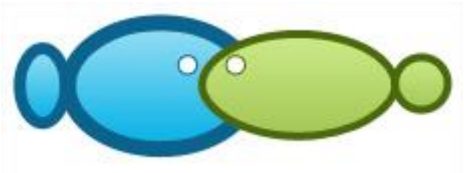

Evaluation of the legal-size proportion of mud crabs (*Scylla* spp.) caught by traditional traps as a basis for sustainable management in Indragiri Hilir Regency, Riau Province, Indonesia

[1]Polaris Nasution, [1]Muhammad Natsir Kholis, [1]Arthur Brown, [2]Clara Yoalndika, [1]Onja, [1]Nurul Hiqmah

[1] Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru, Indonesia; [2] Department of Fisheries Socioeconomics, Faculty of Fisheries and Marine Sciences, University of Riau, Pekanbaru, Indonesia. Corresponding author: M. N. Kholis, muhammad.natsir@lecturer.unri.ac.id

Abstract. Mud crabs (*Scylla* spp.) are a vital marine resource, particularly in Indragiri Hilir Regency, Riau, Indonesia, where local fishermen heavily depend on their capture. However, increasing fishing pressure and the use of traditional traps (pento) have raised concerns about the sustainability of mud crab populations. This study aims to evaluate the proportion of legal-sized mud crabs captured by pento, focusing on length at first maturity (Lm). The research was conducted in Perigi Raja Village using random sampling techniques over 21 days to collect data on species composition, size distribution, and sex ratio of the captured crabs. The results show that a significant proportion of the catch consists of undersized crabs, with only 12% of *Scylla serrata*, 46% of *Scylla paramamosain*, and 67% of *Scylla tranquebarica* reaching legal size. The study also reveals an imbalance in sex ratios, with males predominating in all species. The length-weight relationship analysis shows a strong positive allometric growth pattern (b > 3), indicating that weight increases faster than length in mud crabs. These findings highlight the need for improvements in management practices, including selective fishing techniques and stricter regulation enforcement, to ensure the sustainability of mud crab populations and the surrounding mangrove ecosystems.

Key Words: crab sustainability, fishing techniques, mangrove ecosystems, sex ratio.

Introduction. Crabs are estimated to number around 100 species in the Portunidae family in Indonesia. One of the species in the Portunidae family is the mud crab (WWF 2023). The mud crab (*Scylla* spp.) is an important economic aquatic organism, and its life is greatly influenced by the presence of mangrove forests (Chairunnisa 2004; Tahmid et al 2015). Mud crabs in Indonesia are obtained from wild stocks. As the economic value of mud crabs increases, so does the fishing pressure on this species. According to Irvansyah et al (2012), mud crabs are macro-benthic fauna belonging to the subphylum Crustacea. They live in mangrove forests and estuarine waters.

The reproduction of mud crabs is a complex biological process, beginning with mating, sperm storage, spawning, and larval stages. Female crabs usually spawn after molting and are fertilized by males. After fertilization, the eggs develop and hatch into zoea larvae, then megalopa, and finally juveniles before reaching adulthood (Tiurlan et al 2019).

One of the areas with significant potential for mud crabs is Indragiri Hilir Regency, Riau, Indonesia. The region has a mangrove forest area of 129,455 hectares. The condition of the natural aquatic ecosystem makes it an important habitat for various marine species, including mud crabs. The primary fishing areas are spread across several regions in Indragiri Hilir Regency, one of which is Perigi Raja Village. Approximately 90–95% of the local fishermen depend on mud crab fishing. The fishing activities typically

take place in shallow waters such as rivers, estuaries, and mangrove forests, which also serve as the primary habitat for this species.

Geographically, Perigi Raja Village is characterized by relatively flat terrain, predominantly consisting of peat, clay, and muddy soils, with hilly areas in the southern part. The region is located in the coastal zone between rivers and the sea, influenced by seawater characteristics such as tides, wave patterns, salinity, and sea currents. Based on its geographical features, the area can be categorized as an estuarine region. Estuarine areas are known for their fertile waters, making them one of the most productive natural habitats in the world (Arnando et al 2022).

Mud crabs in the area are caught using traditional fishing gear known as traditional traps known as "pento". This fishing device is typically made from bamboo or wire woven into a basket-like shape, with one or more entrances designed to allow crabs to enter but making it difficult for them to exit. The use of traditional traps in Perigi Raja Village reflects local wisdom and serves as an affordable alternative for small-scale fishermen. However, with the development of modern fishing technologies and increasing pressure on aquatic resources, the sustainability of traditional traps use is under threat. The high market demand for mud crabs in Indonesia has led to increased fishing intensity of this economically valuable species (Riyanto et al 2025). Therefore, there is a significant need to understand and evaluate the ecological impacts of year-round traps use on sustainability.

Preliminary survey results indicate that many of the caught crabs are still small or have not reached gonadal maturity (length at first maturity), meaning they are caught before they can reproduce. If this issue persists, it will further reduce the wild population and stock of mud crabs. According to Riyanto et al (2025), crab production in Indonesia reaches hundreds of thousands of tons, with most of it coming from wild capture rather than aquaculture.

Therefore, this study aims to examine the proportion of legal-sized mud crabs captured by the trap. Additionally, the study will identify the species of mud crabs, the length-weight relationship, and the growth patterns of mud crabs in Perigi Raja Village. The proportion or percentage of legal-sized crabs, as well as the biological factors, are crucial for the sustainable management of mud crab resources. If the proportion is dominated by undersized crabs, it is necessary to evaluate the construction, fishing areas, fishing seasons, and the management of traps moving forward, as was done by Kholis et al (2018) on drift bottom gillnets in Bengkalis Island.

Research on legal-size catch has been widely conducted, but studies on the size of mud crabs caught by traditional traps are still limited. Previous studies (Hoek et al 2015; Beku et al 2021; Riyanto et al 2025), show that crabs caught in traps are often below the legal size. In contrast, Herliany and Zamdial (2015) found that mud crabs on Enggano Island had reached legal size, but their growth was negatively allometric, indicating the need for intensive management to ensure their sustainability.

Material and Method. The study was conducted in Perigi Raja Village, Indragiri Hilir Regency, Riau Province, Indonesia, from August to October 2025. The methodology employed was experimental fishing, with data collection using random sampling techniques. Data were collected through direct fishing operations using traditional traps (Figure 1) over a period of approximately 21 days. The equipment used included a trap, a ruler, a caliper, a camera, a measuring tape, a pH meter, a thermometer, and a GPS tracker. The study's subjects and objects of investigation were mud crabs (*Scylla* spp.).

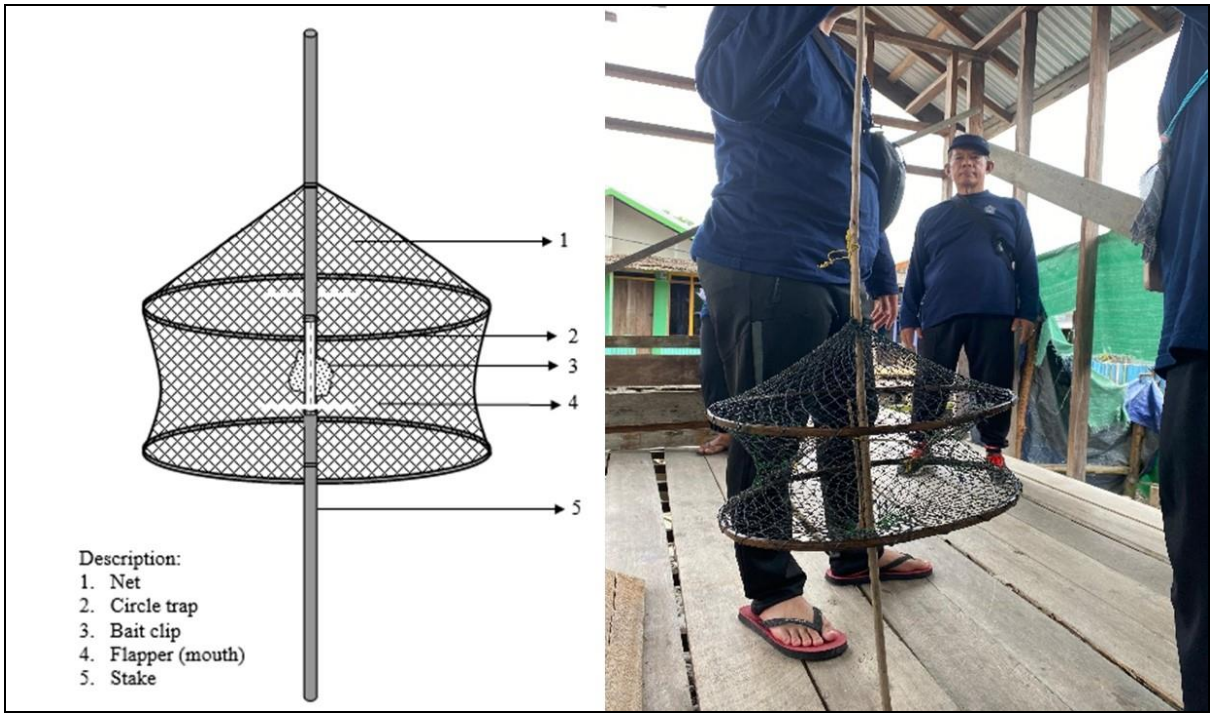

Figure 1. Construction of a traditional trap (pento).

Data analysis. All data were analyzed using descriptive statistical methods. The length at maturity (Lm) of mud crabs was determined by referring to the legal size based on the Indonesian Ministry of Marine Affairs and Fisheries Regulation No. 7 of 2024 (KKP 2024) (legal size of mud crabs > 12 cm). The data were presented by calculating the proportion of legal-size crabs from the catch during the trial period. Subsequently, the species and sex of the mud crabs were analyzed using the guidelines from the WWF Indonesia handbook on mud crabs capturing (WWF 2023). Finally, the length-weight relationship and growth pattern of the mud crabs were analyzed using the following equation (Effendie 1979; Kholis et al 2018, 2024; Anggoro et al 2021):

$$W = aL^b$$

Where W is the body weight of mud crabs (g), L is the carapace length (mm); a and b are constants.

The value of b is used to estimate the relationship between length and weight, with the following criteria:

1. b = 3, the mud crab exhibits isometric growth (weight increase is proportional to length increase);
2. b > 3, the mud crab exhibits positive allometric growth (weight increases faster than length);
3. b < 3, the mud crab exhibits negative allometric growth (length increases faster than weight).

Results

Composition and distribution of legal-size proportion. The composition of the catch from traditional traps consisted entirely of mud crabs from the Portunidae family and the *Scylla* genus, with a total of 100 crabs captured. The species distribution included *Scylla paramamosain* (39 crabs), followed by *Scylla serrata* (34 crabs), and *Scylla tranquebarica* (27 crabs). This indicates that traditonal traps are highly effective for capturing mud crabs. However, the size distribution of the crabs varied, and not all individuals could be classified as legal-sized. The proportion of legal-size versus undersize crabs differed across species, highlighting the need for more targeted management practices. For *Scylla*

paramamosain, only 46% of the crabs reached the legal size, while the remaining 54% were undersized. This suggests that more than half of the population of this species was still below the legally permissible size, potentially threatening the sustainability of the population in the area. In contrast, *Scylla tranquebarica* showed a better proportion, with 67% reaching the legal size, while only 33% were undersized. This indicates that *Scylla tranquebarica* has a higher likelihood of meeting regulatory requirements compared to *Scylla paramamosain*, although some individuals still fall below the legal size threshold. On the other hand, *Scylla serrata* had a much more imbalanced ratio, with only 12% reaching the legal size and 88% remaining undersized. This suggests that the majority of the *S. serrata* population is being captured before reaching the legal size, which could adversely affect conservation efforts and fisheries resource management.

Overall, the data indicate a pressing need for improved management and monitoring of catch sizes to ensure the sustainability of mud crab populations, particularly in the waters of Perigi Raja Village. A more detailed breakdown of the legal-size proportions across species is presented in Figure 2.

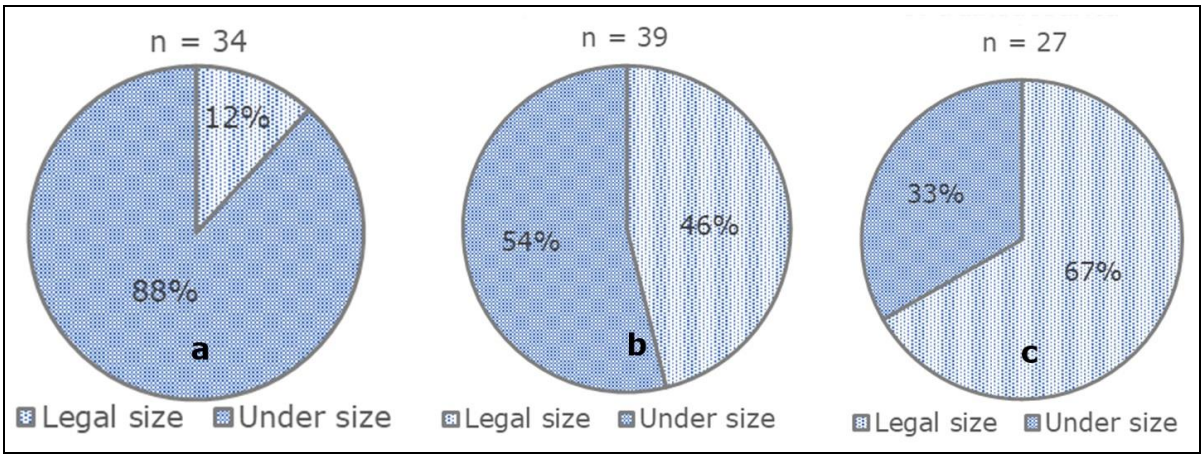

Figure 2. Distribution of the percentage of legal-size mud crabs: a) *Scylla serrata*; b) *Scylla paramamosain*; c) *Scylla tranquebarica*.

Identification of species and sex. The mud crabs captured by traditional traps in Perigi Raja Village comprised of three species: *Scylla paramamosain, Scylla serrata, and Scylla tranquebarica*. These species exhibit distinct morphological characteristics, which can be used to differentiate them in the field. *Scylla paramamosain* is generally recognized by its triangular frontal lobes and prominent anterolateral spines, while *Scylla serrata* is distinguished by its broad, rounded frontal region and a more robust, spiny carapace. *Scylla tranquebarica*, on the other hand, has a more moderate frontal lobe and less pronounced spines along the carapace. These species-specific traits are critical for proper identification and assessment in fishery management, as shown in Table 1.

The most abundant catch was *Scylla paramamosain* with 39 individuals, followed by *Scylla serrata* (34 individuals) and *Scylla tranquebarica* (27 individuals) (Figure 3). Data in Figure 4 show that all three mud crab species were dominated by males, but the degree of dominance varied. For *Scylla paramamosain*, the composition was 79% males and 21% females (3.8:1), while *Scylla tranquebarica* showed the most skewed ratio, with 89% males and 11% females (8:1). *S. serrata* had the most balanced sex ratio, with 65% males and 35% females (2:1). The ranking from the most skewed to the most balanced was: 1) *Scylla tranquebarica*, 2) *Scylla paramamosain*, and 3) *Scylla serrata*. This pattern suggests that males are more frequently captured, possibly due to their higher acti vity levels, greater responsiveness to bait, or because the sampling season causes females to be more hidden or migratory. For management purposes, this condition requires caution in capturing females (especially egg-bearing females) and calls for an evaluation of gear selectivity and catch timing to maintain a balanced population composition.

Table 1

Morphological differences of mud crabs

No	*Key morphological characteristics*	 *Scylla serrata*	 *Scylla paramamosain*	 *Scylla tranquebarica*
1	Spines/teeth on the frontal lobes (between the eyes).	Tall, with a blunt point to a sharp tip; concave edges, and the spaces between the spines are rounded.	Tall and more triangular, with straight/angled sides.	Moderate, with a blunt tip and rounded spaces.
2	Anterolateral row of teeth/spines on the carapace (outer edge of the carapace).	The row appears narrow; the outer edge is straight with a slight concavity.	Not a primary distinguishing feature; refer to the characteristics of the chela and frontal region.	The row appears wide; the outer edge is convex.
3	Palm of the chela – dorsal side, just behind the base of the dactyl.	Generally, without specialized sharp spines (not a key characteristic).	There is a distinct pair of sharp spines.	Usually, only a blunt protuberance (not sharp spines).
4	Reticulation/polygon pattern on the chela and walking legs.	Strong/clear on all legs and chelae (male & female).	Weak on the chelae and the first two pairs of legs; stronger on the last two pairs of legs (especially in females).	Generally weak on the extremities.
5	Reticulation pattern on the abdomen	Present in females (diagnostic); not prominent in males.	Often absent (variable); when present, usually weak.	Absent/very weak in both.
6	Brief field notes	Often appears "textured" due to strong reticulation; the combination of a high frontal lobe and narrow anterolateral spines aids in separation.	Easily recognized by the triangular frontal spines and a pair of spines on the palm of the chela.	Combination of moderate frontal lobe and broad-convex anterolateral spines.

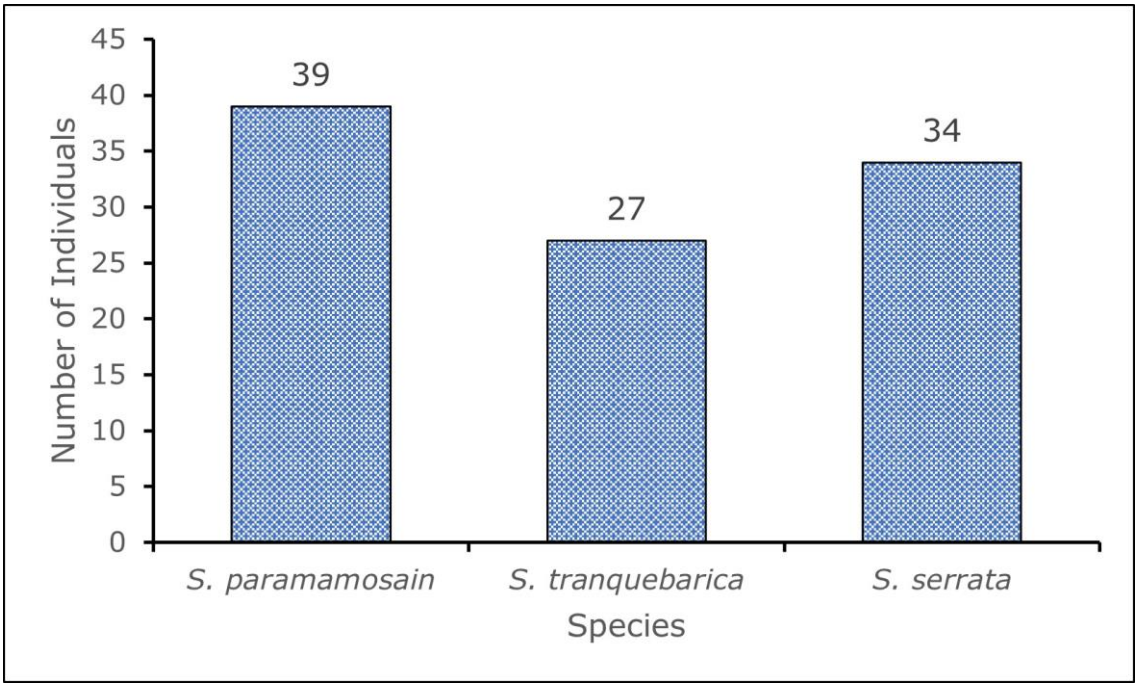

Figure 3. Number of mud crabs captured by traditional traps (pento).

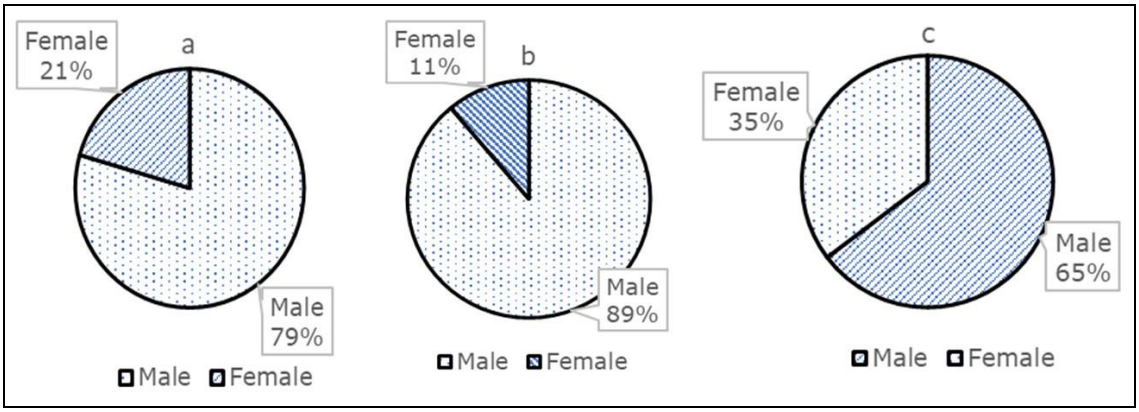

Figure 4. Sex ratio distribution of mud crabs: a) *Scylla paramamosain*, b) *Scylla tranquebarica*, c) *Scylla serrata*.

Length-weight relationship. The analysis of the length-weight relationship for mud crabs resulted in the regression equation y = 4.0004x - 13.157, where y represents the body weight (g) and x represents the carapace length (CL) (mm). This equation indicates that for every increase of 1 mm in carapace length, the body weight of the mud crab increases by approximately 4 grams. The R^2 value for the length-weight relationship was found to be 0.9372, suggesting a very strong correlation between body weight and carapace length. This high R^2 value confirms the reliability of the regression model and indicates that body weight is strongly dependent on carapace length in mud crabs. As the carapace length increases, so does the body weight, which is a typical allometric growth pattern observed in many marine species. A more detailed representation of the length-weight relationship is presented in Figure 5.

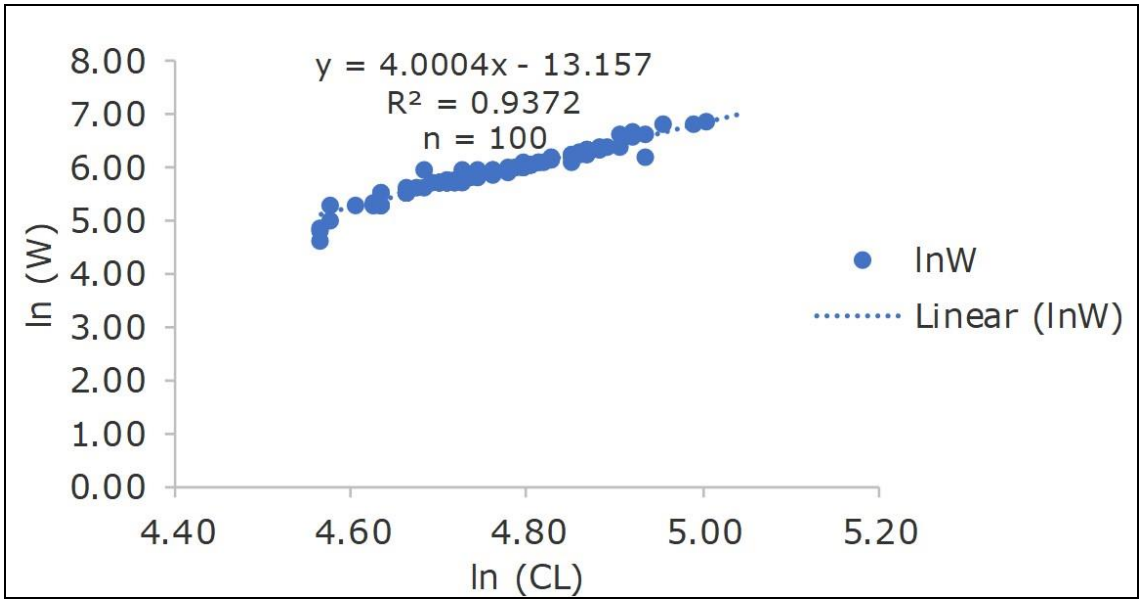

Figure 5. Length-weight relationship of mud crabs

Growth pattern. The growth pattern of mud crabs was analyzed using the regression equation $W = 1.3455^{CL} - 212.92$, which describes the relationship between body weight (W) and carapace length (CL). The value of b obtained for mud crabs was 4.0004 (b > 3), indicating a positive allometric growth pattern. This suggests that the growth rate of body weight exceeds the growth rate of carapace length. Such a growth pattern implies that mud crabs allocate more energy towards increasing their body mass rather than length, leading to a faster accumulation of biomass. This has important implications for size-based management strategies, as individuals with faster weight gain may be more susceptible to capture at larger sizes. A more detailed representation of the length-weight relationship is provided in Figure 6.

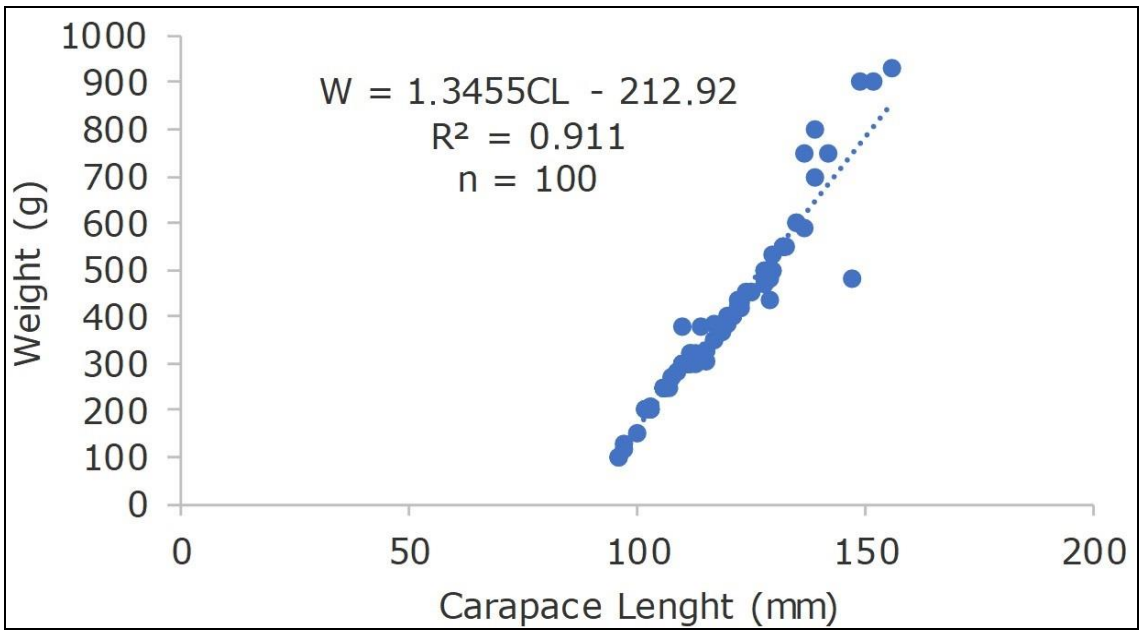

Figure 6. Growth pattern of mud crabs

Discussion. The evaluation results show that the majority of the mud crabs captured have not reached their gonadal maturity size (legal size), which may negatively affect the sustainability of the population in the waters of Perigi Raja Village. Ecologically, this condition indicates high exploitation pressure on the mud crab population, particularly because the fishing gear used, namely traditional traps (pento), is less selective in

capturing individuals that meet the regulatory size requirements (Cahyadinata et al 2025). Mud crabs are highly dependent on mangrove ecosystems as their primary habitat for feeding, shelter, and reproduction, so a decline in stocks due to non-selective capture could disrupt the balance of the supporting mangrove ecosystems (Apriyanto et al 2025). Furthermore, recent studies show that *Scylla serrata* species also exhibit restricted movement patterns within mangrove and estuarine areas, where the male-to-female ratio is found to be higher, which may indicate selective fishing pressure or habitat factors influencing sex distribution (Fazhan et al 2022).

The study found three species of mud crabs captured by traditional traps, all belonging to the *Scylla* genus, namely *Scylla paramamosain*, *Scylla serrata*, and *Scylla tranquebarica*. These species exhibit distinct morphological characteristics, such as shell size and shape, as well as growth patterns. Among the three species, *Scylla paramamosain* dominated the catch with 39 individuals, followed by *Scylla serrata* (34 individuals) and *Scylla tranquebarica* (27 individuals). Overall, the traditional traps proved to be quite effective in capturing mud crabs, but not all individuals captured met the legal size requirements. This is a significant concern, as the capture of individuals before reaching gonadal maturity size may reduce the mud crab populations and affect the structure of the supporting coastal ecosystems (Bir et al 2020; Aneesa et al 2025).

Gonadal maturity size (length at maturity) is a key factor in ensuring the sustainability of mud crab populations. According to the study results, it was found that 46% of *Scylla paramamosain* individuals reached legal size, while the remaining 54% were still categorized as undersize. *Scylla tranquebarica* showed a better proportion, with 67% of individuals reaching legal size, while *Scylla serrata* exhibited the most imbalanced ratio, with only 12% of individuals reaching legal size and the remaining 88% classified as undersize. This indicates that the majority of the *Scylla serrata* population is being captured before reaching reproductive maturity, which could potentially jeopardize the sustainability of this species in the future (Herliany & Zamdial 2015). Furthermore, a recent study based on length-based stock assessments in Indragiri Hilir, Riau, Indonesia, also found that the exploitation rate of mud crabs is relatively high, with a spawning potential ratio (SPR) of only 4% for females and 6% for males, indicating that this resource is under intense fishing pressure (Riyanto et al 2025). The undersized carapace size of mud crabs is caused by several factors, such as capture before reaching reproductive maturity, suboptimal management policies, and damage to mangrove habitats, which reduce breeding areas. Additionally, overfishing, the use of non-selective fishing gear, and environmental changes such as unstable temperature and salinity also slow down the growth of mud crabs (Pane & Hasanah 2020).

A previous study by Wijaya and Yulianda (2017) also emphasized that size-based management of carapace size should be combined with sustainable conservation policies, such as restrictions on catch during the reproductive season and providing education to fishermen about the importance of appropriate catch sizes. The Indonesian government, through the Ministry of Marine Affairs and Fisheries, has also initiated several programs, such as regulated fishing and sustainable fisheries resource management, aimed at protecting key species like mud crabs from the threat of overexploitation (Hardiyanti et al 2018; Afrianti et al 2025). Another local issue in Perigi Raja Village is the poisoning of mud crabs and fish species around the mangrove area. This has caused mass mortality of crabs from juvenile to adult sizes, disrupting regeneration and making recovery difficult. Another serious impact is the destruction of mangrove forests due to poisoning and illegal logging of mangrove trees and nipa palm trees in the surrounding area. Routine monitoring, law enforcement, and the application of data-driven technology in fisheries resource management can better support efforts to maximize the economic benefits of this sector without compromising its sustainability..

In addition to body size, the sex composition also shows a significant imbalance. The research data indicate that the majority of mud crabs captured by traditional traps were dominated by males, with *Scylla paramamosain* recording 79% males and 21% females, *Scylla tranquebarica* recording 89% males and 11% females, and *Scylla serrata* showing a more balanced ratio with 65% males and 35% females. This pattern suggests that males are more frequently captured, possibly due to their higher activity levels and

greater responsiveness to bait. Previous studies by Kantun et al (2022) and Silaban et al (2023) also indicated that the sex ratio in several mud crab species tends to be biased towards males, which may be influenced by reproductive factors or sexual selection occurring in their ecosystems. Another possibility is ecological factors such as habitat imbalance or environmental conditions not supporting female spawning, which might contribute to this imbalance (Sunarto et al 2015; Tamsil et al 2023). The capture of females, especially egg-bearing females, requires special attention in the management of this resource, as capturing females can reduce the number of individuals capable of reproduction, which in turn may decrease population sustainability (Hoek et al 2015). Furthermore, Fazhan et al (2022) found that the high male-to-female ratio in some *Scylla* species may reflect selective fishing effects or habitat changes that differ between sexes. Therefore, selective management of male and female capture is crucial to maintaining a balanced sex composition in the population.

The growth pattern of mud crabs observed in this study also provides important insights into the efficiency of energy use in their growth process. The analysis indicates that mud crabs follow a positive allometric growth pattern ($b > 3$), meaning their weight increases faster than their carapace length. For instance, based on the regression equation $W = 1.3455^{CL} - 212.92$ (where W is body weight and CL is carapace length), it shows that their weight increases more rapidly than their length. This condition may affect the crab's resilience to capture pressure and environmental changes, and provides valuable information for managing the optimal capture size in line with the population's capacity to grow and reproduce. Previous research in Indonesia showed that for *Scylla paramamosain*, the value of b for males, females, and the total was 3.23, 2.59, and 2.71, respectively, with some conditions showing negative allometric growth for females (Suryandari et al 2018; Rahayu et al 2023). Additionally, the study by Aneesa et al (2025) on *Scylla serrata* found growth patterns and biometric indices of the species with variations between sexes, further confirming that size-based management should consider sex and species dimorphism.

Overall, the results of this study show that although traditional traps are effective in capturing mud crabs, there are still significant challenges in managing the sustainability of this resource. The capture of individuals that have not reached legal size and the imbalance in the sex ratio of the catch indicate the need for improvements in trap design and fishing season management. In addition, the implementation of stricter regulations and increased education for fishermen on the importance of sustainability and resource conservation must also be reinforced. According to Pratama and Ryabtsev (2025), a community-based approach involving fishermen in monitoring and management can enhance the effectiveness of existing regulations, while also supporting the conservation of mud crabs as a high-value economic commodity.

From an economic perspective, mud crabs have a large market potential, both for domestic consumption and export. However, to ensure that this commodity remains sustainable in the long term, proper management practices must be implemented, including improving trap selectivity, enforcing regulations on legal catch sizes, and protecting the reproductive phases of this species. Additionally, traceability of the catch, from capture in the fishing grounds to the final consumer, is essential, as demonstrated by Wiryawan et al (2021) in shrimp fisheries. This system is crucial to ensure that traded fishery products meet sustainability and quality standards, as well as to identify and minimize the potential for illegal or irresponsible practices in the fishery supply chain. In the long term, the sustainability of mud crab resources will support the economic stability of coastal communities that rely on this fishery as their primary livelihood (Cahyadinata et al 2025).

Conclusions. This study concludes that the majority of the mud crabs captured have not reached the legal size. Only 12% of *Scylla serrata* met the legal size, 46% of *Scylla paramamosain* met the legal size, and the highest legal size proportion was observed in *Scylla tranquebarica* at 67%. The majority of the catch was dominated by males. The length-weight relationship of mud crabs captured by traditional traps (pento) showed a very strong correlation, with a positive allometric growth pattern ($b > 3$), where the

weight increased faster than the length. These findings underscore the need for improvements in trap design and fishing season management to ensure the sustainability of mud crab populations. Additionally, stricter regulations and enhanced education for fishermen on fishery resource conservation are necessary.

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Conflict of interest. The authors declare that there is no conflict of interest.

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Authors:
Polaris Nasution, Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau, 28293, Pekanbaru, Indonesia, e-mail: polaris.nasution@lecturer.unri.ac.id
Muhammad Natsir Kholis, Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau, 28293, Pekanbaru, Indonesia, e-mail: muhammad.natsir@lecturer.unri.ac.id
Arthur Brown, Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau, 28293, Pekanbaru, Indonesia, e-mail: arthur.brown@lecturer.unri.ac.id
Clara Yolandika, Department of Fisheries Socioeconomics, Faculty of Fisheries and Marine Sciences, Universitas Riau, 28293, Pekanbaru, Indonesia, e-mail: clarayolandika@lecturer.unri.ac.id
Onja, Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau, 28293, Pekanbaru, Indonesia, e-mail: onja6130@student.unri.ac.id
Nurul Hiqmah, Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau, 28293, Pekanbaru, Indonesia, e-mail: nurul.hiqmah4227@student.unri.ac.id

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