Growth and Chemical Composition of the Body of Mud Crab (*Scylla olivacea*) Cultured with Silvofishery Systems at Several Genera of Mangrove Vegetation

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DOI: 10.29322/IJSRP.9.11.2019.p9593
http://dx.doi.org/10.29322/IJSRP.9.11.2019.p9593

ABSTRACT

Mud crab is one of aquatic organisms occupying mangrove ecosystem that has high economic value and potential for cultivation with Silvofishery system. The current study was conducted in the mangrove areas of Mandalle Village, Pangkep Regency, South Sulawesi Province. This study was aimed to compare the growth rate and the chemical composition of the body of mud crab (*Scylla olivacea*) that cultured with Silvofishery system on a variety of mangrove vegetation. The experimental container used an embedded cage made from bamboo with length, width and height of 1.5 x 1.5 x 1.5 m each. Tested animal used was mud crab (*S. olivacea*) collected from Pallime Village, Cenrana Subdistrict, Bone Regency, South Sulawesi Province with weight of 155±10 gram and cultured for 40 days. The study consisted of three treatments with five replications each. The three genera of mangrove vegetation used were *Avicennia*, *Rhizophora*, and *Sonneratia*. The collected data were analyzed using non-parametric statistics (Kruskal Wallis and Mann Withney U Test). The results of the analysis of Kruskal-Wallis and Mann Whitney U test showed that different genera of mangrove had a significant difference ($p < 0.01$) to the production of the mangrove litter, the growth rate and chemical composition of the crab's body. However, it was not significant ($p > 0.05$) in the survival of mangrove crabs. The best litter productivity, growth rate, and the chemical composition of the body of mud crab (protein, fat, Ca, P, and energy) were contributed by *Rhizophora*.

Keywords: mud crabs, body chemical composition, growth rate, silvofishery

I. INTRODUCTION

Silvofishery is one model of aquaculture activity in the mangrove area. The basic principle of this cultivation system is the multiple uses of the existing mangroves without eliminating the natural function of the ecosystem, so that fishery products are resulted and mangrove are still sustainable in playing a biological, ecological and economic function (Takashima, 2000; Karim *et al.*, 2017). Various species of important economic biota that can be cultivated in mangrove areas with *silvofishery* systems, one of them is mud crab (David, 2009; Karim *et al.*, 2019).

Mangrove crab known as mud crab is one commodity from crustacean genera which have important economic value. This type of crab has been commercially cultivated in several tropical countries including Indonesia. Mangrove crabs are well known both in the domestic and foreign markets because of the delicious taste of meat and high nutritional values. Based on the results of proximate analysis it is known that mangrove crab meat contains 44.85-50.58% protein, 10.52-13.08% of fat and 3579-3.724 kcal/g of energy. In addition, the crab meat contains a variety of important nutrients such as minerals and fatty acids ω-3 (EPA and DHA). The crabs are also a source of protein, niacin, folate, potassium, vitamin B12, phosphorus, zinc, copper and selenium (Brown, 2008; Mirera, 2014; Karim, 2013).

Mangrove ecosystem consists of various species of vegetation, and every species of mangrove vegetation produce different litter that contribute different nutrient contribution in aquatic environment (Zamroni and Rohyani, 2008; Asriani *et al.*, 2019). Therefore, the different types of mangrove vegetation as location of mud crab cultivation with silvofishery system is predicted would produce different growth and quality of crabs. Therefore, in order to generate the rapid growth and high quality of crabs cultured with Silvofishery system, it is necessary to conduct studies on the proper mangrove vegetation types.

This study was aimed to compare the growth rate and chemical composition of the body of mud crabs that are cultured by the silvofishery system in various mangrove vegetation.

II. RESEARCH METHODS

Study Sites

The study was conducted in the mangrove areas of Mandalle Village, Mandalle District, Pangkajene Islands Regency, South Sulawesi Province, Indonesia. Mangrove litter measurements and proximate crab analyzes were carried out at the Nutrition and Feed Laboratory, Faculty of Animal Husbandry, Hasanuddin University, Makassar, Indonesia.

Study Materials

Bamboo cages with length, width, and height respectively 1.0 m x 1.0 m x 1.0 m were embedded in mangrove areas. The outer part of the cage was covered with *waring* (plastic nets) which aimed to protect the cage from the garbage and dirt carried by the waves. Feed used was a trash fish in the form of minced *Tilapia* fish. Feeding was done once a day i.e. in the afternoon at 5 pm with a dose of 10% of crab biomass. To maintain the water circulation in the cage running smoothly, the bamboo cleavage between one and the other was given a distance of approximately 1 cm.

Test animals used were male mangrove crabs (*Scylla olivacea*) with weight of 155 ± 1.0 g. The crabs were obtained from a crab collector in Pallime Village, Cenrana District, Bone Regency, South Sulawesi, which was kept for 40 days. Before being stocked to the study containers, the crabs were adapted to the environmental conditions for two days and then the weight was selected by weighing on a digital balance with accuracy of 1.0 g.

Samples of mangrove litter were collected using a litter-trap with a size of 100 cm x 100 cm made of nylon net. These litter traps were placed in the line transect plot in each 10 m x 10 m mangrove measurement plot with a height of 1.5 m above the ground level to avoid tides. Collection of mangrove litter was done once a week for six weeks, and as replicates, sampling was started from day 7, 14, 21, 28, 35, and 42. This was intended to obtain data or results that are accurate and have a diversity of data. The litter that has been collected was weighed to get the value of the wet weight. Wet weight of the litter was obtained after being weighed before being put within the oven. The dry weight of the litter was obtained after dried within an oven at 80° C until reaching a constant weight, (Soeroyo, 2003; Zamroni and Rohyani 2008). The parameters measured at this stage was the mangrove litter productivity.

Survival rate was calculated using the following formula:

$$SR = N_t / N_o$$

Where: S is survival rate (%), N_t is the number of live crabs at the end of the study, and N_o is the number of crabs at the beginning of the study.

Daily crab growth rate is calculated using the following formula:

$$SGR = 100 \times (\ln W_t - \ln W_0)/t$$

Where: SGR = daily growth rate of the crabs (%/day), W_o is the average weight of crab at the baseline (g), and W_t is average weight of crab at the end of the study (g).

The chemical composition of the body measured was protein, fat, and energy. Protein was analyzed using the kjedal method, fat with the soxlet method, and energy using a calorimeter bomb. Analysis was performed following the AOAC (1990) procedure.

As the supporting data during the study, several physical and chemical parameters were measured i.e. temperature, salinity, pH, dissolved oxygen, ammonia and nitrite. Temperature, salinity, pH and dissolved oxygen were measured two times a day i.e. morning (at 7 am) and afternoon (at 5 pm). The ammonia and nitrite were measured three times during the study, namely at the beginning, middle, and end of the study.

Data gathered from this study were analyzed using non-parametric statistics (Kruskal Wallis and Mann Withney U-Test).

III. RESULTS AND DISCUSSION

Results

Production of the Mangrove Litter

Production of litter in different genera of mangrove vegetation is presented in Table 1.

Table 1. The average value of the litter production in several genera of mangrove vegetation

Vegetation Genera	Litter production ($g/m^2/day$)
Avicennia	1.67 ± 0.08 [b]
Rhizophora	2.47 ± 0.07 [a]

Sonneratia	1.33 ± 0.05 [c]

Remarks: different letters on the same column show the significant differences (P <0.05) of litter productivity among mangrove genera

The results of the non-parametric analysis of Kruskal Wallis showed that the genera of mangrove vegetation had a very significant effect (P <0.01) on litter productivity. Furthermore, with Mann Withney Analysis, it was found that there were significant differences (P <0.05) of litter productivity among mangrove vegetation. The value of litter production, N and P produced are significantly different among the three vegetation, while for organic C in *Rhizophora* is not significantly diferrent (p > 0.05) with *Sonneratia* but diferrent from *Avicennia*.

Crab Survival and Growth Rates

Average daily growth rates of mangrove crabs that cultured on some mangrove vegetation are presented in Table 2.

Table 2. Average value of mangrove crab survival and growth rate

Vegetation Genera	Survival Rate (%)	Growth Rate (%/day)
Avicennia	94.00 ± 5.48	0.8 6 ± 0.01 [b]
Rhizophora	96.00 ± 5.48	0.9 6 ± 0.04 [a]
Sonneratia	96.00 ± 5.48	0.8 5 ± 0.03 [b]

Remarks: Different letters in the same column indicate a significant difference (P < 0.05) between mangrove vegetation types

The results of the analysis of non-parametric Kruskal Wallis test showed that the mangrove vegetation genera had no significant effect on the survival rate (p> 0.05), but was highly significant (P <0.01) to the growth rate of mud crabs. Furthermore, the results of the analysis of Mann Withney U Test revealed that there were significant differences (P <0.05) between mangrove vegetation on the growth rate of mangrove crabs. The growth rate of mangrove crabs that cultured in *Rhizophora* vegetation is significantly different from those cultured in *Avicennia* and *Sonneratia*.

Chemical Composition of Crab Body

The chemical composition of the body of mangrove crabs that are cultured by the silvofishery system in various genera of mangrove vegetation is presented in Table 3.

Table 3. The chemical composition of the body of mangrove crabs that are cultured by the Silvofishery system on various genera of mangrove vegetation

Mangrove Vegetation	Body Chemical Composition (%)				Energy (Kcal/g)
	Protein	Fat	Ca	P.	
Avicennia	42.76 ± 0.33[b]	11.50 ± 0.63[b]	1.81 ± 0.0 [b]	2.17 ± 0.08[b]	3,777 ± 77.64[b]
Rhizophora	45.61 ± 0.29[a]	12.82 ± 0.41[a]	1.93 ± 0.03[a]	2.48 ± 0.11[a]	3,878 ± 34.05[a]
Sonneratia	43.22 ± 0.28[b]	11.33 ± 0.38[b]	1.89 ± 0.02[b]	2.12 ± 0.04[b]	3,791 ± 18.92[b]

Remarks: different letters indicate significant differences among treatments at 5% level (p <0.05)

The results of the Kruskal Wallis Analysis showed that the difference in mangrove vegetation had a very significant effect (p <0.01) on protein, fat and crab energy. Content of protein, fat, and energy of mangrove crab are the best cultured in vegetation of *Rhizophora* than crabs reared on *Avicennia* and *Sonneratia* vegetation.

Water quality

Ranges of water quality in the mangrove crab environment during the study are presented in Table 4.

Table 4. Range of environmental water quality values for crabs cultivation during the study

Parameter	Value Range		
	Avicennia	*Rhizophora*	*Sonneratia*
Temperature (°C)	25 - 30	25 - 30	25 - 30
pH	7.06 – 7.95	7, 08 - 7, 95	7.08 – 7.96
Salinity (ppt)	17 - 29	17 - 29	17 - 29

DO (ppm)	3.12 – 4.45	3.11 – 4.46	3.12 – 4.45
Ammonia (ppm)	0.00 5 - 0.011	0.005 - 0.011	0.005 - 0.012
Nitrite (ppm)	0.22 – 0.42	0.22 – 0.4 1	0.23 – 0.42

Discussion

Based on Table 1 above, the highest productivity of litter is performed by *Rhizophora*, with a value of litter production, N, P, and organic C consecutive succession is 2.47 g/m^2 /day higher than *Avicennia* 1.67 and *Sonneratia* 1.33 g/m^2 /day.

The high litter productivity in *Rhizophora* vegetation shows that this vegetation has a high fertility rate that is able to support the life and growth of the fauna that live within it. High litter productivity in the *Rhizophora* vegetation is influenced by the density of the vegetation. Zamroni and Rohyani (2008) which found that the litter production in *Rhizophora* is higher because its density is higher than other genera. In addition to the density, the different genera of mangrove and tree diameter is also considered to influence production of litter per day. Difference in mangrove litter production was also caused by differences in geographic location, variation of vegetation conditions, and forest composition structure and the high and low densities in the mangrove forest.

Several research results show that *Rhizophora* vegetation has higher litter production than other genera (Day *et.al.*, 1987 and 1996; Amarasinghe and Balasubramaniam, 1992; Hossain and Hoque, 2008; Zamroni and Rohyani, 2008). Litter production in each genera of mangrove vegetation was found to be dominated by leaf components with a percentage of 62-78%, This was reported by Ake-Castillo *et.al.* (2006), Mahmudi *et al.* (2008), Ulqodry (2008), Bernini and Rezende (2010), and Abib and Appado (2012) that the main components of mangrove litter are leaves (> 50%). This is one form of adaptation of mangrove plant itself more abort the leaves to adapt to the saline environmental conditions, because salt is absorbed by the mangrove plants will be stored in the leaves (Zamroni and Rohyani, 2008).

The average survival rate obtained in this study was quite high, ranging from 94-96%, indicating that the three genera of mangrove vegetation were able to support the life of mangrove crabs. This is due to the mangrove vegetation is typical inhabitant of coastal ecosystems is the original habitat of the mangrove crab, where mud crabs live, breed and forage in this ecosystem. The mangrove crab population is typically associated with mangrove vegetation when its conditions is still good (Wijaya *et al.*, 2010).

Based on Table 2 above, it is known that the highest daily growth rate is produced by *Rhizophora* vegetation, with an average growth rate of 0.96 %/day. The high rate of growth of mangrove crabs in *Rhizophora* vegetation is due to this vegetation having higher litter productivity compared to other vegetation. Litter productivity is one indicators of the quality of the mangrove ecosystem. The research findings are in aggreement with the opinion of Tahmid *et al.* (2015) which states that there is a relationship (positive correlation) between the quality of mangrove ecosystems as mangrove crab habitat with the weight and width of mangrove crab carapace found.

The protein content of mangrove crab maintained in *Rhizophora* vegetation averaged 5.61%, while in *Avicennia* and *Sonneratia* are 42.76 and 43.22%, respectively (Table 3). This shows that the maintenance environment provides an anabolic effect in the form of increased protein synthesis in the body of the test crab. The high content of protein is one indicator of increased growth (Whiteley et al. 2001).

Table 3 also shows that crabs cultured in different mangrove vegetation have different fat, Ca and P contents. The change in the percentage of fat in each vegetation culture shows the use of fat, as an energy source and the formation of body fat. The fat content of crabs maintained at *Rhizophora* averaged 12.82%, while those of crabs cultured at *Avicennia* and *Sonneratia* were 11.50 and 11.33%, respectively. Piliang and Djojosoebagia (2006) stated that the main function of fat as a component of the cell membrane that functions as an energy source and is a factor in cholesterol synthesis and acts as body fat as an insulator and protector of important organs. The fat content of mangrove crabs maintained on *Rhizophora* vegetation is higher than the crabs cultured at *Avicennia* and *Sonneratia*. Likewise, the highest Ca and P contents of mangrove crabs is produced in crabs that are kept in *Rhizophora*.

The difference in protein and fat content influences the crab energy content. Based on Table 3, it appears that the higher the protein content and crab fat, the higher the energy content, and vice versa. The results of this study show that the average energy content of mangrove crabs maintained in *Rhizophora* vegetation is 3,878 kcal/g which is higher than *Avicennia* and *Sonneratia* which is 3,777 and 3,791 kcal/g.

The difference in crab body chemical composition in the form of protein, fat, and energy influences the absolute growth of mangrove crabs. The higher the body's nutrient content, the faster its growth. This can be observed from the crab growth rate (Table 2) where the crab growth rate is highest in the crabs that are cultured in *Rhizophora*. Growth is described as an increase in body protein (Kim and Lall, 2001). According to Rosa and Nunes (2003), organisms tend to have a composition of optimum biochemical depending on their adaptation strategy. Carbohydrate and fat contents of the crab body is the expression of an adaptive characteristics of animals.

In general, the results of this study illustrate that higher protein, fat, Ca, P, and energy content is generated in crabs that are cultured in *Rhizophora* compared to *Avicennia* and *Sonneratia*. This is caused by higher productivity of *Rhizophora* compared to *Avicennia* and *Sonneratia* (Table 1). High productivity affects the level of water fertility and abundance of nutrients and feed. With abundant food availability, the chance of crabs to consume feed is higher. The more feed consumed, the greater the chance of being deposited. The abundance of nutrients and feed in mangrove areas provides an opportunity for mangrove crabs to grow and breed (Carpenter and Niem, 1998; Keenan, 1999).

Based on Table 4 above, it can be seen that the environmental temperature of crab rearing during the study ranges from 25-30 °C, pH 7.08 - 7.95, salinity 17 - 29 ppt, dissolved oxygen 3.12-4.45 ppm, ammonia 0.005-0.012 ppm, and nitrite 0.22 – 0.40 ppm. These value range are appropriate to support the life of mangrove crabs. The optimum temperature for growth of mangrove crabs is 26 - 32 °C, salinity 15-30 ppt, pH range 7,0 - 8,5; dissolved oxygen > 3 ppm, ammonia < 0.1 ppm and nitrite < 0.5 ppm (Christensen *et al.*, 2005; Karim, 2013).

CONCLUSION

Based on this study, it can be concluded that the best litter production, survival, and growth rate of mangrove crabs are produced by vegetation of *Rhizophora* each of 2.47 g /m^2 /day, 96%, 0.96%/day. Likewise, the chemical composition of the body of mangrove crabs (protein, fat, Ca, P and energy) is best produced in crabs that are cultured on *Rhizophora* vegetation by 45.61; 12.82; 1.93; 2.48% and 3,878 kcal/g, respectively.

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