BIOLOGICAL ASPECTS OF MANGROVE CRAB (*Scylla serrata*) AT THE BELADEN ESTUARY, DOMPAK, TANJUNGPINANG, RIAU ISLANDS

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ABSTRACT

Mangrove crab (*Scylla serrata)* is one of the marine organisms that are of significant economic importance. The habitat is distributed in the coastal areas of Indonesia, within the extensive mangrove ecosystems, such as the estuary of Beladen in Dompak, Tanjungpinang. The Beladen estuary area features a flourishing mangrove ecosystem, which supports a diverse range of crab species, with a particular focus on the populations. Therefore, this study aimed to obtain several aspects of mangrove crab in the Beladen estuary, Tanjungpinang. Sampling by the census method was also carried out once every two weeks from May to June 2022. The results showed that the size composition of mangrove crab had a carapace width (CW) of 70-144 mm. The length-weight relationship reported that female and male exhibited a negative and positive allometric growth pattern ($b < 3$) and ($b > 3$), respectively. The proportion of male and female was 63% compared to 37% (sex ratio 1:0.59). The value of gonadal maturity index (GMI) in each size class ranged from 2,6512-7,1445 and 1,8751-6,7979 for male and female mangrove crab. Male and female gonadal maturity levels were predominantly categorized as II and III, indicating that crab with mature gonads was not encountered.

Keywords: beladen estuary, biological aspects, mangrove crab, *Scylla serrata*

INTRODUCTION

Mangrove crab (*Scylla serrata*) is found in mangrove forest and beach (Brown, 1993; Mirera 2011) with hard and rounded shells (Brown 1993; Pratiwi 2010; Felder & Thoma 2022; Inoue *et al.* 2022). This organism possesses dark brown or black skin with a body length of 20 cm (Andreetta *et al.* 2014; Iromo *et al.* 2022). In addition, mangrove crab assumes a significant role within mangrove ecosystems by contributing substantially to ecological equilibrium. This includes the capacity to assist in preserving balance by actively preying on insects and plants, shaping water flow dynamics, and upholding the stability of the mangrove forest floor (Kristensen, 2008; Cannicci *et al.* 2008; Not *et al.* 2020). Furthermore, the species are an important food source for several types of birds and fish.

Previous studies showed that mud crab populations had declined dramatically in some areas due to mangrove forest encroachment (Le Vay 2001; Sara 2010; Ikhwanuddin *et al.* 2011; Varkey *et al.* 2023). Habitat ecology analyses have been conducted to understand the habitats, including studies on their behavior and interactions with the environment (Bir *et al.* 2020; Karniati *et al.* 2021; Leoville *et al.* 2021). Genetic diversity studies are conducted to understand how the differences between the populations can affect adaptation and resistance to environmental

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changes (Hassan & Mustapah 2019; Ines *et al.* 2019; Wang *et al.* 2020). Meanwhile, reproductive studies are systematically undertaken to enhance the comprehension of the intricate reproductive processes exhibited by crab. These include an exploration of the multifaceted factors that exert influence over reproductive success rates and population growth dynamics.

Dompak Island is a coastal area located in Dompak Village, which is part of Bukit Bestari District, Tanjungpinang City, Riau Islands Province. The province (Novitri *et al.* 2021) is dominated by the livelihoods of the community, mostly as fishermen using the results of coastal resources in the ocean. The coastal expanse of Dompak, within the Beladen estuary increases the profusion of mangrove vegetation. Therefore, this habitat provides a conducive environment for the proliferation of various species, which represent a prominent component of the aquatic fauna inhabiting coastal waters within the mangrove ecosystem. Among the members of the brachyuran tribe belonging to the family Portunidae, mangrove crab, scientifically known as *Scylla* spp., is important due to its considerable prevalence. The species predominantly resides in coastal areas and shallow waters adjacent to mangrove ecosystems (Pratiwi 2010).

Mangrove crab is popular among the public for the delicious meat and high nutritional content (Nanda *et al.* 2021; Sari *et al.* 2022). Therefore, the species has long been an important source of income for local communities (de Oliveira Cortes *et al.* 2019; Rahman *et al.* 2020; Bhuiyan *et al.* 2021; Crespo *et al.* 2021; Miah *et al.* 2022). However, the population is under great pressure due to the encroachment or conversion of mangrove forest as well as unsustainable fishing practices (Triharyuni 2020; Fazhan *et al.* 2021; Leoville *et al.* 2021; Sakib *et al.* 2022). This has resulted in fishermen catching fewer and smaller mangrove crab. Due to the substantial fishing activities conducted by fishermen, coupled with the use of mangrove forest that neglected considerations of resource sustainability, there has been a marked decline in the populations (Elizabeth *et al.* 2003). Therefore, it is necessary to reorient sustainable fisheries resource use activities that prioritize aspects of biological aspects for fisheries management activities. This study determines several aspects of mangrove crab biology related to the relationship between carapace width and weight, sex ratio, gonadal maturity level, and gonadal maturity index (GMI).

MATERIALS AND METHODS

Time and Location

This study was conducted at the Beladen estuary, Dompak, Tanjungpinang, Riau Islands. Data collection was carried out for two months from May to June 2022 with a frequency of data collection every two weeks.

Data Collection

This study used a survey method of direct observation for data collection and mangrove crab (*S. serrata*) sampling was carried out by the census method. According to Astari (2019), census or saturated sampling was a determination method when all members of the population were used as samples. Mangrove crab was obtained from fishermen who caught crab at the Beladen estuary. Furthermore, bubu folding was one of the most common fishing gear used by fishermen. Measurement of the width of mangrove crab was carried out using a caliper with an accuracy of 0.01 mm. The measurement of the carapace width started from the end of the right spine to the left. Mangrove crab was weighed with a digital scale of 0.1 g accuracy (Overton *et al.* 1997). Observation of the sex ratio was carried out by analyzing the morphological characteristics in the abdomen of male and female mangrove crab. Male and female had a narrowed and dilated abdomen shape, respectively. Determination of the degree of maturity of gonads was conducted by visually observing the sample according to the five-category approach (Tiurlan *et al.* 2019) (Table 1).

Data Analysis

The Relationship of Carapace Width and Weight

Growth patterns can be seen through the analysis of the relationship between carapace width and weight. The formula for the relationship of carapace width and weight is described by the equation according to King (2007) in Safira *et al.* (2019) as follows:

$$W = aCW^b$$

Where:
W = Weight (grams)
CW = Carapace width (mm)
a = Constant
b = Slope

The linear regression approach shows the relationship between the two parameters. The value of b is used to estimate the growth rate of the two analyzed parameters and the hypotheses used are as follows. A value of b = 3 is known as an isometric growth pattern (the pattern of growth of width equals the growth of weights). A value of b ≠ 3 signifies an allometric pattern and when b > 3, the value is known as a positive allometric growth pattern (weight growth is more dominant). Furthermore, a value of b < 3 is called a negative allometric growth pattern (carapace width growth is more dominant).

The general form of a t-test for a regression coefficient is (Steel and Torrie 1993):

t=β^1−β1,0SE(β^1)

Where:
β^1 = Estimated slope coefficient
β1,0 = Hypothesized value of the slope under the null hypothesis
SE(β^1) = Standard error of the estimated slope coefficient

At the 95% confidence interval, the t_test value is compared with the t_tabel value, then the decision taken to determine the growth pattern is $t_{test} > t_{table}$: reject the null hypothesis (H0), $t_{test} < t_{table}$: fail to reject the null hypothesis (H0).

Sex Ratio

Sex ratio is a comparison of the number of male and female crab in a population with the ideal conditions for maintaining the viability of a species at 1:1 (50% male and 50% female). The proportion is important to determine the ratio of male and female crab caught with the equation:

$$P = \frac{n}{N}\ x\ 100\%$$

Where:
P = The proportion of crab (female or male)
n = Number of female or male crab
N = Total number (female + male)

To find out whether the proportion of males and females in ideal conditions, namely 1:1, the Chi-Square test (X^2) with a confidence level of 95% (α=0.05) with the test procedure is:

H_0: The ratio of male and female crab is 1:1
H_1 : Comparison of male and female crab instead of 1:1

For the test criteria, when $X^2count > X^2table$ and $< X^2table$, then H_0 is accepted and H_1 is accepted. The value of X^2 of the table using degrees free (db) = 2-1 = 1. Therefore, the value of X^2 of the table (0.05:1) = 3.841 is obtained.

Gonadal Maturity Index (GMI)

GMI is calculated using the formula according to Effendie (2002) in Suryakomara (2013) as follows:

$$Gonadal\ maturity\ indeks\ (GMI) = \frac{Wg}{Wb}\ x\ 100\%$$

Where:
GMI = Gonadal maturity index (%)
Wg = Gonadal weight (g)
Wb = Body weight (g)

RESULTS AND DISCUSSION

The Relationship of Carapace Width and Weight

The results obtained were 26 and 15 male and female mangrove crabs. The relationship between carapace width and body weight was grouped according to gender. Figure 1 shows the coefficient of determinations (R^2) for male and female mangrove crab, which are 0.9552 or 95.5% and 0.9476 or 94.7%. Additionally, the values of the constant (b) derived from the equation $W = 0.00003W^{3.4144}$ and $W = 0.0008CW^{2.7034}$ are at 3.4144 and 2.7034, respectively (Figure 2).

Table 1 Classification of the maturity level of mangrove crab gonads

GML	Male	Female
1	Filament testicles, clear white in color, located near the heart under the liver	The ovaries remain underdeveloped and assume the form of a pair of filaments positioned along the dorsal area. They are situated above the digestive glands, exhibiting a yellowish hue. The ovaries appear translucent and take on a whitish coloration.
2	The testicles begin to grow in clear white around them	The ovaries increase in size and begin to expand with a milky white color.
3	Shaped testicles of milky white color	The ovaries increase until pale yellow coloration is formed.
4	Same as GML 3, but enlarged in size	The volume of the ovaries becomes larger and fills the entire chest cavity, the egg is pale yellow to golden yellow, and the digestive glands shrink. This is because the ovaries and egg grains can be seen with a microscope.
5	The testicles are already visible milky white color and the shape becomes denser	The ovaries are replete with cells, nearly ripe, transitioning from an orange to a deep red color.

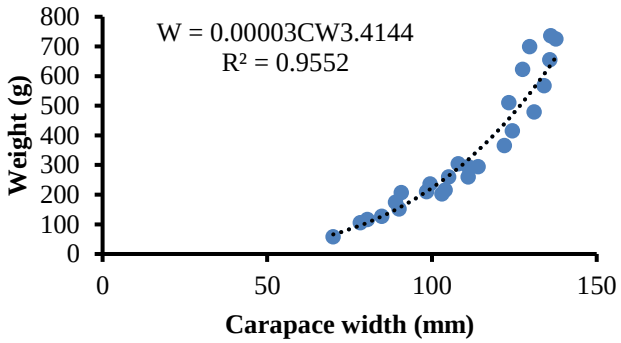

Figure 1 The relationship of carapace width with the weight of male mangrove crab in the Beladen estuary from May to June 2022

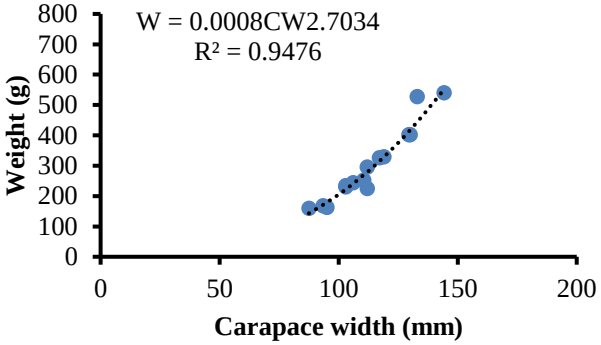

Figure 2 The relationship of carapace width with the weight of female mangrove crab in the Beladen estuary from May to June 2022

Table 2 Growth pattern of mangrove crab in the Beladen estuary from May to June 2022

Sex	Parameters of the relationship of carapace width and weight of mangrove crab			
	Number of samples	Sprouted parameter values (b)	Correlation value (R^2)	The nature of the growth pattern
Male	26	3.4144	0.9552	allometric positive
Female	15	2.7034	0.9476	allometric negative

In male crab, the growth pattern is allometrically positive with a constant value of b > 3 since b = 3.4 (Table 2). Therefore, the growth body weight of crab is faster than the carapace width. According to Tiurlan *et al.* (2019), an increase in the body weight of mangrove crab directly influences the width of the carapace. In Table 1, female crab has a negative allometric pattern with a constant value of b < 3 (b=2.7). This phenomenon occurs due to increased use of food intake closely linked to the carapace width during the molting and gonadal maturity processes, hence, female growth exhibits a negative allometric pattern. Male crab allocates a significant portion of the energy intake towards expanding carapace during the mating process, resulting in an increased body weight. This is due to the additional weight contributed by the enlarged carapace, leading to a positive allometric growth pattern.

Sex Ratio

Based on the calculations, there are different sex ratios of male and female mangrove crab. Therefore, the highest and lowest sex ratio values are found in male and female mangrove crab, as presented in Figure 3.

Crab collection was conducted from May to June 2022, where a total of 41 specimens were gathered. Among these, 26 and 15 individuals at 63% and 37% were identified as male and female crab (Figure 3). The sex comparison analysis showed a predominance of male crab, with a ratio of 0.63 to 0.37 when compared to female. The chi-squared analysis of X^2 using a = 0,05 (95% confidence level) obtained the calculated value X^2 = 2.9512 (2.95) and the table X^2 = 3.8415 (3.84) to ($X^2 count < X^2 table$). Therefore, H_0 was accepted since there was no difference in proportion between male and female. According to the hypothesis in the chi-square test, the population of mangrove crab was balanced when ($X^2 count < X^2 table$). These results showed that the sex ratio met the criteria expected to keep the resource condition stable or balanced.

Female crab dominated slightly from catches by fishermen due to changes in the attitudes of their respective individuals in finding suitable habitats. Differences in the ratio of male to female were related to food availability and the life cycle of mangrove crab, specifically during reproductive and seasonal changes (Hardiyanti *et al.,* 2018). According to Tahmid *et al.* (2017), the greater activity exhibited by male crab was attributed to their inherent habits and behaviors. Male crab was observed to be more active in foraging, resulting in a higher likelihood of being captured. Female was predominantly caught due to the specific fishing areas selected since crab fishing was conducted in deeper waters. Therefore, adult female crab with mature gonads would migrate to deep waters.

Gonadal Maturity Index (GMI)

GMI compares gonadal weight to body weight. Growth of gonads has a relationship with the weight gain of the body, as presented in Table 4.

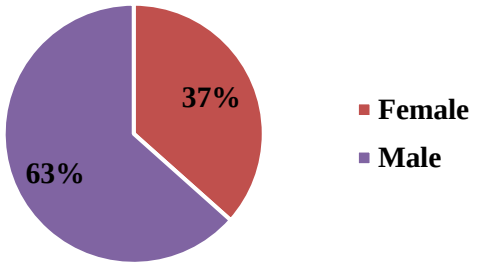

Figure 3 Sex ratio of mangrove crab in the Beladen estuary from May to June 2022

Table 3 Ratio of male to female mangrove crab based on chi-square test at Beladen Estuary from May to June 2022

Sex		Sex-ratio		X^2	X^2	Information
Male	Female	Male	Female	Count	Table (α0.05)	
26	15	63%	37%	2.9512	3.8415	Balanced

Table 4 GMI of mangrove crab in the Beladen estuary from May to June 2022

Sex	Average				
	Sampling I	Sampling II	Sampling III	Sampling IV	Sampling V
Female	4.1026	6.7979	3.3583	1.8751	2.3134
Male	0	7.1445	5.6394	2.6512	2.7686

Table 4 shows that GMI value of male and female gonads changes. The highest and lowest GMI is sampling II and I of male crab with a value of 7.1445 and 0. The highest and lowest female GMI values of sampling II and I are 6.7979 and 1.8751, as shown in Table 4. According to Suryakomara (2013), the growth of gonads is directly proportional to the maximum increase in weight and size when spawning occurs. GMI value and the weight of female gonads is greater than male. Suryakomara (2013) argued that the peak of the spawning season varied between the geographical locations of the waters and this was influenced by annual temperature variations (Hamid *et al.,* 2015). The maturity index is the percentage of gonadal weight to the body weight of the female. The development is increasingly in line with the magnitude of the index and reaches high values in the spawning period. Therefore, GMI is the quantitative unit used to express the gonadal change (Fatma *et al.,* 2020).

Gonadal Maturity Level

The number of mangrove crab was 41 heads consisting of 26 males and 15 females with a length range of 75.5 – 136 mm and 93.5 – 141.5 mm, respectively. The size class of mangrove crab caught at the Beladen estuary during the study is found in Figures 4 and 5.

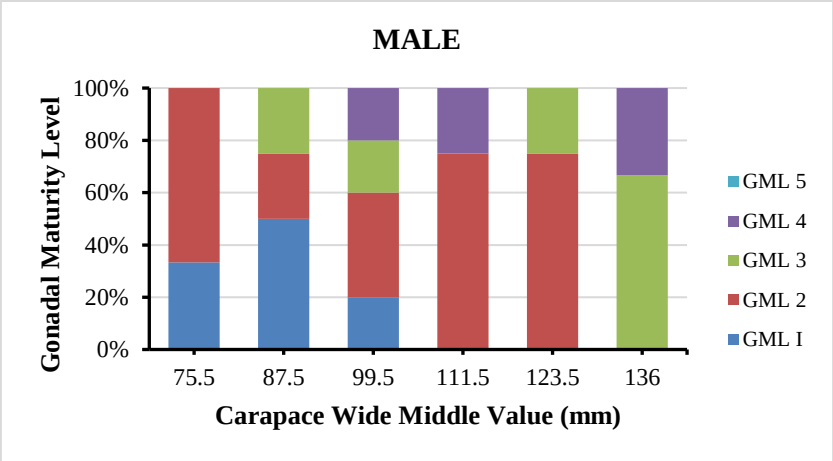

Figure 4 The composition of the maturity level of male mangrove crab gonads in the Beladen estuary in May to June 2022

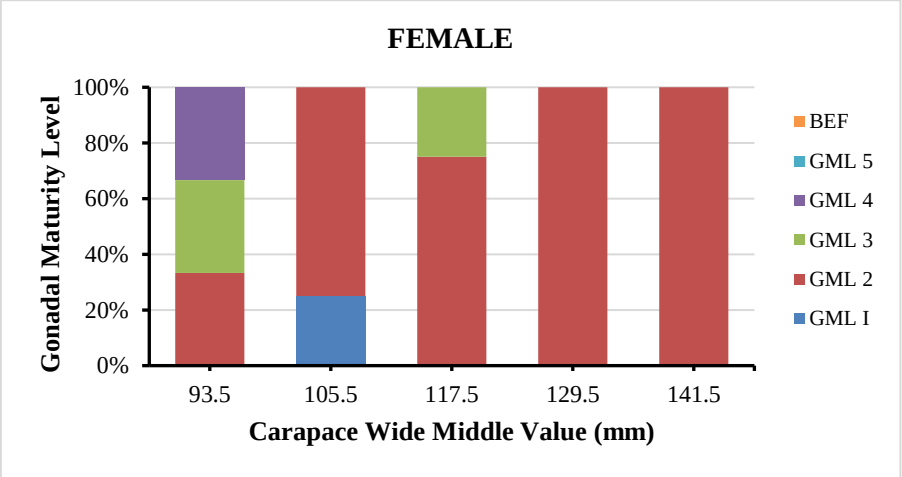

Figure 5 The composition of the maturity level of the female mangrove crab gonads in the Beladen estuary in May to June 2022

Male crab with the largest and smallest size is found at a carapace length of 136 mm and 75.5 mm. Meanwhile, female crab with the largest and smallest size is found at a carapace length of 141,5 mm and 93.5 mm, respectively. The results showed that male and female crab was in the highest and lowest GML conditions, namely GML 2 and 5, and no females were found carrying eggs on the abdomen. Crab caught obtained the smallest length size of medium maturing gonads on GML 3 with a size of 87.5 mm and 93.5 for male and female.

Mangrove crab in GML 2 was very likely to be influenced by environmental conditions in terms of water quality and food availability. However, it was the nature of the spawning to take place in the year. Tiurlan *et al.* (2019) found mangrove crab spawning eggs in the year with a peak period influenced by certain water conditions. During the reproductive phase, adequate nutrients and protection were required from disturbances impacting the body morphology. These conditions were essential to ensure the proper support for reproductive development and gonadal maturity. Female mangrove crab also migrated to the middle of the sea at GML 3 and 4 with the purpose of mating. The mating process unfolds gradually in mangrove waters with the development of eggs since female crab moved to sea waters for reproduction. Hardiyanti *et al.* (2018) explained that migration was a form of mangrove crab effort to obtain suitable water conditions to determine food, reproduction, nursery, and spawning locations. Therefore, the use of mud crab must pay attention to the size.

CONCLUSIONS

In conclusion, the growth pattern of mangrove crab at the Beladen estuary was positive and negative allometric with b values of 3.4144 and 2.7034 in male and female. Furthermore, the sex ratio was still in a balanced state, where female and male mangrove crab had the highest GMI percentages of 6.7979 and 7.1445, respectively.

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