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Culture of mud crab, *Scylla serrata* Forskal, 1775 with different feed formulations

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Abstract
Mangrove crab culture requires feed in sufficient quantity and quality. Aquaculture uses raw fish feed, but this feed has several limitations, namely limited availability, seasonality and inefficient storage. The use of artificial feed is an alternative for successful culture. This study aims to analyze different feed formulations on the growth and molting of mud crabs. 60 mangrove crabs of 60-90 g size were reared using crab boxes. The crabs were reared in ponds for 60 days. Four feed formulations were tried as treatments and repeated three times. Parameters measured were growth, molting, survival and water quality. Data were analyzed at the 95% confidence level. The results showed that the feed formulations tested had no effect on the test parameters. Feed formulations with lower protein levels of 31.29-35.97% and extreme fluctuations in water salinity are thought to be the cause of low growth and molting of mud crabs.

Keywords: Mud crab, feed, formulation, growth, molting

1. Introduction
Mangrove crab, *Scylla serrata* Forskal, 1775 is a fishery commodity that has high economic value and its demand continues to increase. This crab has been one of the most favored fishery commodities since the 1980s for the domestic market and export commodities. Export destination countries include Singapore, Thailand, Hong Kong, China, America, and Europe [1]. Crab production has been derived from natural catches, therefore aquaculture efforts continue to be supported to meet domestic and export market demands.

Crab culture requires quality feed and sufficient quantity. The feed for crab culture used so far is trash fish. This feed is considered to provide better growth and more profitable because the price is relatively cheap. A study conducted by [2] reported that feeding raw fish resulted in higher crab growth compared to feed in the form of shellfish. However, the use of raw fish feed also faces several problems. The availability of raw fish feed is limited and seasonal, the price is unpredictable, and there is competition with human needs [3].

One way to overcome this problem is to switch to using artificial feed. The advantage of using artificial feed is that the amount can be adjusted to the needs, can be stored for a long period of time, and can be formulated with a nutritional composition that suits the needs of mud crabs [4]. Studies have been conducted on the use of artificial feed, among others, reported by [5], namely by formulating the use of vegetable ingredients such as soybean flour, corn flour, and cassava as an adhesive; the use of amaranth extract (*Amaranthus* spp.) on the molting of orange mud crab [6, 7]. In addition, research on the right size of feed for crabs as reported by [8] is 10 mm in diameter.

There are several challenges in using artificial feeds, including the high cost of using imported fishmeal. Therefore, alternative sources of local raw materials are needed that can be used as a source of animal protein to reduce dependence on imported fishmeal. One of the local raw materials that can be used is Amazon sailfin catfish, *P. pardalis* and maggot meal. Amazon sailfin catfish is an invasive fish species that can act as a predator or competitor for native species and its utilization has not been maximized. Its use as a source of feed protein has been reported by several researchers [6, 7, 9, 10].

Amazon sailfin catfish contains 38.6% protein, 15.63% fat, 4.26% ash, and 7.45% water [11]. Maggot or Black Soldier Fly (BSF) larvae are insects that can be used as animal feed or fish feed because they contain 40-50% protein, 29-32% fat [12]. According to [13], protein derived from insects is more economical, environmentally friendly, has a high feed conversion value, and can be produced efficiently. To reduce dependence on commercial fishmeal, the use Amazon sailfin catfish and maggot meal can be an alternative source of protein in feed for mangrove crab rearing. Both ingredients can complement each other if formulated with the right composition. This study aims to analyze different artificial feed formulations on growth and feed efficiency in mud crab culture.

2. Materials and Methods

2.1 Feed ingredient preparation and feed processing

Amazon sailfin catfish are cleaned and the entrails removed and then dried for five days (depending on the intensity of the sun). To maximize the drying process, it is then oven dried at 70 °C for 24 hours. The dried fish was ground using a blender and sieved using a sieve with a mesh size of 425 µm [9]. Maggot meal was obtained from a local commercial trader. In addition to Amazon sailfin catfish meal and maggot meal, the other ingredients were cornmeal, fine bran, copra meal, vitamins and minerals. The experimental feed formulation is presented in Table 1.

Table 1: Feed formulation treatment and feed proximate test results

Feed ingredients	Feed formulation treatment			
	A	B	C	D
Amazon sailfin catfish meal	31.5	30	30	29.5
Maggot meal	30	30	30	29.5
Soy meal	24	24	24	24
Fine bran	6	6	6	5
Corn meal	5.5	4	1	0
Fish oil	0	3	6	9
Vitamins dan minerals	3	3	3	3
CMC	0.5	0.5	0.3	0.5
Total	100	100	100	100
Results of feed proximate test				
Protein (%)	35.97	34.97	33.97	31.29
Lipid (%)	6.31	7.30	8.87	9.94
Karbohidrat (%)	30.37	33.15	33.07	35.29
Clude (%)	18.2	17.44	17.75	17.21
Moisture (%)	8.70	7.15	6.83	6.27

All the ingredients are prepared, first the ingredients that have the highest amount are mixed and finally the least amount (vitamins and minerals). After all the ingredients are evenly mixed, warm water is added and kneaded and then ready to be molded into pellets with a diameter of 10 mm. The finished feed is dried for approximately 3 hours. The feed is proximate tested, after which it is ready for use.

2.2 Crab culture

The sixty mangrove crabs with body weight of 60-90 g were selected. The cultivation container is a crab box measuring 20 cm long, 15 cm wide and 15 cm high. On the sides and bottom of the crab box, waring with a mesh size of 1 cm was installed so that the feed given did not fall through the holes in the crab box [14]. Furthermore, the crab box is placed on a raft made of bamboo, equipped with floats from used bottles. The raft containing the crab box was placed in the pond and then 1 crab/crab box was added. Acclimatization of crabs was carried out for 5 days after which their weight was measured using an electric scale with an accuracy of 0.1 g and their length using a fish measuring board with an accuracy of 0.1 mm.

Crab culture was carried out for 60 days, the feeding dose was 5% of body weight/day with a frequency of feeding twice a day, namely 2% in the morning and 3% in the afternoon [15]. Sampling of growth and other parameters was done every 15 days. Pond water changes were carried out periodically based on the tidal cycle (one high tide and one low tide in one day).

2.3 Test parameters and data analysis

The experimental design used in this study was a completely randomized design (CRD) consisting of four treatments and each repeated three times. The treatments were different feed formulations (Table 1). The parameters observed were: Absolute weight growth, molting percentage, survival rate. Absolute growth was calculated using the equation proposed by [16] as follows:

$$\Delta t = Wt - Wo$$

Description: Δt: Absolute weight growth (g)
Wt: Final biomass weight (g)
Wo: Initial biomass weight (g)

Molting Percentage The percentage of mangrove crab molting during maintenance was calculated using the formula (1) as follows:

$$M = Mt/Mo \ x \ 100$$

Description: M: Percentage of molting (%)
Mt: Number of crabs molted (n)
Mt: Total number of crabs reared (n)
Survival rate (SR), calculated using the formula [16] as follows:

$$SR = Nt/No \ x \ 100$$

Description: SR: Survival rate (%)
Nt: Final number of crabs (n)
No: Initial number of crabs (n)

Water quality observed were temperature, salinity, pH, dissolved oxygen, ammonia and nitrite. Temperature was measured using a thermometer, salinity with a refractometer, and pH with a pH meter, ammonia and nitrite using a spectrophotometer. To determine whether the treatment affected the test parameters, an analysis of variance (ANOVA) was conducted at the 95% confidence level and continued with Duncan's further test. Quality parameters were analyzed descriptively.

3. Results

Observations of absolute weight growth, molting percentage and survival rate of mud crabs reared for 60 days are presented in Figures 1.

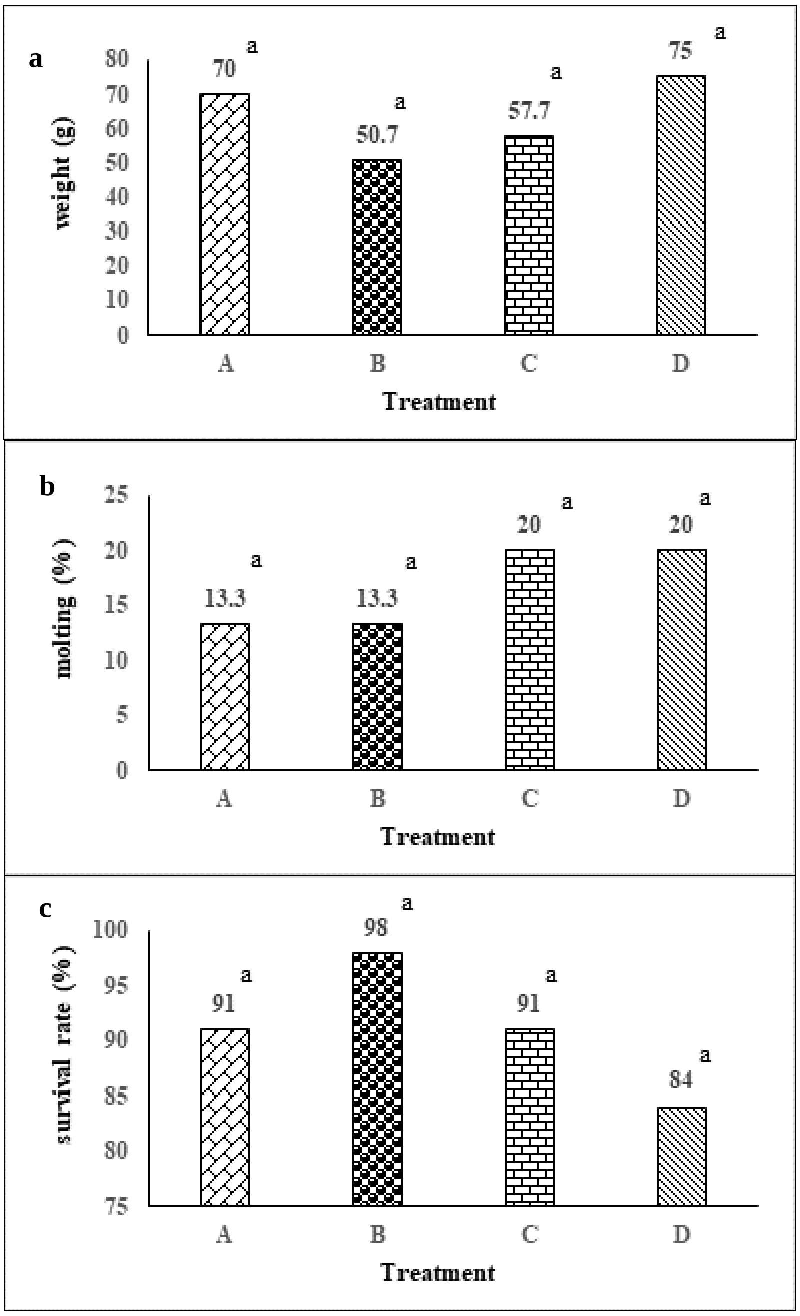

Fig 1: Absolute growth (a), molting percentage (b) and survival rate (c) of mud crabs treated with different feed formulations. Same letter above parameter value indicates non-significant based on ANOVA 0.05%.

Table 2: Water quality parameters, range during the study and optimum range according to literature

Parameter	Range during the research	Optimum range according references
Temperature (°C)	28-31	29 °C [17]; 20-30 °C [18]
Salinity (ppt)	5-15	20 ppt [19]; 25 ppt [20]
pH	7-8	7,75 – 8,50 [21]
Dissolved Oxygen (ppm)	4-5	±5,51 mg/l [22]
Ammonia (ppm)	0.109	< 0.5 [17]
Nitrite (ppm)	0.075	<0,05 [17]

4. Discussions

In crab culture, growth is very important because it is related to maintenance time and production. If growth can be stimulated in a short period of time, the cultivator can harvest faster with lower maintenance costs, meaning more profit is obtained. The results of this study showed that different feed formulations had no effect on absolute growth, number of molts and crab survival rate. The results of the feed proximate test show that the range of protein, fat, carbohydrate values is not too large so it is thought that it has not had a significant effect.

Growth and the number of crabs molting in this study were relatively low, it is suspected that there are several factors that cause it, namely unfavorable water quality conditions, namely salinity is not in optimal conditions, relatively high nitrite levels so that the accumulation of these factors is thought to cause crab energy to be used more for adaptation to the environment than used to grow. The growth is influenced by internal factors and external factors [1, 23]. Internal factors include genes, species, sex and physiological status of the organism. While external factors include environmental conditions such as temperature, salinity, dissolved oxygen, pH, turbidity, organic matter, stocking density, feed, pests and diseases.

This study was conducted in a community aquaculture area, the water inlet and outlet mechanism still follows the tidal mechanism so that the water turnover process does not run optimally. Low salinity was caused by rain during the study. The extreme change in external factors is thought to be the cause of the crabs losing a lot of energy for the environmental adaptation process. In addition, it is also suspected that the relatively low feed protein content of 31.29-35.95% is lower than the needs of crabs as carnivorous organisms, which is 46.90% to 47.03% [24].

Protein is the most expensive component of feed raw materials so the feed formula tried in this study was lower. The use of lower protein aims to reduce feed costs, and maintain the high quality of ammonia and nitrite in the water. Feed with high protein has the potential to reduce water quality, because the results of protein metabolism are ammonia and nitrite. However, the results of this study showed low growth and molting of crabs. Feed protein functions as a source of energy for growth and tissue repair [25].

The survival rate of mangrove crabs from this study was relatively high at 84-98%. This data indicates that the feed provided is still sufficient to support good survival, although growth and molting are not maximized. More comprehensive studies are needed on feed formulations that can support high growth, molting, and survival in crabs. Fluctuations in salinity and tend to be extreme are thought to be the main causes of low growth and molting of crabs. According to [25], salinity is closely related to osmoregulation of aquatic animals, if there is a sudden decrease and in a large enough range, it will make it difficult for animals to regulate the osmose pressure of their body fluids with their environment so that it can cause disruption of growth.

5. Conclusion

Different feed formulations had no effect on growth, molting and survival of mud crabs. Lower feed protein levels and extreme salinity fluctuations are thought to be factors that cause growth and molting to not be maximized. Broom fish meal and maggot should be considered as one of the feed ingredients.

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