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Biomass and Abundance of Sesarminae Crabs in a High Shore Malaysian Mangrove Forest

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ABSRACT The biomass and abundance of grapsid crabs and other macrobenthos in the disturbed and undisturbed upper shore mangroves of the Kapar Mangrove Forest Reserve, Klang, Malaysia were studied. Nine species of the Sesarminae crabs which occurred in the disturbed forest contributed a biomass of 5.61 $\pm$1.67 g dry wt m^{-2} out of the total macrofaunal biomass of 9.83 g dry wt m^{-2}. In contrast, only 5 species of Sesarminae occurred in the undisturbed forest with a biomass of 8.25$\pm$ 2.1 g dry wt m^{-2} out of a total macrofaunal biomass of 18.72 g dry wt m^{-2}. *Perisesarma onychophorum* (de Man) occurred with the highest biomass (2.66 $\pm$0.93 g dry wt m^{-2}) in the disturbed forest while *P. eumople* (de Man) occurred with the highest biomass in the undisturbed forest (6.03 $\pm$1.53 g dry wt m^{-2}). Forest structure and sediment water content in the high shore influences colonization by the Sesarminae crabs, while timber harvests create an impact on the macrobenthic community.

(**Key words**: Sesarminae crabs, biomass, mangroves, high shore, Malaysia)

INTRODUCTION

The mangrove substratum is dominated by brachyurans of the families Grapsidae and Ocypodidae. Grapsid crabs play significant roles in sediment chemistry and primary productivity in the mangroves (Smith et al. 1991), as well as zonation and colonization (Smith et al. 1989), nutrient retention and litter decomposition (Lee, 1998). Grapsid crabs of the subfamily Sesarminae which are dominant in the upper shore mangroves, have the ability to tolerate low salinities and are partially adapted to respire in air and water (Macintosh, 1988)

The abundance, biomass and temporal variation of crab populations in tropical mangrove forests have generally received inadequate attention, especially in Peninsular Malaysia where the near land mangroves are colonized mainly by stands of *Bruguiera* spp. and *Rhizophora apiculata* Bl. This high shore mangroves which come under the inundation class 4 of Watson (1928), have been extensively reclaimed and converted to agriculture, aquaculture ponds, industrial estates and new townships.

Few studies have been carried out on macrobenthos in the upper shore mangroves (Berry, 1972; Sasekumar, 1974; Lee, 2008), thus there is a scarcity of data on their abundance or biomass. This study seeks to quantify the biomass and density of Sesarminae crabs in an upper shore mangrove forest in Selangor, Malaysia

MATERIALS AND METHODS

Two study sites (1 and 2) were established in the Kapar Mangrove Forest Reserve, situated north of Port Klang on the west coast of Peninsular Malaysia (Fig. 1). Site 1 was a disturbed forest where *Bruguiera* and *Rhizophora* trees were cut down three months before this study began. The general vegetation consisted of *Bruguiera sexangula* (Lour.) Poir, *B. parviflora* (Roxb.) Wight & Arn. Ex Griff, *Rhizophora mucronata* Lamk., and *R. apiculata*. Tree cover was less than 20 % and fallen trunks and branches lay scattered over the whole area. Site 2 was located 3.5 km north of the Site 1.

Site 2 was a relatively undisturbed forest of *Rhizophora mucronata, R. apiculata, B. parviflora* and *Sonneratia alba* trees of over 15 m in height. Diameter at breast height of some *Sonneratia* trees exceeded 80 cm. Both sites were about 4.4 m above Chart Datum, and were occasionally covered by high water of spring tides. However, Site 2 was always waterlogged in view of its location between two small tributaries of S. Kapar Kecil (Fig. 1).Sediment analysis for grain size was carried out according to Buchanan (1971). Water which collected in 30 cm deep pits was measured at each sampling occasion for salinity using a refractive AO optical salinometer. Dissolved oxygen was measured using a portable Beckman Field Oxygen Meter. Five sediment samples (up to a depth of 1 cm) were collected at each site during each sampling occasion

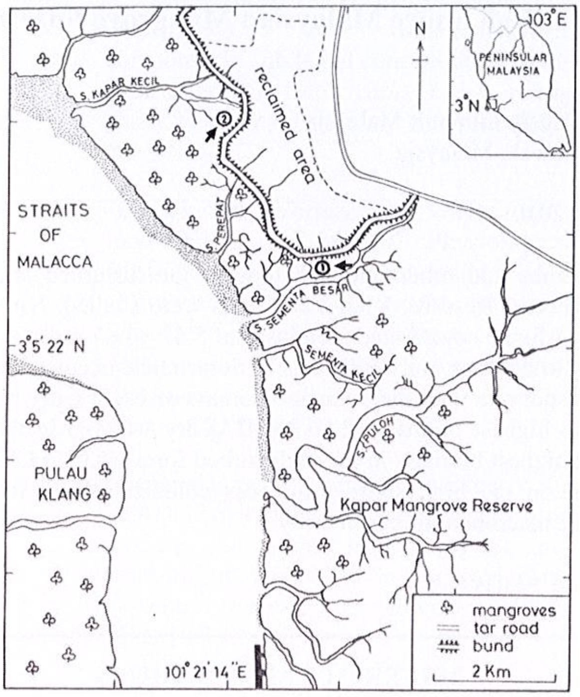

Fig.1. Map of study Site 1 (near S. Sementa Besar) and Site 2 (near S. Kapar Kecil) in the Kapar Mangrove Reserve.

and analyzed for organic matter content. Ten grams of dry sediment was combusted in a muffle furnace for 5 hours at 550 °C and the loss in weight was attributed to its organic matter content.

At each site, a grid of 50m by 200 m was sampled monthly from August 1980 to October 1981. Sampling quadrates were selected using a table of random numbers. Crabs were collected by pushing a 33 x 33 cm steel frame of 40 cm height quadrate into the substrate to a depth of 20 to 30 cm. Benthic sampling in mangrove forests presented many problems due to the complexity of the environment with the abundance of pneumatophores, prop roots, leaf litter and fallen tree trunks (Lee, 2008).

If the sampling steel frame hit–a root or stem, it shifted slightly in order for it to sink into the substrate. The use of a steel frame sampler increased sampling accuracy. Three replicates of four quadrates each were collected within the sampling grid fortnightly from each site. The total sample size was 12 quadrates per site per month. Crabs were collected by striking them with a small mud ball before picking them up and placing them in labeled plastic bags. The samples were brought back to the laboratory and then killed by cold shock in a deep freeze.

Sesarminae crabs were identified using keys of Serene & Soh (1967 & 1970), Campbell (1967) and Tweedie (1936, 1940, 1950 & 1954). The biomass (dry weight) of each species of a particular size class was recorded. Juvenile Sesarminae crabs were identified by comparing with the adults when the specimens were still fresh and wet as their body colour patterns were morphologically similar. Crabs were oven dried to constant weight at 60 °C for 14 days and re-weighed for dry weight. Gastropods (after removal of shells), polychaetes and sipuncula were similarly oven dried as above.

RESULTS

3.1. Sediment parameters

The sediment at both sites consisted predominantly of silt (54 to 66 %) and clay (13 to 16 %) fractions. Sediment water content in Site 1 was 52 % and 64 % in Site 2. Organic carbon content was 17 % in Site 1 and 18.3 % in Site 2. Sediment water salinity varied from 5.1ppt to 26ppt in Site 1 and 24.1ppt to 36.5ppt in Site 2. The oxygen content of sediment water measured over a 24-hour period in Site 2 varied from 0.22 to1.37 mg l^{-1}.

3.2.Biomass and density estimates

3.2.1 Site 1 (disturbed forest)

Nine species of Sesarminae with a biomass of 5.61 ± 1.77 g dry wt m^{-2} occurred in the disturbed mangroves (Table 1). In contrast, the mean macrofaunal biomass (without Sesarminae) was 4.22 ± 1.67 g dry wt m^{-2} (Table 2). Thus the disturbed forest supported a faunal biomass of 9.83 g dry wt m^{-2}.

The smallest species *Nanosesarma batavicum* occurred only once in the samples. In the large sized *Episesarma* group, biomass contribution was significant. *P. eumolpe* was the second most abundant species but it contributed only 4.9 % of the mean annual biomass (Table 1).
The most abundant species in terms of biomass in Site 1 was *P. onychophorum*. It contributed 47.6 % of the mean Sesarminae biomass in the disturbed forest (Table 1). Juveniles of carapace width 2 to 10 mm contributed about 65 % of the mean annual density although their biomass was not significant compared to the adults (Leh, 1982).

Table 1. Biomass values of Sesarminae crabs in Site 1 (dry wt m^{-2}) in high shore disturbed mangroves in Sementa, Selangor

Month of sampling	Species									Total
	Perisesarma onychophorum (de Man)	*P. eumople* (de Man)	*Clistocoeloma merguiensis* de Man	*Neosarmatium smithi* (H. Milne Edwards)	*Episesarma versicolor* (Tweedie)	*Sesarmoides kraussi* (de Man)	*Sarmatium crassum* Dana	*Nanosesarama batavicium* (Moreira)	*Parasesarma melissum* (de Man)	
Oct' 80	2.4659	0.2477	0.4663	1.4777	0.5	0.423	2.3529			7.4835
Nov' 80	1.2319	0.583	0.5869	5.5528	0.2192	0.0718	0.294	0.028	0.0604	8.1033
Dec' 80	1.6822	0.0565	0.4874	0.194	0.1664	0.627	0.174		0.022	3.4095
Jan' 81	3.6801	0.8326	0.3914	0.0989	0.7938		0.6336		0.0017	6.4321
Feb' 81	4.0725	0.1919	0.4847	0.5506	0.0669				0.0128	5.3804
Mac' 81	3.0894	1.1059	0.36	0.1469	0.223					4.9252
Apr' 81	3.1089	0.0238	0.124	0.1823		0.3483			0.0028	3.7901
May' 81	2.104	0.0034	0.655	0.1965	4.0578	0.0016	0.0851		0.008	7.2178
Jun' 81	2.1399	0.0663	0.0836	0.0097	0.0417		1.4973		0.0101	3.8486
Jul' 81	2.2871	0.072	0.2096	0.0062		0.0251	0.7582		0.0212	3.3794
Aug' 81	4.0649	0.6614	0.0906		0.1445				0.0635	5.0249
Sep' 81	2.0344		0.1944	0.8508		0.0165	5.2354		0.0427	8.3742
Mean	2.6634	0.3204	0.3445	0.7722	0.5178	0.1261	0.9192	0.0023	0.0204	5.6141
±SD	0.9312	0.3823	0.1987	1.6242	1.2850	0.2491	1.7353	-	0.0230	1.8519

Table 2. Macrofauna density and biomass (excluding Sesarminae crabs) in Site 1 (disturbed forest) in Sementa, Selangor.

Sampling month	Dec' 80	Apr' 81	Sep' 81
Density (no. m^{-2})			
Taxon			
Polychaeta			
Glycera spp.	6.89	5.36	2.3
Leiochrides sp.	18.37	6.89	11.45
Crustacea			
Uca rosea (Tweedie)	21.81	15.3	6.89
U. triangularis (H. Milne Edwards)	9.18	14.54	6.89
Ilyoplax punctata (Tweedie)	4.59	7.65	3.44
Paracleistostoma depressum (de Man)	11.48	-	0.77
Gastropoda			
Cerithidea obtusa (Lamarck)	-	-	1.15
Assiminea brevicula (Pheiffer)	3.44	6.89	
Ellobium aurisjudae (L.)	-	-	1.15
Insecta			
Coleoptera larvae	2.3	1.53	-
Araenae			
Pardosa sp.	-	0.77	-
Sipuncula			
Phascolosoma arcuatum (Gray)	1.15	0.77	1.15
Others			
Amphipoda	-	-	1.15
Sample size	8	12	8
Biomass (g dry wt m^{-2})	6.5041	3.6187	2.5492

Mean macrofauna biomass: 4.22 ± 1.67 g dry wt m^{-2}
Biomass range: 2.55 - 6.50 g dry wt m^{-2}

3.2.2 Site 2 (undisturbed forest)

Five species of Sesarminae with a biomass 8.25 ± 2.1 g dry wt m^{-2} occurred in the undisturbed forest (Table 3). In contrast the mean macrofauna biomass was 10.49 ± 6.06 g dry wt m^{-2} (Table 4). Thus the undisturbed forest supported a total faunal biomass of 18.72 g dry wt m^{-2} (Tables 2 and 4). Most of the macrofauna biomass other than sesarmid crabs was contributed by *Cerithidea cingulata, Uca rosea* and *Telescopium telescopium.*

There were only five species of Sesarminae in this undisturbed forest and the two large species were *Episesarma versicolor* and *Sarmatium crassum. P. eumolpe* was the most common species, and contributed 73.2 % of the annual mean Sesarminae biomass (Table 1) while *P. onychophorum* only contributed 12.7 %. The sesarmid biomass averaged about 44 % of the total macrofaunal biomass (Table 3).

The density and biomass of macrofauna other than Sesarminae in these two sites also varied considerably (Tables 2 & 4). The disturbed site had a lower biomass (4.22 ± 1.67 g dry wt m^{-2}) than the undisturbed site (10.49 ± 6.06 g dry wt m^{-2}) The stable environment provided by a mature forest appears conducive for Sesarminae crabs to reach a high biomass indicative of climax density.
The surface area exposed by borrows for oxidation increased by 41 % in Site 1 and by 27 % in Site 2 (Leh, 1982). The maximum volume of sediment turnover per km^2 would amount to 4.37 x 10^3 and 3.00 x 10^3 m^3 in sites 1 and 2 respectively.

Table 3. Biomass values of Sesarmine crabs in Site 2 (undisturbed forests) (g dry wt m^{-2}) in Sementa, Selangor.

Month of sampling	Species					Total
	P. onychophorum	*P. eumolpe*	*E. versicolor*	*Clistocoeloma merguiensis*	*Samartium crassum*	
Oct' 80	1.4229	8.446	0.2634	1.0699	0.1462	11.3484
Nov' 80	1.4083	8.2713	0.2609	0.9769	1.4618	12.3792
Dec' 80	0.4285	5.6134		0.2076	0.0124	6.2619
Jan' 81	1.2774	4.0654	0.0072	0.0918		5.4418
Feb' 81	0.7095	8.5755	0.0502	0.2917		9.6269
Mac' 81	0.2917	5.9349	0.005	0.4562	0.0359	6.7237
Apr' 81	0.5563	5.2172	0.4478	0.2609	1.2504	7.7326
May' 81	0.8136	5.6583	0.0034	0.6479		7.1232
Jun' 81	2.6976	4.8567		0.1433		7.6976
Jul' 81	2.3119	5.7911		0.4011		8.5041
Aug' 81	0.4708	4.8723	4.1482	0.3833		9.8746
Sep' 81	0.1981	5.1325	0.9325			6.2631
Mean	1.0489	6.0362	0.6798	0.4482	0.5813	8.2481
±SD	0.8014	1.5303	1.3350	0.3240	0.7130	2.1576

Biomass range : 5.44 - 12.38 g dry wt m^{-2}

Whether such a volume of sediment turnover takes place in a year or a month remains unknown as all crabs may not construct new burrows and many may occupy used burrows.

DISCUSSION

Most studies on mangrove macrobenthos have been based on sampling by random throws of quadrates (Sasekumar, 1974; Warner, 1969) or pit fall traps or time regulated crab catches (Ashton, 2002). These methods introduced an element of bias in sampling as crabs would escape as a quadrate fell to the ground. In the present study, a metal frame quadrate was rapidly pressed into the sediment to cut off escape of crabs. Thus densities recorded in this study are higher than that recorded in an earlier study (Sasekumar, 1974; Pinto, 1984). The present study site corresponds to the supra-littoral zone of Jamaican mangroves (Warner, 1969) and the high shore mangroves (Sasekumar, 1974). The taxonomic parallel between crab faunas in different mangroves in different localities may be attributed to the substrate structured by the growth of mangroves (Warner, 1969).

The distribution of crabs in the mangrove forest may be related to tidal exposure, grain size of substrate, moisture, organic content and food availability (Macnae 1968; Sasekumar, 1974; Frith et al., 1980). Sesarminae crabs of the genus *Perisesarma, Clistoceoloma, Sesarmoides, Sarmatium, Neosarmatium, Parasesarma* and *Nanosesarma* were most common in the upper intertidal zone of the mangrove shore. There were 9 species in the disturbed forest, while there were only 5 species in the undisturbed forest. The most common species in

Table 4. Macrofaunal density and biomass (excluding Sesarminae crabs) in Site 2 (undisturbed forest) in Sementa, Selangor.

Sampling month	Dec' 80	Apr' 81	Sep' 81
Density (no. m^{-2})			
Taxon			
Polychaeta			
Glycera spp.	1.15	-	2.3
Leiochrides sp.	2.3	-	1.15
Crustacea			
Clibanarius striolatus	2.3	-	-
Uca rosea	5.74	2.76	4.59
Ilyoplax punctata	1.15	-	0.92
Paracleistostoma depressum	13.77	0.92	1.15
Gastropoda			
Cerithidea obtusa	1.15	1.84	1.15
Assiminea brevicula	19.51	13.77	2.3
Ellobium aurisjudae	2.3	-	-
Nertia articulata	1.15	-	-
Cerithidea cingulata	4.59	0.92	3.44
Telescopium telescopium	3.44	1.84	-
Periophthalmus sp.	1.15	-	-
Sample size	8	10	8
Biomass (g dry wt m^{-2})	18.1484	9.9772	3.3375

Mean macrofauna biomass: 10.49 ± 6.06 g dry wt m^{-2}
Biomass range: 3.34 - 18.15 g dry wt m^{-2}

the disturbed forest was *P. onychophorum*, while in the undisturbed forest it was *P. eumople*. These two forests were significantly different in Sesarminae crab biomass ($p<0.01$; Table 5). The forest floor in the undisturbed forest was wet throughout the year due to its proximity to the tributaries of S. Kapar Kecil (Fig. 1), while the disturbed forest was dry during low neap tidal periods. The water content of the substrate appears to be an important factor in colonization by Sesarminae crabs. The wet substrate in the mature forest appears to be conducive for colonization by *P. eumolpe*.

Tree cover plays an important role in faunal abundance. Infaunal studies suggested that a 2-year-old mangrove forest had the greatest biomass and species number followed by the mature and 15 year old stand, although species diversity was highest in the mature forest and lowest in the 2 year old forest (Sasekumar and Chong, 1998). Sesarminae crabs seem more responsive to ecosystem degradation or restoration since they are thought to be key stone species with respect to nutrient cycling (Bosire et al. 2008). Greater abundance of macrobenthos in disturbed forests may be attributed to rapid colonization through recruitment into the environment which may be considered unstable in the absence of tree cover (Zainal & Sasekumar, 1994). Re-growth of trees may stabilize the benthic community gradually until the climax situation is attained where the forest is populated by lesser number of macrobenthic species.

A change in macrofaunal community structure with forest age was also noted in Ranong, Thailand, where the highest macrofaunal diversity was observed in forest stands of intermediate age (7 to 10 years old) because of the associated environmental heterogeneity provided by both open and forested areas (Macintosh et al. 2002). Until more details of the interaction between crab species are known, it is premature to discuss the differing macrofaunal diversities among forest stand of different ages.

Table 5: Mean total biomass and number of species recorded of Sesarminae crabs and other macrofauna in disturbed and undisturbed forests. ** Significance at p<0.01.

Biomass (g dry wt m^{-2})	Site								ANOVA
	Disturbed				Undisturbed				
	Mean	n	sd	No of species recorded	Mean	N	sd	No of species recorded	p-level
Sesarminae crabs	5.614	12	1.852	9	8.248	12	2.158	5	0.004**
Other macrofauna	4.224	3	2.046	13	10.488	3	7.419	13	0.231

Grapsid crabs play a vital role in sediment turnover and exposure of sub-surface sediment to air. These crabs may be regarded as ecosystem engineers when they macerate and consume mangrove leaves and other plant tissue (Leh & Sasekumar, 1985). Five species of Sesarminae crabs in the high mangrove shore had between 83 and 96 percent of their proventriculus filled with mangrove plant material. Small amounts of crab tissue and other invertebrates were also found, indicating their partly carnivorous food habits. The more important role of sesarminae crabs in the ecosystem is their extensive burrowing activities which render the anoxic sediment suitable for growth of plants and colonization by other animals (Kristensen, 2008).

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