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CORRECTION OF BLUE SWIMMING CRAB FOLDING TRAP ENTRANCE

KOREKSI PINTU MASUK BUBU LIPAT RAJUNGAN

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ABSTRACT

Folding crab traps are widely used by Indonesian fishermen because they are easy to construct and operate. Observations suggest that crabs frequently struggle to pass through the entrance channel, as their legs become entangled in the mesh. The spines on the sides of their bodies usually become entangled in the net threads because the entrance is too narrow. Consequently, the chance of crabs being trapped is very low. The objective of the study is first to determine the combination of slope angle and mesh size for the channel that allows for crabs to pass through easily. The study attempted to combine the traverse angles of 20°, 30°, and 40° with mesh sizes of 0.125", 0.35", and 1.25". The second objective is to determine the elliptical or rectangular entry gap that is easy for crabs to pass through. Laboratory-scale research and the research data were analysed parametrically using two-way ANOVA and Tukey's post hoc test. The results indicated the combination of an angle of 20° and a mesh size of 0.125" was the best configuration, because 26 individual of crabs could pass through the entry gap. The following combination, 20° (0.35") and 30° (0.125"), each passed through 25 crabs. A total of 369 individual of crabs (63.6%) could pass through the rectangular gap, while 211 individuals (36.4%) passed through the elliptical gap. The combination of a 20° angle and a mesh size of 0.125" with a rectangular entry gap is easier for crabs to pass through compared to other combinations.

Keywords: elliptical gap, folding trap, mesh size, rectangular gap, slope angle

ABSTRAK

Bubu lipat rajungan banyak digunakan oleh nelayan Indonesia karena mudah dibuat, dioperasikan. Hasil pengamatan menunjukkan bahwa rajungan sering mengalami kesulitan ketika melewati lintasan masuk, karena kaki-kakinya terperosok ke dalam mata jaring. Duri-duri pada sisi badannya sering tersangkut pada benang jaring, karena celah masuk terlalu sempit. Akibatnya adalah peluang rajungan terperangkap menjadi sangat rendah. Tujuan penelitian pertama adalah memperoleh kombinasi sudut kemiringan dan ukuran mata jaring lintasan yang mudah dilewati rajungan. Penelitian mencoba mengombinasikan antara sudut lintasan 20°, 30°, dan 40° dengan ukuran mata jaring 0,125", 0,35", dan 1,25". Adapun tujuan kedua adalah menentukan celah masuk berbentuk elips atau persegi panjang yang mudah dilalui oleh rajungan. Penelitian skala laboratorium dan data hasil penelitian diuji secara parametrik dengan analisis ANOVA dua arah dan Tukey. Hasil penelitian menunjukkan kombinasi sudut 20° dan ukuran mata jaring 0,125" merupakan konfigurasi terbaik, karena sebanyak 26 rajungan dapat melewati celah masuk. Kombinasi berikutnya, 20° (0,35") dan 30° (0,125") masing-masing dilalui oleh 25 rajungan. Sebanyak 369 individu (63,6%) dapat melewati celah persegi panjang, sedangkan 211 individu (36,4%) lainnya melewati celah elips. Kombinasi sudut 20° dan ukuran mata jaring 0,125" dengan bentuk celah masuk persegi panjang lebih mudah dilewati rajungan dibandingkan dengan kombinasi lainnya.

Kata kunci: bubu lipat, celah elips, celah persegi panjang, sudut lintasan, ukuran mata jaring

INTRODUCTION

The blue swimming crab (*Portunus* sp.) is known for inhabiting the bottom of coastal waters. Therefore, various types of fishing gear operating at the bottom can catch blue swimming crabs. Some of these include set-bottom gillnets, seine nets, rampus nets, Danish seiners, and crab traps (Wagiyo *et al.* 2019). Blue swimming crabs are bycatch in apolo nets, rampus nets, and cantrang nets (Wahyu *et al.* 2008). Blue swimming crab nets, also known as kejer nets, and folding crab traps are specifically designed for catching blue swimming crabs (Bayyinah and Nurkhasanah 2020).

Crab nets and folding crab traps are well-known among Indonesian fishermen and are used in various coastal waters (Puspito 2013). However, folding crab traps have several advantages that crab nets do not. They trap live crabs, which results in a higher selling price compared to crabs caught in crab nets, which tend to be damaged, even though the number is smaller. Another advantage is that the traps are easy to make due to their simple shape and readily available materials (Puspito 2009).

The folding trap is not an Indonesian fishing gear but rather originated from other countries, namely Japan and England (Archdale *et al.* 2006). Indonesian fishermen adopted it to catch blue swimming crabs; hence, the name changed to the folding crab trap. Its construction is straightforward, shaped like a block with two entrances located on both narrow surfaces (Utami *et al.* 2021). The ratio of length to width and height of the trap is 1.38–1.59 and 2.32–3.00, respectively (SNI 8085:2022). Non-uniformity is observed at the entrance, which significantly impacts the success of blue swimming crab fishing operations using the folding trap (Wijayanti *et al.* 2018; Aditya *et al.* 2020; Susanto *et al.* 2021). The entrance consists of a trajectory angle α, the mesh size (ms) of the trajectory, and the shape of the entrance slit.

Direct observation of the behaviour of blue swimming crabs as they passed through the entrance revealed two problems. The crabs' legs became trapped in the mesh of the net as they crawled along the path. Furthermore, the crabs' bodies became entangled in the net threads as they moved along the wall toward the entrance of the trap. These problems resulted in the crabs having difficulty entering or becoming trapped inside the folding trap. Therefore, a study of the entrance was necessary to ensure the trap was easily accessible to the crabs. The objectives of the study were 1. to determine the angle and mesh size of the path that was easily accessible to the crabs, and 2. to determine the gap that was easily accessible to the crabs for entering the trap.

Many researchers have studied the construction of folding traps, with a primary focus on catching mud crabs and blue swimming crabs. Research specifically designed to determine the entrance to a folding blue swimming crab trap has yielded varying results. Wijayanti *et al.* (2018) concluded that a good trap is one with a 30° traverse angle and a 1.50-inch mesh size. Mahiswara *et al.* (2018) found that the most effective mesh size to be 2 inches. Aditya *et al.* (2020) and Susanto *et al.* (2021) obtained different results, stating that the optimal angle and mesh size for a folding crab trap are 40° and 1.25 inches, respectively. However, the differences in previous research indicate that there is no consensus on the optimal entrance for a folding crab trap. Therefore, further research is needed to re-examine 1. the combination of the slope angle and mesh size of the traverse, and 2. the shape of the entrance gap, specifically between elliptical and rectangular, to determine an entrance shape that is easy for crabs to pass through.

METHODS

Time and location

The research was conducted between January and May 2025 at the brackish water hatchery of the Pariaman Secondary Fisheries Business School (SUPM), Padang Pariaman Regency, West Sumatra Province. All research activities were conducted on a controlled laboratory scale.

Tools and materials

The equipment used in the research included a crab holding tank measuring 280×250×100 (p×l×t) (cm), an aquarium measuring 120×50×50 (cm), two units of folding traps with elliptical and rectangular inlets, a 1 Hp blower, an aerator, a 6-inch digital calliper, a 1 kg digital scale, a 3 m measuring tape, a 30 cm ruler, a protractor, a hacksaw, scissors, a net needle, 9 CCTV units, and one laptop unit. The research materials consisted of 136 star crabs, trash fish feed, seawater, netting, a 0.35-inch mesh polyethene (PE) multifilament net, a 1.25-inch PE multifilament net, 210d/6 PE thread, and a 47×20×0.6 (p×l×Ø) (cm) galvanised iron frame.

Research design and procedures

The study consisted of two stages, namely (1) determining the entry path consisting of the angle of inclination and the mesh size of the trap net, and (2) determining the construction of the entry gap. Both stages of the study were conducted using an experimental method. The experimental design used a completely randomised design (CRD) to evaluate the effect of treatment variations on the success of crabs passing through the entry path and the shape of the folding trap entry gap. The CRD was chosen because it allows for objective and systematic analysis of the effects of the variables being tested.

The research sequence began with determining the proportional width and thickness of the crab carapace. The goal was to ensure that the crab samples were of normal size. The crab samples consisted of crabs of suitable catchable size (LT) and those of unsuitable catchable size (TLT). According to the Regulation of the Minister of Maritime Affairs and Fisheries Number 7 (2024), suitable catchable crabs have a carapace width (l) of ≥10 cm. The following research stage was determining the entrance to the folding trap.

Stage 1. Folding trap entry route

Determining the entrance path of the folding trap began by creating a combination of the slope angle and mesh size of the path. Both sizes were adjusted to the traps commonly used by fishermen. The slope angle sizes were 20°, 30°, and 40°. The mesh sizes consisted of 0.125”, 0.35”, and 1.25”. Thus, the combination of slope angle and mesh size of the path used for treatment was 20° and 0.125”, 20° (0.35”), 20° (1.25”), 30° (0.125”), 30° (0.35”), 30° (1.25”), 40° (0.125”), 40° (0.35”), and 40° (1.25”). The test was carried out in the following sequence:

1. Nine blue swimming crabs of various sizes were placed in an aquarium equipped with a 20° angled net with a 0.125” mesh size;
2. The blue swimming crabs were positioned in front of the net, and bait was placed behind it (Figure 1).
3. The blue swimming crabs’ activity was observed for 30 minutes;
4. The number of blue swimming crabs that passed through and were retained by the net was counted;
5. The same test was repeated three times with different blue swimming crabs; and
6. The next test used eight other combinations, with the seawater replaced first. The goal was to maintain clean and clear seawater quality, avoid bait odour contamination, and prevent sedimentation of blue swimming crab waste.

Stage 2. Entry gap

The second stage of research involved testing the shape of the entrance gap that would be easy for crabs to pass through. The two entrance gap shapes tested were elliptical and rectangular. Fishermen commonly use the elliptical shape, so it has no fixed dimensions and tends to narrow. The rectangular gap is adapted to the flat and wide shape of crabs. The research sample consisted of crabs of various sizes, ranging from 8.00 to 12.20 cm. The testing sequence was as follows:

1. A trap with an elliptical opening was positioned in the centre of the aquarium. The angle and mesh sizes were adjusted according to the results of the first phase of the study;
2. A total of 30 blue swimming crabs, consisting of 15 LT and 15 TLT individuals, were placed in front of the trap, and bait was suspended inside (Figure 2);
3. The blue swimming crabs’ activity was observed for 30 minutes;
4. The number of blue swimming crabs that passed through and were retained at the entrance was counted;
5. The test was repeated 20 times using different blue swimming crabs; and
6. The next test used a rectangular opening.

Data analysis

Determining the proportionality of the blue swimming crab sample size using the carapace width (l) and the carapace thickness (t) data. Both data sets were plotted in graphical form. The relationship between the carapace width and carapace thickness was depicted in the form of a simple linear regression line and analyzed descriptively and comparatively. The equation used the following formula (Steel and Torrie 1981):

$$t = a + bl$$

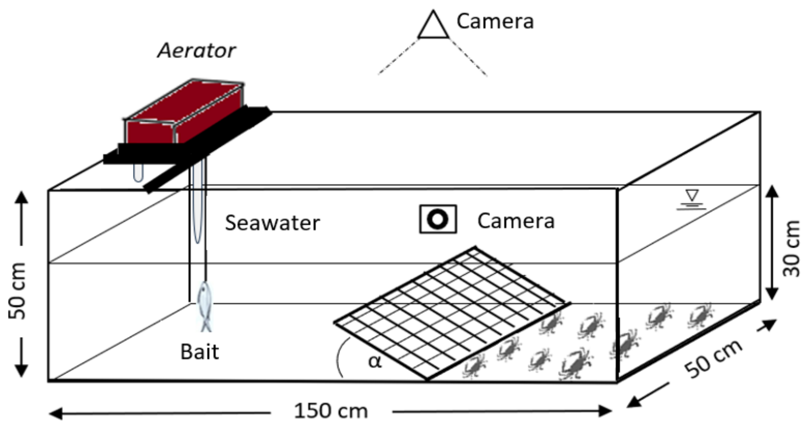

Figure 1. Illustration of the position of the track between the blue swimming crab and the bait.

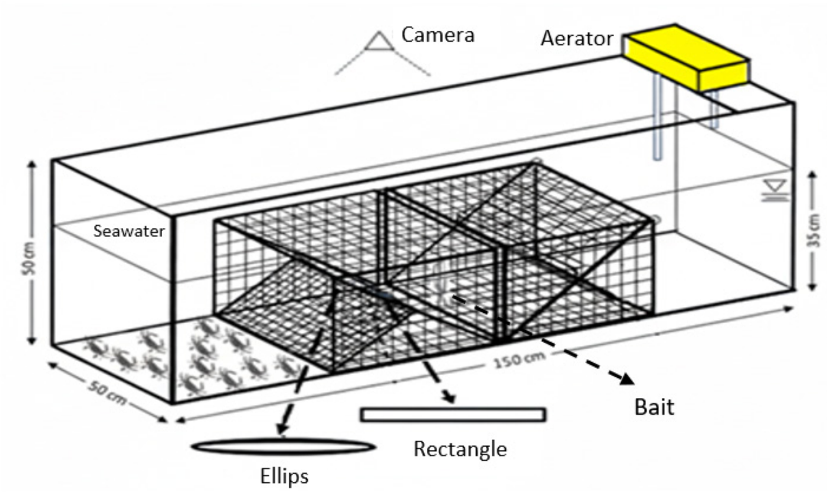

Figure 2. Illustration of the position of the folding trap entrance between the blue swimming crab and the bait.

Parameter a describes the point where the curve intersects the vertical t-axis (intercept), while b is the slope coefficient of the regression line (slope). The results of the regression analysis are interpreted through the correlation coefficient (r) and determination coefficient (R^2) values. The r value is used to measure the strength and direction of the linear relationship between the thickness and width of the crab carapace, while R^2 indicates the proportion of variation in crab carapace thickness. The R^2 value ranges from 0 to 1. The independent variable is able to explain the dependent variable well if the R^2 value is close to 1. Conversely, a smaller R^2 value indicates that the independent variable is less effective in representing the dependent variable (Ghozali 2016).

Analysis of the first and second research stages was conducted using a parametric ANOVA test using a completely randomised design (CRD). The RAL method was used to compare the success rate of blue swimming crabs passing through various angles of inclination and mesh sizes of the entrance paths of different folding traps. According to Mattjik and Sumertajaya (2006), the linear model is.

$$Y_{ij} = \mu + \tau i + \varepsilon ij$$

The hypothesis consists of 1. H0: $\tau 1 = \tau 2 = \tau 3 = \ldots = \tau 9 = 0$, or the treatment does not affect the observed path combination, and 2. H1: There is at least one treatment that affects the path combination $\tau i \neq 0$.

Further data were analyzed using IBM SPSS Statistics v.31 through a two-way analysis of variance (ANOVA) with replications. Replications were conducted to evaluate the influence of mesh size and trajectory angle α on the observed variables. The test was intended to determine the main effect of mesh size, the main effect of trajectory angle, and the interaction between mesh size and trajectory angle. If the ANOVA results showed a significant difference, the analysis was continued with a post hoc test using the Tukey HSD (Honest Significant Difference) method to identify treatment pairs that showed significant differences. Data on the shape of the entry gap were analysed using the Chi-square test (X^2) to determine whether there were differences in catch distribution between the two types of gaps. Meanwhile, binary logistic regression analysis was used to analyze the probability of catchable crabs through the two kinds of gaps.

RESULTS AND DISCUSSION

Proportional crab size

A total of 136 individual of crab were sampled, consisting of 71 individuals suitable for capture and 65 individuals unsuitable for capture. The relationship between carapace thickness and width is demonstrated by the regression equation t = 0.2786 + 0.2118l (Figure 3). The correlation coefficient (r) is 0.92, indicating a very close relationship between the two (Ghozali 2016). Therefore, the study can be conducted and the results can be analysed, as all crabs are of normal or proportional size.

The regression results showed that carapace width plays a significant role in explaining variations in carapace thickness of crabs with R^2 = 0.85. This means that approximately 85% of the variation in carapace thickness can be explained by carapace width, while the remainder is influenced by other factors outside the model (Kalsum and Dimenta 2023). The strong positive relationship between the two morphometric parameters indicates a balance in the width and thickness of the crab carapace, so the data obtained are considered representative to support the research. In accordance with the opinion of Rasheed and Mangal (2024), the growth of carapace width and thickness occurs in a balanced or proportional manner, with a correlation coefficient of R2 = 0.98.

Folding trap entry route

The swimming crab is a type of crustacean with a flattened body and five pairs of legs. Each pair consists of one pair of chelipeds or pincers, three pairs of walking legs, and one pair of swimming legs (Sunarto 2012). The pointed tips of the walking legs, which are similar to those of the blue swimming crab (Miswar *et al.* 2017), cause the crab move slowly when crawling along the surface of the waterbed. The paddle-like swimming legs enable the crab to swim actively (Hartnoll 1971; Schmidt *et al.* 2020).

Research conducted by Azra *et al.* (2018) indicates that swimming legs are utilised for vertical movement or swimming within the water column. Movement of the blue swimming crab on uneven or inclined surfaces is expected to be difficult. The success of blue the swimming crab through the inclined passage is influenced by the angle of inclination and the mesh size of the passage. Zhang *et al.* (2023), Ludirosari *et al.* (2025), and Park *et al.* (2025) added that determining the angle of the folding trap trajectory should be based on its movement behaviour.

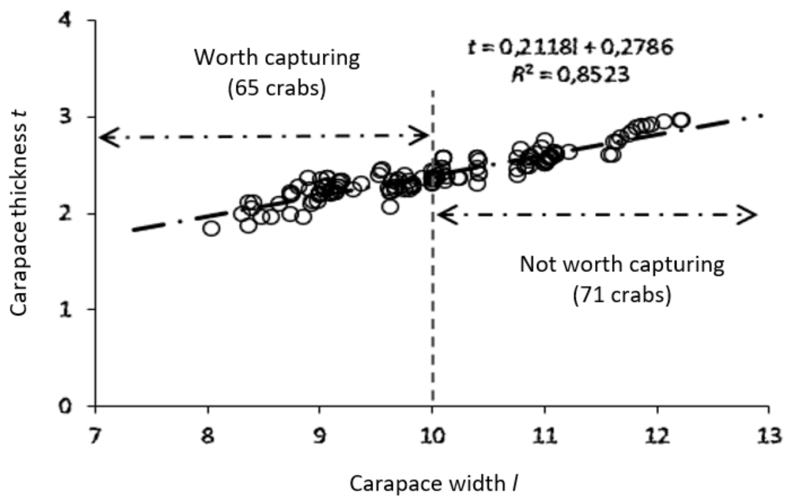

Figure 3. Relationship between thickness and width of crab carapace.

The results of the literature review explain that an angle of 30° is the best angle for the trajectory of a folding crab trap (Wijayanti *et al.* 2018). Different opinions were expressed by Aditya *et al.* (2020) and Susanto *et al.* (2021), who recommended a 40° angle for the folding trap. Based on the experimental results, the slope angle of the track significantly influenced the ability of the crabs to pass through it. The 20° track angle was successfully passed by 73 crabs, followed by 30° (59 crabs) and 40° (46 crabs) (Figure 4). The results of statistical tests also showed that the number of crabs that could pass through the 20° angle was significantly different from those that could pass through the 30° and 40° angles ($p < 0.001$). The number of crabs that could crawl through the 30° angle was also significantly different from the 40° angle ($p < 0.001$). This means that the chance of the crabs being able to pass through the track is greater if the angle is smaller. The results of direct observation proved that crabs tend to be more active in moving by crawling. Furthermore, the crabs will rely on their swimming legs when passing through the track at a large angle. Thus, the trajectory with a large angle becomes an obstacle to the crabs crawling movement.

The mesh size of the traverse is actually one of the factors that influence crab movement, in addition to the traverse angle. SNI 8085:2022 standardizes the traverse mesh size at 1.25”–1.50”. Susanto *et al.* (2021) reinforce this by stating that a 1.25” mesh size is more appropriate for the traverse angle of a folding crab trap. However, test results show that crabs actually experience difficulty navigating traverses with a 1.25” mesh size. The data obtained showed that the number of crabs that could pass through the path with a mesh size of 1.25” was only 50 individuals, 0.35” (59 individuals), and 0.125” (69 individuals) (Figure 5). The leading cause is that the crabs have a tapered foot shape. The movement of the crabs often stops because their walking legs get stuck in the mesh, and their swimming legs are difficult to move because they get caught in the net thread (Figure 6). Statistical testing also showed that the number of crabs that could pass through the mesh size of 0.125” was significantly different from 0.35” and 1.25” ($p < 0.001$). Meanwhile, the number of crabs that could pass through the mesh size of 0.35” was not significantly different from 1.25” ($p = 0.085$). Thus, the chance of success of crabs passing through the mesh size of 0.125” is greater than 0.35” and 1.25”.

The study successfully identified the best combination of slope angle and mesh size of the track. The statistical test results showed a significant difference between treatments at a 95% confidence level with an F count (8.298) > F table (2.070). The combination of a 20° slope angle with a mesh size of 0.125” was the easiest for crabs to pass through. The total number of crabs that passed through was 26 individuals, or an average of 2.89 individuals per trial (Figure 7). Next, the following sequence was 20° and 0.35” (25 individuals), 30° and 0.125” (25 individuals), 20° and 1.25” (22 individuals), 30° and 0.35” (19 individuals), 40° and 0.125” (18 individuals), 40° and 0.35” (15 individuals), 30° and 1.25” (15 individuals), and 40° and 1.25” (13 individuals).

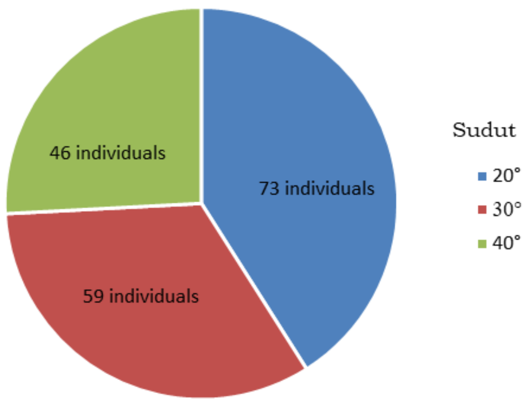

Figure 4. Number of crabs that can pass through angles of 20°, 30°, and 40°.

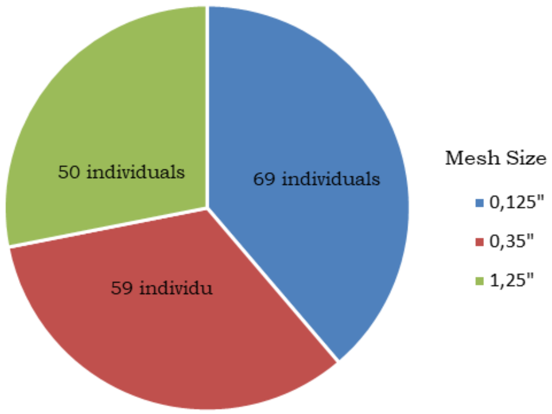

Figure 5. Number of crabs that can pass through the track with mesh sizes of 0.125”, 0.35”, and 1.25”.

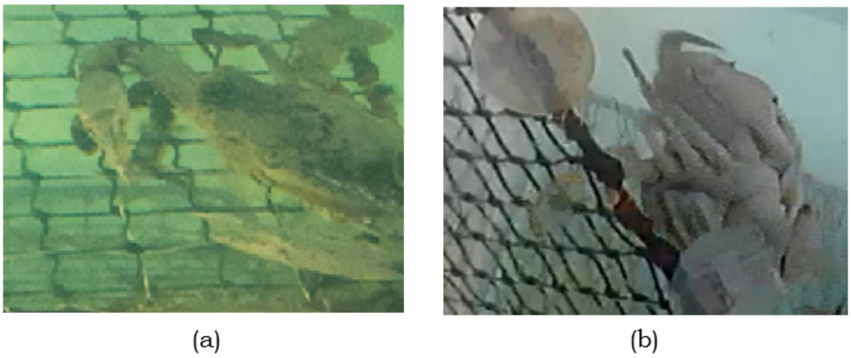

Figure 6. Walking legs (a) and swimming legs (b) caught in the net.

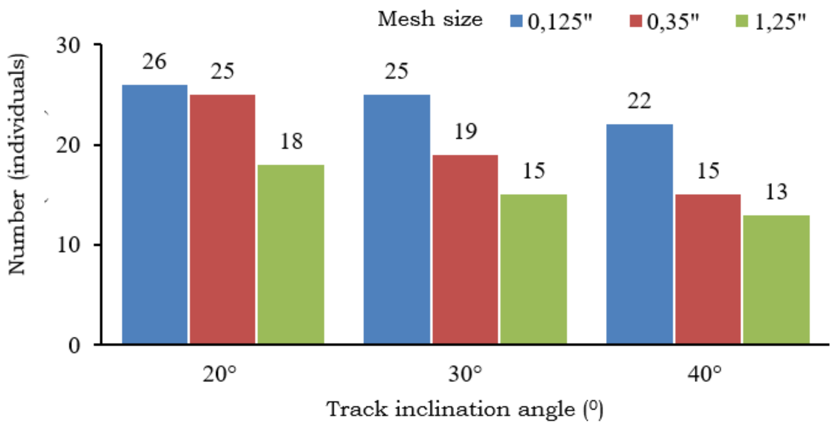

Figure 7. The number of crabs that can pass through the track based on the combination of the angle of inclination and the mesh size.

Entry gap

The entrance gap test used a 0.125” mesh size with a slope angle of α = 20°. The entrance gap was elliptical and rectangular. The highest part of the unstable ellipse ranged from 0.5 to 7.3 cm. The rectangular entrance gap had a height of t = 2.5 cm, or greater than the carapace thickness of crabs suitable for capture (t > 2.3 cm), to allow easy passage for all crab sizes. According to Zulkarnain *et al.* (2019), the entrance gap is the part of the folding trap entrance that is last passed by the crab. Based on the experimental results, the narrow shape of the gap significantly affected the crab’s ability to pass through. Only 211 individual of crab successfully passed through the elliptical gap. A total of 86 crabs, or 40.8% of all crabs, were suitable for capture (LT), and 125 individual of crab (59.2%) were not suitable for capture (TLT). The number of crabs that successfully passed through the rectangular gap reached 369 individuals. Approximately 49.6% (183 individuals) had LT size, and 186 individuals (50.4%) had TLT (Figure 8). The difference in the number of crabs that passed through the rectangular gap compared to the elliptical gap was significantly different, with the F count value of 148.316 > F table 4.098 and the significance $p < 0.05$. The results of the Chi-square test (X^2) explained that the distribution of the number of crabs that could pass through the elliptical and rectangular gaps was 36.4% and 63.6%, respectively. This means that the number of crabs that could pass through the rectangular gap was 1.43 times more than the number that could pass through the elliptical gap.

The success of swimming crabs in passing through the opening of a folding trap is determined by the shape of the entrance. Fishermen typically use elliptical openings that narrow at both ends and widen in the middle. Rectangular openings in folding traps are uncommon. Zulkarnain *et al.* (2011) stated that the shape of the entrance affects the ease with which swimming crabs can enter the folding trap. Therefore, the shape of the opening must be adapted to the crab's movement behaviour (Hasanah *et al.* 2017).

Direct observations indicate that the difficulty swimming crabs face when passing through the opening of a folding trap is primarily influenced by their movement patterns and body morphology. Their movements always veer to the left or right, as the segments between their walking legs are connected by fold joints (Sunarto 2012). The part of the crab's body that hinders their movement through the opening is the marginal spine on the carapace (Figure 9).

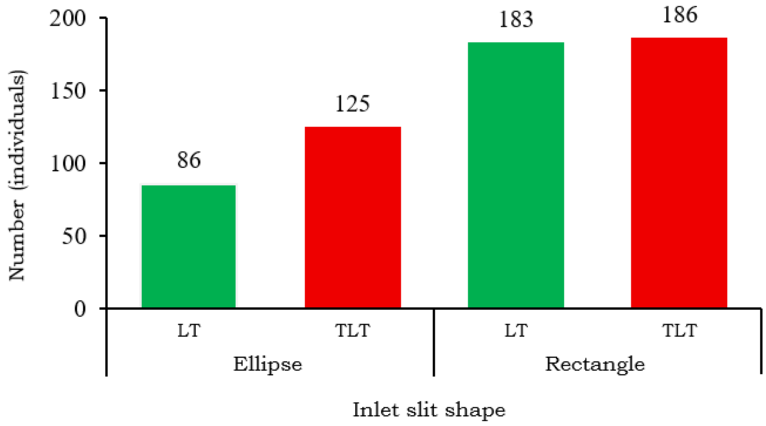

Figure 8. Number of crabs passing through the entrance gap.

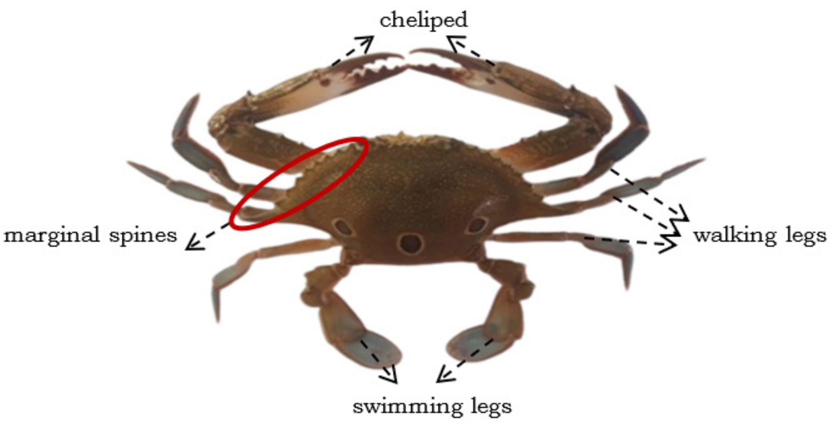

Figure 9. Walking legs, swimming legs, and marginal spines of the swimming crab.

The movement of the swimming crab toward the entrance of the folding trap consists of three patterns, namely heading directly to the center and to the left or right of the gap. The swimming crab can move directly toward the corner of the gap or hit the wall and follow the wall toward the corner of the gap (Figure 10). The swimming crab can directly pass through the elliptical gap when its movement is directed straight to the centre of the gap, where the gap opening is wider. Furthermore, the movement of the swimming crab along the wall or directly toward the corner of the gap will be blocked at the end of the narrowing gap. The swimming crab will have more difficulty passing through the gap because its marginal spines get caught in the net. The same movement pattern also occurs when the swimming crab passes through the rectangular gap. The difference is that the swimming crab can pass through the rectangular gap from any position.

The weakness of both folding trap entrances lies in the height of the end of the track. The angle of inclination α = 20° with a track length of 20 cm results in an entrance height of only 6.84 cm. Crabs of various sizes can easily escape from the folding trap. The rectangular gap allows crabs to pass through from all positions, while the elliptical gap only has a wide centre. Therefore, the rectangular gap is more feasible to use in folding crab traps than the elliptical one. Furthermore, efforts to prevent crabs from escaping are carried out by installing grids along the entrance gap, such as the shape of the entrance gap designed by Puspito (2013, 2015) (Figure 11). The top and bottom sides of the gap are equipped with 6 mm diameter iron rods as retaining fingers (grids). The distance between the two iron rods is made equal to the gap height t = 2.5 cm. The length of the diagonal of the rectangle formed between the grids and the iron rods is set at 4.3 cm, or equal to the carapace length of the smallest catchable crab. The goal is to prevent the crab from escaping from the folding trap, either horizontally or obliquely. This ensures a 3.5 cm spacing between the grids. Meanwhile, installing the grid support rods in the elliptical gap is difficult. The gap's unstable construction and curved shape make the grids difficult to shape and prevent them from completely sealing the entry gap.

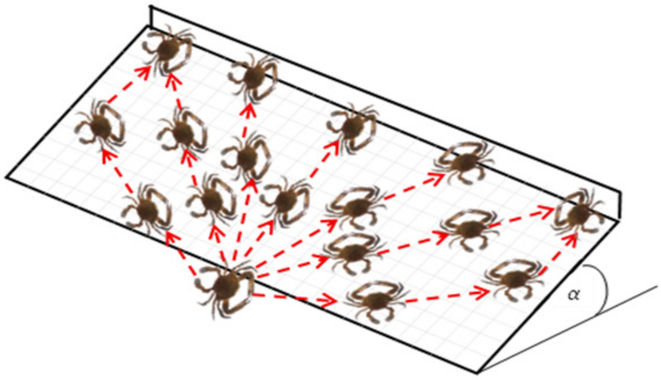

Figure 10. The direction of movement of the crab towards the entrance of the trap.

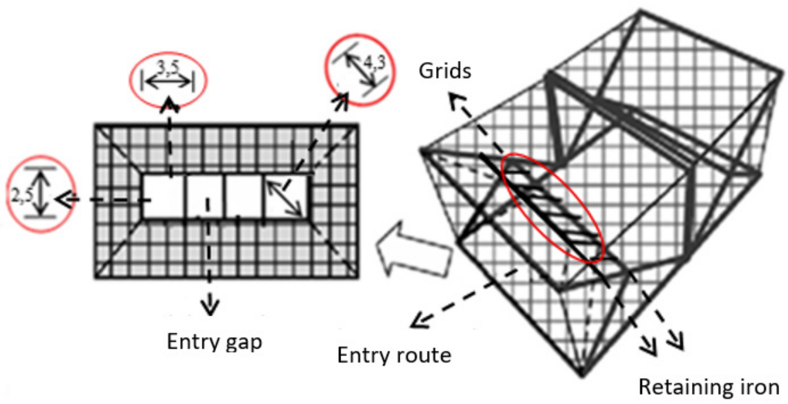

Figure 11. Position of grids on the folding trap (Puspito 2014).

CONCLUSION

Research has identified the best configuration for a folding trap entrance based on the angle of inclination and mesh size of the passage. Results indicate that a passage angle (ɑ) of 20° with a mesh size (ms) of 0.125” is the most effective combination and allows for easy passage for crabs. In other words, a smaller trajectory angle (ɑ) and mesh size (ms) combination makes it easier for crabs to pass through. The shape of the entrance gap also significantly influences the success of crabs entering the folding trap. Rectangular gaps was proved more effective than elliptical gaps, with a 1.43-fold higher success rate. This difference are influenced by the crabs’ lateral (sideways) movement patterns and the presence of marginal spines on the sides of the carapace, which often get caught in narrow gaps. Rectangular gaps allow crabs to pass through from a variety of positions, while elliptical gaps are only adequate in their widened centre.

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