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Design of entrance and escape gaps in collapsible trap for mangrove crabs *Scylla* sp.

Gondo Puspito

Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor 16320, Indonesia. Corresponding author: G. Puspito, gpuspito@yahoo.com

Abstract. Research was done to obtain entrance and escape gaps design that enable all size of mangrove crabs (*Scylla* sp.) entered and let the small sized crabs out. Both gaps were made from rectangular-shape metal with 30 cm length. Entrance gaps and escape gaps width are 7 cm and 3.3 cm respectively, because the smallest of adult crabs carapace thickness is 3.3 cm. Gaps were equipped by 10 triggers with 8 cm and 5 cm length, in order to avoid crabs going in and out trap easily. The experiment has used 2 new designed traps and 2 standard traps which were usually used by fishermen. Entrance gaps of fishermen traps only have oval shape with uncertain width. The four traps were sunk in to a water tank which contained 16 adult and 11 small crabs for 20 minutes long. Within 20 times experiments, the new designed traps caught 127 crabs while only 13 crabs for the standard one. Furthermore, escape gaps test was done by putting 5 adult and 5 small crabs in to 2 new designed traps. By 3 trials all of small crabs could escaped.
Key Words: trigger, mangrove crabs, *Scylla serrata*.

Abstrak. Penelitian ditujukan untuk mendapatkan rancangan celah masuk perangkap lipat yang mudah dimasuki oleh semua ukuran kepiting bakau dan rancangan celah keluar yang dapat membebaskan kepiting berukuran kecil. Rancangan kedua celah dibuat berbentuk 4 persegi panjang dengan panjang 30 cm. Lebar celah masuk ditetapkan 7 cm atau lebih dari ketebalan karapas kepiting dewasa sebesar 3,3 cm. Adapun lebar celah keluar 3,3 cm. Masing-masing celah dilengkapi 10 trigger dengan panjang 8 cm dan 5 cm. Ini dimaksudkan agar kepiting tidak dapat keluar masuk celah. Uji celah masuk menggunakan 2 perangkap dengan rancangan celah masuk baru dan 2 perangkap standar. Selanjutnya, keempat perangkap dimasukkan ke dalam bak air yang sudah diisi 16 kepiting dewasa dan 11 kepiting kecil selama 20 menit. Dari 20 kali pengujian, perangkap dengan rancangan celah masuk baru mampu memerangkap 127 kepiting, atau 980% dari perangkap standar yang hanya mendapatkan 13 kepiting. Selanjutnya, pengujian rancangan celah masuk dilakukan dengan memasukkan 5 kepiting dewasa dan 5 kepiting kecil ke dalam 2 perangkap yang dilengkapi dengan celah keluar. Dari 3 kali pengujian, seluruh kepiting berukuran kecil dapat membebaskan diri keluar dari perangkap.
Kata Kunci: Celah masuk, celah keluar, trigger, perangkap lipat dan kepiting bakau.

Introduction. Collapsible trap is a trap which catches crabs (*Scylla* sp.) and swimming crabs (*Portunus* sp.), newly recognized by Indonesian fishermen. Its byproduct catches are bottom organisms such as lobster, shrimps and snails. This trap types originated from UK and Japan. According to Archdale et al (2006), British fishermen call it a box-shaped pot, while Japanese fishermen named it “kagotoku shiroyama kenmousha”. Its shape resembles to a beam composed by wires with a diameter of 3 cm. The entire body is covered by net. On both sides there is a gap of entrance.

The utilization of collapsible trap is increasingly widespread because it has many advantages compared to other fishing gear. Almost the whole catch is usually still alive so it has a high selling price. Other advantages of the trap are the materials which can be obtained easily, low cost of manufacturing, easy and inexpensive maintenance, it is able to be operated in difficult locations, and it does not need a wide place in the boat since it can be folded and stacked.

The preliminary studies in laboratory showed that the main weakness of the collapsible trap is the entrance gap design which is in the form of narrow gaps-ellipse-shaped. It may cause a frequent stuck of the crabs because carapace thorns stuck on net. As the result, other crabs cannot get into the trap. Another weakness of the trap is that there are no escape gaps, which cause all size of crabs may caught without any selection. This fact will not support crabs resources sustainability.

Research was done to obtain entrance and escape gaps design that enable all size of mangrove crabs (*Scylla* sp.) enter and let the small sized crabs out. The whole research was conducted in the laboratory under controlled circumstances.

Several studies on the trap improvement have been reported by Archdale et al (2006) for the two different entrance gaps while the escape gaps have been described by Jirapunpipat et al (2008), Boutson et al (2005), and Winger & Walsh (2007, 2011). This study is a refinement of those five studies. The design of entrance gaps and escape gaps are based on the shape of carapace, size of carapace and behavior of the crabs.

Material and Method. The study begins with determining the proportionality of carapace size of 27 mangrove crabs *Scylla serrata*. Carapace width and body thickness data were collected to obtain the regression and correlation equation that describes the relationship between the carapace width and its thickness. The relationship closeness is determined by the value of correlation coefficient (r). If $r > 0.71$, the relationship is very close (Nugroho 2005) and the research can be proceed. Based on the equation, it can be determined the carapace thicknes of adult crab and use it as a base to determine the size of entrance and escape gaps. Measurement position of thickness and width of crabs carapace can be seen in Figure 1.

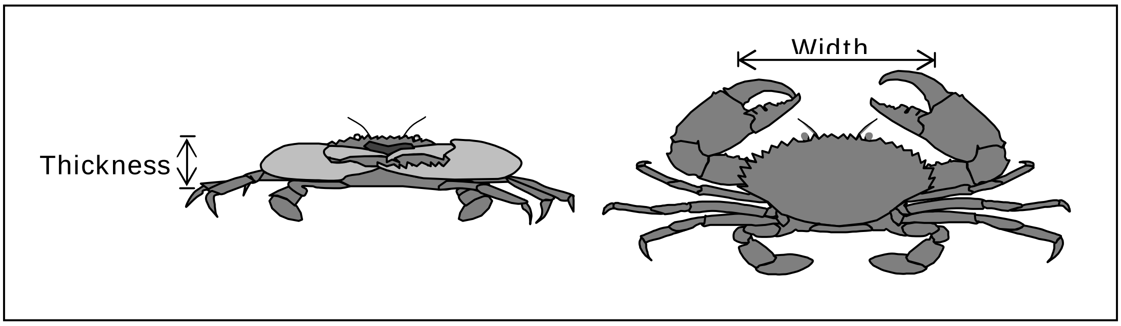


Figure 1. Position of crab carapace thickness and width measurement.

Next step of the research is to improve the design of entrance gaps and to equip the trap with escape gaps. Furthermore, both gaps then were being tested using experiment method. The entire study took place between January to March 2013 in Laboratory of Fishing Gear Technology, Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Bogor Agricultural University. Standard trap that is usually used by fishermen is presented in Figure 2. Its specifications are described in Table 1.

Table 1

Specifications for collapsible trap

No.	*Description*	*Specification*
1	Shape	Beam 50 × 30 × 15 (cm)
2	Cover	Polyethilene net of 210/D6; 1.25 inch of mesh size
3	Frame	Galvanized iron rod; ø 5 mm
4	Entrance gaps shape	Elliptical-shape narrow gaps; 30 cm length

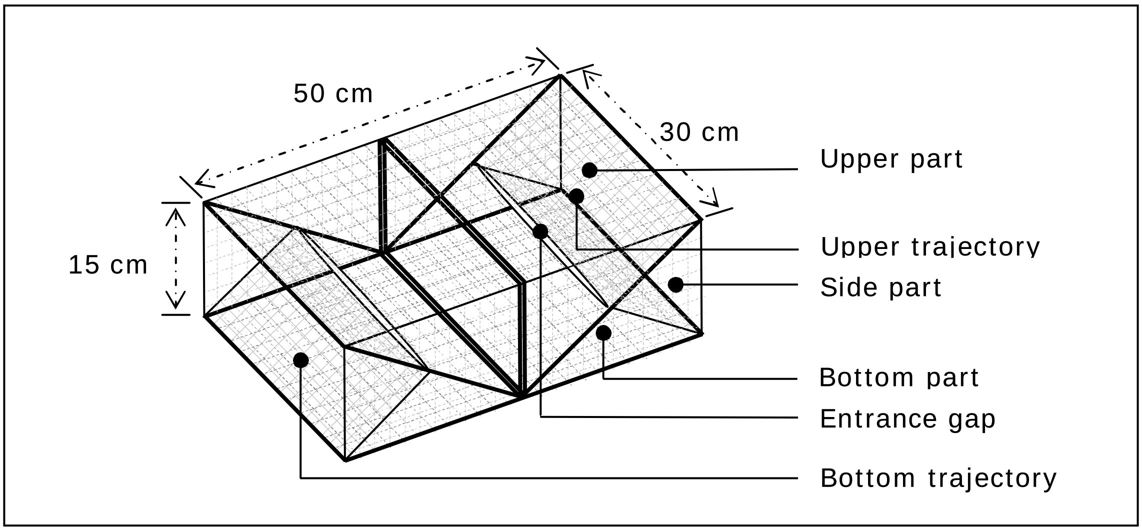


Figure 2. Collapsible trap and its parts.

Improvement of gaps entrance design. Gaps are designed in rectangular-shape, made of metal frame in 3 mm diameters. Gaps length is equal to the width of trap which is 30 cm. Width of gaps is made larger than carapace thickness of adult crab. Entrance gaps design of 2 standard traps at this stage are improved.

To examine the catch effectiveness, both traps with new design of entrance gaps were operated together with the two standard traps. The traps were sunk into 3.500 litres capacity of experiment water tank which was filled with 1.400 litres of seawater. The same traps were positioned facing each others. The test sequences are:

- the four traps were stuffed with rainbow shrimp *Penaeus semisulcatus* as bait and placed in the experiment water tank;
- a total of 27 crabs put into the experiment water tank;
- after 20 minutes of soaking, the number of crabs that get into each trap were calculated;
- test was carried out by 20 times replications with interchangeable trap position.

In Figure 3, it is explained the arrangement of traps in experiment water tank. Crabs that entered both type of traps were counted as the data and then presented in the form of graph and analyzed descriptively and comparatively.

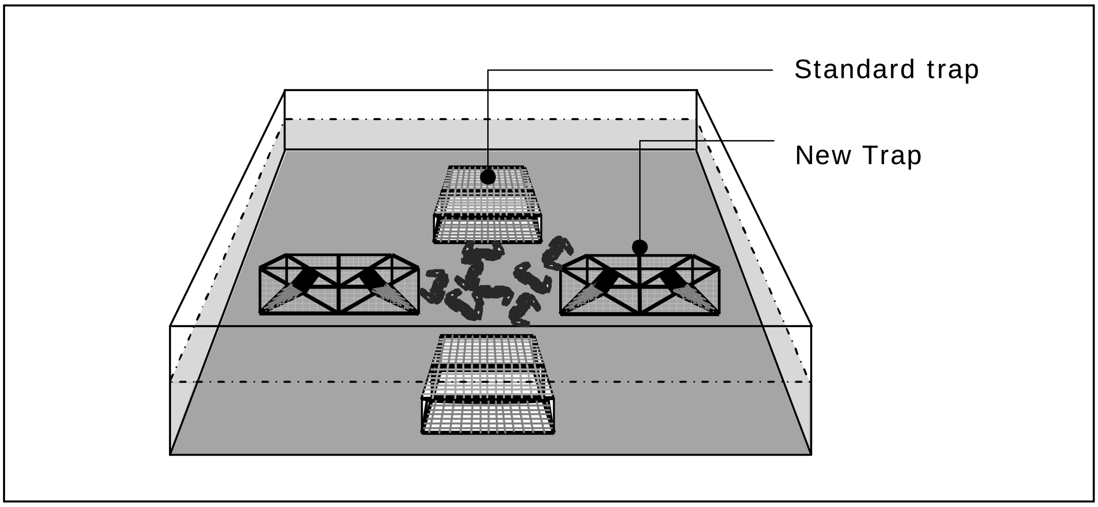


Figure 3. Illustration of traps composition in the experiment water tank.

Designing the escape gaps. Experiment is aimed to obtain design and placement position of escape gaps in trap. The escape gap is intended to let small crabs passing out.

Gaps are designed in rectangular shape. The width is adjusted to the smallest adult crab carapace thickness.

Determination of escape gaps is conducted in two ways. First, through the observation of the damage location in some traps owned by fishermen. Second, direct testing in laboratory by putting some crabs with various sizes in the trap for 20 minutes. Furthermore, the location used as a shelter by small crabs is determined. Escape gaps are made closer to those locations.

The effectiveness of the escape gaps is examined in experiment water tank. For this study 10 crabs were used, with carapace width of 10.7, 9.4, 10.8, 10.1, 10.1, 7.1, 7.8, 7.6, 6.3 and 6.5 cm, respectively. The test sequence is as follows :

- a total of 5 crabs are put into the first trap and the rest of them are put into the second trap;
- both traps are put into experiment water tank;
- bait of rainbow shrimp *P. semisulcatus* is stuffed around the traps;
- crabs that managed to get out of the trap are recorded;
- test was performed in 3 replications.

Proportionality of crab carapace's size. The relationship between thickness and width of crab carapace was used as experiment sample, described by regression equation $t = 0.352\ w + 0.377$ (Figure 4). Value of closeness relationship between those two is explained by correlation coefficient $r = 0.97$, or $r > 0.71$. It indicates that there is a very close relationship between thickness and the width of sample crabs carapace (Nugroho 2005).

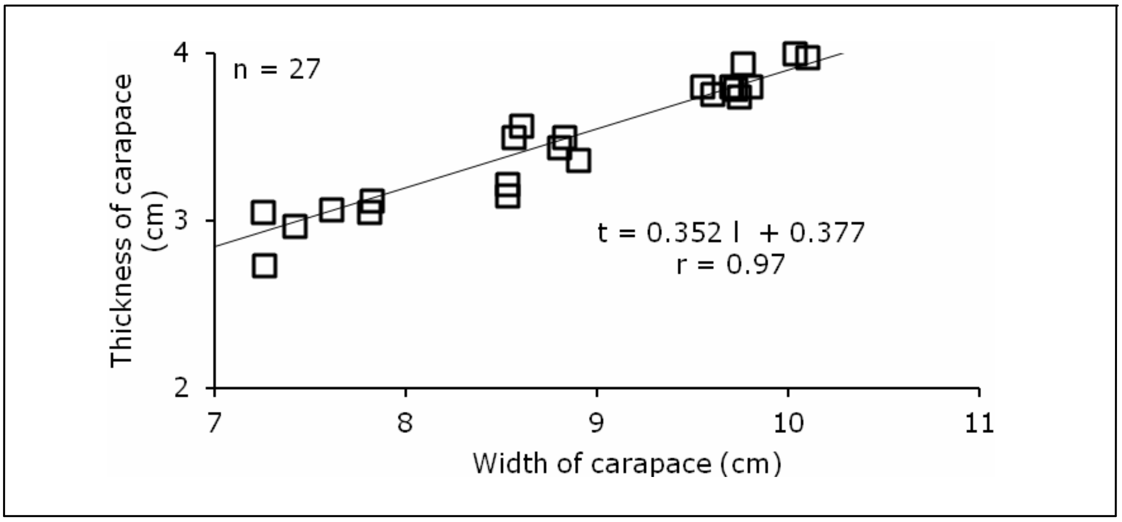


Figure 4. Relationship between thickness and width of crab's carapace used as experiment samples.

Width of entrance and escape gaps of trap. The observations in laboratory showed that crabs can pass through a gap if the width of the gap is slightly greater than the thickness of the carapace. In addition, the length of gaps should be larger than the width of carapace and the gaps width should be based on the thickness of the crab carapace.

In this study, the entrance gaps and escape gaps of trap are based on thickness of crab carapace. This value is difficult to obtain. References found only mentioned the width of adult crab carapace. According to Le Vay (2001), *S. serrata* crab has mature gonads for the first time or have become mature at carapace width of 8.3 to 14.4 cm. It means that the 27 crabs were used as research sample consisted of 16 adult crabs with carapace width more than 8.3 cm and 11 small crabs with carapace width less than 8.3 cm.

Based on regression equation in Figure 4, the thickness of adult crab carapace ranged from 3.30 to 5.45 cm. Therefore, the entrance gaps width should be designed of more than 3.30 cm, while the escape gaps width should be less than 3.30 cm. The lengths of both gaps are designed to be more than 14.4 cm.

Design of entrance gaps. Entrance gaps are designed in rectangular shape to make them easily passed by the crabs. They are located at the same position as standard entrance gaps in standard traps with a length of 30 cm. In this study the width of entrance gaps is set at 7 cm in order for all size of crabs can pass through easily (Figure 5).

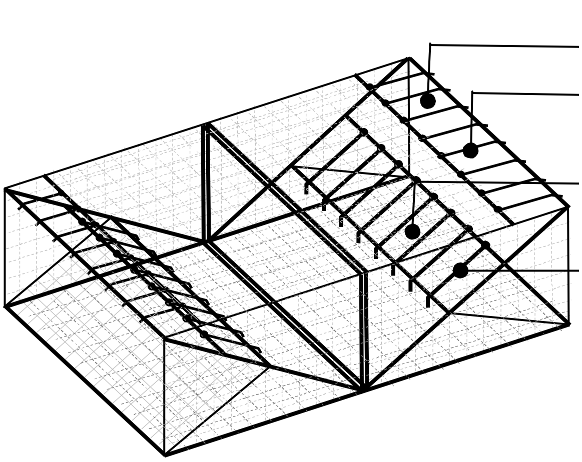


Figure 5. Designs of entrance gaps and escape gaps.

Crab is a very aggressive animal (Hill 1982). It can explore every part of trap by using its sharp legs assisted with swimming legs so that it can easily pass in and out a simple rectangular shaped entrance gap. Archdale et al (2007) proved that crabs can come and go through the tunnel-shaped entrance gaps. Jirapunpipat et al (2008) and Winger & Walsh (2011) proved that crabs can free themselves through the hole made in the wall of the net. Therefore, a row of iron rod or 'trigger' needs to be added along the sides over the gaps as a barrier in order that the crabs cannot pass out of the trap. In this study, each of 'trigger' is made from galvanized iron rod, in 3 mm diameters and 8 cm length. Ten triggers are set along side the gaps.

The testing of collapsible trap with the new entrance gaps compared with standard collapsible trap gives very different results. New trap caught 127 crabs, while the standard only caught 13 crabs (Figure 6). New collapsible trap is evidently easier to be accesed by crabs compared with the standard ones.

Based on direct observation, the crabs tend to move toward the entrance gaps down the wall of the trap. In the new trap, crabs can easily pass through entrance gaps by lifting 1 to 3 triggers. After the crabs fall in to the trap, trigger will be immediately closed down due gravitation. Crabs that are caught in the trap can no longer get away through the entrance gaps. This condition is different from the standard trap's condition. Generally, crab has difficulties to pass through the entrance gaps because its thorny claws and carapace are usually stuck on the net. This is similar to the results of Archdale et al (2006) that states ellipse-shaped gaps is difficult to be passed by crabs, because the thorns in its carapace and its claws will be stuck first in the net. The stuck crabs in the gaps will cause others can not pass through the gaps because of being blocked. In some cases, crabs avoid the trap because of seeing other crabs are caught in the entrance gaps. This has occured in replications 5, 7, 19, and 20, respectively.

Average number of crabs caught by new trap reached 4-5 individual/trap. This number is greater than the crabs caught by standard trap which only contained 1-2 individual/trap. Moreover, observations of the behavior of the trapped crabs showed that crabs have a solitary nature, they also have their own territory and they keep themseles away from other crabs (Warner 1997). The most favorite positions for the crabs are at the four corners of the trap. This is what caused number of catches of new trap reached

4-5 individuals. Thus, the operation of new trap by the same amount of standard trap could increase number of fisherman's catches nearly 100%.

The similarity between the new trap and the standard one is that the crabs trapped in it can not escape. The trigger at the entrance gaps of the new trap will block the crab movement out of the trap while on the standard trap which is of a narrow gaps and unstable – because it was not equipped with metal frame - made it difficult for crabs to pass through.

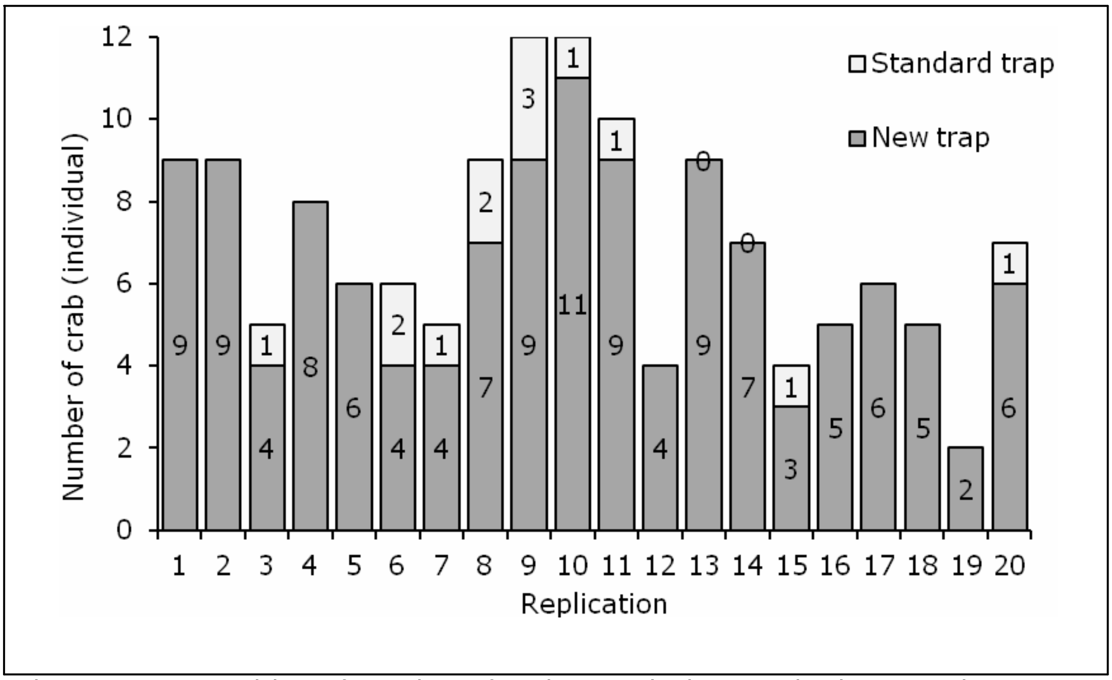
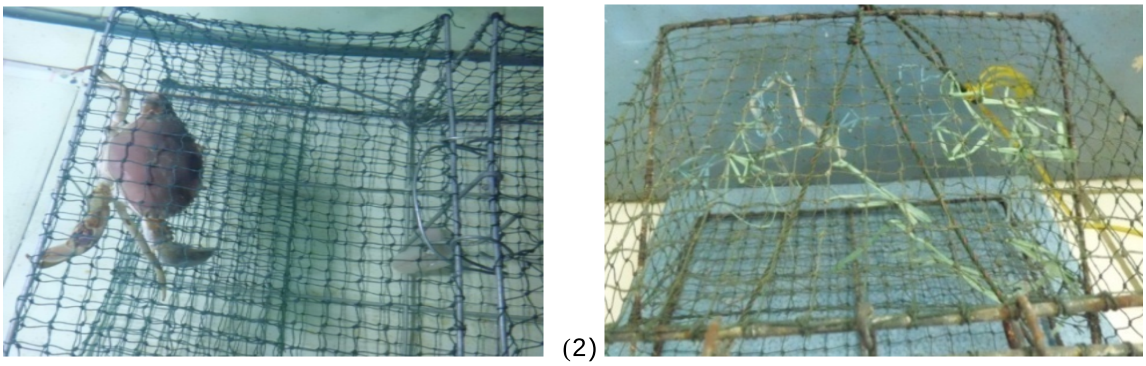


Figure 6. Composition of number of crabs caught by standard trap and new trap.

Escape gaps. This study is rather different from the researches which have been done previously by Jirapunpipat et al (2008), Boutson et al (2005), and Winger & Walsh (2007, 2011). In those studies, they designed a very diverse shape and size of escape gaps, and did not base it on the shape and size of small crab carapace. Escape gaps are not placed in the areas that are always inhabited by small crabs. Moreover, in those researches escape gaps were only a hole-shaped which can also serve as an entrance gaps, while in this study, escape gaps are in rectangular-shaped or adjusted to the shape of small crab carapace, therefore they are easy to be passed by. Placement of gaps is determined based on location on trap that has always inhabited by small crab. The using of trigger is intended to block the crabs that would enter from outside.

Based on laboratory observation, the trapped crabs tend to crawl all over the inside part of trap. If there are more than two crabs in the trap, the motion activities will increase and each crab would try to avoid the others. Small crabs would eschew and escape into the end of the upper trajectory (Figure 7-1). According to Nontji (1993), this is due to the nature of the crab cannibalism that frequently occurs, particularly in confined spaces, both for the adult crabs and the small crabs. Based on field observations, the nets on the upper trajectory often found ruined by crabs because the trap is always occupied by small crabs. Evidence of damage on those part can be seen in fishermen's trap that were fixed with plastic strap (Figure 7-2). Therefore, the most possible position of gaps placement is along the upper side at front of the trap.

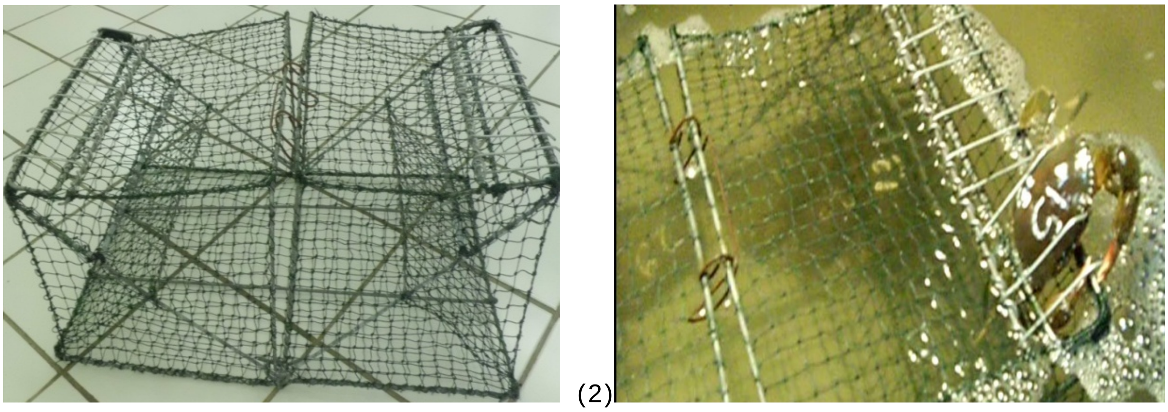
Width of escape gaps should be designed carefully because it is intended only for the passage of small crabs. Therefore, the width of escape gaps should be less than 3.3 cm. Thus, the size of escape gaps are 30×3.3 (cm). A total of 10 steel rods with 0.3 cm in diameter and 5 cm length, are used as triggers. The entire rods are being set on the line up outside of the gaps to prevent crabs from getting caught (Figure 5). Ten (10) crabs were used: 5 adult crabs with carapace width of more than 8.3 cm (10.7, 9.4, 10.8, 10.1, and 10.1 cm) and 5 small crabs with the carapace width of less than 8.3 cm (7.1, 7.8, 7.6, 6.3 and 6.5 cm).



(1) (2)

Figure 7. End of upper trajectory as the shelter for small crab eschew from adult crab (1) and upper trajectory nets of trap ruined by the crabs (2).

To test the escape gaps, a trap was filled with 3 adult crabs and 2 small crabs while the another is filled with 2 adult crabs and 3 small crabs. In 3 repetitions, it turns out that all small crabs could get out of the trap. All of adult crabs are retained in the trap. In Figure 8, it is shown the new modificated trap that are used in this research and the crab position while trying to free itself through the escape gaps.



(1) (2)

Figure 8. New trap used for testing the escape gaps (1), and position of small crab while trying to escape from trap (2).

Finally, the presence of escape gaps at the end could maximize the number of adult crabs caught in each trap. When any small crab could escape from trap, it will make space in it. As a result, crabs that are out of trap will be tempted to get into the trap. Miller (1990) stated that a large volume of space in the trap will increase number of catches.

Recommendations. The tests of both gaps design for collapsible trap in laboratory obtained a very satisfactory result. However, the location for the trap to be operated must be considered to ensure its effectiveness. Traps should be positioned on a flat surface of bottom waters. If the bottom waters surface contour is sloping or bumpy, traps installation should be in horizontal position. The slanted position of trap will lead the triggers on both gaps to be opened and causing the crabs to move in and out easily. In addition, trigger material should be made of galvanized iron rod or iron rod coated with plastic. Stain on iron trigger sometimes makes trigger difficult to close again.

Conclusions. Design of entrance gaps and escape gaps of collapsible trap are in rectangular-shaped, 30×7 (cm) and 30×3.3 (cm) sized. Each of them are equipped with 10 trigger in 3 mm diametres and 8 cm and 5 cm lengths.

New model of entrance gaps caught 127 crabs, or 980% compared to standard trap that only caught 13 crabs. Escape gaps could release all small crabs with carapace width of 7.1, 7.8, 7.6, 6.3, and 6.5 cm.

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Author:
Gondo Puspito, Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Bogor Agricultural University, Bogor 16320, Indonesia, e-mail: gpuspito@yahoo.com

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