Some Biological Aspects of Mud Crabs (*Scylla serrata*) in Mangrove Ecosystem, Banda Aceh and Aceh Besar

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Abstract. In the study area, mud crabs *S. serrata* has high economic value and one of the biota aquatics cached by fishermen. However, their presence is decreasing due to anthropogenic activity and the changing of habitat characteristics. The aims of the study are to analyse morphometrics and growth pattern of mud crabs (*S. serrata*), and to analyse the biological aspects of mud crabs. The research was conducted in December 2022 until March 2023 located in mangrove rehabilitated at Cadek Village (location 1), and Deah Raya village (location 2), Aceh Province. Purposive sampling method was applied to determine the research location. Totally, 120 mud crabs' samples were obtained and sample was carried out at Marine Biology Laboratory, USK. The growth pattern of the male mud crab showed a positive allometric, while the female showed an isometric growth pattern for both locations. Furthermore, the sex ratio of male and female in the 1st location was unbalanced (1:2) and balanced in the 2nd location (1:1.14). The gonad maturity level (GML) of mud crabs in both locations was dominated by level one gonad maturity. The biological aspect study can be one of the future conservation approaches in maintaining sustainability of mud crabs in mangrove ecosystem.

1 Introduction

Mangrove ecosystems serve as habitats and feeding grounds for aquatic fauna [1, 2]. One of the aquatic faunas with high economic value is *Scylla serrata*, also known as mud crabs [3-6]. Mud crabs have wide distribution and live in association with mangrove vegetation [7, 6, 8]. Mud crab plays a crucial role in mangrove ecosystem by converting nutrients and enhancing mineralization, oxygen-carrying capacity of the soil, and providing support for aquatic organisms male causes an increasing crab harvesting in the estuarine ecosystem [9, 10, 11]. Without efforts to improve aquaculture of mud crab, there may be a future decline

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in the population and potentially disrupting ecosystem stability [12]. Furthermore, the aquaculture of *S. serrata* depend on wild catch, which has been decreasing in number. Before determining crab farming management strategies, knowledge of the biological aspects of mud crabs is needed [13-16]. Biological studies include morphometric measurements and length-weight relationships as the basic for understanding species availability. Morphometrics refer to the measurement of the length and width size or the comparison of the sizes of various external body parts of organisms. Length-weight relationships are used to understand growth patterns of biota aquatic [17, 18]. Moreover, biological aspects are crucial for all organisms to maintain themselves and to produce the next generation [19, 20].

Research on the growth pattern of *S. serrata* has been conducted extensively, previous studies reported a negative allometric growth pattern of *S. serrata* [18, 21, 22]. Additionally, research on the reproductive biology of *S. serrata* has been conducted, Asmara [23] reported sex ratio of *Scylla serrata* was 1:2.05 and the number of eggs ranged from 345,923 to 1.472,639 eggs. Arfiati *et al.* [14] showed a sex ratio ratio of 1.15:1, indicating a balanced gender composition. Gonad maturity levels (GML) were dominated by GML II, with gonad maturity index values ranged from 6.84% to 18.49%. Research on the growth pattern and reproductive biology of mud crabs (*S. serrata*) in the mangrove ecosystem of Aceh Besar and Banda Aceh is limited, extensive management activities are needed for the mud crab to sustain its population through over-exploitation. Therefore, it is essential to obtain the growth pattern and biological aspects of mud crab such as maturity size, sex ratio, fecundity, and GML. The objectives of this research are to analyze the morphometrics and growth patterns of *S. serrata* and to analyze the biological aspects of *S. serrata* in mangrove ecosystem, Banda Aceh and Aceh Besar, Aceh Province.

2 Materials and Methods

2.1 Research Location

The research was conducted from December 2022 to March 2023 in the mangrove ecosystems of Banda Aceh and Aceh Besar (Figure 1). Sample analysis was performed at the Marine Biology Laboratory, Faculty of Marine and Fisheries, Universitas Syiah Kuala (USK).

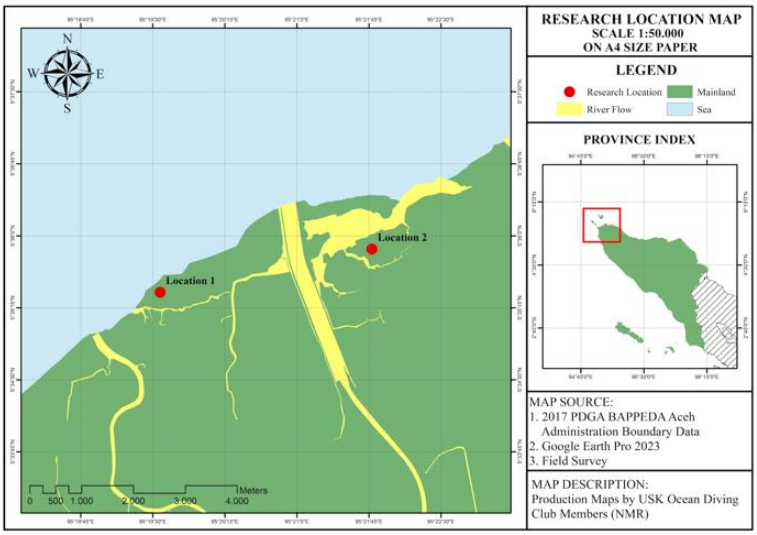


Fig 1. The research location was showed in red dot

2.2 Sample Collection

The live mud crab (*S. serrata*) collected randomly from two mangrove rehabilitated location, namely Cadek and Deah Raya Village. Mud crabs' sample were obtained from crab collectors and using crab trap with diameter of 54 cm, and it was placed during low tide [24]. A total of 100 specimens were sampled from each location, the sample was collected weekly. Furthermore, crabs were transported to the Marine Biology Laboratory, Faculty of Marine and Fisheries, USK for detailed biological observation.

2.3 Morphometric and Growth Pattern

Morphometric characters were measured using calipers with a precision of 0.01 mm for the length and width carapace, and their weight was determined using a digital scale with a precision of 0.1 g [25]. Morphometrics are used to confirm specific types in taxonomy and evaluate size differences [26].

2.4 Biological Reproductive

The observation of the sex ratio between male and female of mud crabs was differentiated through morphology and secondary sexual characteristics, such as by examining the shape of the abdomen of each crab sample obtained [14]. The determination of the Gonad Maturity Level (GML) of mud crabs was done by opening the carapace of the crab samples and determining the gonad maturity level based on morphological characteristics, including shape, length, color, and the filling of the body cavity by the gonads [27]. Fecundity was calculated only in mature female mud crabs with final Gonad Maturity Levels (GML IV and GML V). According to Burnawi [28], the crab gonads to be counted were divided into three parts: anterior, middle, and posterior.

3 Results and Discussion

3.1 Morphometric characteristics

The total number of mud crab samples obtained during the research was 200 individuals, with each location consisting of 100 individuals. The population of mud crabs in the mangrove area of location 1 (Cadek Villages) consisted of 40 males and 60 females, while the mangrove area of location 2 (Deah Raya Village) had 44 males and 56 females. The ranged of carapace width (CW) of mud crabs at locations 1 was 72 – 127.40 mm, and location 2 was 68.60 -131,40. 92.59 mm, respectively. The average of carapace width (CW) of mud crabs at locations 1 and 2 was 93.88 mm and 92.59 mm, respectively. Moreover, the carapace length (CL) average obtained were 63.35 mm and 62.28 mm, and average of carapace height (CH) were 36.98 mm and 36.27 mm.

The morphometric measurements of mud crabs in locations 1 and 2 showed relatively similar morphometric sizes. The highest values were obtained in carapace width (CW) measurements, with average values of 93.88 mm and 92.59 mm. Morphometric characters were studied to assess size differences in mud crabs [29]. The carapace width of mud crabs also determines their life stage. According to Safitri *et al.* [30], mud crabs have three life stages: juvenile, sub-adult, and adult, which can be distinguished by carapace width.

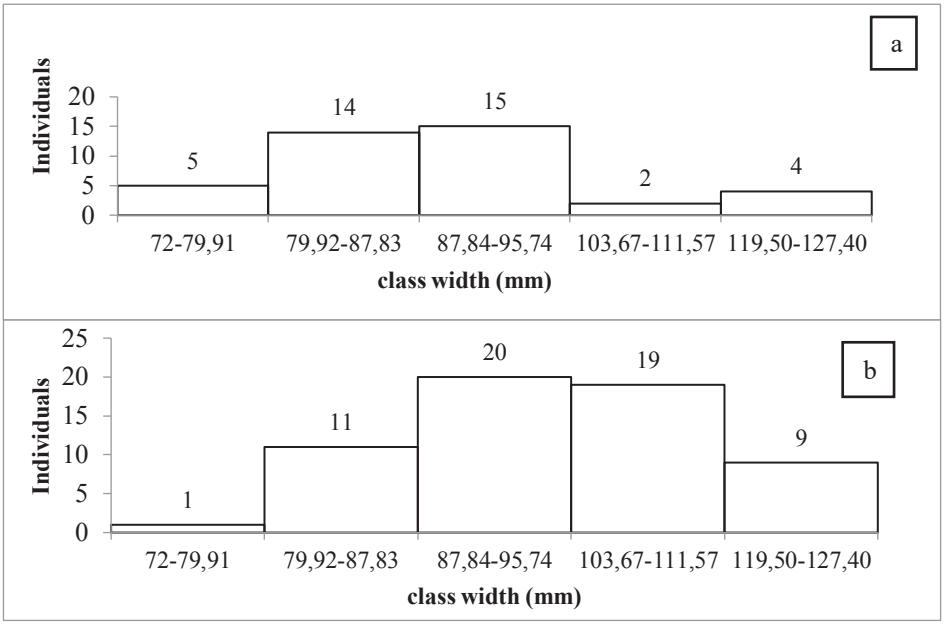


Fig 2. Frequency distribution of carapace width of mud crab in location 1 (a) male, (b) female

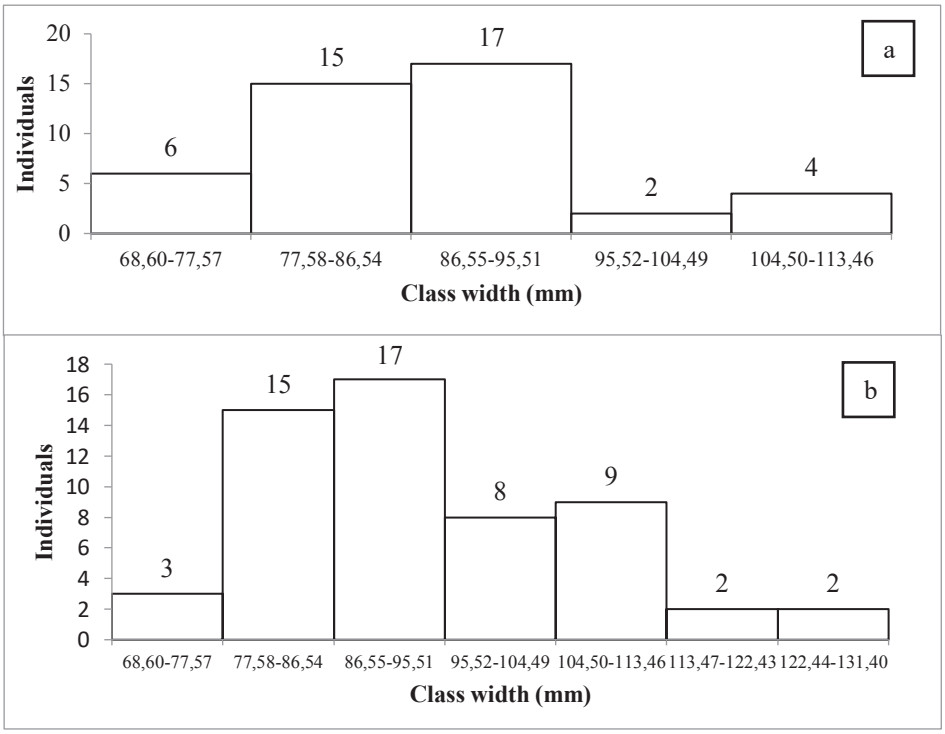
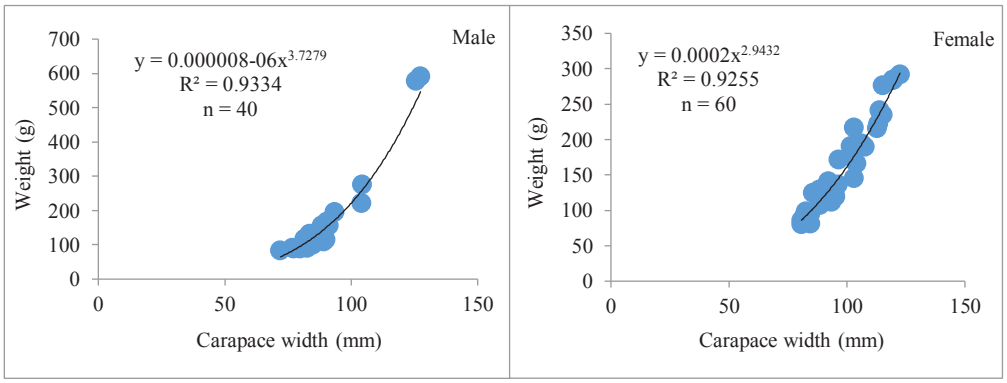


Fig 3. Frequency distribution of carapace width of mud crab in location 2 (a) male, (b) female

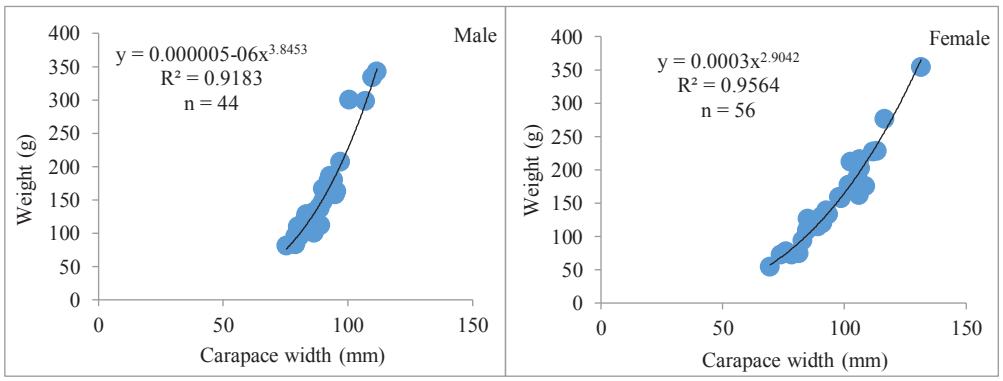
3.2 Length and weight relationship

The relationship between carapace width and weight of male and female mud crabs in the Cadek (location 1) and Deah Raya (location 2) mangrove areas were presented in the form of curves in Figure 4 (a,b) and Figure 5 (a, b). The relationship between carapace width and weight of male mud crabs in location 1 showed a positive allometric pattern growth, however female mud crabs exhibited a pattern of isometric growth.



(a) (b)

Fig 4. The relationship between carapace width and weight of mud crabs in location 1 (a) male and (b) female.



(a) (b)

Fig 5. The relationship between carapace width and weight of mud crabs in location 2 (a) male and (b) female.

The relationship between carapace width and weight of male mud crabs in mangrove location 1 and location 2 resulted in positive allometric growth pattern. Positive allometric growth means that body weight increases faster than carapace width [21]. The relationship between carapace width and weight of female mud crabs in mangrove locations 1 and 2 yielded positive values, indicating isometric growth. According Effendi [31], proportional growth between length/width and weight is referred to as isometric growth. Differences in the growth pattern of male and female mud crabs are usually influenced by environmental factors, energy utilization, and food intake. Wijaya *et al.* [10] noted that female mud crabs consume more food for molting and gonad maturation, however, male crabs tend to use their food intake for elongating and enlarging their claws, which play a significant role in the mating process.

3.3 Sex ratio

The sex ratio of mud crabs in the location 1 and 2 showed in Figure 6. The sex ratio in location 1 was 1:2, and according to the chi-square test results, the number of male and female crabs was not balanced. In contrast, location 2 had a sex ratio of 1:1.14, which categorized into the balanced category.

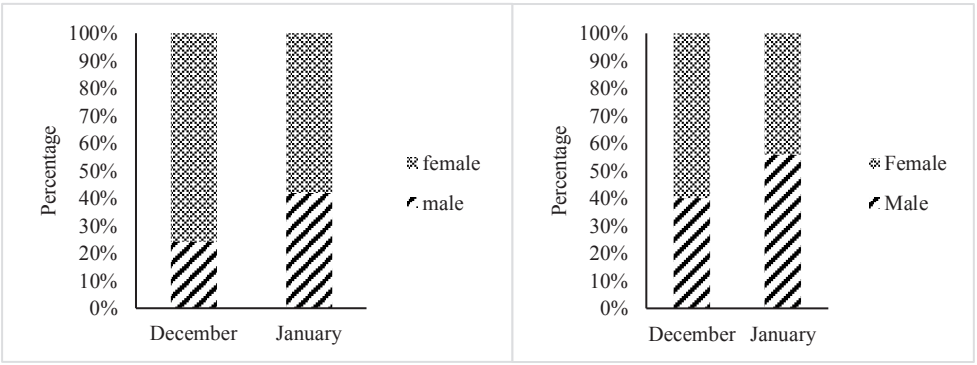


Fig 6. The sex ratio of mud crabs (a) location 1 and (b) location 2

The total number of mud crabs observed for biological reproduction in locations 1 and 2 was 60 individuals. In location 1, there were 20 males and 40 females, with a sex ratio of 1:2. Chi-square test results at a 95% confidence interval indicated an overall imbalance in the number of mud crabs. In contrast, location 2 had 28 males and 32 females, with a sex ratio of 1:1.14, and chi-square test results indicated a balanced overall sex ratio. Female mud crabs dominated over males in both locations 1 and 2. Kannathasan and Rajendran [19] recorded the sex ratio (male: female) as 1:1.01 in the southeast coast of the Bay of Bengal of India. The balance or imbalance of the sex ratio is influenced by food availability and the life cycle of mud crabs, especially during the reproductive season [32]. Paul *et al.* [20] also suggested that the balance of the sex ratio is related to the capture area and trap placement.

3.4 Gonad Maturity Level (GML)

The observations regarding the Gonad Maturity Level (GML) of male and female mud crabs can be seen in Figure 7 and 8. The assessment of GML through morphology was presented in Table 1 and Table 2. GML in mud crabs is divided into 5 level. In location 1, male and female mud crabs were dominated by GML I, accounting for 57% and 41%, respectively. In the mangrove area of location 2, male mud crabs were dominated by GML I (71%), while female mud crabs had GML I (38%).

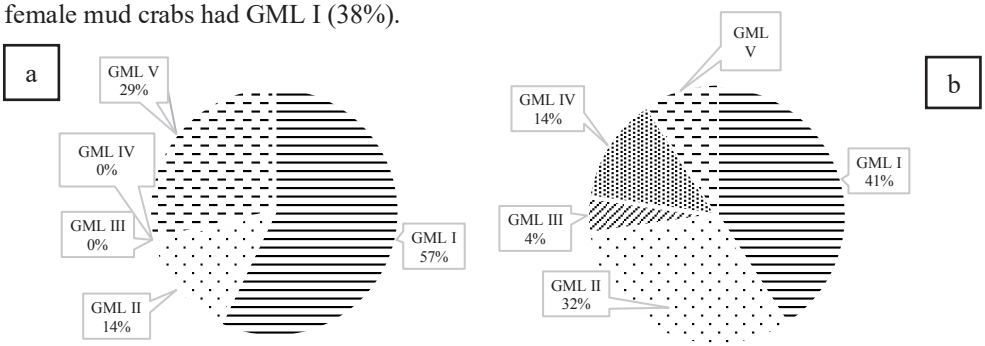


Fig 7. Percentage of Gonad maturity level (GML) in location 1 (a) male, and (b) female

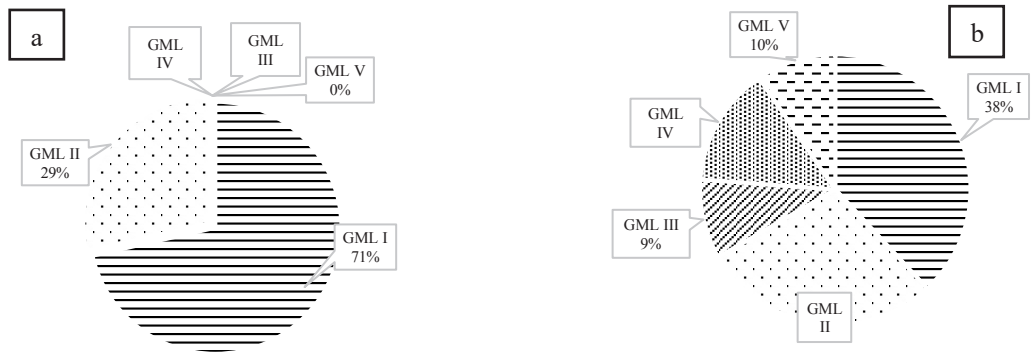


Fig 8. Percentage of Gonad maturity level (GML) in location 2 (a) male, and (b) female

Table 1. Description of the gonad maturity level (GML) of male mangrove crabs.

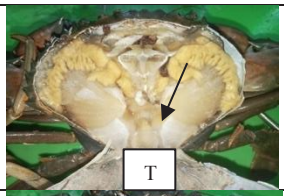
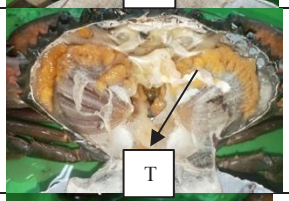
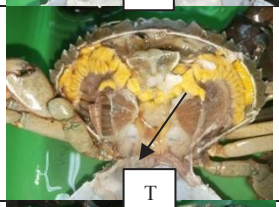
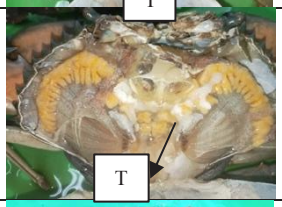
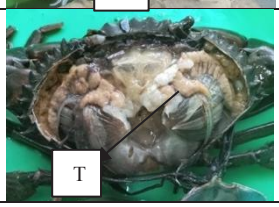
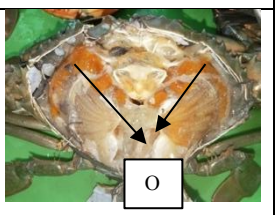
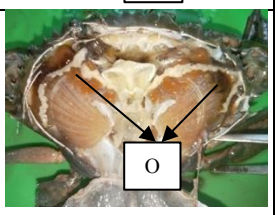
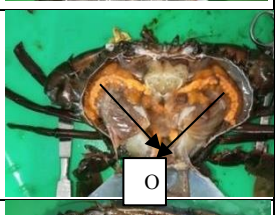
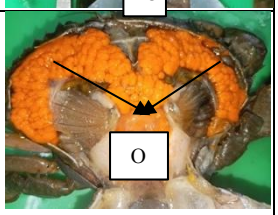
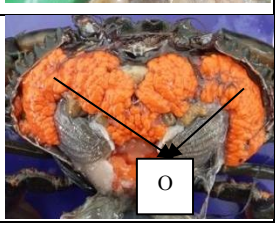
GML	Morphology characteristic	Picture
I	The testes (T) are translucent white and have a filament-like shape.	
II	The testes are larger than those in GML I and are translucent white in color.	
III	The testes are yellowish-white in color and have a more distinct shape.	
IV	The testes are larger than those in GML III and have a milky white color	
V	The testes are well-defined, denser in texture, and have a milky white color.	

Table 2. Description of the gonad maturity level (GML) of female mangrove crabs

GML	Morphology characteristic	Picture
I	The ovaries (O) have a filament-like shape, are located above the digestive gland, and are translucent white in color (immature stage).	
II	The ovaries are larger than those in GML I, and they are beginning to expand and extend into the surrounding area. They have a milky white color (under-developed stage).	
III	The ovaries continue to enlarge, and the individual eggs become visible to the naked eye. They have a pale orange color (early-developed stage).	
IV	The ovaries continue to grow and almost fill the entire abdominal cavity. The eggs are orange in color and easily distinguishable. The digestive gland becomes smaller and is compressed due to the development of the ovaries (late-developed stage).	
V	The ovaries are filled with mature oocytes that have a reddish-orange color. They almost entirely occupy the abdominal cavity. The eggs are clearly visible, especially when viewed from the posterior edge (mature stage).	

Gonad Maturity Level (GML) in male mud crabs in location 1 was dominated by GML I (57.1%), and no crabs were found in GML III and GML IV. Female mud crabs in location 1 consisted of 22 individuals, mainly in GML I (40.9%). In location 2, there were 14 male mud crabs, primarily in GML I (71.4%), while the observed female mud crabs numbered 21, with GML I (38.1%) being dominant. The dominance of GML I-II in female mud crabs might be because the sampling occurred outside the breeding season, although some mature gonads were found. There was also a difference in the percentage of GML IV and GML V between male and female mud crabs in locations 1 and 2. The percentage of female mud crabs in the mangrove area of location 1 with GML V was higher than in location 2, while the reverse was for GML IV in females, which was higher in location 2 than in location 1. This difference in gonad maturation is due to variations in maturity among mud crabs. According to Brojo and Sari [33], differences in gonad development can be attributed to different groups with varying breeding stages. Reynolds *et al.* [34] suggested that differences in gonad development are influenced by regional variations and fishing pressure.

3.5 First Size Gonad Maturity

The size at first gonad maturity in mud crabs was determined using a logistic function, and at the cumulative proportion of 50% of all individuals that reached gonad maturity. The size at first gonad maturity of female mud crabs in location 1 was 108.94 mm, while in location 2 was 104.61 mm (Figure 9).

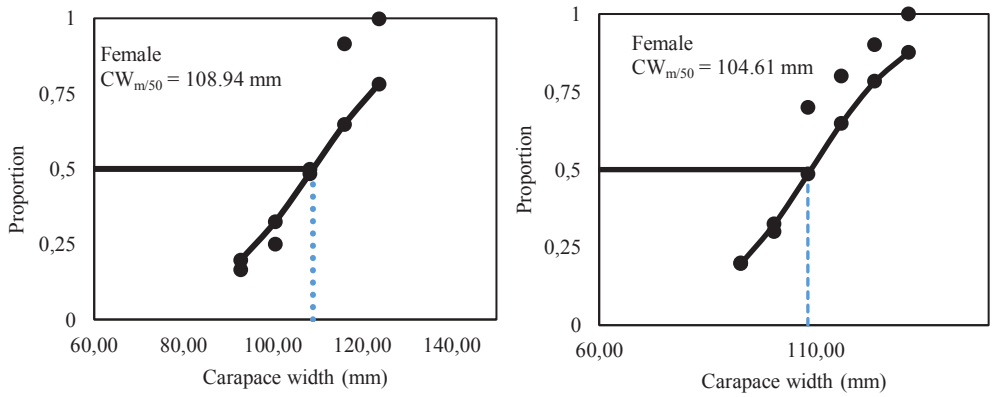


Fig 9. First size gonad maturity of mud crab

The size at first gonad maturity in mud crabs was determined using logistic functions on the cumulative proportion of 50% of all individuals that reached gonad maturity. The size at first gonad maturity for female mud crabs in the location 1 was 108.94 mm. Meanwhile, the size at first gonad maturity for female mud crabs in the location 2 was 104.61, respectively. According to Ikhwanudin *et al.* [35], differences in the size at first gonad maturity in mud crabs in various locations can be attributed to ecological conditions such as food availability [36] and environmental factors in each research location [37]. Jirapunpipat and Kasetsart [37] stated that differences in the size at first gonad maturity among populations of the same species are influenced by variations in the molting frequency.

4. Conclusion

The morphometric characteristics of mud crabs (*S. serrata*) in the rehabilitated mangrove ecosystems (location 1 and 2) are quite similar, however the average values of measurements, particularly the carapace width is dominated by female mud crabs in the location 1. The growth pattern of male mud crabs in the location 1 and 2 were positive allometric growth pattern, however female mud crabs exhibit an isometric growth pattern. The sex ratio of mud crabs, both male and female, in the location 1 was imbalanced (1:2), and balanced (1:1.14) in location 2. The percentage of Gonad Maturity Level (GML) in mud crabs in both locations were dominated by GML I. The data reveals differences in reproductive characteristics between these two areas, with notable variations in sex ratios and reproductive parameters.

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