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MOVEMENT PATTERNS OF BLUE SWIMMING CRAB, *Portunus pelagicus* IN THE SARAWAK COASTAL WATER, SOUTH CHINA SEA

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Abstract: A study was carried out to determine the movement patterns of *P. pelagicus* within the near-shore marine embayment of the Sarawak coastal water, South China Sea. These mark-recapture tagging studies were conducted for about five months from 26th March till 30th August 2005 comprising 48 sampling trips. Out of 976 crabs tagged and released, 212 (21.72%) were recaptured. The mean distances moved by male and female crabs were 7.36 km ± 1.78 and 9.15 km ± 1.87 respectively. The study shows that the female crabs moved significantly ($p=0.01$; $p<0.05$) further than males. The percentage of tagged crabs recaptured within the original release site were 50.0% for male and 45.83% for female crabs. The result shows that the male crabs only significantly ($p=0.01$; $p<0.05$) moved towards the deeper off-shore areas as compared to the near-shore areas. On the other hand, the female crabs moved significantly more towards both deeper off-shore and shallow near -shore areas. Most of the tagged crabs were recaptured within the sampling site of 2 km radius after a minimum of 30 days at liberty. The movement activities from the study were not necessarily limited because only 21.72% of the tagged-and-released crabs were recaptured. Thus, the main movement activities were attributed to the migration movements associated with reproduction and this can be seen from the tagged crabs which were recaptured at the off-shore deeper water.

KEYWORDS: Movement patterns, mark-recapture, tagging, *Portunus pelagicus,* Sarawak coastal water

Introduction

The blue swimming crab*, Portunus pelagicus,* is distributed throughout the Indo-Pacific region and is closely associated with sheltered near-shore marine water and estuaries (Ikhwanuddin *et al.*, 2009a, b; de Lestang *et al.*, 2003). Large numbers of *P. pelagicus* frequently enter estuaries as juveniles (Potter & de Lestang, 2002) and the female *P. pelagicus* sometimes become ovigerous in estuaries (Potter & de Lestang, 2002). Studies also showed that the portunid crabs that often occupied the marine embayment would not leave this environment to spawn which always occur in high-salinity regions (Potter & de Lestang, 2002). Literature reviews shows that the movement of *P. pelagicus* in and out of estuaries into open ocean occurs for spawning and as a reaction to lower salinity (Potter & de Lestang, 2002). Study shows that *P. pelagicus* has strong swimming ability and are capable of moving through substantial distances of 20 km per day as in Queensland, Australia (Sumpton & Smith, 1991). However, a tagging study by Potter *et al*. (1991) in Queensland, Australia showed fairly small-scale movement of crab populations, where, of the recaptures, 79% were caught less than 2 km from their release point and only 4% were recaptured more than 10 km from the release point. Literature reviews shows that there is no study on the movement patterns of *P. pelagicus* in any of the water bodies of Malaysia. Thus, the main objective of the present study was to determine the movement patterns of *P. pelagicus* within the near-shore marine embayment of the Sarawak coastal water, South China Sea. The movement patterns of crabs were assessed through the tagging study within the study area.

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Materials and Methods

Crab samples were collected from shallow water biotopes (mean depth at 15.78 m) within Talang-talang Island, centred at 1°53'N, 109°48'E within 2.0 km radius of the coastal water of Sematan Fishing District. The Sematan Fishing District is located at the most western part of Sarawak coastal water of South China Sea, stretching from Tanjung Dato to Sampadi (Figure 1). Sampling was done within the period of about five months, beginning from 26th March till 30th August 2005 with 48 sampling trips. During these months *P. pelagicus* were most abundant in the environment. Samples were obtained from gill nets through a series of sampling trips from 24 sampling stations within shallow water biotopes of the study site (Table 1 and Figure 2). The study site was also identified as the commercial fishing ground for *P. pelagicus*. In present study, crabs were caught by means of gill nets of 16.5 cm mesh size, 2.1 m (height) x 24.5 m (length) net dimension size per set of the gill net (Figure 3). Only one gill net set was used with seven pieces of net per set of the gill net per sampling trip. The nets were of the same type commonly used by the local crab fishermen in Semantan during the daytime.

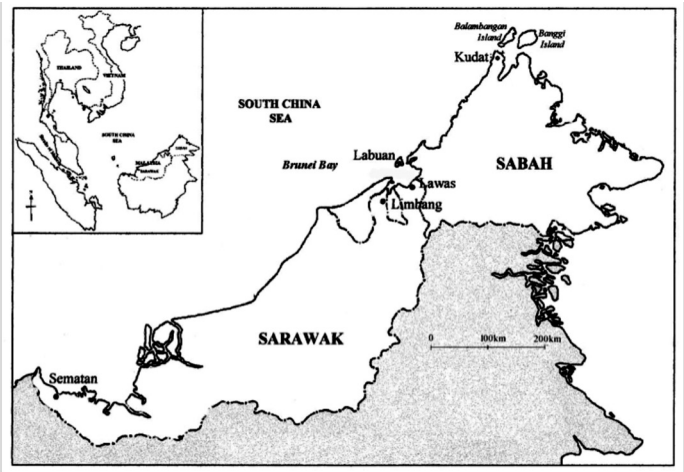

Figure 1: Location of the study site at Sematan Fishing District, Sarawak coastal water of South China Sea.

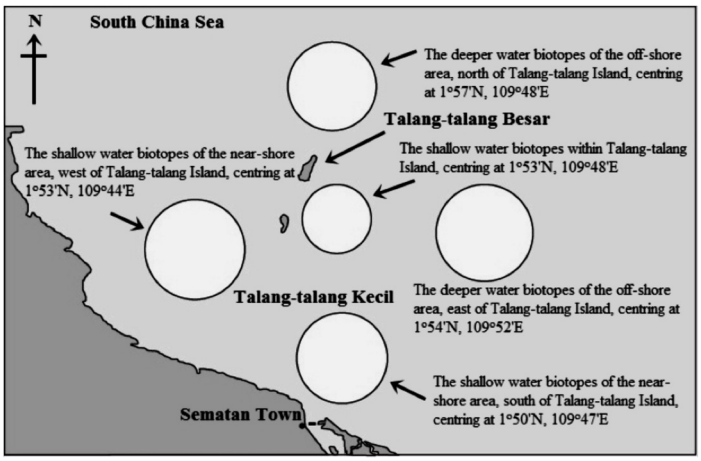

Figure 2: Crabs were recaptured from five sites which are the original sampling sites of release within the 2 km radius by biosampling, off-shore area north of Talang-talang Island, off-shore area east of Talang-talang Island, near-shore area toward Sematan beach shoreline and near-shore area within the Sematan estuary by the local fishermen.

Table 1: GPS positions for the 24 sampling stations within the shallow water biotopes of the Sematan Fishing District, Sarawak.

Sampling station no.	GPS Position (Lat/Lon hddd°mm'ss.s")	Sampling trip no.
1	N1 53 51.3 E109 48 10.6	1 and 25
2	N1 54 56.3 E109 48 10.1	2 and 26
3	N1 54 37.4 E109 48 57.2	3 and 27
4	N1 53 51.8 E109 49 15.7	4 and 28
5	N1 53 07.2 E109 48 57.2	5 and 29
6	N1 52 46.6 E109 48 10.6	6 and 30
7	N1 53 01.1 E109 47 29.3	7 and 31
8	N1 53 48.9 E109 47 07.5	8 and 32
9	N1 54 35.5 E109 47 23.5	9 and 33
10	N1 53 25.7 E109 47 52.0	10 and 34
11	N1 53 03.0 E109 48 13.1	11 and 35
12	N1 52 59.2 E109 47 56.2	12 and 36
13	N1 53 07.7 E109 47 31.1	13 and 37
14	N1 53 44.7 E109 47 43.0	14 and 38
15	N1 53 26.0 E109 48 35.2	15 and 39
16	N1 54 19.0 E109 48 52.0	16 and 40
17	N1 54 44.0 E109 48 24.2	17 and 41
18	N1 54 19.4 E109 47 20.8	18 and 42
19	N1 54 30.0 E109 48 02.5	19 and 43
20	N1 54 00.0 E109 48 47.5	20 and 44
21	N1 53 42.2 E109 48 53.0	21 and 45
22	N1 54 17.1 E109 47 45.4	22 and 46
23	N1 53 34.7 E109 47 16.9	23 and 47
24	N1 54 27.1 E109 48 26.8	24 and 48

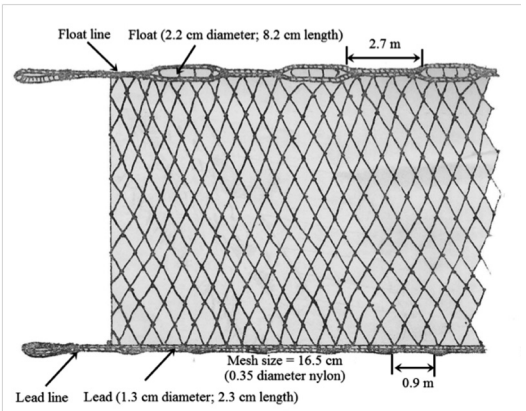

Figure 3: Gill nets specification used in the present study.

All *P. pelagicus* caught during sampling period of daytime within the study site were recorded. Captured crabs were counted, sexed, measured for carapace width and body weight and, unless damaged, they were tagged with the small-size anchor T-bar tags. The damaged crabs were released back without tagging to the water where they were caught. Undamaged tagged crabs were also released carefully at the capture site. Anchor T-bar tags were used in the present study in a similar manner as used in other mark-recapture studies for mangrove crab, *Scylla* spp. (Ikhwanuddin, 2001). The tagging equipment was supplied by Hall print, Australia. Small-size (total length of 3.5cm or series no. T2113) anchor T-bar tags were used during the study. Each T-bar tag was individually numbered. The tags were inserted with a Dennison tagging gun into the posterior margin of the crab's body; between the carapace and abdomen. The tag insertion was put in slightly off-centre to avoid damaging the dorsal abdominal artery (Ikhwanuddin, 2001) and also to avoid tag loss at moult.

In this mark-recapture study, the gill net sets were placed at each of the 24 sampling stations at the study site with two sampling trips per sampling

station, i.e. 48 sampling trips at 24 sampling stations (Table 1). At each sampling session, the stations were marked with Global Position System (GPS) to recognise the sampling stations; the distances between stations were measured using GPS. After tagging and recording, each crab was returned to the water at the station where it was caught. The local fishermen were informed about these tagging activities and the captures of tagged crab by the local fishermen were also recorded. The captured tagged crabs were recorded from the tag number, carapace width, sexes, date of crab recaptured and the actual location where it was caught. The gill net soaking time for the study was set within 24 hours.

Crab size was measured as the external carapace width, which is the distance between the tips of 9th antero-lateral spines of the carapace (Ikhwanuddin *et al.,* 2011; 2010; 2009a) (Figure 4). The carapace width was measured to the nearest 0.1 cm with vernier callipers. Crabs were separated into male and female based on the shape of the abdomen (Figure 5). The female crab has a wider and globular abdomen. In younger female, the abdomens are invariably triangular and it is narrow and straight for male crabs.

Data were presented as mean ± SD. The t-test was used to test the difference between mean of two samples distance (km) moved by male and female crabs in the present study. The tests for a Fixed-Ratio Hypothesis of Chi-Square Test were used to test the number of male and female tagged crabs recaptured outside the sampling site.

Results

Tagged crab recapture

Out of 976 tagged-and-released crabs, 212 (21.72%) were recaptured with 96 are males and 116 are females (Table 2). Results showed that a total of 102 crabs were caught within the sampling site of 2 km radius from the release point and 110 crabs were caught outside the sampling site by the local fishermen (Table 2).

Distance moved by tagged crabs

The mean distance moved by recaptured crabs outside the sampling site caught by the local fishermen is shown in Table 3. The mean distance moved by male and female crabs were 7.36 km ± 1.78 (range = 3.59 – 12.4 km; n = 58) and 9.15 km ± 1.87 (range = 5.33 – 12.8 km; n = 52) respectively. Results from t-test showed that there were highly significant differences ($p=0.01$; $p<0.05$) between the distance moved by the male and female. In fact, the female crabs moved further than the males (Table 3). The distances were measured for recaptured crabs within the sampling site where these crabs were caught within 2 km radius of the sampling site. The mean crab size of tagged crab recaptured outside the sampling site was 15.92 cm ± 1.29 (range 13.13 – 18.63 cm; n = 58) for male crabs and 16.97 cm ± 1.21 (range = 13.39 – 18.97 cm; n = 52) for female crabs (Table 3). The mean size of tagged crabs recaptured within the sampling site was 15.78 cm ± 1.55 (range = 11.88 – 18.88 cm; n = 58) for male crabs and 16.59 ± 1.27 (range = 13.52 – 18.48 cm; n = 44) for female crabs (Table 3).

Furthest recaptured position of tagged crabs

Crabs were recaptured from five sites which were the original sampling site of release within the 2 km radius by biological sampling trips and the north of the sampling site or off-shore area north of Talang-talang Island, the east of the sampling site or off-shore area east of Talang-talang Island, the west of the sampling site or near-shore area toward Sematan beach shoreline and the south of the sampling site or near-shore within the Sematan estuary by the local fishermen (Table 4). The tagged male crabs were recaptured at 50% within the original release site, 14.66% within the north, 18.97% within the east, 6.90% within the west and 9.48% within the south of sampling site (Table 4). The tagged female crabs were recaptured at 45.83% within the original released site, 5.21% within the north, 30.21% within the east, 6.25% within the west and 12.5% within the south of sampling site (Table 4). Results from Chi-Square Test showed

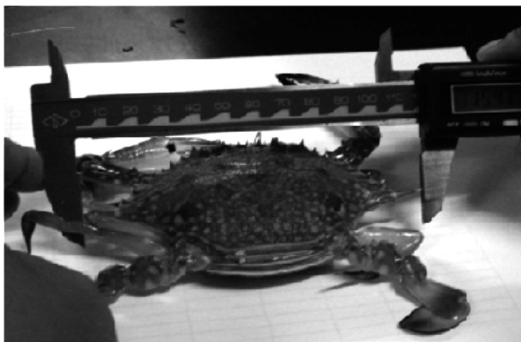

Figure 4: Crab size is measured as the external carapace width, which is the distance between the tips of 9th antero-lateral spines of the carapace.

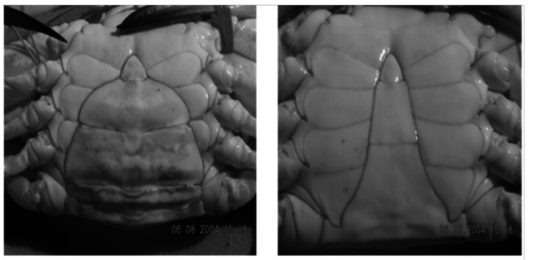

Figure 5: Structure of abdominal flap showing the difference between male and female crab of *P. pelagicus*. The female crab has a wider and globular abdomen (left) and the male crab has a narrow and straight abdomen (right).

Table 2: Total number and percentage of tagged crab of *P. pelagicus* recapture.

Sex	No. of crabs tagged & released	No. of tagged crab recaptured			% of tagged crab recaptured
		From biosampling*	From fishermen**	Total	
Female	534	44	52	96	17.98
Male	442	58	58	116	26.24
Total	976	102	110	212	21.72

** = No. of tagged crab recaptured from 1st recapture only within the sampling site of 2km radius.*

*** = No. of tagged crab recaptured by fishermen outside the sampling site.*

Table 3: Mean distances (km) between released and recaptured site and, crab size (cm) of tagged crabs recapture of *P. pelagicus*.

	Sex / category	Male	Female
Distance moved by tagged crab outside the sampling site (km)	Mean	7.36[a]	9.15[a]
	Max	12.4	12.8
	Min	3.59	5.33
	Sd	1.78	1.87
	n	58	52
Tagged crab size (CW) recaptured outside the sampling site (cm)	Mean	15.92	16.97
	Max	18.63	18.97
	Min	13.13	13.39
	Sd	1.29	1.21
	n	58	52
Tagged crab size (CW) recaptured within the sampling site (cm)	Mean	15.78	16.59
	Max	18.88	18.48
	Min	11.88	13.52
	Sd	1.55	1.27
	n	58	44

[a] = Significant difference between the distance moved by the male and female crabs.

Table 4: Furthest recapture position for tagged crabs of *P. pelagicus* within and outside the sampling site.

Sex		Original sampling site*	North of sampling site**	East of sampling site^	West of sampling site^^	South of sampling site*^	Total recapture
Male	No.	58	17[a]	22[a]	8	11	116
	%	50.00	14.66	18.97	6.90	9.48	100.00
Female	No.	44	5	29[a]	6	12[a]	96
	%	45.83	5.21	30.21	6.25	12.50	100.00
Total		102	22	51	14	23	212

* *Recaptured at the original sampling site of release within the 2km radius by biosampling.*
** *Recaptured at the north of the sampling site or off-shore area north of Talang-talang Island by the local fishermen.*
^ *Recaptured at the east of the sampling site or off-shore area east of Talang-talang Island by local fishermen.*
^^ *Recaptured at the west of the sampling site or near-shore area toward Sematan beach shoreline by local fishermen.*
*^ *Recaptured at the south of the sampling site or near-shore area within the Sematan estuary by local fishermen.*
a = *Significantly the male crab moved more toward the north and east of the sampling site and significantly the female crab moved more toward the east and south of the sampling site.*

the significant movement ($p=0.01$; $p<0.05$) of male crabs towards the deeper off-shore areas (north and east of the sampling site as compared to the shallow near-shore areas (west and south of the sampling site). Meanwhile, the female crabs showed significant movement ($p=0.01$; $p<0.05$) towards the deeper off-shore areas of the east sampling site and to the shallow near-shore areas of the south of the sampling site as compared to the other two recapture sites.

Distance between released and recaptured sites of tagged crabs

Out of 102 crabs, 56 males and 38 females were caught within the sampling site of 2 km after the crabs were released. Most of the tagged crabs were recaptured within 30 days after being tagged, out of which, 107 of 212 crabs were male crabs and the rest were females (Table 5). However, recaptures were still continued after 90 days for one female crab which were caught with the time at liberty of 61 to 90 days. Only one male and two females moved more than 12 km during the study period (Table 5).

Discussion

Movement of the crabs in the study within the sampling site were indicated by tag returns. Present study showed that 102 crabs were caught out of 976 tagged-and-released crabs which were released within 2 km radium of the sampling site and 110 crabs were caught by the local fishermen outside the sampling region. Moreover, movement within the sampling site was to a mean distance of 7.36 km for male crabs and 9.15 km for female crabs outside the sampling site. Movement activities from the study were not necessarily limited because only 21.72% of tagged-and-released crabs were recaptured and it might be that many of these tagged crabs had moved to deeper water towards the off-shore marine embayment where they were not caught by the local fishermen. This low recapture rate of tagged crabs within the release point area was also similar to the findings by Potter *et al.,* (1991) in Queensland, Australia where 14.7% of the tagged crabs were caught back less than 2 km from their release point. Results of the present study also indicated that the time of releasing the crabs does not greatly affect the distance moved. As such, the results showed that out of 212 tagged recapture crabs, 107 males and 75 females were caught within the 30 days study period. Present study observed that significantly the male crab moved much more towards the deeper off-shore areas which is west and south (Sematan estuary) of the sampling sites. Results also demonstrated that female crabs significantly moved towards the deeper off-shore areas of the east sampling site

Table 5: Distance between release and recapture sites of tagged crabs of *P. pelagicus* at liberty for varying time periods by crab sexes.

Sex	Time at liberty (Days)	Distance moved (km)							Total
		<2*	≥2 - <4[a]	≥4 - <6[a]	≥6 - <8[a]	≥8 - <10[a]	≥10 - <12[a]	≥12[a]	
Male	1 - 30 days	56	4	8	19	17	2	1	107
	31 - 60 days	2	0	1	5	1	0	0	9
	61 - 90 days	0		0	0	0	0	0	0
	91 - 120 days	0	0	0	0	0	0	0	0
Female	1 - 30 days	38	0	1	12	12	9	3	75
	31 - 60 days	5	0	0	3	4	4	2	18
	61 - 90 days	1	0	0	0	1	0	0	2
	91 - 120 days	0	0	0	0	1	0	0	1
Total		102	4	10	39	36	15	6	212
Percentage		48.11	1.89	4.72	18.40	16.98	7.08	2.83	100.00

* *Distance moved by tagged crab recaptured from 1st recapture only within the sampling site of 2 km radius during the biosampling.*

a = Distance moved by tagged crab recaptured outside the sampling site by the local fishermen.

and to the shallow near-shore areas of the south of the sampling site as compared to the other two crabs' recaptured sites.

Three mechanisms can be used to explain these movement activities; (i) restricted movement centring on more-or-less temporary home-site, (ii) free-ranging movements in which crabs may forage over extensive distances and not return to a fixed place each day and (iii) migration associated with reproduction. Tagged-recaptured crabs were those whose movements were restricted to a more-or-less temporary home-site and they showed short-distance daily-feeding movements. The free-ranging movements during which crabs may forage over extensive distances and not return to a fixed place each day could be seen from the recaptured tagged crabs at the shallow near-shore areas which is the west and south of the sampling site. The possible reason for this finding might be attributed to the presence of sea-grass beds abundant in the shallow water (Ikhwanuddin *et al*., 2009b) as compared to deeper water. This sea grass may provide food and refuge functions for these crabs. The main movement activities were attributed to the migration movements associated with reproduction. This can be seen from the tagged crabs recaptured at the off-shore deeper water, towards the north and east of the sampling site for male crabs and at the near-shore shallow water, towards the south and west of the sampling site for the female crabs. Campbell (1984) stated that female *P. pelagicus* require a sandy substrate for successful egg extrusion and attachment to the pleopods. Study in Moreton Bay, Queensland, Australia showed that the migration of mature females onto sand banks for eggs extrusion may be partly responsible for the variation of sex ratios just prior to the spawning season (Sumpton, Potter & Smith, 1994). This could be the reason why the female crabs moved towards the near-shore shallow water where the seabed's bottom mainly consisted of sandy substrate of the estuary and the flat sandbank areas near to the coastline. Males prefer deeper gutter and lower slopes of sand banks (Kangas, 2000). This could be the reason why the male crabs of the present study moved towards the off-shore deeper water where the seabed bottoms mainly consisted of sandy substrate with deeper gutter. Ikhwanuddin *et al*. (2009b) stated that the seabeds at the shallow and deeper water of the study site mainly consisted of sandy substrate. Studies show that *P. pelagicus* undergo breeding migration, whereby berried females migrate to a more oceanic environment in the deeper water (de Lestang *et al*., 2003; Potter & de Lestang, 2002). On the other hand, study by Ikhwanuddin *et al*. (2009b) showed that the

monthly percentages of the berried females from the total female crabs sampled from the deeper water were lower as compared to the other two crabs' recapture sites. The other possible reason contributing to the preferences of female crabs towards shallow water rather than deeper water was that the both marine embayments provided oceanic environment but the near-shore shallow water as mentioned earlier had an abundance of seagrass beds as compared to the deeper water.

Conclusion

From this study, 21.72% crab samples were successfully recaptured after the day of release at the sampling site. Furthermore, findings also showed that both male and female crabs much preferred to move towards the deeper off-shore areas compared to the shallow near-shore areas. Findings of this study can be used as the baseline for further study on the movement patterns of this species at the other spots. Findings also may be useful in management and exploitation of *P. pelagicus* resources for both fishery and aquaculture management in Malaysian coastal waters especially and within the Indo-Pacific region generally.

Acknowledgements

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