

# Reproductive biology of the mud crab (*Scylla serrata*) in the mangrove area of Teluk Bogam Village, Central Kalimantan

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**Abstract.** The mud crab (*Scylla serrata*) is one of the fisheries resources in Teluk Bogam Village Central Kalimantan, and is utilized by the local community as a livelihood; however, information on its biology is very limited. This study aims to analyze the reproductive biology of the mud crab (*Scylla serrata*) in the mangrove area of Teluk Bogam Village as a basis for fisheries management. The study was conducted from August 2024 to January 2025, with a total of 215 individuals (93 males and 122 females), caught by fishermen using folding traps. The parameters observed included length frequency distribution, carapace width and weight relationships, condition factors, sex ratio, gonad maturity stages (GMS), first gonadal maturity size, gonado-somatic index, fecundity, and oocyte diameter. The study results showed a sex ratio of 1: 0.76 for mud crabs, with a dominance of females. The peak spawning season for mud crabs is estimated to occur in November. The size at first maturity for males was 113,13 mm, while for females was 116,67 mm. Fecundity ranged from 820,858 to 2,419,923 oocytes. The spawning type of mud crabs is a total spawner, meaning all fertilized oocytes are released simultaneously.

## 1. Introduction

Teluk Bogam Village is one of the villages located in Kumai Subdistrict, Kotawaringin Barat Regency, Central Kalimantan. This area has significant natural resource potential, particularly in the fisheries sector, especially mud crabs (*Scylla serrata*). This commodity is utilized by the local community as one of their primary sources of income. *S. Serrata* has the widest distribution compared to other mud crab species. This species is widely distributed throughout the western Indo-Pacific region and is closely associated with mangrove ecosystems. *S. serrata* makes a significant contribution to both industrial and traditional fisheries across its range, with catch and landing levels increasing significantly over the past few decades. This indicates that *S. serrata* is not only ecologically important but also economically important [1].

The high potential presence of *S. serrata* in mangrove ecosystems and its economic value make this species an important resource that needs to be conserved. High pressure on

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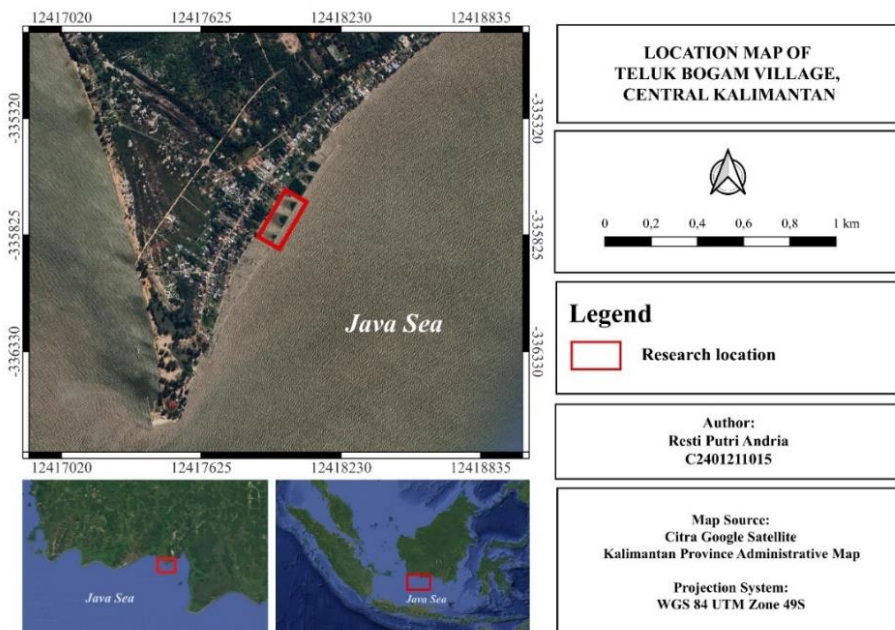
mangrove ecosystem degradation due to human activities, such as residential development and fishing activities in the waters of Bogam Bay, can lead to a decline in habitat quality and threaten the *S. serrata* population. Additionally, uncontrolled fishing without proper fisheries management also harms the sustainability of this species.

One important factor influencing the sustainability of mud crabs is reproduction. Reproduction plays an important role in sustainable management, particularly in developing catch strategies to maintain the availability of exploited populations and evaluating the effectiveness of fisheries regulations [2]. To date, the biological aspects of crab reproduction in the mangrove areas of Teluk Bogam Village have not been studied. Therefore, it is important to research the biological aspects of reproduction in this region. This study aims to analyze the reproductive biology of mud crabs (*S. Serrata*) in the mangrove areas of Teluk Bogam Village as a basis for effective fisheries management.

## 2 Research methods

### 2.1. Time and location

Crab sampling was conducted monthly, for 6 months (August 2024 - January 2025) in Teluk Bogam Village. Sample analysis was conducted at the Macro Biology Laboratory, Department of Aquatic Resource Management, Faculty of Fisheries and Marine Science, Bogor Agricultural University.



**Fig. 1.** Location of the mud crab (*S. serrata*) research in the mangrove area of Teluk Bogam Village, Kumai District, Kotawaringin Barat Regency, Central Kalimantan.

## 2.2. Data collection

The data used in this study is primary data. The sample was obtained from the catch of fishermen in Teluk Bogam Village using folding crab traps, amounting to 215 crabs (122 females and 93 males). Weighing was performed using a digital scale (accuracy 1 gram). Observation of crab gonads was conducted by dissecting the crab carapace and classifying the gonadal maturity level based on [3]. The calculation of oocyte number (fertility) was performed using a combined gravimetric and volumetric method on females that had reached maturity and had gonads that were used. Oocyte diameter measurements were performed using a composite microscope equipped with a micrometer and connected to a computer with 4x10 magnification, assisted by the *Beta View 3.7* application.

## 2.3. Data analysis

### 2.3.1. Carapace width distribution frequency

The frequency distribution of carapace width is determined through class intervals, class midpoints, and frequencies in each carapace width group. The frequency distribution of carapace width is presented in a bar graph between carapace width and crab weight, which is used to observe the normal distribution. According to [4], the frequency distribution of carapace width can be calculated using the following formula:

$$\text{Number of classes} = 1 + 3,32 \text{ Log } n \tag{1}$$

$$\text{Class Width} = \frac{(\text{Max} - \text{Min})}{\text{Number of classes}} \tag{2}$$

$$\text{Class distance} = \text{Class width} + \text{nst} \tag{3}$$

Description:

n : Number of data observed  
 nst : Smallest unit value

### 2.3.2. Sex ratio

Sex ratio was calculated by comparing the number of male crabs and the number of female crabs using the formula of [4]:

$$\text{Sex ratio} = \frac{\text{Number of male crabs}}{\text{Number of female crabs}} \tag{4}$$

The relationship between male and female crabs in determining the similarities or differences in portions between male and female mud crabs can be known by analyzing the sex ratio using the *Chi-square* test, using the following formula:

$$\chi^2 = \frac{\sum(o_i - e_i)^2}{o_i} \tag{5}$$

Description:

$\chi^2$  count : *Chi-square* test  
 $o_i$  : Observed frequency of male and female mud crabs  
 $e_i$  : Expected frequencies of male and female mud crabs

### 2.3.2. Gonad maturity stage (GMS)

The level of maturity of crab gonads was determined by comparing several factors, such as color, size, and volume of gonads and egg grains, and looking at changes in gonad morphology based on the classification of gonad maturity levels [3].

### 2.3.3. Size at first gonad maturity stage ( $CW_{m50}$ )

The value of the size of the first maturing gonads was determined at a percentage of 50% using the [5] equation:

$$P = \frac{1}{1 + e^{-r(CW - CW_m)}} \quad (6)$$

Description:

- P : Proportion of gonadally mature crabs in each carapace width class interval.
- $CW_m$  : A measure of the width of the carapace of gonadally mature crabs.
- r : Slope of the curve
- a : Intercept

### 2.3.4 Gonado-somatic maturity (GSI)

The gonado-somatic index is the relative ratio between the weight of the gonads and the body weight of the crab. The gonadal maturity index value is determined using formula [4]:

$$GSI = \frac{\text{Gonad weight}}{\text{Crab body weight}} \times 100 \quad (7)$$

### 2.3.5 Fecundity

Fecundity values can be used to determine the number of oocytes in the gonads of mature and spent crabs. Calculation of the number of oocytes was done using a combined method of gravimetry, volumetry, and counting. The following formula is used to calculate fecundity [4]:

$$F = \frac{G \times V \times X}{Q} \quad (8)$$

Description

- F : Fecundity
- G : Total gonad weight (g)
- V : Dilution content (cc)
- X : Number of oocytes per cc
- Q : Weight of sample egg (gram)

### 2.3.6. Egg diameter

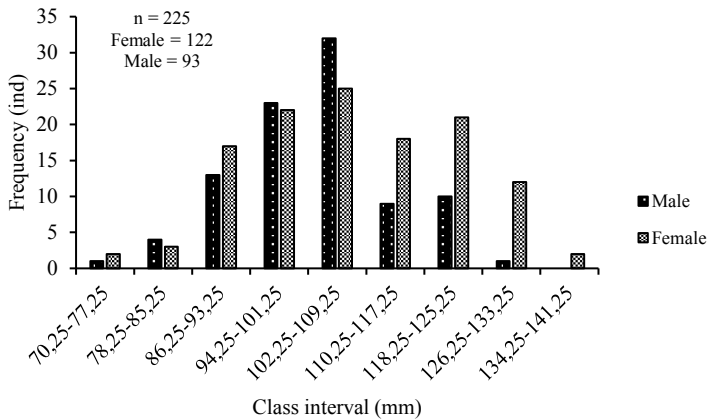
Egg diameter measurements were taken under a compound microscope with the aid of a micrometer connected to a computer. The results of the analysis were presented in the form of a histogram to show the distribution of egg sizes.

### 3 Results and discussion

#### 3.1 Results

##### 3.1.1 Frequency distribution of carapace width

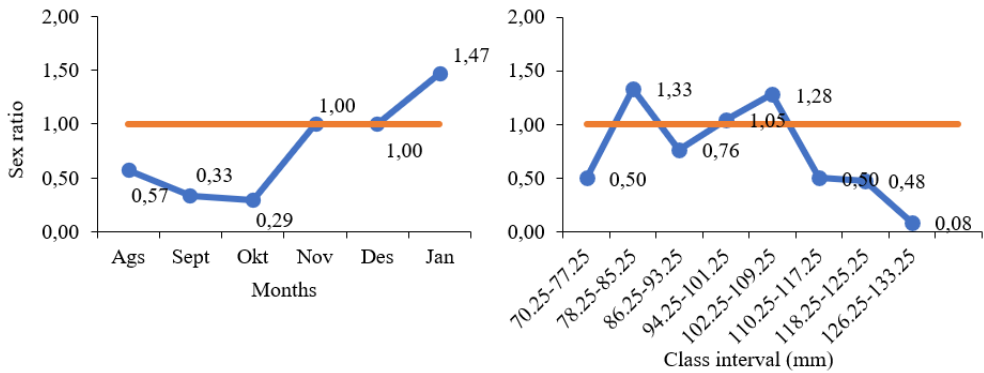
Carapace width frequency distribution is the distribution of the frequency of individuals or the number of individuals in various size groups of a particular carapace width. Frequency distribution diagram of carapace width of mud crabs from August 2024 to January 2025. The frequency distribution of male mud crab length was mostly found in the class interval 102.25-109.25 mm (with a total of 32 individuals), while in the class interval 134.25-141.25 mm, no male mud crabs were found. The frequency distribution of the length of female mud crabs was mostly found in the 102.25-109.25 mm class interval (with a total of 25 individuals), while the lowest frequency distribution of female mud crab length was found in the 70.25-77.25 mm and 134.25-141.25 mm class intervals, with a total of 2 individuals.



**Fig. 2.** Frequency distribution of the carapace width of mangrove crabs (*S. serrata*) in Teluk Bogam Village.

##### 3.1.2 Sex ratio

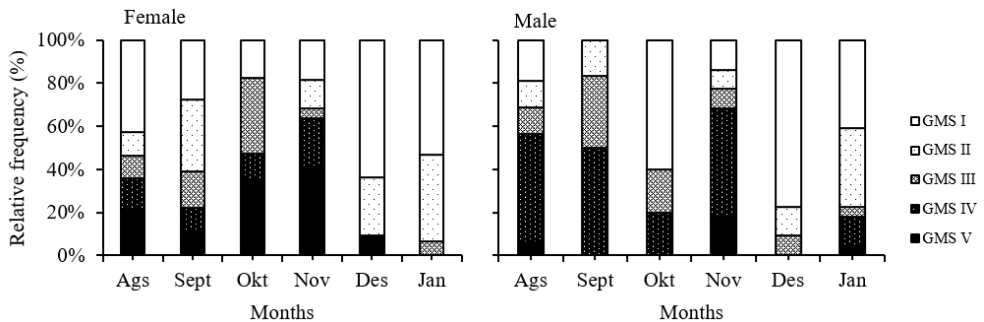
The sex ratio is a parameter used to determine the balance between the male and female sexes in the population. The sex ratio of mud crabs during the observation period from August to January is presented in Figure 2. The sex ratio of male to female mud crabs (*S. serrata*) based on Figure 2 shows the highest value in January, with a value of 1.47, and the lowest sex ratio in October, with a value of 0.29. Based on the chi-square test, the total sex ratio of mud crabs in Teluk Bogam Village is 1: 0.76 with a predominance of female crabs. The sex ratio of mud crabs (*S. serrata*) based on shows that the dominant size of female mud crabs is found in the 86.25-93.25 mm size class, while male mud crabs are found in the 78.25-85.25 mm size class.



**Fig. 3.** Sex ratio of mud crabs (*S. serrata*) based on observation time and size in Teluk Bogam Village, Central Kalimantan.

### 3.1.3 Gonad maturity stage (GMS)

Determination of the level of gonadal maturity in reproduction is used to determine whether an individual has matured gonads with immature gonads in stock populations in the waters [4]. Based on morphological observations, the level of gonadal maturity in mud crabs is classified into five. The results of morphological identification of mud crab GMS during observations from August to January are presented in Figure 3.

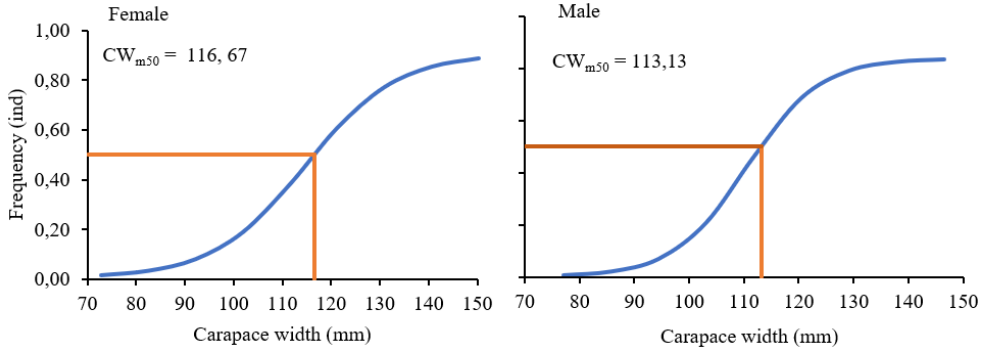


**Fig. 4.** Gonad maturity stage of mud crab (*S. serrata*) in Teluk Bogam Village, Central Kalimantan.

The morphological maturity level of mud crab (*S. serrata*) gonads during the observation period from August to January, as shown in Figure 3, indicates that most of the mud crabs caught had not yet reached gonadal maturity. The percentage of female mud crabs that were not yet gonadally mature was 68.9%, while that of male mud crabs was 65.6%. Meanwhile, mature mud crabs accounted for 31.1% of female mud crabs and 34.4% of male mud crabs, with the highest gonadal maturity occurring in November.

### 3.1.4 First gonadal maturity size (CWm50)

The first gonadal maturity size is the size at which 50% of the observed species population has reached gonadal maturity, denoted by the notation L50 or Lm (CWm50 for crabs). The first gonadal maturity size of female and male mud crabs is presented in Figure 4.

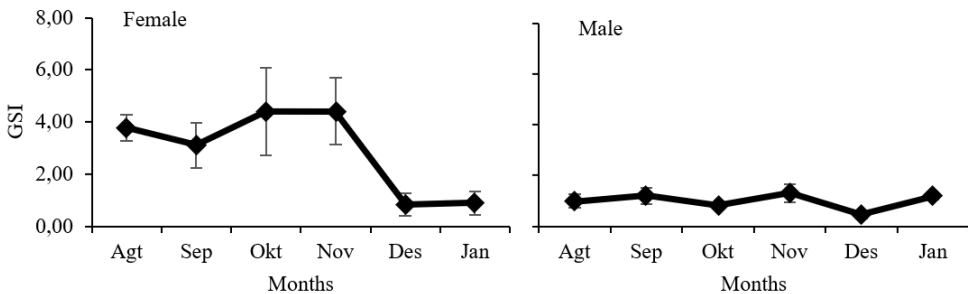


**Fig. 5.** Size of gonads at first maturity in mud crabs (*S. serrata*) in Teluk Bogam Village, Central Kalimantan.

The results of the analysis (CWm50) in Figure 10 show that the first gonadal maturity value for female mud crabs is found at a carapace width of 116.67 mm. Meanwhile, the first gonadal maturity value for male mud crabs is found at a carapace width of 113.13 mm.

### 3.1.5 Gonado-somatic index (GSI)

The gonad maturity index can be used to determine the reproductive ability of crabs, as well as a reference to predict crabs that are ready to spawn and show the percentage of weight in producing mature gonad. The percentage of gonad maturity level will increase or reach the maximum limit at the time of spawning. After the spawning process is complete, the level of gonad maturity will decrease again. The results of the gonado-somatic index (GSI) every month during the observation are presented in Figure 5.

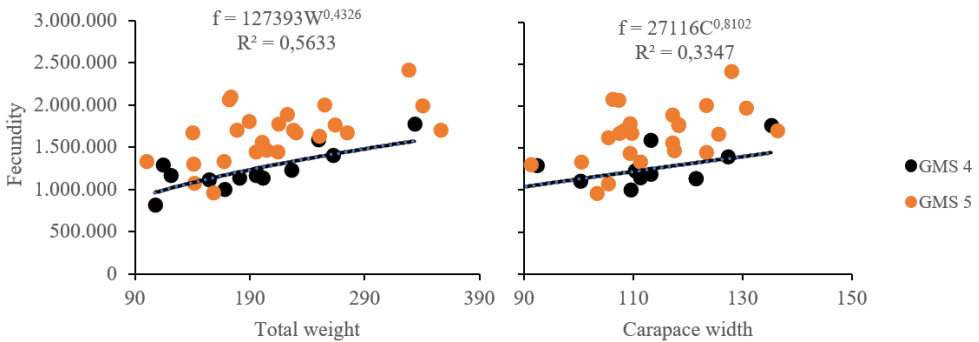


**Fig. 6.** Gonad maturity index of mud crab (*S. serrata*) in Teluk Bogam Village, Central Kalimantan.

The results of the gonadal maturity index analysis based on Figure 5 show that female mud crabs have a higher average GSI value than male mud crabs. The highest GSI values for both female and male mud crabs were recorded in November, with values of  $4.4166 \pm 1.2270$  for female mud crabs and  $1.3048 \pm 0.3505$  for male mud crabs. The lowest GSI values for both female and male mud crabs were recorded in December, with values of  $0.8330 \pm 0.4421$  for female mud crabs and  $0.4586 \pm 0.1428$  for male mud crabs.

### 3.1.6 Fecundity

Fecundity in reproductive analysis is used to predict the number of individuals that will be produced and to determine the number of individuals in a particular age class [4]. The fecundity observed in female mud crabs is that of female mud crabs that have reached gonadal maturity. The fecundity value of mud crabs ranged from 820,858 to 2,419,923 oocytes. The mud crabs used were gonadally mature females with a carapace width of 86.25-136.25 mm (Figure 6).



**Fig. 7.** Relationship of fecundity with carapace width and weight of mud crab (*S. serrata*) in Teluk Bogam Village, Central Kalimantan.

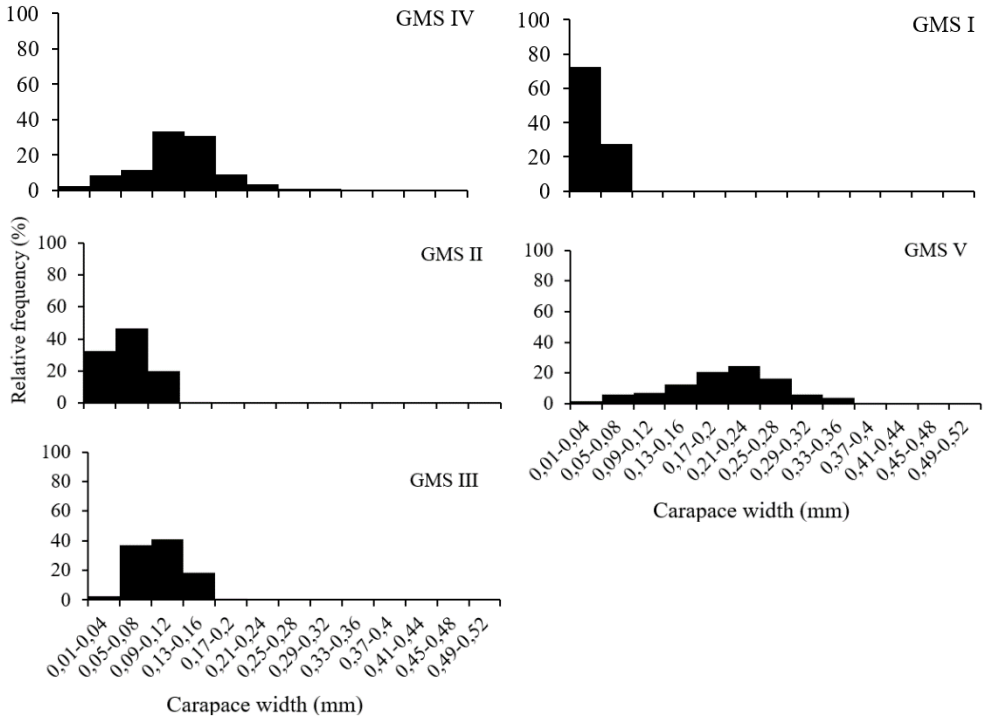
The relationship between fecundity and body weight and carapace width, based on Figure 6, shows a positive correlation, where the greater the weight and carapace width, the greater the number of oocytes produced. The relationship between fecundity and total weight is shown by the equation  $F = 127393W^{0.4326}$  with a coefficient of determination value of  $R^2 = 0.5633$ . The relationship between fecundity and carapace width is shown by the equation  $F = 24689C^{0.3347}$ , with a coefficient of determination value of  $R^2 = 0.3347$ .

### 3.1.7 Oocyte diameter

The diameter of an egg is the centre line or length of the egg, measured using a calibrated micrometer on a microscope. The diameter of oocytes in the ovary increases as the gonads mature [4]. The distribution of mud crab egg diameter is presented in Figure 7. The results of egg diameter measurements conducted on female mud crabs based on Figure 7 obtained an average diameter of  $0.09 \pm 0.01$  mm for GMS I,  $0.13 \pm 0.02$  mm for GMS II,  $0.19 \pm 0.02$  mm for GMS III,  $0.33 \pm 0.02$  mm for GMS IV, and  $0.36 \pm 0.02$  mm for GMS V.

## 3.2 Discussion

The frequency distribution of carapace width can be used to group carapace sizes from smallest to largest, which is useful in determining age groups. Additionally, this frequency distribution is used to observe shifts in carapace size, which reflect the number of age groups (cohorts) present in a population [6]. Crab length is measured based on carapace width, because during growth, carapace width increases more significantly than length.



**Fig. 8.** Oocyte diameter of mud crab (*S. serrata*) oocytes in Teluk Bogam Village, Central Kalimantan.

The results of the carapace width frequency distribution based on Figure 3 show that the peak frequency of mud crabs is at 102.25-109.25 mm for both males and females. Most of the crabs caught in this study still do not meet the minimum catch size (Minimum legal size) as regulated in Ministry of Marine Affairs and Fisheries Regulation No. 7 of 2024 on the Management of Lobsters (*Panulirus* spp.), crabs (*Scylla* spp.), and mud crabs (*Portunus* spp.), which stipulates that the minimum legal size for crabs is a carapace width of over 12 cm or 120 mm per individual. According to [7], the carapace width of mud crabs (*S. serrata*) is classified into three phases: juvenile, young, and adult. In the juvenile phase, the carapace width is <70 mm, in the young phase it is 70–120 mm, and in the adult phase it is >120 mm.

The frequency distribution results show that the mud crabs caught in Teluk Bogam Village are dominated by young crabs, accounting for 89% of females and 98% of males. Adult crabs caught consisted of 11% females and 2% males, while juvenile crabs were not found. This finding suggests that the fishing gear used by fishermen remains insufficiently selective, potentially disrupting recruitment processes and contributing to overfishing or overexploitation. This condition is related to the developmental phase at the megalopa stage, where crabs begin to migrate to the muddy seabed and then move towards the coast. This process begins with movement towards the river mouth, which is then continued towards the mud ecosystem to return to the mating process [8].

In comparison, research conducted by [7] shows that crab catches using bubu traps in Lawele Bay, Southeast Sulawesi, consisted of 9.5% juvenile crabs, 90.5% adult crabs, and no juveniles. These results indicate that the bubu fishing gear used to catch mudcrabs in Lawele Bay is highly selective. Conversely, the fishing gear used in Teluk Bogam Village is less selective and therefore needs to be designed or modified to be able to catch crabs that have reached adulthood.

In addition to the use of less selective fishing gear, another possible reason for the crab catch in Teluk Bogam Village not meeting the requirements of Ministry of Marine Affairs

and Fisheries Regulation No. 7 of 2024 and the classification of carapace width is that the average size of adult mud crabs in Teluk Bogam Village does not reach the minimum size permitted for capture according to current regulations. This condition is due to the provisions in the Ministry of Marine Affairs and Fisheries Regulation No. 7 of 2024 regarding the minimum size of mud crabs that can be caught, which is universal across all locations and for all types of crabs. However, the size and biological characteristics of crabs vary by location due to differences in environmental conditions.

The distribution of mud crabs in the waters is influenced by several factors, such as oceanography, physical and chemical conditions of the water, food availability, behaviour and life cycle. The distribution of crab carapace width is influenced by several factors, including environmental conditions and exploitation levels. A supportive environment accelerates mud crab growth, and low exploitation levels provide opportunities for crabs to reach optimal size. In addition, crab feeding habits, such as their response to bait on fishing gear and irregular feeding patterns, also influence size distribution. Crabs prefer to hide in holes to avoid predators and engage in burrowing activities during their life cycle, which also contributes to carapace size variation [9].

The sex ratio of mud crabs in Teluk Bogam Village is unbalanced, at 1: 0.76, with a predominance of female crabs. These results are in line with the findings of a study conducted by [10], which found an imbalance in the sex ratio of male and female crabs, with female crabs dominating. This imbalance is thought to be related to food availability and the life cycle of mud crabs, especially during the reproductive period. In contrast to the results of [11], male crabs were more dominant than females. The difference in sex ratio is suspected to be influenced by seasonal variations, location, and crab body size.

The sex ratio composition tends to change according to the spawning season [10]. In this study, the spawning season occurred in November, when crabs began to migrate to the sea to spawn. Before migrating, mud crabs usually settle first in mangrove or coastal areas to forage, mate, and accelerate gonadal maturation. This is indicated by the dominance of female crabs before November. Female mudcrabs generally seek water bodies with suitable conditions for the spawning process, particularly regarding water temperature and salinity parameters. According to [12], the reproductive season or spawning season for mud crabs occurs throughout the year, but the peak varies in each water body. According to [13], the level of gonadal maturity in crabs is influenced by environmental factors. The main factors affecting gonadal development include temperature, food, light period, and season. During the reproductive phase, mud crabs require sufficient nutrient intake, both in terms of quality and quantity.

The first gonadal maturity size in a species occurs at a certain age, when available energy is no longer used for body metabolism but is instead focused on gonadal maturation. The first gonadal maturation size (CWm50) in male mud crabs is 113.13 mm, smaller than that of female mud crabs, which have a first gonadal maturation size of 116.67 mm. These results are consistent with the research by [10], which showed that the first gonadal maturity size in male mud crabs is smaller than that of female crabs, with a size of 80.13 mm for males and 82.54 mm for females. Each species has a different first gonadal maturity size, and even the same species can experience size differences depending on environmental conditions and geographical location. Species of the same size and age do not always reach gonadal maturity at the same age and length.

Fecundity is one of the important parameters that needs to be studied in reproductive biology analysis, which refers to the number of oocytes produced by female mud crabs to determine their reproductive potential. Mud crabs that have reached gonadal maturity have varying levels of fecundity. This difference is closely related to the size of the female parent, where the number of oocytes increases as the parent's body size increases. Fertility increases with body weight and carapace width, reaching its peak at a certain size and age. This increase

is influenced by the fertility cycle within the organism's body. Additionally, fertility is influenced by species, age, individual size, diet, and living environment [4]. The results of this study are in line with the findings of [14], with fertility ranging from  $2,116,514 \pm 505,669$  oocytes.

Egg diameter increases with gonadal maturity. Egg size varies between species, possibly due to differences in morphological characteristics. Additionally, it is known that mud crab diameter ranges from  $0.36 \pm 0.02$  mm. Based on these measurements, it is known that mud crabs have a total spawning type, meaning all fertilised oocytes are released at once. This finding is consistent with the results of a study by [15]. According to [4], as the gonads develop, the egg diameter also increases.

The lack of information on the reproductive biology of crabs (*S. serrata*) in Teluk Bogam Village, combined with increasing exploitation intensity, necessitates appropriate management efforts to ensure the crab population remains stable. Based on this study, one form of management that can be applied is seasonal management, particularly by reducing catches during the spawning season in November. This aims to provide mud crabs with the opportunity to reproduce optimally. Another effort that can be made is to avoid catching crabs below the first gonadal maturity size, which is 116.67 mm. Catching crabs below this size prevents them from having the opportunity to lay oocytes or hatch their oocytes. Additionally, the implementation of environmentally friendly aquaculture practices, such as silvofishery, can also be a solution in maintaining the sustainability of mud crabs. Silvofishery is an aquaculture activity conducted alongside mangrove ecosystem conservation. This activity creates a stable environment that supports the natural reproduction of mud crabs.

## 4 Conclusion and recommendation

### 4.1 Conclusion

Mud crabs (*Scylla serrata*) in the mangrove area of Teluk Bogam Village still do not meet the minimum catch size and show an unbalanced sex ratio with a predominance of females. The peak spawning period for female and male mud crabs is estimated to occur in November, with fecundity ranging from 820,858 to 2,419,923 oocytes, and the spawning type classified as total spawner.

### 4.2 Recommendation

Further research is needed on the reproductive biology of mud crabs (*Scylla serrata*) in the mangrove area of Teluk Bogam Village, with a larger sample size and a longer observation period (one year), to obtain more representative results and determine the spawning frequency over a year. Additionally, research on the gonads of crabs carrying oocytes is needed to confirm that the crabs are total spawners, enabling the development of sustainable mud crab management strategies based on a thorough understanding of reproductive biology and optimal management approaches.

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