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The Effect of Fresh Feed Combinations on Survival Rate, Growth, and Production of Mud Crab (*Scylla olivacea*) Cultured by Silvofishery Model

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Abstract. One of the important factors that influence the success of mud crab cultivation is the feed which generally uses trash fish. However, the use of trash fish still has limitation, so it takes the role of other fresh feed or a combination of fresh feed to complement the nutritional content of trash fish. This study was aimed to determine the best combination of fresh feed on survival, growth, and production of mud crab (*S. olivacea*) reared by the silvofishery model. This research was conducted from November 2021 to January 2022 in Mandalle Village, Pangkajene and Islands Regency, South Sulawesi Province. The study used a container in the form of a circular bamboo cage with a diameter of 1.5 m. The test animals used were male mangrove crabs (*Scylla olivacea)* weighing 150 ± 10 g as many as 120 individuals. This study was designed using a randomized block design consisting of 4 treatments with 3 replications each, namely *Tilapia* fish, a combination of *Tilapia* fish and Ricefield snails, a combination of *Tilapia* fish and blood clams, a combination of *Tilapia* fish and chicken intestines. The data obtained were analyzed using analysis of variance. The results of the analysis of variance showed that the combination of fresh feed had no significant effect on mangrove crab survival, but had a very significant effect on growth, and had a significant effect on mangrove crab production. The resulting survival values ranged from 93.33 to 96.67%. The highest absolute growth of mud crab was produced in the combination of tilapia and blood clams, which was 45.3 g, while the lowest was in single tilapia, which was 18.87 g. The best production of mud crab was produced in a combination of tilapia fish and blood clams, which was 1930.83 g. However, in general, all treatments produce optimal production values.

Keywords: Mud crab, fresh feed combination, growth, production, silvofishery

INTRODUCTION

Mangrove forest is one of the water areas that has certain characteristics and plays an active role in the development of the surrounding environment (Lisna et al., 2017). Ecologically, mangrove forests are utilized by various types of aquatic organisms, such as crabs, fish and various species of shellfish as nursery grounds, spawning grounds, and feeding grounds (Majid et al., 2016). One form of utilization of mangrove forests is silvofishery, which is a traditional cultivation system that combines the process of aquaculture and mangrove planting which is packaged by prioritizing environmental sustainability (Paruntu et al., 2016). One of the aquatic organisms that can be cultured in the silvofishery model is the mud crab.

The mangrove crab, also known as the mud crab is one aquatic organisms belonging to the portunidae family and lives in almost all coastal waters, especially on beaches overgrown with mangroves. Mangrove crabs have good adaptability and are widespread at various points in the mangrove forest area (Gita, 2016). Public demand for mangrove crabs continues to increase, both in local and international markets. This is because the mud crab has a delicious and unique meat taste, as well as a high nutritional content. Cultivation of mangrove crabs has been commercially carried out by several countries, one of which is Indonesia (Dayal et al., 2019).

The important thing that needs to be considered in the cultivation of mud crabs is the nature or habits of crabs that can affect the survival, growth and production of mud crabs, one of which is eating habits or food habits.

One factor that play an important role in determining the success of mud crab cultivation is feed. The feed used must meet the requirements, among others, its provision, processing and nutritional content in accordance with crab eating habits (Koniyo, 2020). The feed that is commonly given is fresh feed, one of which is trash fish because the price is relatively cheaper and affordable. However, the use of single trash fish as the main feed source is not recommended, because its availability is influenced by season, lacks variety, and inconsistent nutritional content. Therefore, the role of other fresh feed or a combination of fresh feed is needed to complement the nutritional content of trash fish, so that it can support the growth of crabs.

As for some fresh food that can be combined with trash fish, among others, snails or rice field snails, blood clams, and chicken intestines. The fresh feed was chosen because it is easy to obtain, the price is affordable, and it has completed nutritional content consisting of protein, carbohydrates, fat, and several minerals that play an important role in growth (Zubarno et al., 2021). The use of the right combination of fresh feed is expected to produce maximum and effective survival, growth, and production of mud crabs.

In connection with the above, in order to produce the best survival, growth and production of mud crabs, research is needed on the right combination of fresh feed, so that it is expected to produce maximum mud crab production. This study was aimed to determine the right combination of fresh feed on survival, growth, and production of mud crab (S. olivacea) reared by the silvofishery model, so research on this needs to be done.

Materials and Methods

Experimental Materials

The tested animals used were male mud crabs (*S. olivacea*) weighing 150 ± 10 g, stocked with a density of 10 fish/cage totaling 120 individuals. The crabs were imported from crab collectors in Pallime Village, Cenrana District, Bone Regency, South Sulawesi.

The containers used are cages made of bamboo in the form of a circle with a diameter of 1.5 m totaling 12 pieces. These containers were plugged in the mangrove area of Rhizophora sp. The outside of the cage is lined with waring which aims to protect the cage from garbage and dirt carried by the waves. To keep the water circulation in the cage running smoothly, between the bamboo halves one to another is given a distance of about 1 cm.

The feed used was a combination of fresh feed according to treatment consisting of trash fish, ricefield snails, blood clams, and chicken intestines. The feed given was 10% per day from crab biomass, with a frequency of feeding 2 times a day, 3% in the morning at 6 am and 7% in the afternoon at 5 pm.

Procedure

The research was preceded by a preparatory stage which included: providing research materials and equipment including bamboo, blocks and saws, making cages, installing cages in mangrove areas, and procuring crabs. First, the bamboo is cleaned and then cut and split into several pieces measuring 4 cm. Then the pieces of bamboo are arranged regularly so that they are in the form of a kere, then they are attached by nailing to the cage frame made of wooden blocks.

To keep the water circulation in the cage running smoothly, between the bamboo halves one to another is given a distance of about 1 cm. The outside of the cage is lined with waring which aims to protect the cage from garbage and other debris. Before stocking the test crabs, their weight was selected and adapted to the environmental conditions of maintenance for 2 days. Adaptation is done by immersing the crab into the water around the cage. Initial weight and carapace width measurements were also carried out before stocking. The carapace width was measured using a ruler or ruler, while the weight was measured using a digital sitting scale with an accuracy of 1 g.

During the study, the test crabs were fed with trash fish and a combination of fresh feed according to the treatment, which had been cut into small pieces and mixed in a container first. The dose of feed given was 10% of the crab biomass with a frequency of feeding twice a day, ie in the morning at 6 am as much as 3% and in the afternoon at 5 pm as much as 7%. The method of feeding carried out is fixed or given every day without counting the remaining feed. To determine the water quality of the maintenance environment during the research, physical and chemical measurements of the aquatic environment were carried out. Measurements were made in the morning and evening before feeding. The composition of the type of feed used after proximate is presented in Table 1.

Table 1. Composition of the type of feed used after proximated

Material	Protein	Fat	BETN	Coarse Fiber	Ash
Tilapia fish	63.97	12.36	1.88	2.37	19.42

Ricefield Snail	61.80	13.61	3.48	2.01	19,10
Blood Clams	61.42	13.40	4.84	1.87	18.47
Chicken Gut	59.70	18.32	2.32	3.14	16.52

Results of Proximate Analysis (2022) at State Polytechnic of Pangkep

At the end of the study, the number of live crabs was counted, and the weight of the harvested crabs was re-weighed.

Experimental Design

This study was designed using a randomized block design consisting of 4 treatments, and each treatment consisted of 3 replications. Thus, this study consisted of 12 experimental units. The treatments for the different combinations of fresh feed used in mud crab fattening are as follows:

A. Trash fish (control)
B. Trash fish + ricefield snail
C. Trash fish + scallop
D. Trash fish + chicken intestine

Study Parameter

Parameters that will be observed in this study are survival, growth, and production of mud crab.

Survival Rate

The survival rate is calculated using the formula (Huynh and Fotedar, 2004) as follows:

$$SR = (N_{ti}/N_0) \times 100$$

Note:

SR = Mud Crab Survival Rate (%),
N_{ti} = Number of live crabs at the end of rearing (individual),
N_0 = Number of crabs at the start of rearing (individual).

1. Growth Rate

The absolute growth of crabs was calculated using the formula (Changbo *et al*., 2004; *in* Karim *et al*, 2016):

$$PM = (B_t - B_0)$$

Note:

PM = Absolute Growth (g),
B_o = Mean Weight of Crab at Initial Rearing (g),
B_t = Mean Weight of Crab at the end of Rearing (g).

2. Production

Production was calculated at the end of the study using the formula:

$$P = N_t \times B_t$$

Keterangan:

P = Crab Production (g),
N_t = Number of live crabs at the end of rearing (individual),
B_t = Average final weight of crabs at the end of rearing (g).

3. Water Quality

As supporting data, during the research, several physical and chemical parameters of the crab rearing environment were measured, including: temperature, salinity, pH, dissolved oxygen, nitrite, and ammonia. Temperature was measured using a thermometer, salinity with a hand refractometer, pH with a pH meter, dissolved oxygen was measured using a DO meter, and ammonia and nitrite were measured using a spectrophotometer.

Temperature, salinity, pH, and dissolved oxygen were measured twice a day during the study, namely in the morning at 06.00 WITA and in the afternoon at 17.00 WITA. The nitrite and ammonia were measured 3 times during the study, namely at the beginning, middle, and end of the study.

Data Analysis

The data obtained in the form of survival, growth, and production of mud crabs were analyzed using analysis of variance (ANOVA) and further W-Tuckey test. As a tool to carry out the statistical test, the computer software package SPSS version 23.0 was used. The water quality parameters were analyzed descriptively based on the viability of the life of the mud crab.

Results

Mud Crab Survival Rate

The average survival rate of mud crab (*S. olivacea*) reared by the silvofishery model in various combinations of fresh feed can be seen in Table 2.

Table 2. Average survival of mud crab (*S. olivacea*) reared by silvofishery model in various feed combinations

Fresh Feed Combination	Survival Rate (%) (n=3)
Tilapia fish	$93.33 \pm 5{,}77$
Ricefield Snail	$93.33 \pm 5{,}77$
Blood Clams	$96.67 \pm 5{,}77$
Chicken Intestine	$96.67 \pm 5{,}77$

Note: There was no significant difference between the light treatments: (p>0,05)

The results of the analysis of variance showed that the effect of the combination of fresh feed had no significant effect (p>0.05) on the survival of mud crabs reared by the silvofishery model.

Mud Crab Growth

The average growth rate of mud crab (*S. olivacea*) reared by the silvofishery model on various combinations of fresh feed can be seen in Table 3.

Table 3. Average growth of mud crab (*S. olivacea*) reared by silvofishery model on various combinations of fresh feed

Fresh Feed Combination	Absolute growth (g) (n=3)
Tilapia fish	$18.87 \pm 1{,}70^{c}$
Ricefield Snail	$25.57 \pm 0{,}51^{b}$
Blood Clams	$45.3 \pm 1{,}61^{a}$
Chicken Intestine	$25.5 \pm 0{,}50^{b}$

Note: Different letters in the same column indicate significant differences between treatments at the 5% level (p<0,05)

The results of the analysis of variance showed that the combination of fresh feed had a very significant effect (p<0.01) on the growth of mud crabs reared by the silvofishery model. Furthermore, the results of the W-Tuckey test showed that the effect of using single tilapia fish was significantly different (p<0.05) with all treatments. The combination of tilapia fish and field snail showed no significant difference (p>0.05) with the combination of tilapia fish and chicken intestine, but the two treatments were significantly different (p<0.05) with the combination of *Tilapia* fish and blood clams.

Mud Crab Production

The average production of mud crab (*S. olivacea*) reared using the silvofishery model in various combinations of fresh feed can be seen in Table 4.

Table 4. Average production of mud crab (*S. olivacea*) reared using the silvofishery model on various combinations of fresh feed

Fresh Feed Combination	Production (g) (n=3)

Tilapia fish	$1655,77 \pm 95,85^{b}$
Ricefield Snail	$1725,03 \pm 104,97^{ab}$
Blood Clams	$1930,83 \pm 86,44^{a}$
Chicken Intestine	$1679,7 \pm 104,19^{ab}$

Note: Different letters in the same column indicate significant differences between treatments at the 5% level (p<0,05)

The results of the analysis of variance showed that the combination of fresh feed had a significant effect (p<0.05) on the production of mud crabs reared with the silvofishery model. Furthermore, the results of the W-Tuckey test showed that the administration of *Tilapia* fish alone was not significantly different (p>0.05) with the combination of *Tilapia* fish and ricefield snails, and the combination of *Tilapia* fish and chicken intestines. However, it was significantly different (p<0.05) with the combination of tilapia fish and blood clams. Likewise, the effect of the combination of *Tilapia* fish and blood clams was not significantly different (p>0.05) with the combination of *Tilapia* fish and field snails and the combination of *Tilapia* fish and chicken intestines.

Water Quality

During the research, several physical and chemical parameters of the mangrove crab water environment were measured as supporting data including temperature, salinity, pH, dissolved oxygen (DO), ammonia, and nitrite. The range of values for the physico-chemical environment of the mud crab reared by the silvofishery model during the study can be seen in Table 5.

Table 5. Physicochemical range of crab (S. olivacea) aquatic environment maintained by silvofishery model during the research

Parameter	Value Range	Optimum Range (Referensi)
Temperature (ºC)	25-30	25-35ºC (Hastuti *et al.*, 2016)
pH	7,12-7,96	7,5-8,5 (Hastuti *et al.*, 2016)
Salinity (ppt)	15-25	10-30 (Hastuti *et al.*, 2016)
DO (ppm)	3,00-5,22	>3 ppm (Karim, 2013)
Ammoniac (ppm)	0,005-0,014	<0,1 (Karim, 2013)
Nitrite (ppm)	0,24-0,42	<0,5 (Karim, 2013)

Discussion

Survival Rate of the Mud Crab

Table 2 showed that the provision of fresh feed in the form of *Tilapia* fish, a combination of *Tilapia* fish and field snails, a combination of tilapia fish and blood clams, also a combination of *Tilapia* fish and chicken intestines resulted in the same survival of mangrove crabs in fattening maintained by the silvofishery model. This is due to the conditions of the maintenance environment that are still in accordance with the needs of mangrove crabs, namely mangrove habitat and the availability of sufficient food, so that the mangrove crabs are still able to maintain their survival. According to Kumalah et al. (2017) mangrove vegetation is a natural habitat for mud crabs. According to Watanabe (1998) in Wahyuningsih et al., (2015), there are two factors that affect the survival of organisms, namely biotic factors consisting of age, sex, resistance to disease and the ability to adapt to their environment. Abiotic factors include the availability of food and the quality of living media.

The survival rate of mud crabs produced in this study was quite high, ranging from 93.33 to 96.67%. Several research results on mud crab fattening maintained by silvofishery models, among others, by Karim et al. (2017) with the treatment of giving different types of feed resulted in a survival rate of 86.67-93.33%. Wamnebo et al. (2018) with different feed dosage treatments resulted in 46.67-83.33% survival. Furthermore, Karim et al. (2020) with the treatment of different pen culture confinement models resulted in a survival rate of 76.67-96.67%.

Growth of the Mud Crab

Table 3 indicated that the average absolute growth of mangrove crabs was highest in crabs fed a combination of tilapia fish and blood clams, which was 45.3 g, while the lowest was given to tilapia fish alone, which was 18.87 g.

The highest growth of mud crabs was produced by giving a combination of tilapia fish and blood clams which could be caused by the nutrient content, in the form of protein, carbohydrates, fats, minerals and so on from the combination of tilapia fish and blood clams that were in accordance with the needs of mangrove crabs, so that they could spur their growth. According to Alamsyah and Fujaya (2013), mud crabs will grow well if the feed is available in sufficient quantities and contains all the necessary nutrient elements in optimal quantities. Lovell (1998 in Sudarmono et al., 2018) states that growth is highly dependent on available energy and excess energy spent from various activities. Energy needs for all activities and maintenance of the body must be met first through the metabolic process, then if there is excess energy then it is used for growth. If the energy from the available feed is insufficient, the crab will use the protein in its body to carry out activities. This causes the weight of the crab to decrease and can cause death.

In the combination of tilapia fish and blood clams, mud crab can use tilapia fish as a source of protein, because it contains the highest protein compared to other fresh feeds, namely field snails, blood clams and chicken intestines. Protein is one of the important nutrients that affect the growth of crabs. According to Winestri et al. (2014) protein is one of the macronutrient components that have a major role in growth. Proteins function as forming new tissue and replace damaged body cells. In addition to protein, tilapia fish also contain other nutrients such as carbohydrates and fats that crabs need. In addition to containing high levels of nutrients in the form of protein, fat and carbohydrates, blood clams also contain minerals that support the growth and life of crabs. This is in accordance with the statement of Nurjanah et al. (2021), that blood clams are one type of shellfish that can be used as a source of protein and minerals. The mineral components such as Cu, Mg, Ca, Fe, Zn, and Se can act as antioxidants. Antioxidants function to prevent the occurrence of free radicals and avoid lipid peroxidation which causes damage and instability to intracellular components such as membranes, nucleic acids and enzymes, resulting in pathological conditions and decreased body resistance which can indirectly reduce growth (Winestri et al., 2014). According to Dayal et al. (2019). The increase in growth in crabs is not only due to the high proportion of essential amino acids from the diet, but also due to the content of macro minerals, such as potassium, phosphorus, and elements such as iron, manganese, selenium, and zinc which help accelerate the mineralization process in mud crabs.

Tilapia fish is a fresh feed that has the highest protein content, but singly produces the lowest absolute growth value. This can be caused by the crab's ability to utilize feed, where the crab cannot eat the whole feed, but must be shredded first, thus allowing the feed not to be consumed completely and destroyed and thrown to the bottom. In addition, only about 20-30% of the energy contained in feed protein is utilized, then the rest is deaminated into amino acids. According to Lovell (1998 in Sudarmono et al., 2018) feed quality is not only determined by the high protein content but is also determined by the ability to digest and absorb the feed eaten. In addition, excess protein in the diet can reduce growth because a lot of energy is needed to demineralize amino acids and remove excess nitrogen.

Apart from nutrition, the absolute growth of mud crab is also influenced by the texture of the type of feed used. Tilapia fish, has a smooth flesh texture with a higher water content which allows easier digestion and does not require a large amount of energy in the metabolic process, so that the energy possessed can be used for the growth of mud crabs. In addition, *Tilapia* fish has a distinctive smell that stimulates crabs to eat and is a sinking food, making it easier for crabs to find because crabs prefer to forage at the bottom of the water. Blood clamss have a flesh size that is not too large and spreads when given to crabs, so the crabs do not expend a lot of energy looking for food. In addition, blood clams do not have bones, so the entire flesh can be eaten by crabs.

Ricefield snail as a combination feed with *Tilapia* fish in the silvofishery model of mangrove crab rearing has a harder meat texture and the legs are the largest limb, which causes low digestibility, so the crabs need more energy when eating them. In addition, ricefield snails do not have a strong odor, thereby reducing the appetite of mangrove crabs. Meanwhile, chicken intestines as a combination feed with tilapia fish are floating in water, so their existence is not immediately known by crabs. According to Akbar et al. (2016), floating feed will be influenced by the wind and gather at one point, so that the distribution is uneven. Differences in nutrient content, digestibility, aroma, and the nature of the feed used as treatment in this study gave significantly different results.

Several results of research on the growth of mud crabs maintained by silvofishery models include Karim et al. (2017), with the treatment of giving different types of feed, the absolute growth value of mud crabs was 49.50 g. Wamnebo et al. (2018), with the treatment of giving different types of feed, the absolute growth value of mud crabs was 55.0 g. Mustakim et al. (2018) showed that the absolute growth value of mud crab was highest in media according to tides, which was 22.01 g. Karim et al. (2020), with the treatment of different pen culture confinement models resulted in absolute growth of 88.88 g.

Mud Crab Production

Based on Table 4, it is known that the average production of mangrove crabs per treatment container is best for crabs fed a combination of *Tilapia* fish and blood clams, which is 1930.83 g, with a total production of 5819.5 g, while in fact the average crab production The lowest mangrove per treatment container was produced in crabs fed single *Tilapia* fish, which was 1655.77 g, with a total production of 4967.3 g. The average production of crab fed a combination of tilapia fish and ricefield snails per treatment container was 1725.03 g, with a total production of 5175.1 g and the average production of a combination of tilapia fish and chicken intestines per treatment container, which was 1679. 7 g, with a total production of 5039.1 g. Differences in production values that occur in mangrove crabs can be caused by the nutritional content of the feed as the treatment given, and the ability of crabs to utilize feed. But in general, the production value of mud crab produced is quite good. This is because the maintenance of mangrove crabs with the silvofishery model is able to support the life of crabs, because mangroves are the original habitat of crabs that are able to provide live viability and provide natural food for crabs. This is in accordance with the statement of Karim et al. (2018) that mangroves are the original habitat of mud crabs, so it is very suitable to be used as a conservation and maintenance area for crabs. In addition, the waters around the mangroves also provide a food source for crabs, such as benthos and tapioca (Karim., 2013). Based on the research results of Karim et al. (2018), the best mangrove vegetation to obtain the best mangrove crabs is *Rhizophora* sp. This is because *Rhizophora* sp. has a higher litter productivity than the productivity of other mangrove vegetation.

In addition to the natural food available in the mangroves, the provision of a combination of fresh feed also greatly supports crab production. This is because, feed is a source of material that provides energy for crabs to carry out their activities and growth. The combination of fresh feed treatment for crabs was able to complement the nutritional needs of crabs obtained from feed in nature, and were able to provide constant and continuous feed. According to Djunaedi (2016), the factors that influence the level of crab production in an aquaculture business are the percentage of mouIting, growth rate, and survival and these factors are influenced by internal and external factors. Internal factors include age, sex, heredity, relative growth rate, reproduction, adaptability, disease resistance, and the ability to utilize feed. External factors include, water quality, density, and the amount and composition of amino acids contained in the feed. One of the main factors that influence the success of mud crab production is feed.

Water Quality

Based on the results presented in Table 5, it can be seen that the physical and chemical parameters of the mangrove crab aquatic environment measured during the study were temperature, pH, salinity, dissolved oxygen (DO), ammonia and nitrite. The temperature values obtained during the study ranged from 25-300C. According to Hastuti et al. (2019), the optimum temperature for the growth of mud crabs is between 25-350C. According to Karim et al. (2013), temperature is one of the important abiotic factors that affect the activity, appetite, survival, and growth of mud crabs. Therefore, it can be concluded that the range of temperature values at the time of the study was still within the tolerance limits for mud crab cultivation.

The pH values obtained during the study ranged from 7.12-7.96. According to Hastuti et al. (2016), the optimal pH in the maintenance of mud crabs is between 7.5-8.5. According to Karim (2013), for maximum growth, mud crabs should be cultivated in media with a pH between 7.5 and 8.5. Therefore, it can be concluded that the range of pH values at the time of the study was still within the tolerance limits for mud crab cultivation.

The results of the measurement of salinity or salt content obtained during the study ranged from 15-25 ppt. According to Hastuti et al. (2016), the optimum salinity for the life of mud crabs ranges from 10-30 ppt. Karim (2013) stated that mud crabs are euryhaline organisms, which are able to live in a wide salinity range and include osmoregulator type aquatic organisms. Therefore, it can be concluded that the range of salinity values at the time of the study was still within the tolerance limit for mud crab cultivation.

The content of dissolved oxygen (DO) obtained during the study ranged from 3.00-5.22 ppm. According to Karim (2013), in order to get the best growth of mud crab, the dissolved oxygen (DO) content in the cultivation location must be greater than 3 ppm. Therefore, it can be concluded that the range of dissolved oxygen (DO) values at the time of the study was still within the tolerance limit for mud crab culture.

The results of the measurement of ammonia (NH3) obtained during the study ranged from 0.005 to 0.014 ppm. According to Karim (2013) in order for mud crabs to grow well, the concentration of ammonia in the live media is not more than 0.1 ppm.

The results of the measurement of nitrite (NO2) obtained during the study ranged from 0.24 to 0.42 ppm. According to Karim (2013) in the cultivation of mud crabs, nitrite levels should not exceed 0.5 ppm.

Conclusion

Based on the results of the research conducted, it can be concluded as follows:

1. The survival of mangrove crabs reared by the silvofishery model with various combinations of feed resulted in the same survival.
2. The highest absolute growth of mud crab was produced in the combination of tilapia and blood clams, which was 45.3 g, while the lowest was in single tilapia, which was 18.87 g.
3. The best production of mud crab is produced in a combination of tilapia fish and blood clams, which is 1930.83 g. h in general, all treatments produce optimal production values.

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