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Optimizing Feeding Frequency of Blood Cockles and Sardine for Mud Crab (Scylla serrata) Growth in Apartment Systems

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Abstract

This study aims to determine the optimal feeding frequency for mud crabs (Scylla serrata) using a combination of sardine (Sardinella spp.) and blood cockles (Anadara granosa) in an apartment system. A completely randomized design (CRD) with four treatments (feeding frequencies of 3×, 2×, 1× per day, and 1× every two days) was applied. Results showed that feeding frequency significantly affected growth ($p < 0.01$ or $P<0.05$) but not survival (100% in all treatments). The highest growth (35.33 g) and production (594.34 g) were observed in crabs fed once daily, whereas more frequent feeding led to lower growth. These findings suggest that feeding mud crabs once a day optimizes growth and feed efficiency in aquaculture systems.

Keywords: Apartment System; Food Frequency; Mud Crab; Growth; Production; Survival

1. Introduction

Mud crabs are one of the non-oil and gas export commodities that are increasingly in demand in the global market. According to the PDSI KKP (2021) the export value of crabs and swimming crabs ranked as the fourth largest after shrimp, tuna-skipjack-mackerel and squid-cuttlefish-octopus in 2021, with an export value reaching USD 611.22 million. Currently, wild-caught mud crabs dominate the market, but their low body weight reduces market value. One way to increase the weight of mud crabs is through fattening cultivation methods (Adila *et al.*, 2020).

Currently, one of the emerging technologies for fattening mud crabs is the apartment system. This method offers several advantages, including cleaner crabs, efficient use of space and water, and easier maintenance (Haikal *et al.*, 2022). The apartment system can prevent cannibalism among crabs since each compartment houses only one crab. The success of crab fattening using the apartment system largely depends on the availability of feed, which serves as a key source of nutrition for mud crabs (Akbar *et al.*, 2023).

The availability of feed that is adequate in quality, quantity, affordability, consistency and timely delivery is crucial for the success of mud crab fattening cultivation. Providing the right type of feed that meets the nutritional needs of mud crabs ensures optimal growth and high survival rates (Ningsih & Affandi, 2023). The frequency of feeding is also important to make the process more efficient (Tulangow *et al.*, 2019).

In practice, feeding schedules in mud crab farming remain inconsistent. Some farmers feed their crabs twice a day, while others only once. Research by Suyuti *et al.* (2012) showed that feeding once a day resulted in weight gain that was not significantly different from feeding twice a day. Similarly, a recent study by Sianturi *et al.* (2024) using a recirculating aquaculture system (RAS) apartment model concluded that feeding once, twice, or three times daily had no significant effect on survival rate, absolute weight gain, or feed utilization efficiency. Tulangow *et al.* (2019) reported that using a battery system with trash fish also revealed that variations in feeding frequency did not significantly affect crab growth. To date, there is no established standard for the ideal feeding frequency when using a combination of scad fish and blood cockles to maximize efficiency. Therefore, further research is needed to determine the most effective feeding strategy to improve the survival, growth, and productivity of mud crabs (*Scylla serrata*) cultivated in an apartment system.

2. Materials and Method

2.1. Time and Location of Research

This research was conducted from December 2023 to January 2024 at the Brackish Water Aquaculture

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Development Center (BPBAP) in Takalar, Mappakalompo Village, Galesong Subdistrict, Takalar Regency, South Sulawesi Province.

2.2. Research Material

The test animals used in this study were male mud crabs (*Scylla serrata*) with an average body weight of 160±7.56 g per individual. The research utilized plastic crab boxes with an apartment-style design as rearing containers. A total of 36 boxes were used, each measuring 30 cm × 20 cm × 17 cm. Each box contained one crab, maintained using a Recirculating Aquaculture System (RAS). The feed provided was fresh feed in the form of chopped *tembang* fish (*Sardinella spp.*) and blood cockles (*Anadara granosa*). The feed dosage was set at 10% of the crab's body weight per day, with feeding frequencies varying based on the treatments. The feeding frequency for each treatment can be seen in Table 1 and the results of the proximate analysis of the feed are presented in Table 2.

Table 1. Feeding frequency

Feeding Frequency	Time	Feed Proportion (%)
3× daily	06:00 WITA (morning)	2%
	12:00 WITA (noon)	2%
	17:00 WITA (afternoon)	6%
2× daily	06:00 WITA (morning)	3%
	17:00 WITA (afternoon)	7%
1× daily	17:00 WITA (afternoon)	10%
1× every two days	17:00 WITA (afternoon)	20%

Table 2. Proximate analysis results of the nutritional composition of scad fish and blood cockle

Feed Type	Composition				
	Protein	Fat	BETN	Crude Fiber	Ash
Scad fish	62.88	17.94	2.06	1.76	15.36
Blood cockle	61.42	13.40	4.84	1.87	18.47
Combination of blood cockle	62.15	15.67	3.45	1.81	16.91

Source: Proximate Analysis Results at the State Agricultural Polytechnic of Pangkep

2.3 Experimental Design

This study employed a Completely Randomized Design (CRD) consisting of 4 treatments and 3 replications. The treatments tested were based on different feeding frequencies using a combination of *tembang* fish (*Sardinella spp.*) and blood cockles (*Anadara granosa*), as follows:

A: Feeding 3 times daily at 06:00, 12:00, and 17:00 WITA.
B: Feeding 2 times daily at 06:00 and 17:00 WITA.
C: Feeding once daily at 17:00 WITA.
D: Feeding once every two days at 17:00 WITA.

2.4 Research Parameter

The parameters observed in this study were survival rate, growth, and production of mud crabs.

Survival Rate (SR)

The survival rate is calculated using the following formula:

$$SR = (N_t/N_0) \times 100\%$$

Explanation:
SR = Mud crab survival rate (%)
Nt = Number of crabs surviving at the end of the maintenance period (individuals)
N0 = Number of crabs at the beginning of the maintenance period (individuals)

Absolute Growth

The absolute individual weight growth is calculated using the following formula:

$$W = (Wt - W0)$$

Explanation:
W = Absolute individual weight growth (g)
W0 = Initial average individual weight (g)
Wt = Final average individual weight (g)

Production

Production is calculated at the end of the study using the following formula:

$$P = Nt \times Bt$$

Explanation:
P = Mud crab production (g)
Nt = Number of surviving crabs at the end of the maintenance period (individuals)
Bt = Average weight of crabs at the end of the maintenance period (g)

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2.5 Data Analysis

The data obtained, which includes survival, growth, and production of mud crabs were analyzed using analysis of variance (ANOVA) at 1% and 5% levels, followed by Tukey's W test at the 5% significance level. The statistical analysis was performed using SPSS software version 25.0. The physical and chemical parameters of the water were analyzed descriptively based on the viability of mud crabs. Water was partially replaced by 20% of the total volume. The filtration system consisted of three stages: mechanical, biological, and chemical filtration. Mechanical filtration used filter cotton to remove solid wastes such as uneaten feed and feces. Biological filtration employed media such as bioballs, pumice stones, or coral stones to support the growth of nitrifying bacteria that convert ammonia into less toxic nitrate. Chemical filtration used activated carbon or zeolite to eliminate odors and specific toxins from the water.

3. Results and Discussion

3.1. Results

3.1.1 Survival Rate

The results of the analysis of variance showed that different feeding frequencies had no significant effect ($p>0.05$) on the survival rate of mud crabs reared in the apartment system.

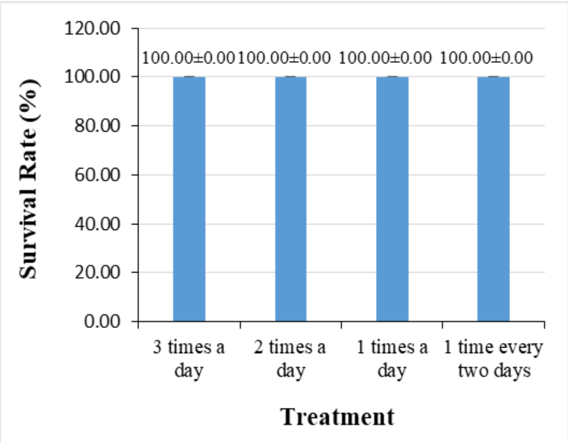

Figure 1. The average survival of mud crabs (*S. serrata*) kept in an apartment system with different feeding frequencies

3.1.2 Absolute Growth

Based on the results of the analysis of variance (ANOVA) showed that the frequency of feeding had a very significant effect ($p<0.01$) on the absolute growth of mud crabs maintained in the apartment system. Furthermore, the results of the W-Tuckey test showed that the treatment of feeding frequency once a day was significantly different ($p<0.05$) with all treatments. Feeding frequency three times a day and twice a day did not show a significant difference ($p>0.05$), but both treatments were significantly different ($p<0.05$) with feeding frequency once every two days.

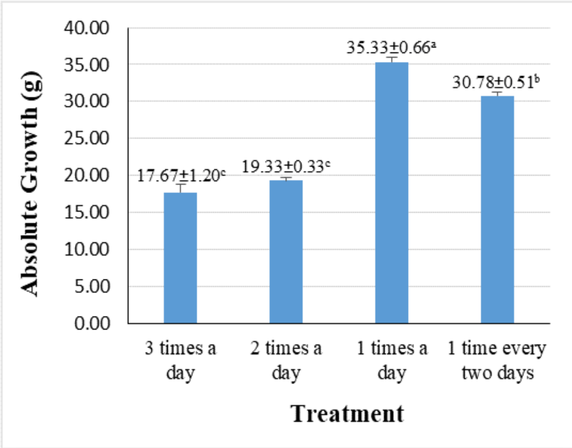

Figure 2. The average absolute growth of mud crabs (*S.serrata*) reared in an apartment system with different feeding frequencies.

3.1.3 Production

The results of the analysis of variance showed that the frequency of feeding had a very significant effect ($p<0.01$) on the production of mud crabs maintained in the apartment system. Furthermore, the results of the W-Tuckey test showed that the average production of mud crabs with the treatment of feeding frequency three times a day and twice a day did not show a significant difference ($p>0.05$), but both treatments were significantly different ($p<0.05$) with feeding frequency once a day and once every two days. Likewise, the effect of feeding once a day was not significantly different ($p>0.05$) with feeding once every two days.

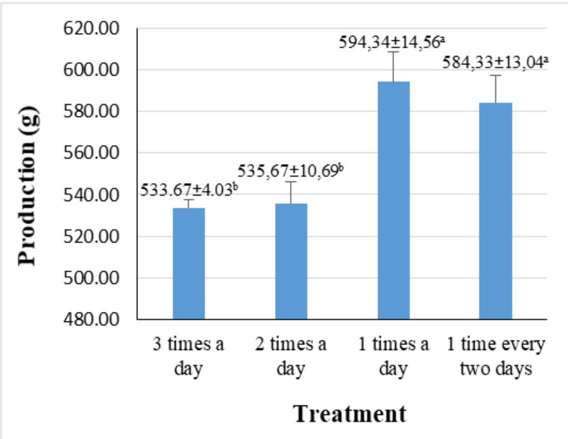

Figure 3. The average production of mud crabs (*S.serrata*) reared in an apartment system with different feeding frequencies.

3.1.4 Water Quality

Based on table 3 the water quality measurement results indicate that, throughout the study, the range of water quality parameters remained within the optimal range for the survival of the cultured mud crabs.

Table 3. Water quality measurement results

Parameter	Result	Optimal Value*
Temperature (°C)	27-32	25-35 (Shelley & Lovatelli, 2011)
pH	7,5-8,1	6,5 – 7,5 (Tahmid *et al.*, 2015)
Salinity (ppt)	30-32	18-32 (Khairunnisa *et al.*, 2023)
DO (ppm)	5,7-6,0	>4,0 (Tahmid *et al.*, 2015)
Ammonia (ppm)	0,006 - 0,0185	<0,1 (Diamahesa, 2024)

3.2. Discussion

3.2.1 Survival Rate

Based on Figure 1, the average survival rate of mud crabs reared in an apartment system with different feeding frequencies showed no significant differences, with all treatments resulting in a 100% survival rate. This consistent survival is likely due to the effective utilization of the feed provided. A feeding dose of 10% of body weight is considered sufficient to meet the energy requirements of mud crabs for survival. As stated by Aslamyah and Fujaya (2013), sufficient feed improves survival, while Qomariyah *et al.* (2014) noted that survival is influenced by both internal factors (such as age and adaptability) and external factors (such as feed quality and availability).

The uniform survival rate across treatments may also be attributed to the nutritional adequacy of the feed used tembang fish and blood cockles which contain essential nutrients like protein, fat, and carbohydrates. Despite variations in feeding frequency, these nutrients were sufficient to meet the crabs' energy needs for survival. This is consistent with Agus *et al.* (2015), who reported that high-quality, nutritionally complete feed can enhance survival.

The use of an apartment system, where each crab is housed individually, also minimized competition for food, ensuring equal feed distribution. Similar results were reported by Manuputty (2014), Maulana *et al.* (2012), and Natan (2014), all of whom observed 100% survival in systems that prevented food competition among mud crabs.

3.2.2 Absolute Growth

Based on Table 2, the highest average absolute growth of mud crabs reared in the apartment system was found in the treatment with a feeding frequency of once a day, at 35.33 g, followed by the treatment with a feeding frequency of once every two days at 30.78 g. Meanwhile, the lowest average growth rates were recorded in the treatments with feeding frequencies of three times a day and twice a day, at 17.67 g and 19.33 g, respectively. This indicates that different feeding frequencies affect the absolute weight growth of mud crabs.

It is important to note that during the research period, none of the mud crabs underwent molting. This likely affected the growth results, as molting is a key phase during which significant weight gain can occur. The absence of molting may explain why the overall absolute growth observed in this study was relatively low compared to other studies.

The highest absolute growth observed in this study is presumably due to the feeding frequency of once a day, which provides an optimal feeding time that aligns with the natural behavior of mud crabs, which are more active in searching for food at night. This is supported by Karim *et al.* (2019), who suggested that feeding should be done in the evening, as mud crabs are nocturnal animals that forage more actively at night. The more feed consumed, the more nutrients are absorbed by the crabs' bodies. According to Asyhariyati *et al.* (2013), if the nutrients obtained from feed are sufficient and of high quality, they can accelerate the growth rate of mud crabs.

Feeding once a day is also appropriate for the rate of gastric emptying in mud crabs, as observed by Aslamyah and Fujaya (2013), who found that the stomach empties in about 8–10 hours when fed 2% of body weight, and 12–14 hours for a 4% feeding dose. In general, gastric emptying stimulates appetite at the next feeding, as the crabs are already hungry by then. The treatment with a feeding frequency of once every two days resulted in an average absolute growth of 30.78 g, which was lower than the once-a-day treatment but higher than the three-times-a-day and twice-a-day treatments. In this treatment, the feed was always completely consumed. However, due to the long interval between feedings, the feed was depleted before the next feeding time, forcing the crabs to use stored energy for daily activities. As a result, less energy was available for growth. This aligns with Djunaedi (2016), who stated that if dietary energy is insufficient, body protein will be broken down to supply energy, which reduces body weight. Additionally, the long feeding interval caused the feed to remain submerged in water for extended periods, resulting in nutrient loss. According to Sayuti *et al.* (2012), when feed stays submerged too long, it becomes less fresh and loses nutritional value, ultimately slowing crab growth.

Observations during the study showed that in the treatments with feeding frequencies of three times and twice a day, leftover feed was often found in the rearing containers. This indicates inefficient feed utilization and suboptimal energy intake, which likely contributed to the lower growth in these treatments. Harisud *et al.* (2019) stated that low growth in mud crabs is caused by low energy intake, where most of the energy obtained from feed is used for survival rather than growth. Crabs can only grow once their basic energy needs are met. This shows that a higher feeding frequency does not necessarily result in better weight gain in mud crabs.

Several previous studies on mud crab fattening, such as those by Manuputty (2014), Karim *et al.* (2019), and Adila *et al.* (2020), reported absolute growth values of 43.35 g, 49.45 g, and 77.36 g, respectively. These figures are higher than the result of the present study, which only reached 35.34 g likely due to the absence of molting during the experiment. In contrast, some crabs in the other studies underwent molting, contributing to greater weight gain.

In addition, other research has shown variation in mud crab growth performance. (Rahadiyani *et al.*, 2014). reported that a combination of formulated and fresh feed significantly improved growth. (Abadi *et al.*, 2020) also found that chicken intestine-based feed led to higher growth than clam and snail-based feeds. These findings suggest that certain types of animal-based feed are more effective in supporting mud crab growth.

3.2.3 Production

In fisheries production refers to all the yields harvested from cultivation or capture activities. The production value is obtained from the percentage of the results during the cultivation period which is based on the number of crabs alive at the end of the cultivation period and the average weight of the crabs at the end of the cultivation period. One cultivation method that can be used to produce mud crabs is fattening. Fattening is essentially the process of rearing crabs that are already large in size but still below the standard consumption weight (Karim, 2013). According to Adila *et al.* (2020) fattening mud crabs has great potential to produce fat crabs and increase the added value for farmers leading to higher economic value.

Based on Table 3 it can be seen that the highest average production was achieved in the treatments with feeding frequencies of once a day and once every two days with values of 594.34 g and 584.33 g, respectively. The lowest average production was found in the treatments with feeding frequencies of three times a day and twice a day with values of 533.67 g and 535.67 g respectively. The differences in mud crab production in this study were due to variations in the final growth weights across the treatments. The higher the final growth weight and survival rate the higher the production value. In this study, the survival rate was the same across all treatments so the higher growth rates in the once-a-day and once-every-two-days feeding treatments resulted in higher production values. This is in line with the statement by Muhlis *et al.* (2021) which suggests that mud crab production is closely related to growth rate and survival. Optimal growth and high survival rates will support higher production outcomes.

The differences in production values across treatments in this study are also believed to be caused by the feeding frequency as the applied treatment and the crabs' ability to utilize the feed. According to Ningsih and Affandi (2023) the amount of energy absorbed from the feed leads to optimal growth and high survival rates, as feed is one of the key factors for achieving maximum production in mud crab cultivation. The same statement was made by Putri *et al.* (2014) who suggested that providing sufficient and high-quality feed is a determining factor in the cultivation process to achieve production efficiency, allowing mud crabs to grow to their full potential.

Overall, the production value of mud crabs in this study was quite good. This was likely due to the nutritional content of the feed and the water quality conditions that were within the tolerance range for the crabs which likely supported increased mud crab production. Additionally the apartment system of rearing helped prevent cannibalism which in turn contributed to higher survival rates. According to Djunaedi (2016) the production level in mud crab farming is influenced by both internal and external factors. Internal factors include age, lineage, growth rate, disease resistance, sex, and feed utilization, while external factors include water quality, stocking density and the amino acid or protein composition in the feed.

3.2.4 Water Quality

In this study, several water quality parameters were measured, including temperature, pH, dissolved oxygen (DO), salinity and ammonia. Based on the temperature measurements taken during the study, the water temperature ranged from 27-32°C. This condition is still within the optimal range for mud crab farming. Fujaya *et al.* (2019) stated that the temperature range that supports the growth and survival of mud crabs is 25-35°C. The dissolved oxygen levels measured during the study ranged from 5.7-6 ppm. Karim, (2013) recommended that the dissolved oxygen concentration should be maintained above 3 ppm to support the growth and survival of mud crabs. The salinity in the rearing media during the study ranged from 30-32 ppt. The tolerance range for salinity in mud crabs is 5-40 ppt. The pH measurements during the rearing process ranged from 7.5-8.1. Karim (2013) stated that to maximize the growth of mud crabs, the rearing media should have a pH between 7.5-8.5. Ammonia levels during the study ranged from 0.006-0.0185 ppm. This is in line with Karim (2013) statement that the ammonia concentration in the rearing media should not exceed 0.1 ppm to support the life of mud crabs.

According to Hastuti *et al.* (2019)water quality needs to be carefully monitored to ensure that the water in the rearing medium remains in optimal condition for the survival of mud crabs. During the

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study, water quality was maintained in stable conditions by applying a recirculation system. Water quality management was carried out by siphoning leftover feed and feces that settled at the bottom of the rearing containers to prevent accumulation, ensuring the water quality remained good. Siphoning was done before the next feeding.

4. Conclusion

These findings provide valuable insights for mud crab farmers, suggesting that a once-daily feeding strategy optimizes growth while maintaining survival rates. Future research should explore the impact of different feed compositions and molting frequency on growth performance.

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