.8-12.5 mg/L  |
| Temperature | 27.25 - 29˚C | 11-29˚C  |
| pH | 6.29 – 8.86 | 4.8-9.8  |

4. discussion

The cultivation method is one of the factors that affects the survival of the mussels during cultivation. The results of this study indicate that differences in cultivation methods can significantly affect the absolute weight of the Kijing mussels during 60 days of cultivation (Figure 2). However, the stocking density treatments and the interaction between stocking density and cultivation method did not affect all parameters measured in this study. Cultivation with the bottom (substrate) method resulted in better growth of Kijing mussels compared to the floating method, as it increased the absolute weight of the Kijing mussels to 106.38 g. This is believed to be because the bottom method is more similar to the mussels' natural habitat. The Kijing mussel is a freshwater species that lives in ponds, lakes, rivers, or other freshwater environments. It prefers waters with a muddy, sandy bottom that are not too deep (Bódis *et al*., 2011; Padwa *et al*., 2015).

Additionally, one behavior of the Kijing mussel is its tendency to burrow into the sand or mud, so the bottom method provides more suitable conditions for the mussels’ activities compared to the floating method. Putri (2005) explains that mussels generally burrow into sandy or muddy sediments, while some species attach themselves to hard objects using byssus. Furthermore, Spyra *et al.* (2016) stated that the Kijing mussel is one of the species that burrows into the substrate (clam), thus it is also known as a mudflat clam. The results of this study align with previous research by Padwa *et al.* (2015), which showed that the absolute weight of Kijing mussels did not significantly differ when using bottom cultivation methods with different substrates.

The absolute weight growth of the Kijing mussels in this study was quite good, ranging from 38.45 to 106.81 g, as the initial size of the seeds used was relatively small, between 3–5 cm. This is in line with Elyani (1990),, who stated that small Taiwanese Kijing mussels (2–5 cm) grow faster than larger ones (8–11 cm). This is because adult mussels tend to invest more energy into gonad formation, so food and energy are primarily used for reproduction rather than growth.

A different trend was observed in the growth of the length of the Kijing mussels, where there were no significant differences in all treatments (Figure 3). This is suspected to be due to the faster growth of the soft tissue compared to the shell. The length growth of the mussels in this study was measured by shell length, while the weight of the mussels was measured based on soft tissue. Runtu *et al.* (2016), mussel growth occurs in two parts: the soft tissue growth and the shell growth. The growth of the shell and the soft tissue do not occur at the same rate. The soft tissue grows faster than the shell. Furthermore, Tamsar *et al.* (2013) explained that the length increment of Kijing mussels becomes smaller, meaning that as the mussels age, their growth rate slows down or stops once they reach their maximum length. This growth pattern follows the Von Bertalanffy growth model.

No significant differences were found in the specific growth rate of the Kijing mussels either (Figure 4). This is suspected to be because the specific growth rate of Kijing mussels is more influenced by factors such as food availability, environmental temperature, age, and nutrient content in the water (Padwa *et al*., 2015). Furthermore, Albayani *et al.* (2022) stated that the specific growth rate is influenced by plankton in the water, as well as the clarity and light intensity, which affect the planktonic food available. During this study, all treatments received the same type of food, which was plankton that naturally grew in the ponds. It is assumed that the food and nutrients available were the same across all treatments. Sahuailiwane *et al.* (2015) stated that Taiwanese Kijing mussels are plankton feeders, meaning they filter food through their gills, with phytoplankton being their primary food source. Since they are sessile and have low mobility, their food supply depends on the plankton available in the surrounding water or carried by water currents. Natural food is a critical factor in successful cultivation, so its availability must be sufficient, of good quality, and continuous.

The survival rate of the Kijing mussels at the end of cultivation in this study was very high, reaching 100% across all treatments (Figure 5). This shows that all treatments—cultivation method, stocking density, and the interaction between these two factors—were well-tolerated by Taiwan mussels. One factor that affects the survival rate of Kijing mussels is water quality. The results of this study show that the water quality parameters, including DO, pH, and temperature, during 60 days of cultivation, were optimal for Kijing mussel cultivation (Table 1).

Temperature is an important water quality parameter that can affect the growth of Kijing mussels (*A. woodiana*). The temperature range measured during the 60-day cultivation period was between 27.25 – 29°C. This temperature range is considered optimal for the growth of Kijing mussels (*A. woodiana*), which is in line with the opinion of Komarawidjaja (2006), who stated that Kijing mussels can survive in low-oxygen conditions and can grow and develop in water temperatures ranging from 24 – 29°C.

The degree of acidity or pH provides a measure of the water’s acidity or alkalinity and is important for water management in aquatic environments. Based on the results of the 60-day cultivation, the pH ranged from 6.29 to 8.86. This range is tolerable for Kijing mussels, as they can survive in waters with a pH between 4.8 and 9.8 (Hastuti *et al*., 2012) The pH values measured during this study were within the range in which Kijing mussels can live well.

Dissolved oxygen (DO) is essential in aquatic environments, as it plays a crucial role in respiration and metabolism. Dissolved oxygen is usually found in higher concentrations in the surface water layers due to diffusion from the air into the water. The measured DO in the Kijing mussel cultivation during 60 days ranged from 3 to 7 mg/L. Kijing mussels (*A. woodiana*) require dissolved oxygen between 3 – 12.5 mg/L, but they can survive in low DO concentrations. Sahusiliwane *et al.* (2015), stated that Taiwanese Kijing mussels require a dissolved oxygen concentration of 6 ppm to grow well. However, Kijing mussels (*A. woodiana*) can regulate their metabolism effectively, allowing them to survive even in very low dissolved oxygen levels.

5. Conclusion

The cultivation method can affect the absolute weight of Kijing mussels during 60 days of cultivation, while the stocking density treatments and the interaction between stocking density and cultivation method did not affect all parameters measured in this study. Cultivation using the bottom (substrate) method resulted in better growth of Kijing mussels compared to the floating method, as it increased the absolute weight of the mussels to 106.38 g, supported by an absolute length of 3.20 cm, a specific growth rate of 2.17%/day, and a survival rate of 100%.

**Ethical Approval:**

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

**DISCLAIMER (ARTIFICIAL INTELLIGENCE**)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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