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Muhammad Yusri Karim
Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, Indonesia

Hasni Y Azis
Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, Indonesia

Khairul Amri
Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, Indonesia

Nurfadilah
Faculty of Fisheries, Cokroaminoto University, Makassar, Indonesia

Corresponding Author:
Muhammad Yusri Karim
Faculty of Marine Sciences and Fisheries, Hasanuddin University, Makassar, Indonesia

Survival rate, growth and biochemical composition of mangrove crab body (*Scylla olivacea*) cultured with various silvofishery systems with pen culture models

Muhammad Yusri Karim, Hasni Y Azis, Khairul Amri and Nurfadilah

Abstract
Silvofishery of mangrove crab culture is one of aquaculture activities in the mangrove area using pen culture. The aim of this study was to find the best model for survival, growth and chemical composition of the body of mangrove crabs (*Scylla olivacea*). The container used an embedded cage made of bamboo. Tested crabs used had 155 ± 10g weight. A randomized block design consisting of 4 treatments namely: triangles, rectangles, pentagons, and circles. It is proved that different culture model had a very significant effect (p<0.01) on survival, growth and chemical composition of the mangrove crabs. The best survival rate was produced in the pentagon and circle models, while the best crab body chemical composition was produced in the circle model and the body chemical composition was 46.67% of protein, 13.12% of fat, and energy of 3.883 Kcal/g).

Keywords: Mangrove crabs, pen culture, growth, survival, body chemical composition

1. Introduction
Silvofishery is one of the models of aquaculture activities in mangrove areas. The basic principle of this cultivation system is the multiple uses of mangrove areas without eliminating the natural function of the ecosystem, in order to obtain fishery and mangrove products that can still play a biological, ecological and economic function [1-4]. The ratio between the maintenance area and mangrove vegetation is 1: 5.5, that is 1 part for cultivation purpose and 5.5 parts for vegetation.

Various types of aquatic biota may be cultivated with silvofishery systems. One of them is mangrove crab. Mangrove crab is an important economically valuable fishery commodity, that has high nutritional value, and is preferred by consumers. Mangrove crabs belong to the genus of *Scylla*, which consists of four species i.e. *Scylla serrata*, *S. tranquebarica*, *S. paramamosain*, and *S. olivacea* which are widely distributed throughout the coastal zone of the Indo-Pacific region [5, 6].

Currently, crab is cultivated within ponds using a variety of technologies and cultivation containers. Generally, there are two types of systems for laying mangrove crab culture containers, namely the pen culture (bottom confinement) and floating cages (bottom-free brackets) [7]. Mangrove crab silvofishery system with pen culture in the mangrove area is a crab culture system by sticking a cage in the bottom of mangrove area.

One factor influencing the success of silvofishery of mangrove crab culture using pen culture is the pen culture model used. The form of pen culture will affect the behavior and activity of crabs because there are angles that can limit the movement and activity of the crabs. The difference in the pen culture model as a container for maintaining mangrove crab silvofishery systems is thought to result in the survival, growth and biochemical composition of different crab bodies. Therefore, in order to produce maximum and high-quality crab culture production, an appropriate pen culture model is needed. To find the right pen culture model for maintaining of silvofishery mangrove crabs in mangrove areas, research is needed.

This study was aimed to find the best pen culture model for survival, growth, and biochemical composition of the body of mangrove crabs (*S. olivacea*) maintained by the silvofishery system.

2. Methods
The study was conducted in the mangrove area of Mandalle Village, Mandalle District, Pangkep Regency, South Sulawesi, Indonesia. Crab proximate analysis was carried out in Nutrition Laboratory at the Pangkep State Agricultural Polytechnic.

The research container used a pen culture made of 2.25 m2 of bamboo which was planted in the mangrove *Rhizophora* area. The outer part of the cage was covered with *waring* (plastic net) to protect the cage from the rubbish and dirt carried by the waves. The feed used was trash fish in the form of chopped *Tilapia* fish. Feeding was done once a day i.e. in the afternoon at 5pm with a dose of 10% of crab biomass. To keep the water circulation in the confinement running smoothly, the bamboo cleavage between one and the other was given a distance of about 1 cm.

The tested animals used were male mangrove crabs (*S. olivacea*) measuring 155 ± 1.0 g, stocked with 10 individuals per container. The crabs were obtained from crab collectors in Pallime Village, Cenrana District, Bone Regency, South Sulawesi and kept for 40 days. Before the crab was stocked into confinement, it was first adapted to the condition of the maintenance environment for two days. During the adaptation period, crabs were fed in the form of chopped *Tilapia* fish ad libitum. Before the crab was stocked into a research container, first the weight was selected by weighing using a 1.0 g digital portable scale.

The study was designed using a randomized block design (RBD) consisting of four treatments with three replications each so that the study consisted of 12 experimental units. The four types of treatments applied were different pen culture models, namely: triangles, rectangles, pentagons and circles.

The parameters observed in this study were survival, absolute growth, and crab body chemical composition

Survival rate was calculated using the following formula:

$SR = N_t/N_o$

Note: S is survival rate (%), Nt was the number of live crabs at the end of the study, and No was the number of crabs at the beginning of the study.

The absolute growth of crabs was calculated using the following formula:

$$W = W_t - W_o$$

Note: "W" was the absolute growth of mangrove crabs (g), Wo was the average crab weight at the beginning of the study (g), and Wt = the average crab weight 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. The analysis was performed following the AOAC procedure [8].

As supporting data, measurements were made to several physical chemical parameters of water quality, including: temperature, salinity, pH, dissolved oxygen, ammonia, and nitrite. Temperature, salinity, pH, and dissolved oxygen were measured twice a day i.e. in the morning (6 am) and the afternoon (5 pm). The ammonia and nitrite were measured three times during the study, i.e. at the beginning, middle and end of the study.

Research data were analyzed using analysis of variance and W-Tuckey follow-up tests.

3. Result and Discussion
3.1. Results
3.1.1. Survival Rate and Growth
The average survival rate and growth of mangrove crabs maintained in various pen culture models are presented in Table 1.

Table 1: The average survival rate and growth of mangrove crabs that are kept on various pen culture models of pen culture

Pen Culture Model	Survival Rate (%)	Absolute Growth (g)
Triangle	76.67 ± 5.77^b	73,23 ± 2,07^c
Rectangle	93.33 ± 5.77^a	80,06 ± 3,95^b
Pentagon	96.67 ± 5.77^a	81,01 ± 0,27^b
Circle	96.67 ± 5.77^a	88,88 ± 2,62^a

Note: Different letters in the same column show a significant difference ($P<0.05$) between treatments at 5% level ($p<0.05$)

The results of the variety analysis showed that the pen culture model had a very significant effect ($P<0.01$) on survival and growth of mangrove crabs. Furthermore, the results of W-Tuckey's further tests showed that the survival rate of mangrove crabs maintained by the triangle culture pen culture model was significantly different ($p<0.05$) from the other models. However, between the rectangular, pentagon, and circle models did not show a real difference ($p>0.05$). The growth of mangrove crabs maintained by the triangle culture and pen culture models was significantly different ($p<0.05$) from the other models, but the rectangular and pentagon models did not show any significant differences.

3.1.2. Chemical Composition of the Crab Body
The chemical composition of the body of mangrove crabs that are maintained by the silvofishery system that is maintained in various pen culture models is presented in Table 2.

Table 2: Chemical composition of mangrove crab body at several pen culture model

Pen Culture Model	Body Biochemical Composition		
	Protein (%)	Fat (%)	Energy (KCal/g)
Triangle	42,89 ± 0,34^c	10,96 ± 0,13^c	3.660 ± 52,57^c
Rectangle	43,71 ± 0,17^b	11,65 ± 0,27^{bc}	3.756 ± 32,19^b
Pentagon	43,75 ± 0,19^b	12,68 ± 0,52^b	3.766 ± 26,08^b
Circle	46,67 ± 0,16^a	13,12 ± 0,43^a	3.883 ± 15,18^a

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

Variance analysis results showed that the pen culture model had a very significant effect ($P<0.01$) on the content of protein, fat, and mangrove crab energy. Furthermore, the results of W-Tuckey's further tests showed that the content of protein, fat, and energy of mangrove crabs maintained by the circular pen culture model were significantly different ($p<0.05$) from other models. However, between the rectangular and pentagon models did not show significant differences ($p>0.05$).

3.1.3. Water Quality
Physical and chemical parameter were measured for the maintenance of mangrove crabs. The range of physics and chemistry values of the environmental maintenance of mangrove crabs during the study were presented in Table 3.

Table 3: The range of water quality values for environmental maintenance during the study

Parameter	Value Range
Temperature (ºC)	25-30
Salinity (ppt)	15-30
pH	7.23-7.95
Dissolved Oxygen (ppt)	3.15-5.18
Ammoniac (ppm)	0.005 – 0.011
Nitrite (ppm)	0.22 – 0.41

4. Discussion
The best survival rate of mangrove crabs was produced in three pen culture models, i.e. rectangles, pentagons, and circles, while the lowest was in the triangle model. Likewise, the growth and chemical composition of the crab body is best produced in the pen culture with circle model, while the lowest is in the triangle model (Table 1). This shows that the pen culture of circle model is better than other pen culture models.
The two pen culture models (pentagon and circle) placed on *Rhizophora* mangrove vegetation are able to support the life of mangrove crabs. The best survival of mangrove crabs is due to the two pen culture models having wider angles so that crabs can move more freely. Furthermore, mangrove vegetation is a characteristic of the coastal ecosystem which is the original habitat of mangrove crabs, a place where mangrove crabs live, breed and find food. Mangroves are typical coastal ecosystems that have high productivity and have a physical, ecological and economic role [9]. Interaction between components in the mangrove ecosystem makes the ecosystem a good habitat for various types of biota including mangrove crabs. Mangrove crab populations are typically associated with mangrove vegetation where conditions are still good [10]. It is suggested that there is a relationship (positive correlation) between the quality of mangrove ecosystems as mangrove crab habitat [11]. Meanwhile, the lowest survival rate of the crab is produced in the pen culture triangle model, this is because the triangle model has a sharp angle, making it difficult for the crab's movements and behavior, including foraging activities. In addition, the angle in the pen culture of the triangle model causes accumulation of mud and dirt which interferes with the circulation of water that carries oxygen so that it can cause the crab to become stressed. The average survival rate obtained in this study was quite high, ranging from 76.67 to 96.67%. Some research results about the survival of mangrove crabs such as 47-56% [12], 86.25-93.75% [13], 35.0-61.5% [14], 61.67-93.33% [2], and 53.33-96.67% [4].
Based on Table 1, it can also be observed that the highest absolute growth of crabs was produced in the circle model with an average growth of 88.88 g, and the lowest in the triangle model that was 73.23 g. The high growth of mangrove crabs in the pen culture model is due to better maintenance confinement conditions. Pen culture circle model does not have an angle so that crabs are free to do activities both for moving and looking for food. Thus, the metabolic process of crabs will run smoothly including the metabolic process of digestion.
The content of mangrove crab protein that is maintained in the pen culture of the highest circle model is an average of 46.67% and the lowest in the triangle model is 42.89% (Table 2). This shows that the maintenance model provides an anabolic effect in the form of increased protein synthesis in the body of the crab. High protein content is one indicator of increased growth [15].
Table 2 indicates that the crab fat content of different pen culture models also has a different fat content. The highest fat content is produced in the circle model and the lowest in the triangle. The change in fat percentage in each pen culture model shows the use of fat, as an energy source and the formation of body fat. Crab fat content in the circular model averaged 13.12%, while those maintained in the triangular model was 10.96%. The main function of fat as a component of the cell membrane that functions as a source of energy and is a factor in cholesterol synthesis and acts as body fat as an insulator and protector of important organs [16].
The difference in protein and fat content influences the crab energy content. Based on Table 2, it appears that the higher the protein content and crab fat, the higher the energy content, and vice versa. The results of this study indicate that the average energy content of mangrove crabs that are maintained in the circle model is 3,883 kcal/g while the lowest in the triangle model is 3,660 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 may be observed from the absolute growth of crabs (Table 1) where the absolute highest growth of crabs in crabs is maintained in a circle model. Growth is described as an increase in body protein [17]. Organisms tend to have optimal biochemical compositions that depend on their adaptation strategies [18]. The body fat content is an expression of an animal's adaptive characteristics.
Based on Table 3, the temperature of the crab maintenance environment during the study ranged from 25-30 ºC, pH 7.23-7.95, salinity 15-30 ppt, dissolved oxygen 3.15-5.18 ppm, ammonia 0.005-0.011 ppm and nitrites from 0.22 to 0.41 ppm. The range of values is appropriate to support the life of mangrove crabs. The optimal temperature for the growth of mangrove crabs is 26-32 ºC, salinity 15-30 ppt, pH ranges from 7.0 to 8.5; dissolved oxygen> from 3 ppm, ammonia <0.1 ppm and nitrite <0.5 ppm [5,19,20].

5. Conclusion
Based on this research, it may be concluded that the circular pen culture model produces the best survival rate, growth, and chemical composition of mangrove crabs that are maintained by the silvofishery system.

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