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The effect of different fresh feeds on the growth and molting period of mud crab (*Scylla serrata*) cultivated in a single room system

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Abstract
Not all of the crabs obtained from natural catches are of super quality, and most of the meat is not complete enough, which causes farmers to carry out fattening activities. The problem often faced by mud crab cultivators at the fattening stage is the need for alternative feed with high and good nutritional content to support crab growth and the continuity of the molting process. In contrast, mud crab cultivation still relies on trash fish as feed. However, the problems in providing trash fish are due to competition with human needs, the influence of seasons and short shelf life, and varying feed quality. This research aims to determine how providing different types of fresh food affects mud crabs' growth and molting period (*Scylla serrata)* kept in a single-room system. The study used a completely randomized design (CRD) with 3 treatments, namely feeding with goldfish snails (*Pomacea canaliculate*) (A), blood cockles (*Anadara granosa*) (B), and chicken intestines (C) using 10 replications. The test animals, mud crabs with an average weight of 99.53±7.64 g/head, were kept in a *single-room system*. The research was conducted in Blendung Village, Ulujami District, Pemalang Regency, for 35 days with a feeding frequency of once a day at a dose of 5%/BW/day. The best research results were obtained in the chicken intestine feed treatment (C), namely (TFC 160.21±21.26; FCR 7.53±5.15; SGR 0.78±0.58; SR 60%; Absolute Weight 33.93±25.65; Absolute Length 0.97±0.79; Molting Percentage 60%). Water quality during the research was still within the optimum range for rearing mud crabs, namely pH 8.2-9.2; salinity 17.4-29.8 ppt; temperature 26.9-33.2 °C; DO 4.1-6.3 mg/l; ammonia 0.144-1.304 ppm.

Keywords: Crab, feed, molting, single room, growth

Introduction
Mangrove crab (*Scylla serrata*) is a brackish water fisheries commodity with a high selling value on the world market. This commodity is very popular with local and foreign consumers because the meat tastes delicious and is highly nutritious. Mud crab (*S. serrata*) has a protein content of 45.40-50.58%, fat of 10.52-13.08%, and energy of 3,579-3,724 kcal/g (Karim *et al.*, 2005) [15]. The export volume of crabs and crabs in 2021 reached 32,183 tons, an increase of around 4,567 tons compared to 2020, with a total of 27,616 tons. Until now nature has still fulfilled the demand for mud crabs. Naturally caught mangrove crabs are not always super or fat. There are still many crabs found that are skinny, so when they are sold, their economic value is low (Adila *et al*., 2020) [2]. One effort to utilize skinny crabs and increase their monetary value is by carrying out systematic and controlled fattening cultivation. There are several business segments for cultivating mud crabs: rearing, egg crab production, *soft shell crabs*, and fattening (Karim *et al.*, 2018) [16].
Feed is an essential factor in cultivating mud crabs. Feed accounts for more than half of the operational costs in cultivation. According to Fitriani (2013), the highest operational costs in cultivation are feed, namely more than 60%. The choice of feed type is based on the availability of the feed and the content it contains to meet the crab's needs. One of the problems mud crab (S. serrata) farmers face is choosing the right type of feed for the growth and survival of mud crabs. Crabs need to be fed according to the digestibility of the crab's digestive system and its eating habits (Abadi *et al.*, 2020) [1].

In general, mud crab farmers use trash fish as feed. However, the availability of trash fish is still influenced by the season in the catching process, and trash fish are not always easy to find (Harisud *et al.*, 2019) [9]. According to Samidjan *et al.* (2019) [25], mud crab farmers complain about limited trash fish as food at the end of the year.

Steps that can be taken in finding a substitute for trash fish are using alternative feed that can support the growth and survival of mud crabs. Researchers have made previous efforts to address this problem by comparing other types of feed. Based on research conducted by Suhardin *et al.* (2022) [29], feeding golden snails (*Pilla ampullacea*) had a real influence on the specific growth rate (SGR) of mud crabs (*S. serrata*), namely 1.02 g/day at a dose of 9%, 0.95 g/day at a dose of 8%, and 0.72 g/day at a dose of 7%. This aligns with research by Sadinar *et al.* (2013) [24], which produced an SGR of 116.60±0.06 and a survival of 100% in the golden snail treatment (7%). Research on feeding chicken intestines to mangrove crabs was carried out by Failu (2021) [7], which resulted in the highest specific growth rate (SGR) in the chicken intestine feeding treatment with an average of 1.822%, followed by anchovy and squid feeding treatments with an average SGR-an average of 1.464% and 0.991% respectively.

Meanwhile, in the research of Sudarmono *et al.* (2018) [28], giving different types of feed resulted in the highest absolute weight growth in the treatment of blood cockles (*Anadara granosa*) at 23.55 g, followed by the treatment of kalandue clams (*Polymesoda* sp.) at 20.025 g, and the lowest in the treatment of pokea clams (*Batissa violacea celebensis*) amounted to 15.975 g. Therefore, this study compares the effect of golden snails, chicken intestines, and blood clams on the growth rate and molting period of mud crabs (*S. serrata*) kept in a single-room system. This system is expected to reduce cannibalism rates in mud crabs.

Materials and Methods

Study This was held in March-April 2024 in Blendung Village, District Ulujami, Pemalang, Central Java. The test animals used were crab mangroves with a size of 99.53±7.64 grams and as many as 30 heads. The density distribution was one crab/container because the system is a *single room*. Maintenance is done for 35 days, with the frequency of feeding once daily-a type of fresh feed used from golden snails, clams' blood, and chicken intestines. A fixed feeding rate was used. Searching sample growth crabs was done at the study's beginning, middle, and end for known fish growth. The nutrition content of each fresh feed is presented in Table 1.

Table 1: Analysis Proximate feed golden snails (A), blood cockles (B), and chicken intestines (C)

Treatment	Ingredients in 100% Dry Ingredients			
	Ash (%)	Crude Fat (%)	Crude Fiber (%)	Crude Protein (%)
A	16.18	4.57	3.77	75.30
B	15.51	6.92	5.24	77.81
C	16.45	12.89	5.79	81.54

Source: Laboratory Nutrition Faculty Animal Husbandry and Agriculture, Diponegoro University

The method used in the activity study is descriptive and experimental, with a completely randomized design (CRD). Study This use design random complete (RAL) with 3 treatments and 10 replications with the use treatment as follows:

Treatment A: Give a golden snail dose of 5% weight per individual per day.
Treatment B: Giving feed shell blood dose of 5% weight per individual per day.
Treatment C: Giving chicken intestine feed dose of 5% weight per individual per day.

Growth Performance Calculations

Growth parameters include total consumption feed (TFC), ratio conversion feed (FCR), rate growth specific (SGR), weight absolute (Aw) and long absolute (Al), molting period and percentage (MP), viability life (SR), is calculated as follows.

TFC (g) = F1 + F2 +....+ Fn
FCR = Total Feed (Final Weight-Initial Weight)$^{-1}$ (Zonneveld *et al.*, 1991) [33]
SGR (%) = (Ln Final Weight-Ln Initial Weight) maintenance time^{-1} x 100
Aw (g) = Final Weight-Initial Weight
Al (cm) = Final Length-Initial Length
MP (%) = (Number of Final Molting Crabs) (Number of Initial Molting Crabs)$^{-1}$ x 100 (Arifin, 2010) [4]
SR (%) = (Final Number of Crabs), (Initial Number of Crabs)$^{-1}$ x 100 (Effendie, 2002) [6]

Water Quality

Measured water quality during the activity study covers temperature, pH, dissolved oxygen (DO), salinity, and ammonia. Measurement of water quality was carried out before giving crabs food. The measurement process for water quality (apart from ammonia) was done once in the morning. Ammonia measurements were carried out very in a week.

Analysis Statistics

The data obtained during the study was analyzed using statistics from Microsoft Excel 2010 and SPSS software version 26. Data obtained from the Normality test and homogeneity test were carried out. If the data is usually distributed and homogeneous, then continued analysis variance (ANOVA). Analysis variance (ANOVA) was performed to determine whether the treatment applied had an influence. Data analyzed (test) variance at a level of 95% confidence. If the variance analysis obtained different results, then Duncan's multiple area test was carried out. The water quality data obtained was analyzed descriptively.

Results

Giving different fresh food (golden snails, shellfish blood, chicken intestines) provides significant influence (p<0.05) against level survival (SR) and molting percentage (MP) of crab's mangrove (*S. serrata*). The results of measuring growth parameters during the maintenance of crab mangroves can see in Table 2.

Table 2: Growth performance after 35 days of giving fresh feed with different types

Parameter	A	B	C
TFC (g)	188.56±13.98 ^{a}	156.84±60.88 ^{b}	160.21±21.26 ^{b}
FCR (g)	8.43±1.67 ^{a}	10.96±5.36 ^{b}	7.53±5.15 ^{a}
SGR (%)	0.71±0.31 ^{a}	0.58±0.48 ^{b}	0.75±0.53 ^{a}
Aw (g)	24.07±10.17 ^{a}	20.39±22.79 ^{b}	32.65±25.16 ^{a}
Al (cm)	0.44±0.5 ^{a}	0.50±0.87 ^{a}	0.97±0.79 ^{b}
MP (%)	10.00±31.62 ^{a}	20.00±42.16 ^{a}	60.00±51.64 ^{b}
SR (%)	100.00±0.00 ^{a}	80.00±42.16 ^{ab}	60.00±51.64 ^{b}

Note: Values with different superscripts indicate significant differences (p<0.05) between treatments.

The results of measuring growth parameters during the maintenance of crab mangroves can see in Table 3.

Table 3: Mud crabs molting period during rearing

No.	Type of Treatment	Code	Day to Molting
1.	Blood Clams	B2	3
2.	Chicken Intestines	C7	5
3.	Chicken Intestines	C8	16
4.	Chicken Intestines	C4	17
5.	Chicken Intestines	C3	18
6.	Chicken Intestines	C2	18
7.	Chicken Intestines	B3	20
8.	Chicken Intestines	C10	27
9.	Golden snail	A4	33

Water quality

Water quality is one factor that can support aquaculture activities' success. Water quality parameters measured include pH, salinity, temperature, dissolved oxygen (DO), and ammonia. Table 4 shows the results of measuring water quality parameters in rearing fattening mud crabs (S. serrata) pomfret.

Table 4: Water quality parameter values during study

Parameter	Measurement results	Eligibility	Literature
pH	8.2-9.2	7.2-8.8	Kanna (2006) [14]
Salinity (ppt)	17.4-29.8	15-32	Susanto (2008) [30]
Temperature (°C)	26.9-33.2	22-36	Iromo *et.al.*, (2018) [12]
DO (mg/l)	6.1-7.4	>4	Kordi (2012) [17]
Ammonia (mg/l)	0.144-1.304	<1	Kuntiyo *et al.*, (1994) [18]

The results of measuring water quality variables during the research showed that the values fluctuated because they were carried out during the transition between the dry and rainy seasons. Based on existing water quality data, most measurement values are still in the appropriate category for rearing mud crabs.

Discussion

Growth

The level of feed consumption is related to how much the crab consumes feed. Feed consumption is directly related to stomach capacity, digestibility level, and gastric emptying rate. Karimah *et al.* (2018) [16] stated that the higher the ability to digest nutrients, the faster the gastric emptying rate, so the amount of feed consumed increases. The results of the variance analysis showed that providing different fresh feeds did not significantly affect the level of mud crab feed consumption. The highest total feed consumption (TFC) was obtained in the gold snail treatment (A) at 188.56±13.98 grams, while the lowest TFC occurred in the blood cockle treatment (B) at 156.84±60.88 grams. Differences in feed consumption levels during the research are thought to be influenced by environmental conditions around the research. Pratama *et al.* (2018) stated that a decrease in water temperature impacts the metabolic system, energy utilization, and decreased appetite. Weight, age, and palatability variations in crabs influence their feed requirements. According to Putra (2020) [22], several factors influence the level of feed consumption, including age, temperature, palatability, stomach capacity, fish weight, temperature, and nutrition.

The smaller the feed conversion value, the more efficient the utilization of feed into meat. Vice versa, the greater the feed conversion value, the lower the utilization efficiency (Pasi *et al.*, 2022) [21]. The best feed conversion ratio value was produced in treating mud crabs fed chicken intestines (C) with FCR (7.53±5.15). This is thought to be due to the high nutritional content of chicken intestines and the soft texture of chicken intestine meat so that it can be digested well by mangrove crabs (*S. serrata).* According to Wahyuningsih *et al.* (2015) [31], the soft texture of chicken intestines influences the amount of feed consumed because it makes it easier for crabs to digest, so the feed is utilized well. According to proximate analysis, chicken intestines' protein content is 25.18%, which meets the crab's protein needs. According to SNI, Mangrove is around 18-19.5%. The results of the variance analysis showed that providing different types of fresh food during 35 days of rearing did not have a significant effect ($p>0.05$) on the feed conversion ratio of mud crabs (*S. serrata).*

Mangrove crabs treated with chicken intestines (C) produced the highest specific growth rate (SGR) values compared to those treated with golden snails (A) and blood cockles (B). This is possibly caused by the aroma of chicken intestine feed, which mud crabs prefer to other feed types. This is confirmed by Failu (2021) [7], who states that crabs prefer chicken intestines' distinctive and stimulating aroma to other feeders. According to Agustina *et al*. (2020) [1], mud crabs fed chicken intestines produced the best SGR value (0.29±0.11) compared to those fed kepah clams (0.07±0.00) and snails (0.03 ±0.02). In Failu's research (2021) [7], chicken intestine feed treatment provided the highest daily growth rate (SGR) value with an average of 1.82%, followed by anchovy feed and squid feed with an average of 1.46% each and 0.99%. Based on the higher specific growth rate value, Alam *et al.* (2009) [11] suggested that chicken intestine feed is better used as maintenance or fattening feed for mud crabs because it is more economical and has an aroma that stimulates the appetite of mud crabs more than feed.

The growth of mud crabs (*S. serrata*) is directly proportional to the specific growth rate (SGR). Mud crab growth can be maximized if the specific growth rate is maximum. Research by Muswantoro *et al.* (2012) [19] used test animals measuring 70-80 g/head and had entered the adult crab phase so that these crabs would experience significant weight gain only when molting. Still, after molting, the growth that occurred was minimal. The results of the variance analysis showed that providing different fresh feeds did not have a significantly different effect ($p>0.05$) on the specific growth rate of mud crabs *(S. serrata).* The higher the crab's molting frequency, its specific growth rate is higher. Abadi *et al*. (2020) [1] reinforce this statement by saying that mangrove crabs only gain weight when molting, but the growth occurs minimally after molting.

The best absolute increase in weight and length was obtained in chicken intestines (C), with an average of 32.65±25.16 and 0.97±0.79. This is thought to be because the highest number of crabs that experienced molting occurred in the chicken intestine treatment, so the average absolute weight and length growth values were also the best. The increase in absolute length is related to increased molting (Harisud *et al.*, 2019) [9]. Romadhon *et al*. (2022) confirmed this, stating that mangrove crabs naturally undergo a skin molting cycle to grow the crab's length, width, and biomass. This process requires adequate nutrition and optimal environmental conditions. The results of the analysis of variance (ANOVA) showed that

giving different types of fresh food to mud crabs during 35 days of rearing did not have a significant effect ($p>0.05$) on the growth in weight and absolute length of mud crabs.

Molting

Descriptive data analysis showed that 9 of the 30 test crabs experienced the molting phase. The most molting occurred in the chicken intestine feed treatment (C), namely six birds. While the rest each occurred in treating two blood cockles (B) and one golden snail (A). The fastest molting time occurred in treating blood cockles (B2) on the third day and chicken intestine feed (C7) on the fifth. Meanwhile, the longest molting occurred in treatment code C10 (chicken intestines), which molted on day 27-Prasetyo *et al.* (2013) state that crabs molted at 3-37 days. Protein and non-protein energy greatly influence the acceleration of the molting process. Bidayani *et al.* (2019) [9] believe non-protein energy in feed, such as carbohydrates, functions to form chitin in hardening crab shells. Carbohydrates also play a role in saving the use of protein as the primary energy source so that protein energy can be stored in the form of meat biomass and then used for the molting process (Karim, 2005) [15]. It was also stated that the molting period of mud crabs is greatly influenced by internal factors such as health, age, and gonad maturation processes, as well as external factors, namely food availability, temperature, and water salinity.

Based on the results of 35 days of research, mud crabs treated with chicken intestines (C) experienced the molting process with the highest percentage, namely 60%. Meanwhile, in treating blood cockles (B) and golden snails (A), molting was 20% and 10%, respectively. The large number of molting crabs in the chicken intestine treatment is thought to be due to the high protein content in the chicken intestine compared to other treated feeds. This was confirmed by Hariani *et al.*, 2013 that feed containing protein and fat, such as chicken intestines, can increase the survival and growth of mud crabs.

Survival Rate

The higher the SR value is close to 100%, the SR value can be declared good; conversely, if the SR value is close to 0%, then the resistance condition is not good. The survival value is obtained by comparing the number of individuals alive at the end of the experiment with the number of individuals at the beginning to determine how far the mud crabs can survive. One thing that influences survival is biotic and abiotic factors. According to Winestri *et al.* (2014), biotic factors include competition for food, predation, parasites, density, age, and ability to adapt to the environment and handling processes, while abiotic factors are water quality.

The highest survival value was obtained from the golden snail food treatment (A) (100.00±0.00). According to Sadinar *et al.* (2013) [24], the high survival value of mud crabs is because the food provided is by the diet of mud crabs in their habitat, such as golden snails, so that the crabs can utilize the food provided to live and grow. This is to Mulyani's statement (2014) that a survival rate (SR) ≥ 50% is classified as good, 30-50% is classified as moderate, and SR less than 30% is classified as not good. This relatively good survival rate cannot be separated from the crab selection process, container system, availability of sufficient food to meet the growth needs of mud crabs, and water quality that is still within the appropriate range to support increased survival of mud crabs (Wahyuningsih *et al.*, 2015) [31]. According to Agus *et al.* (2015) [3], the survival rate for mud crabs kept in a single room can reach 100%. Based on the results of research that has been carried out, providing different fresh feeds has a significant effect ($p<0.05$) on the survival of mud crabs *(S. serrata)*.

During the research, mortality occurred in several crabs treated with blood shellfish (B) and chicken intestines (C). Death occurs in the first, second, and third weeks. The deaths in the first week were thought to be caused by the crabs' inability to adapt well to the new environment. This is confirmed by Ario *et al.* (2019) [5], who stated that several causes of crab death are the crab's weak body condition due to a lack of ability to adapt to the new environment. As a result, the crab experiences stress, so its appetite decreases and ultimately causes death. The deaths that occurred in the second and third weeks were thought to be due to the parasite *Octolasmis* sp., which infects the gill organs of mud crabs by attaching them like sprouts so that the gills appear black. This is confirmed by Hartanti *et al.* (2021) [10], who said that *Octolasmis* sp can attach itself firmly by hooking its legs to the crab lamella, which can support its rapid breeding process. One of the triggers for these ectoparasites' emergence is the crab's stressed condition and poor water quality, which reduces the crab's immunity.

Apart from fluctuations in water quality and unstable weather, deaths occur because leftover food is left in the crab box container. This causes ammonia to increase and triggers the emergence of fungi and parasites. Ammonia in water comes from the breakdown of organic material, leftover feed, and metabolic products of mangrove crabs. High ammonia levels in water can increase tissue consumption, damage gills, and reduce the blood's ability to transport oxygen (Hastuti *et al.*, 2019) [11].

Water Quality

Based on the research results, water quality measurement values were obtained during the research, including temperature, pH, salinity, dissolved oxygen, and ammonia. The results of temperature measurements during the study ranged from 26.9-33.2 °C. This indicates that the range of temperature values is still optimal for the survival of mangrove crabs. According to Iromo *et al.* (2018) [12], the optimum temperature for rearing mud crabs is 22-36°C. Temperatures that are less than optimal reduce organisms' metabolism, while temperatures above the optimum limit cause organisms to experience stress.

Based on the results of pH measurements during the research, it ranged from 8.2 to 9.2. This indicates that the pH range is classified as less suitable because it exceeds the crab's tolerance limit. According to Kanna (2006) [14], the optimal pH for the growth of mangrove crabs ranges from 7.2 to 8.8. Water with an acidic pH can cause mortality in crabs, as can pH with a high alkaline value. This is because pH can influence physiological and biochemical processes, including controlling the enzyme activity of the gill organs, which impacts oxygen consumption.

During the research, the results of salinity measurements obtained salinity values ranging from 17.4 to 29.8. This salinity range is still considered optimal for the survival of mangrove crabs. According to Susanto (2008) [30], optimal salinity for mangrove crabs ranges from 15-32 ppt or includes brackish waters. According to Praing *et al.* (2014), salinity ranging from 15-30 ppt is optimal for the growth of mud crabs (*S. serrata)*. The dissolved oxygen content values obtained during maintenance ranged from 6.1 to 7.4. This

indicates that the DO range is still optimal for the survival of mud crabs. According to Kordi (2012) [17], the optimal value for the growth of mangrove crabs is 4-7 mg/l. A decrease in dissolved oxygen levels in water can inhibit the metabolic activity of biota because oxygen plays a vital role in aquatic biological chemical processes.

Based on the measurements of ammonia content (NH_3) during the research, ammonia measurement results were obtained ranging from 0.144-1.304 mg/l. The ammonia value is still considered optimal for the survival of mangrove crabs because it exceeds the optimal threshold. According to Kuntiyo *et al*. (1994) [18], the highest ammonia level for mud crab life is a maximum of 1 mg/l. Water with high ammonia can cause cultivars to become poisoned. The uncontrolled presence of ammonia will cause aquatic organisms to consume more oxygen, and their gills will be damaged (Hastuti *et al.,* 2019) [11].

Conclusion

Based on the results of the research that has been carried out, it can be concluded that Providing different types of fresh feed (golden snails, blood cockles, and chicken intestines) to mud crabs (*S. serrata)* had no significant effect on feed conversion ratio (FCR), specific growth rate (SGR), total feed consumption (TFC), increase in absolute weight and length, but significantly different from the survival rate (SR) and molting percentage of mud crabs. Based on research conducted, the treatment of feeding golden snails (*Pomacea canaliculate)* to mangrove crabs (*S. serrata)* produced the highest survival value (SR) (100.00±0.00) compared to other treatments. The best molting percentage of mud crabs was obtained in the chicken intestine treatment (C) (60.00±51.64).

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