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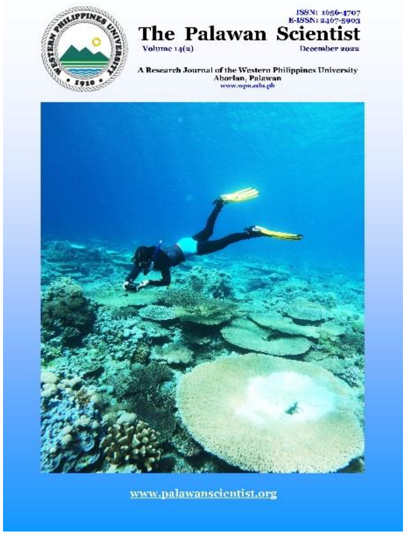

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Fishing trials using banana and fish baits in pots for catching marine crabs: an attempt to tropical selective crustacean trapping

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ABSTRACT

Experimental fishing targeting marine crabs was conducted using crab pots baited with overripe banana locally known as "latundan", which is a hybrid of *Musa acuminata* (Colla 1820) and *Musa balbisiana* (Colla 1820), and cardinal fish *Apogon lineatus* (Temminck and Schlegel 1842). This was done to assess the catch composition and to investigate the effect of the baits on the selective catching of the desired crab species, size, and sex during trapping operations. Four bait treatments were used: no bait (NB), banana (BB), fish bait (FB), and banana-fish combination (FB+). Results showed that the FB+ caught comparable *P. pelagicus* with FB in terms of numbers, and the catch of *T. sima* was about the same. Pots having NB or BB alone caught the fewest crabs during the trapping operations. The combination of banana and fish baits showed no significant difference in the number of crabs caught when using fish baits. *Portunus pelagicus* (Linnaeus 1758) and *Thalamita sima* (Milne Edwards 1834) dominated the catches among crabs comprising a total of 44.21% and 18.95%, respectively. In terms of crab size (carapace width), catches in pots baited with FB alone had smaller crabs in comparison to the catches in pots with FB+, but in *P. pelagicus* no statistical difference was detected. Moreover, FB+ showed gender neutrality for *P. pelagicus*, but more *T. sima* females than males were caught. This shows that banana combined with fish baits has intraspecific selective properties towards some crab species. Furthermore, the addition of bananas to fish baits seemed to decrease the number of non-target species caught. The overall high percentage of crabs caught in the pots baited with FB+ and FB means that these baits may have extra-specific potential in crab trapping thus reducing undesired species trapped in the pots. Furthermore, the inclusion of banana to fish as bait can be beneficial for future studies in resource management and the reduction of fish utilization as bait.

Keywords: banana baits, crab pot, *Portunus pelagicus*, selective fishing, *Thalamita sima*

INTRODUCTION

Economically important crabs are amongst the most exploited marine resources throughout the world due to their commercial demand. The crab *Portunus pelagicus* (Linnaeus 1758) is considered one of the most targeted m arine crustaceans because of its good quality meat among marine crabs. The species was reported to be one of the world's heavily-fished crab species (Permatahati et al. 2020). In the Philippines, this species is continuously harvested in the wild since hatchery for this commodity is not yet fully developed, although studies on the hatchery-related techniques on the species are being done elsewhere (Cabacaba and Salamida 2015). At present, *P. pelagicus* wild stocks are highly threatened and overexploited, yet few efforts have been done to control their extraction and this presents a challenge to the researchers collecting and trapping them since this is one of the sources of livelihood for fisherfolks. Hence intraspecies and extraspecific selective fishing on marine crabs must be done to conserve the resources.

However, selective fishing in tropical areas is very difficult to achieve. The tropical Philippine Sea has a magnitude of underwater organisms that may occupy the same space and time during foraging. This means that fishers and researchers cannot always get the desired species and size of the preferable target organisms during fishing. As a result, massive amounts of the by-catch were disposed of. Different designs of pots and other gears have been used to catch crabs and other crustaceans with high efficiency (Yamane and Fujiishi 1992; Zhou and Kruse 2000; Vazquez Archdale and Kuwahara 2005; Vazquez Archdale et al. 2006; Vazquez Archdale et al. 2007; Winger and Walsh 2007; de la Cruz et al. 2018; Glamuzina et al. 2021; Hanamseth et al. 2022). However, trapping gears may be generally unselective to some extent because they may catch non-target fishes and crustaceans with sizes that are not commercially viable and will result in high bycatch. Furthermore, entrances and exits of crab pots cannot always regulate the catching of smaller sizes. An alternate solution is to look in detail at the food habits of the target species and to study possible baits that might be used to increase catches of typical gears for crab trapping. Kawamura et al. (1995) discovered that fish baits combined with sugarcane can catch more crabs than using fish and or sugarcane separately.

This study was conducted to assess catch composition, and to investigate the selectivity of different baits, including an overripe banana which is locally known as "latundan", which is a hybrid from the species *Musa acuminata* (Colla 1820) and *Musa balbisiana* (Colla 1820), and fish bait *Apogon lineatus* (Temminck and Schlegel 1842) in catching the desired species, size, and sex of marine crabs. Both baits are locally used by fishers in the area for catching marine species and are commonly cheap and available in large quantities.

METHODS

Field Study Site

Experimental trapping was conducted in Barangay Tanao, near the island of Magalumbe, in the Municipality of Batad Northern Iloilo (Figure 1). Batad is known as one of the major suppliers of portunid crabs and other marine products from the Visayan Sea. The area supports the crab meat industry in the nearby areas. Here, crabs are caught using various types of gears like trawls, gillnets, and crab pots/traps.

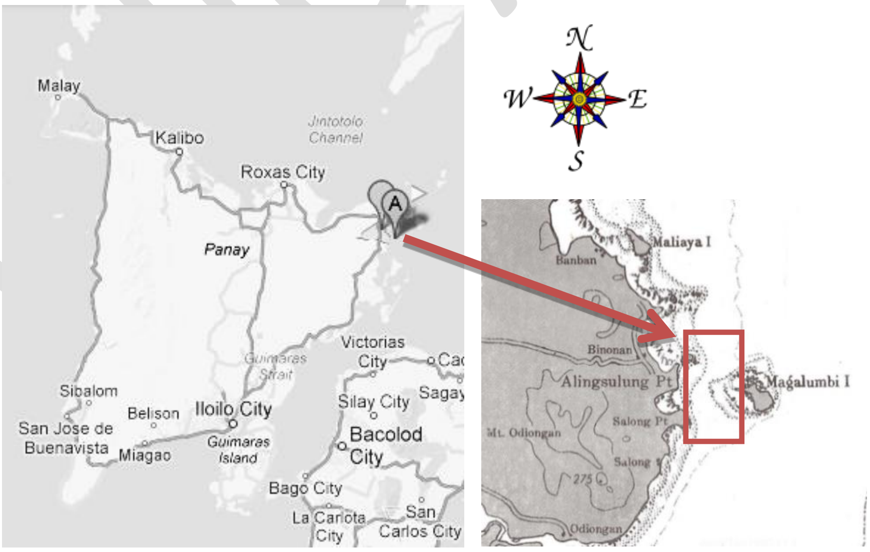

Figure 1. Map showing the location of the crab trapping activity area near the Island of Magalumbe in Barangay Tanao, Municipality of Batad, Iloilo, Philippines.

Day and night local fishers target *P. pelagicus* and other crab species to meet the demands of the local market. Sampling depth ranged from 4 to 12 m. Depths greater than 12 m were not used for trapping because these were usually areas for trawling operations.

Baits and Trapping Gear

Crab pots, locally known as "panggal" are used locally among crab fishers in Batad and they were utilized in this study. The pots measuring 31 x 31 x 10 (Figure 2a) were made of a bamboo frame wrapped with multifilament nylon mesh (6 cm mesh size). Each trap has a bait holder to hold the bait firmly inside the pots (Figure 2b). The gear entrance is located at the upper center portion of the pot and made of plastic materials from unserviceable gallons section with an average diameter of 9.04 ± 0.09 cm (n = 20), which acts as the opening for organisms to enter as they are attracted to the bait inside.

The fish *A. lineatus* and the overripe hybrid banana derived from *M. acuminata* and *M. balbisianna* were utilized as baits to investigate their potential in catching marine crabs (Figures 3a and b). Both baits were chopped into similar sizes and placed into the bait holder and mounted inside the crab pot. This fish bait was used because it was readily obtained as a bycatch from local trawling operations. Additionally, there was an abundant supply of overripe "latundan" bananas in the local markets around Iloilo.

Experimental Design

Four baiting treatments with four replications were used to complete the experimental field crab trapping operation. Baits were chopped into similar portions. The replicated treatments included: banana bait (BB), fish bait (FB), combined fish-banana bait (FB+), and no bait (NB) as control. Pre-weighted (40 g) baits were placed in each crab pot with a 1:1 ratio-wet weight. In the case of the fish-banana bait combination, 20 g fish and 20 g banana were pre-weighted to complete the 40 g bait amount.

Four replications of a series of 32 crab pots were used per trapping operations. In a 32 series of pots, 8 crab pots were randomly assigned for each bait treatment. Thus, in each experimental crab trapping trip, a total of 128 crab pot units were utilized (Table 1). These 128 pot units were arranged in a blocked random manner attached to a rope line with their assigned baits before setting to eliminate area effects. A total of six experimental trapping trips were conducted from November to December 2012. Crab pots were set about 13 m away in a line from each pot position. These pots were set at about 0700H and hauled after an 8-h soaking time.

Experimental crab trapping trips were tracked using a handheld Global Positioning System (GPS) from the starting point to the endpoint (Table 1). Sizing, species sorting, and sex determination was immediately done after each crab trapping operation. Data such as carapace width (CW) and carapace length (CL) of the samples were taken and recorded using a vernier caliper.

Statistical Analysis

The number of crabs caught using the traps did not satisfy the test for normality hence, Kruskal-Wallis H-test was used to compare the number of catch among treatments. Steel-Dwass-Critchlow-Fligner (SDCF) procedure was further used for multiple pairwise comparisons (Hollander and Wolfe 1999). Chi-square analysis (α = 0.05) was done to determine the differences in the sex and size of crabs trapped in the pots. The IBM SPSS ver.20 and XLSTAT 2013 software were utilized for the different statistical analyses conducted.

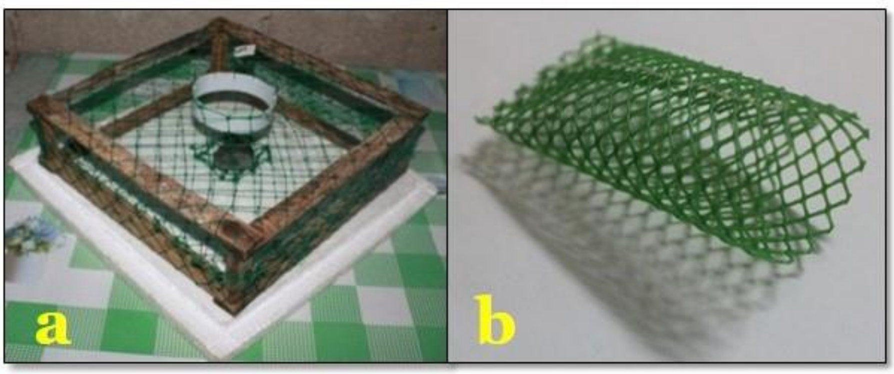

Figure 2. Locally manufactured crab pot "panggal" (a) used to catch marine crabs in the Municipality of Batad, Iloilo, Philippines, and bait holder (b) (height=10 cm with mouth diameter=3.9 cm) made of polyethylene material used in the field sampling (b).

Figure 3. Baits used in catching marine crabs. Fish bait (a) *Apogon lineatus* (and overripe hybrid banana (b) from *Musa acuminata*.

Table 1. Coordinates taken during crab trapping operations conducted at Barangay Tanao, Batad, Iloilo, Philippines. Letters A and B attached at the end of each track code (CRB) denotes the beginning point and ending point of crab pot line series, respectively, while numbers 1 to 6 represent the sampling trips.

Track	Sampling	Depth	Tracked GPS positions		Date (dd-mm-yy)	Crab Pots
Code	Trip #	Range (m)	From	To		Details
CRB1A	1	5.25	N 11^0 23.111’	N 11^0 23.678’	26-11-2012	8 pots NB 8 pots for BB 8 pots for FB 8 pots for FB+ 32 pots x 4 rep. = 128
CRB1B		6.50	E 123^0 09.065’	E 123^0 09.082’		
CRB2A	2	9.00	N 11^0 23.044’	N 11^0 22.311’	27-11-2012	8 pots NB 8 pots for BB 8 pots for FB 8 pots for FB+ 32 pots x 4 rep. = 128
CRB2B		10.00	E 123^0 09.334’	E 123^0 09.317’		
CRB3A	3	9.00	N 11^0 23.044’	N 11^0 22.311’	30-11-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB3B		10.00	E 123^0 09.334’	E 123^0 09.317’		
CRB4A	4	10.50	N 11^0 22.788’	N 11^0 22.174’	01-12-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB4B		11.00	E 123^0 09.545’	E 123^0 09.207’		
CRB5A	5	4.00	N 11^0 22.272’	N 11^0 22.842’	02-12-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB5B		5.25	E 123^0 09.013’	E 123^0 09.146’		
CRB6A	6	6.50	N 11^0 24.549’	N 11^0 23.985’	03-12-2012	8 pots NB 8 pots BB 8 pots FB 8 pots FB+ 32 pots x 4 rep. = 128
CRB6B		5.75	E 123^0 08.855’	E 123^0 09.268’		

RESULTS

Species and Size Composition of Crabs Caught during the Trapping Operation

A total of 95 individuals of various crustacean species and non-target organisms were recorded for the six (6) crab trapping operations (Table 2). Among the crustacean species caught, the main ones were the blue swimming crab *P. pelagicus* with a total count of 42, the four-lobed swimming crab *Thalamita sima* (Milne Edwards 1834) (18), and other minor crustacean species (4) which included the red egg crab *Atergatis intergerrimus* (Lamarck 1818), mantis shrimp *Harpiosquilla harpax* (de Haan 1844), Saint Francis crab *Charybdis feriata* (Linnaeus 1758) and two-spine arm swimming crab *Charybdis* *anisodon* (De Haan 1850). Blue swimming crabs dominated the catches (~ 44.21% of the total organisms caught) irrespective of baits.

Non-target organisms caught by pots during the trapping operation were mostly fishes, while others included four echinoderms, one marine worm, and one mollusk (Table 2). The highest numbers of non-target species were seen in pots baited with FB, whereas the FB+ combination caught fewer non-target species than FB.

Crabs captured by pots under various bait treatments significantly differed in numbers (Kruskal - Wallis H-test, H_0 = 72.853, df = 3, P < 0.001). Unbaited pots (NB) and pots baited with banana (BB) yielded significantly lesser catches than pots baited with fish (FB) and fish mixed with banana (FB+). Furthermore, pots baited with FB and FB+ showed no differences in catches (Figure 4).

In terms of size, large-sized *P. pelagicus* were recorded mostly in pots baited with combined fish and banana baits (FB+) with CWs that ranged from 90.2 to 160.2 mm. In contrast, pots baited with fish only (FB) caught crabs with CWs that ranged from 61.30 to 155.0 mm. However, no statistical differences were seen in the size range of both treatments (Kruskal-Wallis H-test, P > 0.05; Table 3). On the other hand, significant differences in the size range were observed for the species *T. sima* (Kruskal-Wallis H-test, P < 0.05; Table 3).

Pots baited with FB had the same numbers of female and male *P. pelagicus* in the catch, while pots with FB+ had slightly more male than female *P. pelagicus*; however, results were not significantly different (FB, χ^2 = *0.610*, df = 1, P > 0.05 and FB+, χ^2 = 0.692, df = 1, P > 0.05) (Table 4). On the other hand, significant differences were found in *T. sima*, where female is more abundant than males in pots using FB+, while pots with FB did not have differences in terms of sex (FB+, χ^2 = *5.556*, df = 1, P < 0.05 and FB, χ^2 = 0.600, df = 1, P > 0.05).

Table 2. Catch species composition of pots baited with fish (FB), banana (BB), combined banana-fish (FB+), and no bait (NB) during the six crab trapping operations conducted in Barangay Tanao, Batad, Iloilo, Philippines, using a total of 128 crab pots per trapping operation with 32 pots assigned per bait treatment ; n = 24

Pot catches	**Catch count per bait treatments (n = 24)**				**Total**	**%**
	Fish (FB)	Banana (BB)	Fish-banana (FB+)	No bait (NB)	**Count**	
Crustacean species						
1. Portunus pelagicus (Linnaeus 1758)	30	-	12	-	42	44.21
2. Thalamita sima (Milne Edwards 1834)	7	2	8	1	18	18.95
3. Atergatis intergerrimus (Lamarck 1818)	-	-	1	-	1	1.05
4. Harpiosquilla harpax (de Haan 1844)	-	-	1	-	1	1.05
5. Charybdis feriata (Linnaeus 1758)	1	-	-	-	1	1.05
*6. Charybdis anisodon (*De Haan 1850)	-	-	-	1	1	1.05
Subtotal	**38**	**2**	**21**	**2**	**64**	**67.37**
Non-target organism						
Fish	11	3	7	4	25	26.32
Echinoderms	-	2	1	1	4	4.21
Marine worm	1	-	-	-	1	1.05
Mollusc	-	-	1	-	1	1.05
Subtotal	**12**	**5**	**9**	**5**	**31**	**32.63**
Total	**50**	**7**	**30**	**7**	**95**	**100.00**

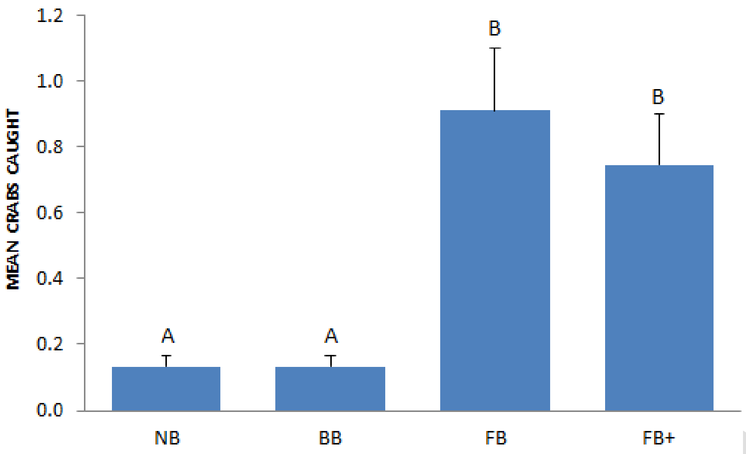

Figure 4. Number (mean ± SEM) of crabs caught per pot baited with no bait (NB), banana bait (BB), fish bait (FB), or fish-banana (FB+). Letter notations indicate a significant difference (Kruskal-Wallis H-Test and Steel-Dwass-Critchlow-Fligner Procedure, $P < 0.05$, n = 24).

Table 3. Differences in crab size composition using the *Kruskal-Wallis test* and *Steel-Dwass-Critchlow-Fligner procedure* (α = 0.05) caught in pots baited with fish (FB) and combined banana-fish (FB+) during trapping operations conducted in Barangay, Tanao, Batad, Iloilo, Philippines.

Species	Bait	Size range (mm)		Mean size	Size differences
		Min.	Max.		
Portunus pelagicus (Linnaeus 1758)	FB	61.30	155.00	132.32	$P > 0.05$; $P = 0.132$
	FB+	90.20	160.20	129.87	
Thalamita sima (Milne Edwards 1834)	FB	54.60	73.40	63.53	$P < 0.05$; $P = 0.009$
	FB+	48.70	151.00	61.428	

Table 4. Statistical differences in sex composition of crabs using Chi-square analysis (α = 0.05) caught in pots baited with fish (FB) and combined banana-fish (FB+) during trapping operations conducted in Barangay, Tanao, Batad, Iloilo, Philippines.

Species	Bait	No. of catches		Total	Differences
		Male	Female		
Portunus pelagicus (Linnaeus 1758)	FB	15	15	30	$P > 0.05$; $P = 0.435$
	FB+	7	5	12	$P > 0.05$; $P = 0.405$
Thalamita sima (Milne Edwards 1834)	FB	4	3	7	$P > 0.05$; $P = 0.439$
	FB+	2	6	8	$P < 0.05$; $P = 0.018$

DISCUSSION

Effect of Banana on Catch Rates

The overripe *M. acuminata x M. balbisiana* hybrid banana lowered the catches of *P. pelagicus* however no statistical differences were observed. Catches for *T. sima* were not affected when the banana-fish bait combination was used. It is assumed that fish is the most effective bait in catching most marine organisms such as crabs since it is commonly used in various capture fisheries. The present result on crab catches with the addition of banana to fish bait can be attributed to the chemical properties of ripe bananas having soluble saccharides like glucose, sucrose, and fructose (Garcia and Lajolo 1988; Tapre and Jain 2012) which may add stimulatory properties toward crustaceans. Studies done in the laboratory have made several successful findings on the stimulatory potential of saccharides to crustaceans (Hartman and Hartman 1977; Trott and Robertson 1984; Zimmer-Faust et al. 1984; Sear et al. 1991; Vazquez Archdale and Nakamura 1992). However, if only bananas were utilized as baits this resulted in a very low catch. Present results showed that banana alone is an inefficient bait for marine crabs. This coincides with similar results obtained by Kawamura et al. (1995), who also observed few catches with sugarcane (sweet agricultural crop) bait treatment only.

Adding banana to fish bait showed comparable results on the number of catches of *T. sima* in comparison with pots baited with fish bait only. Although crabs are highly sensitive to sugars or saccharides (Hartman and Hartman 1977; Vazquez Archdale and Nakamura 1992; Kawamura et al. 1995; Anraku et al. 2001), the amount of sugar present in bananas may not be enough to elicit the chemosensory responses of crabs in such a way as to affect their feeding habits. Synergisms of substances like amino acids from fish and sugars or saccharides from alternative sources like sugarcane are definite to be functional as shown in some studies by Kawamura et al (1995) and Vazquez Archdale and Anraku (2005), however, this is not clear from the results obtained in the present study using banana. Saccharides from banana alone are not enough to attract and influence crab catches; therefore, further studies are needed on the appropriate amount that should be combined with fish bait. However, the 50% addition of banana to fish bait in the present study does not differ statistically from the crab catches using 100% fish bait. This will help reduce the utilization of expensive fish bait and can consequently may reduce operational expenses in crab trapping but an in-depth future investigation on this matter should be done.

Effect of Banana and Fish Baits on Species Selectivity and Non-Target Catch Composition

A moderately low percentage of non-target species were caught in pots with FB+ than in FB. This shows that the addition of banana to fish bait can decrease the catching of non-target species and can use particularly in crab trapping. In addition, results on the use of banana bait alone also show infrequent or low non-target catches. Both results in using FB+ and BB imply that this banana bait can be selectively used to catch crustacean species and may regulate the catching of other marine organisms. As of these days, not many studies are concentrating on the selectivity of bait materials in catching marine crabs, instead, most studies are focusing on gear innovations and designs (Glamuzina et al. 2021; Zhang et al. 2021; Hanamseth et al. 2022).

The presence of non-target species on pots with NB is probably due to the tendency of fish to occupy the space offered by the gear as shelter although occurrence seems to be infrequent. The biology of animals may be attributed to factors influencing catches on baited pots. Furthermore, other organisms or crabs may possess aggressive behaviors which may influence the presence of a by-catch (Tanner 2007). Thus, for a more efficient trapping operation, studying hydrodynamics with timing, gear, and baits as well as the ecology of the target species is necessary.

Effect of Banana and Fish Baits on Crab Size and Sex Selectivity

Size and sex selectivity are often a concern for the effective management of the target species. The capture of legal-sized male and the conserving of female individuals are among the main concerns used by governing bodies in fisheries management. In the case of blue swimming crabs, *P. pelagicus*, males with CW measuring from 8.5 cm or above and females with CW more than 8.7 cm are considered mature and are legally sized and suitable for capture (Chande and Mgaya 2003).

In the present study, the “panggal” crab pot baited with FB and FB+ caught the most mature-sized *P. pelagicus* although, no clear patterns in the size selectivity among the bait treatments are seen. This result conforms to a study that using crab pots is biased in catching mature-sized female *P. pelagicus* than immature crabs (Smith et al. 2004). Biased for bigger sizes may be attributed to a more developed olfactory system in adult crustacean species than in immature ones (Schmidt 2007). In addition, adult swimming crabs have a greater ability to swim and resist strong waves (Chande and Mgaya 2003). This explains the higher number of larger crabs reaching the baited pots than smaller and immature crabs. Longer chelae also support them during competition against small crabs (Matheson and Gagnon 2004; Sneddon et al. 1997). Furthermore, bigger-sized crustaceans like shrimps scare away smaller conspecifics due to the competing potentials of larger conspecifics (Petetta et al 2021). Moreover, a clear result in the present study was seen on pots baited with fish alone (FB) which caught larger *T. sima* compared with pots baited with FB+ ($P < 0.05$).

Combining banana with fish as bait is gender-neutral for *P. pelagicus*. This result is different from the results of Kawamura et al. (1995), who observed that pots baited with a combination of sugarcane and fish were extremely biased for male of this species. In contrast, banana and fish combination bait revealed a biased for female of *T. sima*. This result is similar to the effect of the sugarcane and fish bait combination on *Charybdis japonica* (Milne-Edwards 1861) in the study of Kawamura et al. (1995). Therefore, using banana combined with fish can be useful for sex-selective trapping for *T. sima*, which is important in fisheries management.

Furthermore, the relationship between crab maturity stages on bait attraction can also be one of the focus of future studies because crab maturity plays a big role in the effective management of marine crab capture fisheries.

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