Research Article

Species assemblages of benthic harpacticoid copepods on tide rock pool seaweeds of Pulau Besar, Melaka, Malaysia

Zaleha K.[1]*, Nazia A.K.[2] and Nurul Huda A.I.[3]

[1]*Institute of Tropical Aquaculture, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu. *email: zaleha@umt.edu.my*

[2]*Department of Marine Science, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu.*

[3]*Institute of Oceanography, Universiti Malaysia Terengganu, 21030, Kuala Terengganu, Terengganu.*

ABSTRACT. An ecological survey was carried out to study species assemblage of meiobenthic harpacticoid copepods in different seaweed species found in tide rock pools in Pulau Besar, Melaka. Samples of sediment and four different seaweed species, *Ulva reticulata*, *Padina* sp., *Amphiroa fragilissima* and *Gracilaria salicornia* were collected from tide rock pools on the island during low tide. A total of 25 harpacticoid species from 11 families and 16 genera were identified. Many of the species found were associated exclusively on seaweeds (10 species). *Diarthrodes tetrastachyus*, *Nitocra typica* and *Harpacticus uniremis* were the most abundant species on seaweeds whereas sediment around them was dominated by *Amphiascus rebus*, *Heterolaophonte longifurcata* and *Parastenhelia littoralis. Robertgurneya diversa*, *Robertgurneya oligochaeta, Idomene* sp. and *Nitocra spinipes armata* were only found in sediment samples. Analysis of similarity (ANOSIM) showed that the harpacticoid assemblages on different seaweed species were significantly different ($P<0.001$). The assemblages in seaweed and sediment were also different significantly ($P<0.002$), indicating their life history strategy to adapt to the harsh environment on the island.

Keywords: Rock pool, seaweeds, harpacticoids, The Straits of Malacca

INTRODUCTION

Intertidal vegetated habitats are known to provide food sources thus attracting mobile organisms (Paula *et al*., 2001), becoming a habitat of preference to some of them (Viejo, 1999). Their assemblages on the vegetation become an important food source for marine species entering the zone during high tide (Gee, 1989).

Harpacticoid species assemblage increases in number and diversity with increasing micro-spatial habitat complexity such as that found in seaweed. Hicks (1976) reported that phytal meiofauna in six seaweed species *(Enteromorpha, Corallina, Zonaria, Xiphophora, Pterocladia* and *Ecklonia)* in rocky shores of Crook Straits is dominated by harpacticoid copepods. The phytal dwelling harpacticoid group that is commonly found on

Received 11 August 2009. Revision accepted 27 October 2009

seaweed are from the family Harpacticidae, Porcellidiidae, Thalestridae, and Diosaccidae (Hicks, 1977).

Bottom vegetated sediment in the Malaysian coast is reported to support high abundance and diversity of harpacticoid species (Kassim *et al.,* 2004; Zaleha *et al*., 2005). They consistently become the second dominant meiofauna after nematodes in seagrass bed (Kassim *et al.,* 2008). Different species of harpacticoid from the family of Porcellidiidae reported from seaweed patches in the Sungai Pulai seagrass bed (Zaleha *et al.,* 2008) support the specific role of vegetation in diversity of species assemblage. To date, very few attempts have been made to investigate species assemblages of harpacticoid copepods associated with intertidal vegetation such as intertidal seaweeds. Thus, this study aims to compare the harpacticoid species found on different seaweed species inhabiting the rock pool in the Straits of Malacca and reveals the habitat preference of the harpacticoids in the study area.

MATERIALS AND METHODS

Field Sampling

The sampling location was at intertidal zone of Pulau Besar, Melaka in the Straits of Malacca (02˚ 06.640' N, 102˚ 19.960' E) as shown in Figure 1. The area was visited in July and August 2005 to investigate seaweed species found at the island. There was a half-kilometre stretch of rocky beach with many small tide pools inhabited with different seaweed species.

○ Sampling site at Pulau Besar, Melaka

Figure 1. Map of Malaysia showing Melaka and Pulau Besar (02˚ 06.640' N, 102˚ 19.960' E).

Several tide pools, about 1m in diameter and 0.30m depth were selected, and temperature, salinity, dissolved oxygen and pH value were measured *in situ* using a YSI meter (model YS1 556). Triplicate samples were collected for each seaweed species and sediment.

The whole structure of seaweed was covered with 62 microns net and removed from the substrate by cutting at the base of the attachment. The seaweed was stored in a labelled plastic bag and fixed with 5% of buffered formalin. Surface sediment at each tide pool was scooped in an area of 0.5m x 0.5m, with approximately 5 cm depth and also fixed with 5% of buffered formalin.

Laboratory work

Seaweed samples were rinsed with freshwater five times and observed under a stereo microscope to confirm that all meiofauna were removed. The rinse water was then sieved through 500 µm and 62 µm mesh size net. All animals retained on the 62 µm sieve was regarded as meiofauna and then transferred into petri dishes. Harpacticoids were sorted and quantified under a stereo microscope. The seaweed were identified taxonomically based on general morphological criteria. Then, each species of seaweed was weighed to obtain the wet weight and dried at 60ºC for 72 hrs to obtain the dry weight.

Harpacticoids from the sediment samples were extracted using the simple decantation method. The samples were washed into a 1 litre capacity stoppered measuring cylinder and were made up to 800 ml with seawater, giving a sedimentation height of about 30 cm. The cylinder was inverted several times to suspend the sediment and then left until the sand particles sedimented out (about 60 seconds). The supernatant was decanted through a 62 µm sieve (McIntyre & Warwick, 1984). Organisms retained on the 62 µm sieve were sorted and quantified under a stereo microscope.

All collected meiofauna were preserved in 70 % ethanol. Harpacticoid copepods from the seaweeds and the sediments were dissected for identification (Harris, 2001). The physical features such as head appendages and body surface spinulation patterns were observed under high magnification compound microscope.

Bray-Curtis similarity matrix was calculated on Log_e (x+1) transformed abundance data to reduce contributions to similarity by abundant species and to increase the importance of less abundant species (Somerfield *et al.,* 1995). Two-way crossed analysis of similarities (ANOSIM) was run to the standardised data. Hierarchical Cluster analysis (CLUSTER) was done to find the ‘natural groupings’ of samples. All statistical analyses were performed using software package Primer v5 (Plymouth Routines in Multivariate Ecological Research) as recommended by Clarke & Warwick (2001).

RESULTS

***In situ* environmental measurement**

The temperature, salinity, dissolved oxygen and pH were measured *in situ* during the sampling, which indicated the typical condition of the tropical marine environment (Table 1). The sampling was done in the morning during low tide, thus the temperature was comparatively low.

Species list

Four species of seaweed were identified in this study, *Ulva reticulata, Padina* sp., *Amphiroa fragilissim* and *Gracilaria salicornia*. A total of 25 harpacticoid species from 11 families and 16 genera collected from the seaweeds and the adjacent sediment were identified.

The family Diosaccidae was represented by the highest number of species (7), followed by the Thalestridae (5). Parastenhellidae, Ectinosomatidae, Metidae, Longipediidae, Porcellidiidae and Louriniidae were each represented by a single species (Table 2).

Table 1. *In situ* measurement of temperature (°C), salinity (psu), dissolved oxygen (mg/L) and pH at the rock pool of Pulau Besar Melaka.

Tide pool	Temperature	Salinity	DO	pH
1	25.71	35.42	7.72	7.70
2	25.62	37.75	8.02	7.69

Table 2. List of harpacticoid species found within the rock pool seaweeds in Pulau Besar, Melaka in The Strait of Malacca.

Family	Species
Diosaccidae Sars, 1906	
	Amphiascopsis coralicola
	Amphiascopsis thalestroides
	Amphiascus cinctus
	Amphiascus robinsoni
	Amphiascus rebus
	Robertgurneya diversa
	Robertgurneya oligochaeta
Thalestridae Sars, 1905 sensu Lang, 1948	
	Eudactylopus andrewi
	Eudactylopus fasciatus
	Diarthrodes tetrastachyus
	Phyllothalestris mysis
	Idomene sp.
Ameiridae Monard, 1927 (part.), Lang, 1936	
	Nitocra typica
	Nitocra spinipes armata
	Nitocra sp.
Parastenheliidae Lang, 1944	
	Parastenhelia littoralis
Laophontidae T. Scott, 1905	
	Paralaophonte brevirostris
	Heterolaophonte longifurcata
Harpacticidae, Sars 1904	
	Harpacticus uniremis
	Harpacticus spinulosus
Ectinosomatidae Sars, 1903 (part.), Olofsson, 1917	
	Ectinosoma melaniceps
Longipediidae Sars, 1903 (part.) sensu Lang, 1948	
	Longipedia weberi
Porcellidiidae Sars, 1904	
	Porcellidium fimbriatum
Louriniidae Monard, 1927	
	Lourinia armata
Metidae Sars, 1910	
	Metis jusseaumei

Out of 25 species, 11 species occurred on both seaweed and sediment substrates (Table 3). Many of the species found were associated exclusively on seaweed (10 species). *Robertgurneya diversa*, *R. oligochaeta, Idomene* sp. and *Nitocra spinipes armata* were only found in sediment.

Harpacticoid dominance

Biomass of the most dominant harpacticoid species in different seaweed were compared and summarized (Figure 2). The number of species identified on the seaweed ranged between six (on *Ulva reticulata*) and 12 species (on *Padina* sp.). All seaweed species supported different most dominant harpacticoid species with different species composition. Overall, *Diarthrodes tetrastachyus* was the most abundant (16.2 $\pm$ 11.2 ind./g dry weight), followed by *Nitocra typica*, (12.9 $\pm$ 4.6 ind./g dry weight) and *Harpacticus uniremis* (12.1 $\pm$ 4.7 ind./g dry weight), found on *Ulva reticulata*, *Amphiroa fragilissim* and *Gracilaria salicornia*, respectively.

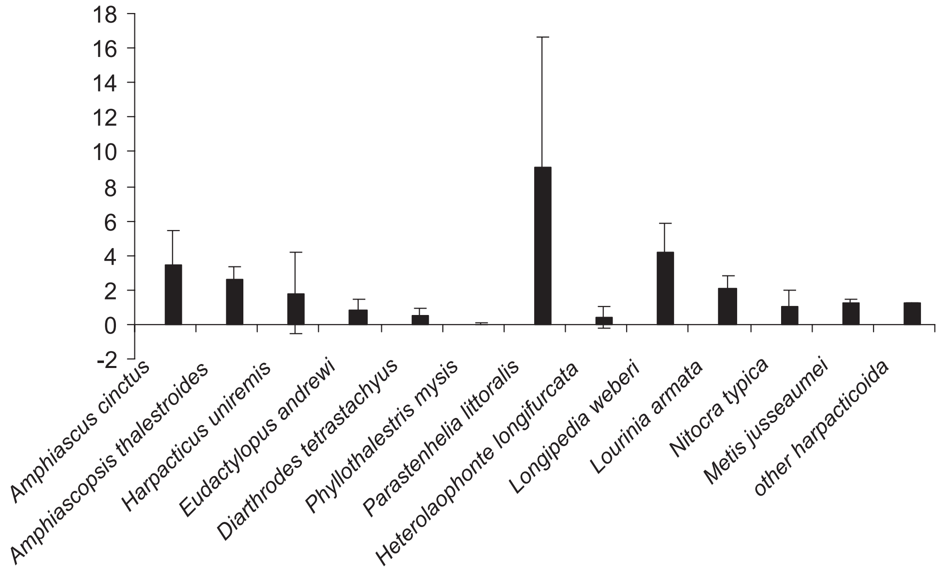
Harpacticoid copepods represented 46.1 % of total meiofauna in the sediment adjacent to *Ulva reticulata* while only 26.6 % was found inhabiting the seaweed (Figure 3). Percentage of harpacticoid copepods for *Padina* sp. followed the same trend with 37.03 % in the sediment but only 26. 83 % in the seaweed.

Table 3. Occurrence of harpacticoid species in seaweeds and sediment of the rock pool in Pulau Besar, Melaka in The Strait of Malacca. (present: + ; none : -).

Species	Seaweeds	Sediment
Amphiascopsis coralicola	+	-
Amphiascopsis thalestroides	+	+
Amphiascus cinctus	+	+
Amphiascus robinsoni	+	-
Amphiascus rebus	+	+
Robertgurneya diversa	-	+
Robertgurneya oligochaeta	-	+
Eudactylopus andrewi	+	-
Eudactylopus fasciatus	+	-
Diarthrodes tetrastachyus	+	-
Phyllothalestris mysis	+	-
Idomene sp.	-	+
Nitocra typica	+	+
Nitocra spinipes armata	-	+
Nitocra sp.	+	-
Parastenhelia littoralis	+	+
Paralaophonte brevirostris	+	+
Heterolaophonte longifurcata	+	+
Harpacticus uniremis	+	-
Harpacticus spinulosus	+	+
Ectinosoma melaniceps	+	+
Longipedia weberi	+	-
Porcellidium fimbriatum	+	-
Lourinia armata	+	+
Metis jusseaumei	+	+
Total number of identified species	21	15

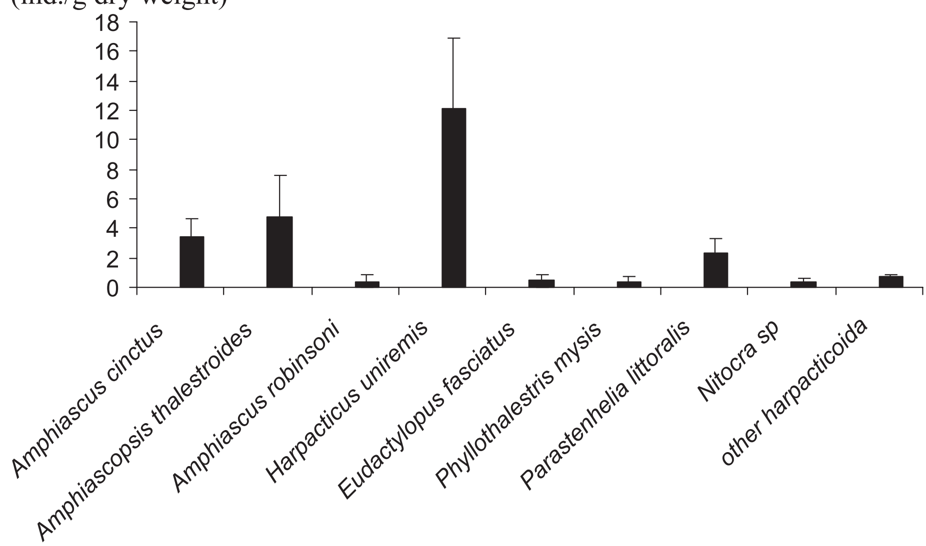
A. *Padina* sp.

(ind./g dry weight)



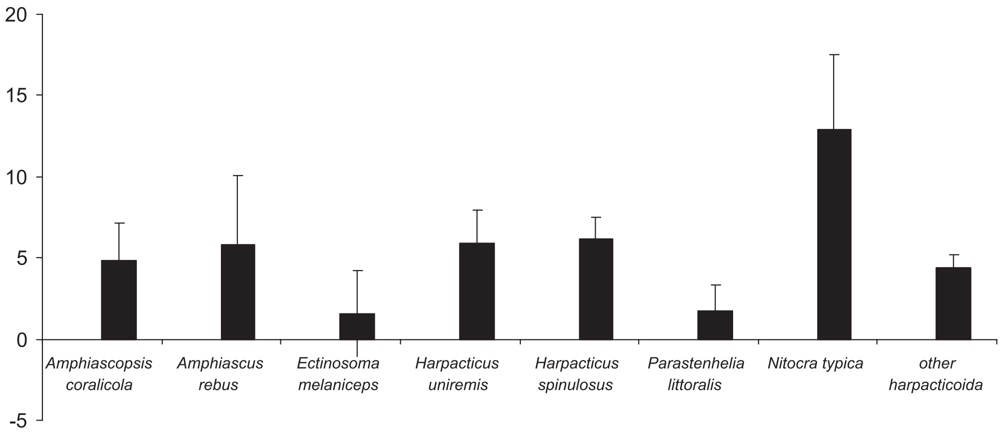
B. *Gracilaria salicoria*

(ind./g dry weight)



C. *Amphiroa fragilissima*

(ind./g dry weight)



D. *Ulva reticulata*

(ind./g dry weight)

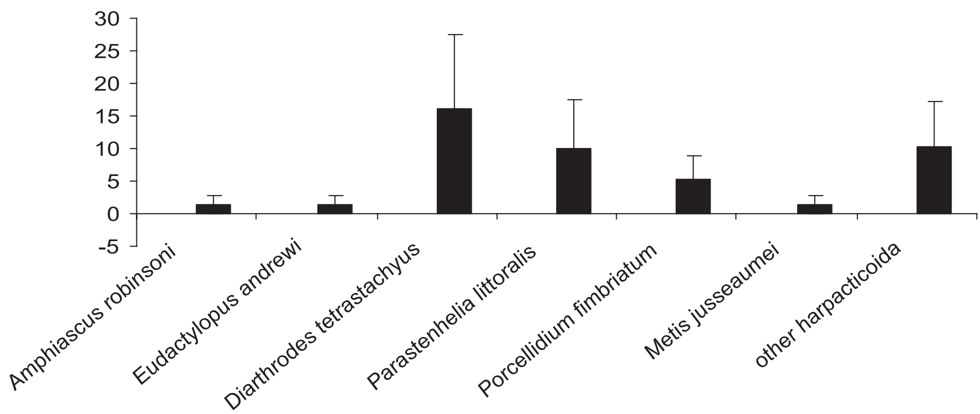


Figure 2. Biomass (ind./g dry weight) of harpacticoid species found in different seaweed species (A,B,C and D) in the rock pools of Pulau Besar, Melaka, The Straits of Malacca. Species were arranged by the same order in Table 2.

On the other hand, percentage of harpacticoids in *Amphiroa fragilissima,* was slightly higher than what was found in sediment with 43.33 % and 41.57 %, respectively.

Bray-curtis analysis of similarities (ANOSIM) showed that the harpacticoid composition were different on seaweeds (P<0.001) and between seaweed and sediment (P<0.002). Hierarchical clustering (CLUSTER) also showed that the composition of harpacticoid species were more similar in replicates of same seaweed species than between different seaweed species (Figure 4). Sediments adjacent to *Ulva reticulata* were separated from other samples indicating that they had the least species similarity when compared to the other samples. The other distinct group was samples of sediment and seaweed *Amphiroa fragilissima* which was separated from the other group. Samples of sediment and seaweed *Padina* sp. was also clustered together but with similarity of less than 60%.

DISCUSSION

Marine seaweeds harbour different species of harpacticoid copepods with the dominance of specific species being determined by the morphological features of the vegetation (Hicks, 1977a). With an increase of surface area, different types of harpacticoids might be found with various body shapes and leg characters that serve for clinging, the same way other meiofauna associate with epiphytic algae (Susetiono, 1998). The findings are in agreement with earlier findings (Hicks, 1980; Bells, 1985) that the common species found at the bottom vegetation were from the family of Diosaccidae, Thalestridae and Harpacticidae.

As reported by Hicks (1980), the Harpacticidae and Thalestridae contributed 72% of the total meiofauna on eight species of macroalgae collected from Robin Hood's Bay and St. Abbs, England. This might be due to the fact that species from these families commonly have a dorsoventrally compressed body with flattened and hooked structure of the first leg (Coull, 1977) that could be used for adaptation to seaweed with flattened surface rather than the cylindrical or needle-like seaweeds. There is a good association of Thalestridae with the flattened surface of bottom vegetation as shown by the report of De Troch *et al.* (2001). They found that Thalestridae was dominant in the leaf samples

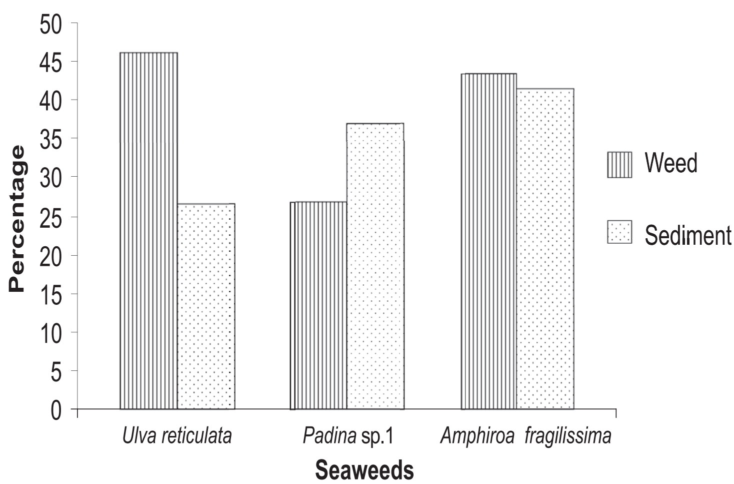


Figure 3. Comparison of harpacticoid copepods percentage found between seaweeds and sediment in rock pool of Pulau Besar, Melaka.

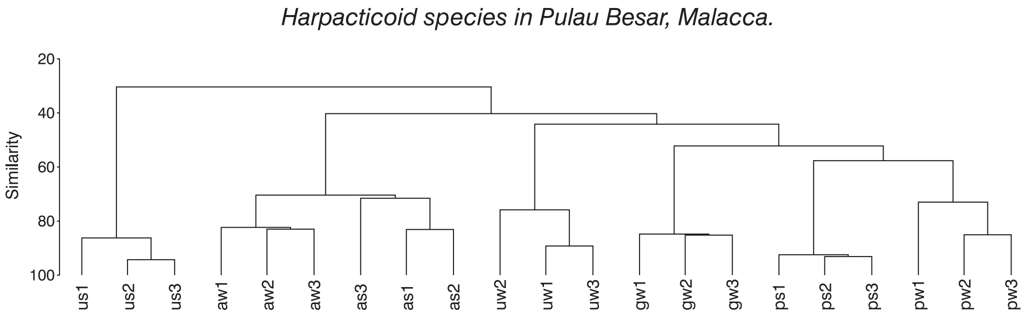


Figure 4. Group cluster based on similarity for each replicate sample of harpacticoids in seaweeds and sediment. (us=sediment of *Ulva reticulata*; uw= seaweed of *Ulva reticulata*; aw= seaweed *Amphiroa fragilissima*; as=sediment of *Amphiroa fragilissima*; gw= seaweed *Gracilaria salicoria*; ps=sediment of *Padina* sp.; pw=seaweed *Padina* sp; 1, 2, 3=number of replicate).

of seagrass in their study area, with *Diarthrodes* sp. becoming the dominant species. On the other hand, species of *Harpacticus chelifer* and *H. uniremis* from Harpacticidae were reported as a successful colonizer on floating algae *Ascophyllum nodosum* (Olafsson *et al.,* 2001), thus supporting the fact that they are morphologically adapted to those types of seaweed. This adaptation might be also related to the interaction between seaweeds with surface microbial film found on them (Hicks, 1977b). It is interesting to note that none of the species of Porcellidiidae is reported in the present study, although about seven species were recorded from the seaweed patches in the seagrass bed of Sungai Pulai (Zaleha *et al*., 2008). The different in tidal zone and less stress condition due to the water depth in Sungai Pulai (Kassim *et al.* 2008) could explain this phenomenon.

Sediment species could benefit the vegetation as their shelter or protection from tidal waves (Keats & Steele, 1993). Seaweed with cylindrical or needle-like structure such as coralline algae may trap much of fine sediment due to the high ratio of the surface per volume. This structure is able to support sediment species with the elongate, cylindrical body shape which is usually found in the families of Diosaccidae, Ectinosomatidae and Laophontidae (Hicks, 1977a).

Although certain species exclusively associated with certain substrate such as different species of seaweed or only to sediment, some other species might be active swimmers that move between seaweeds and sediment to find new dwelling spaces. Some elongated and fusiform body shape of harpacticoid species, such as *Ectinosoma meliceps*, *Amphiascopsis cinctus*, *Mesochra pygmaea* and *Paralaophonte congenera*, were reported to perform vertical swimming between 0.5 to 1m distance (Hauspie & Polk, 1973) and that shows their possibility to occur both on the seaweed and the sediment. Walters (1988) also reported that harpacticoids performed vertical migration in both sediment and seagrass in his study area in subtropical sand and seagrass habitats. This might be one of their strategies to adapt to the habitat.

In conclusion, harpacticoid species assemblages in the tide rock pools of Pulau Besar in the Straits of Malacca showed different preference for seaweeds and sediments. Species assemblages that closely related to the morphology of the seaweeds found in the tide pool may reveals the life history strategy of the marine harpacticoids to adapt to the environment.

ACKNOWLEDGMENTS

Financial supports from IRPA Grant, Ministry of Science and Technology, Malaysia under the RMK-8 is kindly acknowledged. The authors are indebted to Mr. Kamarudin Jauhad of Flexible Tech Sdn. Bhd., Muar, Johor for the technical support during the field work.

REFERENCES

Bell, S. S. 1985. Habitat complexity of polychaete tube-caps: Influence of architecture on dynamics of a meioepibenthic assemblages. *Journal of Marine Research* 43: 647- 671.

Clarke, K.R. & R.M. Warwick. 2001. Change in marine communities : an approach to statistical analysis and interpretation. 2nd edition. Primer-E Ltd: Plymouth., 389 pp.

Coull, B.C. 1977. Marine flora and fauna of the northeastern United States. Copepoda: Harpacticoida. NOAA technical report. NHFS Circular, pp. 1-49.

De Troch, M., S. Gurdebeke, F. Fiers & M. Vincx. 2001. Zonation and structuring factors of meiofauna communities in a tropical seagrass bed (Gazi Bay, Kenya). *Journal of Sea Research* 45: 45 -61.

Gee, J.M. 1989. An ecological and economic review of meiofauna as food for fish. *Zoological Journal of the Linnean Society* 96: 243-261.

Harris, R. 2001. Copepods. In: John, H.S., A.T. Steve & K.T. Karpe (eds.). *Encyclopedia of ocean sciences.* Academic Press, pp. 512-523.

Hauspie, R. & P.H. Polk. 1973. Swimming behaviour patterns in certain benthic Harpacticoida (Copepoda). *Crustaceana* 25: 95-103.

Hicks, G.R.F. 1976. Species composition and zoogeography of marine phytal harpacticoid copepods from Cook Strait, and their contribution to total phytal meiofauna. *New Zealand Journal of Marine and Freshwater Research* 11: 441- 469.

Hicks, G.R.F. 1977a. Species associations and seasonal population densities of marine phytal harpacticoid copepods from Cook Strait. *New Zealand Journal of Marine and Freshwater Research* 11: 621-643.

Hicks, G.R.F. 1977b. Observation on substrate preference of marine phytal harpacticoids (Copepoda). *Hydrobiologia* 56 (1): 7-9.

Hicks, G.R.F. 1980. Structure of phytal harpacticoid copepods assemblages and the influence of habitat complexity and turbidity. *Journal of Experimental Marine Biology and Ecology* 44 (2): 157-192.

Kassim, Z., Norhayati Sabudin & Aini Adawaiah Ahmad. 2004. Composition of benthic fauna from bottom sediment of Perhentian Island, Malaysia. In: Nitithamyong, C. (ed). Proceedings of the First Joint Seminar on Coastal Oceanography, 14-16 December 2003, Chiang Mai, Thailand, Bangkok. Department of Marine Science, Chulalongkorn University, pp. 75-84.

Kassim, Z., F. Diyana M. Fathi & A. Ahmad. 2008. Meiobenthic community of Sungai Pulai Seagrass Bed, Malaysia. *Marine Research in Indonesia* 33 (1): 17-20.

Keats, D.W. & D.H. Steele. 1993. Food of 0-group ocean pout (*Macrozoarces americanus* Schneider) in Eastern Newfoundland: The importance of harpacticoid copepods. *Journal of Fish Biology* 42 (1): 145-148.

McIntyre, A.D. & R.M. Warwick. 1984. Meiofauna techniques. In: Holme, N.A. & A.D. McIntyre (eds.). *Methods for the Study of Marine Benthos.* Blackwell Scientific Publications, pp. 217-240.

Olafsson, E., A. Ingolfsson & M.B. Steinarsdottir. 2001. Harpacticoid copepod communities of floating seaweed: controlling factors and implications for dispersal. *Hydrobiologia* 453-454 (1): 189-200.

Paula, J., C.P. Fidalgo, A. Martins & D. Gove. 2001. Patterns of abundance of seagrasses and associated infaunal communities at Inhaca Island, Mozambique. *Estuarine, Coastal and Shelf Science* 53: 307-318.

Somerfield, P.J., H.L. Rees & R.M. Warwick. 1995. Interrelationships in community structure between shallow-water marine meiofauna and macrofauna in relation to dredgings disposal. *Marine Ecology Progress Series* 127: 103-112.

Susetiono. 1998. Study on meiofauna dynamics at a monotypic seagrass *Enhalus acoroides*, Kuta Bay, Lombok Island. Proceeding, The 10th JSPS/VCC Joint Seminar on Marine and Fishery Sciences, pp. 100-117.

Viejo, R. M. 1999. Mobile epifauna inhabiting the invasive *Sargassum muticum* and two local seaweeds in northern Spain. *Aquatic Botany* 64: 131–149.

Walters, K. 1988. Diel vertical migration of sediment-associated meiofauna in subtropical sand and seagrass habitats. *Journal of Experimental Marine Biology and Ecology* 117(2): 169-186.

Zaleha, K. & H. Khairil Syahrizan. 2005. Benthic community of a lagoonal seagrass, Setiu. Proceedings, 4th Annual Seminar on Sustainability Science and Management. 2-3 May, 2005, Terengganu. Kolej Universiti Sains dan Teknologi Malaysia, pp. 307-311.

Zaleha,K., Abang Jefri Abang Mansor & Hasimah Mohd Said. 2008. Species diversity of Porcellidiidae Sars, 1860 (Copepoda: Harpacticoida) from seagrass bed of Sungai Pulai, Malaysia. 10th Symposium of the Malaysian Society of Applied Biology, 6-8Nov.2008, Kuching Sarawak.