Journal of Sustainability Science and Management 2008 Volume 3 (1): 11-22

SPECIES COMPOSITION AND ABUNDANCE OF PLANKTONIC COPEPODS IN PAHANG ESTUARIES, MALAYSIA

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Abstract: An ecological study on the copepods of estuarine mangrove of Pahang Coast in the east coast of Peninsular Malaysia was carried out to determine the difference in species composition as to understand their contribution to the coastal copepods in The South China Sea. Field sampling was carried out in the estuary of Miang, Bebar, Kuantan and Endau River. Samples of zooplankton were collected by using 65 microns of Kitahara plankton net. A total of 17 copepod families that represented by 35 species were identified. Species biodiversity in the study area was low as indicated by the values of Shannon-Wiener Diversity Index, H' (between 1.36 and 1.79 bits). The combination analysis of clustering (Bray-Curtis similarity) and ordination (2-dimensional MDS configuration) between stations based on copepod species abundance showed the low percentage of similarity (30-35%) for the main grouping. Results from this study indicated the effect of sea water and freshwater inflow towards the different species composition in the mangrove estuarine copepods in Miang, Kuantan, Bebar and Endau River. The relationship and contribution of the estuary as the shelter area for the coastal species was also indicated.

KEYWORDS: Copepod, estuarine mangroves, Pahang coast, Peninsular Malaysia

Introduction

Planktonic copepods are usually the main zooplankton component and they play important role as trophic linkage between the primary producer and upper trophic level in an aquatic food web (Grindley 1984; Robertson and Duke 1987). The nauplii and copepodites of copepods are the central role of secondary production in tropic region and also critical intermediaries between the classical marine food-web and the microbial loop.

In estuarine mangrove ecosystem, the greatest species diversity is commonly occurs among neritic forms near the mouth (lower reach), while estuarine species dominate the upper reach with lower levels of diversity, thus estuarine zooplankton including copepods could be divided into groups based on salinity regime (Grindley 1984). An estuarine harpacticoid copepod *Amphiascus tenuiremis* proved the influence of salinity changes to their population density in a laboratory culture experiment, indicating their existence in the natural environment might be limited to certain salinity regime (Richmond *et al.* 2007). On the other hand, the existence of mangrove forest itself gives influence to the copepod assemblages in the area as shown by copepod community of Merbok estuary in the northern of Peninsular Malaysia (Gee and Somerfield 1997). A preliminary work on Terengganu River estuary, in the east coast of Peninsular Malaysia also showed that the copepod assemblage correlated with the salinity gradient found in the estuary (Zaleha et. al 2003). The assemblage was found in agreement with finding of Chong et al (2002) for Matang Estuary although with lower density.

A study on zooplankton in The South China Sea showed the dominance of copepods in the Peninsular Malaysia coast (Zaleha et. al. 2006). The study indicates that Pahang coast differs from Terengganu by the dominance of calanoids, followed by the harpacticoid copepods. It is not known if the dominance influenced by the copepods from some of major estuaries in Pahang such as Kuantan, Miang, Bebar and Endau rivers which directly connected to The South China Sea. These estuaries are furnished with mangrove forest which is known as feeding, breeding and nursery ground for many marine organisms (Vance *et al.* 1996; Sheridan 1997; Kathiresan and Bingham 2001). The estuaries are less studied than those at the west coast such as Matang Reserve Forest (Alongi *et al.* 1998), Merbok estuary (Gee and Somerfield, 1997) and Kuala Selangor mangroves (Sasekumar 1994).

This study is carried out to determine the difference in species composition and abundance of planktonic copepods from some estuaries in Pahang as to understand their contribution to the copepod community of Pahang coast in The South China Sea.

Material and Methods

Study Area

There were four river estuaries chosen for the present study; Kuantan, Miang, Bebar and Endau River. All estuaries directly connected to The South China Sea thus, influenced by the tidal cycle of the sea (Fig. 1). The estuary mouths fringe by thick mangrove forest at both sides. Eight stations were selected for Kuantan, five for Miang and Bebar and four for Endau River (Table 1).

Field Sampling

Sampling was done from a small boat. Samples of zooplankton were obtained at each station by using a Kitahara zooplankton net with the mesh size of 65 microns, mouth diameter of 0.25m and length of 1m. Triplicate of samples were obtained by lowering the net to the known depth and hauled vertically. Temperature, salinity, dissolved oxygen, pH and water depth was measured in *situ using* a Hydrolab data sounda multiprobe. Samples were then transferred from the end-net bucket into sampling bottles and fixed with 4% of neutralized formaldehyde.

Laboratory Analysis

Samples of zooplankton were first sub-sampled using a modified Polsom splitter to get one sixteenth portion from the original samples. They were then transferred onto a modified Bogorov tray for quantification and observed under a stereomicroscope. Density was calculated in individual L^{-1}.

Species diversity was calculated based on Shannon-Wiener Diversity Index (H'), Pielou's Evenness Index (J') and Margalef's Species Richness Index (d). Bray-Curtis similarity matrix was calculated on Loge (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). From the matrix, cluster analysis (CLUSTER) was done to find the 'natural groupings' of samples. All statistical analysis were performed using the software packages Primer v5 (Plymouth Routines in Multivariate Ecological Research).

Results and Discussion

The physico-chemical parameters for the study area are shown in Table 2. The water depth ranges from 2.5 to 3.2 meters. The salinity range obviously indicates that some of the stations are located in the area with low salinity. This includes areas in Bebar (7.5 – 21.5), Kuantan (5.40 – 8.50) and Endau River (7.0 – 8.21). Stations in Miang River are more influenced by The South China Sea with salinity ranges from 25.9 to 29.3 ppt. Water temperature and dissolved oxygen in all stations show the typical condition of a sheltered tropic coastal area. Nevertheless, the water pH indicates the weak acidic condition in the study area. This could be contributed by either human activity as the sampling area is near to human settlement or the mangrove litters from the forest.

Planktonic copepods in the mangrove areas in Pahang coast comprise at least four main Copepoda Orders that are Calanoida, Cyclopoida, Harpacticoida and Poecilostomatoida. A total of 17 copepod families that represented by 35 species were identified (Table 3). Calanoid copepods represented by 22 species from 10 families, become the highest species number found in this study. Other copepods are represented by only four or five species. Chong *et al.* (2002) reported on the dominance of copepods in Matang Mangroves but with different species assemblages from the same Orders.

In comparing the results between sampling stations, the highest density is found in the estuary of Miang River where the density reaches about 5500 ind.L-1and the number decreases gradually between Endau, Bebar and Kuantan River. Calanoida dominates over other copepods in Kuantan and Endau River whereas Cyclopoida dominates over other copepods in Miang and Bebar River (Fig. 2). Poecilostmatoida showed the lowest density in all stations. The number of copepod species found in this study is a bit lower than those found elsewhere, for example in African mangroves. Zooplankton in mangroves of Makupa creek and Mombasa Harbour Africa was reported to have at least 51 copepod species (Osore *et. al.* 2003).

Figure 3a-d summarized the density distribution of each copepod groups in the mangroves of Kuantan, Miang, Bebar and Endau River. In Kuantan River, the highest density of copepods is found at Station 7 which located nearest to the sea. The highest number of calanoids contributed it. Cyclopoids, harpacticoids and poecilostmatoids concentrated in the station 4 instead. In Miang River, the highest density of copepods is also found at the last station, station 5. The increase density of each copepod group contributes this after decreasing in Station 3. Total density of copepods in Bebar River is high at Station 1 and Station 2 but decreases at station 3. Calanoids show their significant contribution to the density changes of copepods in the river. However, in Endau River the density of total copepods decreases sharply as station moves towards the sea. The decrease in density is mainly due to the decrease in number of calanoid and cyclopoids. There is little increase for the harpacticoids indicating the increase of sea water influence but it is not a significant contribution to the total density.

Table 4 summarizes the biodiversity indices calculated in the present study. The copepod biodiversity in the study area is quite low with the H' value ranges between 1.36 and 1.79 bits. Stevenson (1984) warned the possibility of polluted condition when the H' value falls to less than 3 bits. The low species diversity in the study area is contributed by the less even (J' value) of species found between stations.

Copepod species in Miang and Endau River seems to have very low equitability with J' values of 0.62 and 0.69 respectively. Stations at Miang and Endau River are different in term of salinity condition where Endau experiences wider salinity range with strong influence of freshwater whereas Miang is more influenced by the sea water. Bebar River has more or less the same salinity range as Endau. This factor might explain the different composition and dominant as shown in Fig.3a-d and also the poor species diversity. Froneman (2004) reported on the effect of freshwater interaction to the estuarine zooplankton in southern Africa and the dominance of copepods during the absence of sea water link. On the other hand, estuarine zooplankton in Kaw River estuary is reported to rely on the tidal and water mass isolation for their contribution to the coastal ecosystem (Lam-Hoai 2006). The water mass may bring along different copepod population or breaks the existing community structure. Thus, changing in water condition such as salinity due to the tidal and freshwater inflow might at the same time change the copepod composition during the sampling period.

The difference in species composition between stations is further shown by the cluster analysis. The combination analysis of clustering (Bray-Curtis similarity) and ordination (2-dimensional MDS configuration) between stations based on copepod species abundance shows there is low percentage of similarity (Fig. 4, Fig. 5). Both figures show the adequacy and mutually consistent, with the stress value 0.2. This value indicates the 2-dimensional picture is still useful to show similarity between stations as clustered in Fig. 4.

The five groups of station separated at a 35% similarity threshold are indicated. Station Miang 5 (M5) totally different from others whereas four stations in Kuantan (K6, K7, K2, K8) also separated from other stations (only 30% similarity with other stations). Kuantan has the highest number of station sampled thus contribute to the dissimilarity in the grouping particularly stations far from the sea. As copepods in estuarine are responsive towards the salinity (Richmond *et al.* 2007), the strong influence of freshwater inflow in the study area in Kuantan that reduces the salinity might be the cause of the dissimilarity in species composition. Stations located far from the sea could receive less import from the sea thus the species composition differed (Rawlinson *et al.* 2005).

Due to the high salinity found in Miang and Bebar River, the cyclopoid species that dominated the area are positively from the marine species. The density was highest when station located nearest to the sea. This may indicates the occurrence of more coastal species than the estuarine group as also found in the Kuala Terengganu estuary (Zaleha *et al.* 2003). The density of different copepod groups found in Pahang coastal water was reported by Zaleha *et al.* (2006). Some transects were laid nearest to the sampling stations chosen for the present study. The dominance of calanoids and cyclopoids in the stations with high salinity confirmed the earlier finding on the high abundance of the groups found in Pahang coast in The South China Sea although with lesser density. As reported by Mwaluma *et al.* (2003), copepods of the sea regime maybe more diverse and abundant compared to the area with freshwater influence.

In conclusion, results from this study indicate the effect of sea water and freshwater inflow towards the different species composition in the mangrove estuarine copepods in Miang, Kuantan, Bebar and Endau River. The dominance of calanoid copepods in the estuary mouths shows in agreement with the abundance of the group in coastal area of Pahang. The tendency of occurrence of more coastal species than the estuarine species indicates the relationship and contribution of the estuary as the shelter area for the coastal species. Future studies should attempt to examine the seasonal change in the copepod species composition and the influence of the changing copepod community structure on the plankton food web dynamics of the estuary.

Acknowledgements

This study was part of a project handled by Pahang Forestry Department in cooperation with Mangrove Research Unit (MARU), UMT on Ten Years Forest Management Plan for Pahang. Authors were indebted to the technicians from Pahang Forestry Department for the arrangement of the field work.

References

Alongi, D.M., Sasekumar, A., Tirendia, F., Dixona, P. (1998). The influence of stand age on benthic decomposition and recycling of organic matter in managedmangrove forests of Malaysia. Journal of Experimental Marine Biology and Ecology, 225: 197–218

Chong, V.C., Ooi, A.L. Chew L.L. and Ogawa, Y. (2002). Mangrove zooplankton of Matang mangrove estuaries: Preliminary assessment of spatio-temporal abundance in relation to environmental parameters. Proceeding, Second JIRCAS International Workshop: Studies on sustainable production systems of aquatic animals in brackish mangrove areas. Penang, Malaysia. December 2-3, 2002: 29-54.

Froneman, P.W., (2004). Zooplankton community structure and biomass in a southern African temporarily open/closed estuary. Estuarine, Coastal and Shelf Science 60:125-132

Gee, J.M. and Somerfield, P.J. (1997). Do mangrove diversity and leaf litter decay promote meiofaunl diversity? Journal of Experimental Marine Biology and Ecology, 218 : 13-33.

Grindley, J.R., (1984). The zooplankton of mangrove estuaries. In: Por, F.D., Dor, I. (Eds.), Hydrobiology of the Mangal. Developments in Hydrobiology. Hydrobiologia 20, 79-87.

Kathiresan, K. and Bingham, B.L. (2001). Biology of mangroves and mangroves ecosystems. Advances in Marine Biology, 40 : 81-251.

Lam-Hoai, T., Guiral, D. and Rougier, C. (2006). Seasonal change of community structure and size spectra of zooplankton in the Kaw River estuary (French Guiana). Estuarine, Coastal and Shelf Science 68: 47-61

Mwaluma, J., Osore, M. and Wawiye, P. (2003). Composition, Abundance and Seasonality of Zooplankton in Mida Creek, Kenya. Western Indian Ocean Journal of Marine Sciences Vol.2(2) 2003: 147-155

Osore, MKW, F Fiers and MH Daro. (2003). Copepod composition, abundance and diversity in Makupa Creek, Mombasa, Kenya. Western Indian Ocean Journal of Marine Science Vol.2(1) 2003: 65-73

Rawlinson, K.A., Davenport, J. and Barnes, D.K.A.(2005). Tidal exchange of zooplankton between Lough Hyne and the adjacent coast. Estuarine, Coastal and Shelf Science, 62:205–215

Robertson, A.I., Duke, N.C., (1987). Mangrove as nursery sites: comparisons of the abundance and species composition of fish and crustaceans in mangroves and other nearshore habitats in tropical Australia. Marine Biology 96, 193-205.

Richmond, C.E., Wethey, D.S., Woodin, A.A. (2007). Climate change and increased environmental variability: Demographic responses in an estuarine harpacticoid copepod. Ecological Modelling, 209: 189-202

Sasekumar, A.(1994). Meiofauna of a mangrove shore on the West Coast of Peninsular Malaysia. Raffles Bulletin of Zoology, 42: 901-915

Sheridan, P. (1997). Benthos of adjacent mangrove, seagrass and non-vegetated habitats in Rookery Bay, Florida, U.S.A. Estuarine, Coastal and Shelf Science, 44 (4) : 455-469.

Stevenson R J, (1984). Epilithic and epipelic diatom in the Sandusky River, with emphasis on species diversity and water pollution .Hydrobiologia 114: 161-175.

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

Vance, D.J, Haywood, M.D.E, Heales, D.S, Kenyon, R.A, Loneragan N.R, Pendrey R.C. (1996). How far do prawns and fish move into mangroves? Distribution of juvenile banana prawns Penaeus merguiensis and fish in a tropical mangrove forest in northern Australia. Marine Ecology Progress Series,131:115-124.

Zaleha, K., Kamaruzzaman, B.Y., Nasrudin,M. and Suhaini, A. (2003). Planktonic and benthic copepods in relation to salinity gradient of Terengganu River Estuary, Proceeding 2nd KUSTEM Annual Seminar on Sustainability Science, 5-7 Mei, Terengganu. 35-42.

Zaleha, K., Sathiya, B.M., and Iwasaki, N. (2006). Zooplankton in East Coast of Peninsular Malaysia. Journal of Sustainability Science and Management, vol.1 (2): 74-79

Table 1. Locations of sampling area in the estuarine mangrove ecosystem in Pahang, Malaysia

	GPS Reading
Kuantan River	03°07’45”N,103°26’08”E - 03° 47’15”N, 103°19’19”E
Miang River	03°29’ 7”N,103°27’21”E - 03°29’19”N, 103°27’40”E
Bebar River	03°07’ 3”N,103°26’35”E - 03°07’57”N, 103°26’42”E
Endau River	02°38’57”N,103°36’17”E - 02°41’08”N, 103°35’30”E

Table 2. Some environmental condition of the estuarine mangroves in Pahang, Malaysia

	Miang River	**Bebar River**	**Kuantan River**	**Endau River**
pH	6.5 – 7.22	6.85 – 7.39	6.44 – 7.0	6.44 – 7.0
Temp. (°C)	26.8 – 31.8	28.1 – 28.8	27.4 – 28.9	23.9 – 28.4
Dissolved oxygen (mg/L)	6.88 – 7.15	6.45 – 7.6	4.30 – 7.69	5.59 – 6.69
Salinity (ppt)	25.9 – 29.3	7.5 – 21.5	5.40 – 8.50	7.0 – 8.21
Depth (m)	2.5 – 3	2.5 – 3.6	2.5 – 4.0	2.0 – 4.5

Table 3. Planktonic Copepoda of estuarine mangroves in Pahang, Malaysia

- Class : Copepoda
  - Order : Calanoida
    - Family : Acartiidae
      - *Acartia spinicauda*
      - *Acartia* sp.
    - Family : Paracalanidae
      - *Acrocalanus gibber*
      - *Acrocalanus gracilis*
      - *Acrocalanus monachus*
      - *Bestiolina similis*
      - *Paracalanus aculeatus*
      - *Paracalanus parvus*
      - *Paracalanus* sp.
    - Family : Centropagidae
      - *Centropages furcatus*
      - *Centropages* sp.
    - Family : Temoridae
      - *Eurytemora sp.*
      - *Temora discaudata*
      - *Temora stylifera*
    - Family: Pontellidae
      - *Labidocera acuta*
      - *Labidocera* sp.
    - Family: Scolecithricidae
      - *Scolecithrix sp.*
      - *Subeucalanus subcrassus*
      - *Subeucalanus* sp.
    - Family: Tortanidae
      - *Tortanus* sp.
    - Family: Phaenidae
      - *Phaena spinifera*
    - Family: Pseudodiaptomidae
      - *Pseudodiaptomus* sp.
  - Order : Cyclopoida
    - Family : Oithonidae
      - *Oithona nana*
      - *Oithona aruensis*
      - *Oithona rigida*
      - *Oithona* sp. 1
      - *Oithona* sp. 2
  - Order: Harpacticoida
    - Family : Ectinosomatidae
      - *Microsetella norvegica*
      - *Microsetella rosea*
    - Family : Clytemnestridae
      - *Clytemnestra scutellata*
    - Family : Euterpinidae
      - *Euterpina acutifrons*
  - Order: Poecilostomatoida
    - Family : Oncaeidae
      - *Oncae venusta*
      - *Oncae media*
      - *Oncae* sp.
    - Family : Sapphirinidae
      - *Saphirina* sp.
    - Family: Corycaeidae
      - *Corycaeus* sp. 1
      - *Corycaeus* sp. 2

Table 4. Value of Shannon-Wiener Diversity Index (H'), Pielou's Evenness Index (J') and Margalef's Species Richness Index (d) for planktonic copepods of estuarine mangroves in Pahang, Malaysia

	Kuantan	Bebar	Miang	Endau
Shannon-Wiener Diversity Index (H')	1.36	1.79	1.65	1.73
Pielou's Evenness Index (J')	0.71	0.78	0.62	0.69
Margalef's Species Richness Index (d)	0.89	1.34	1.69	1.50

Figure 1. Map showing the sampling locations in the estuarine mangroves in Pahang, Malaysia

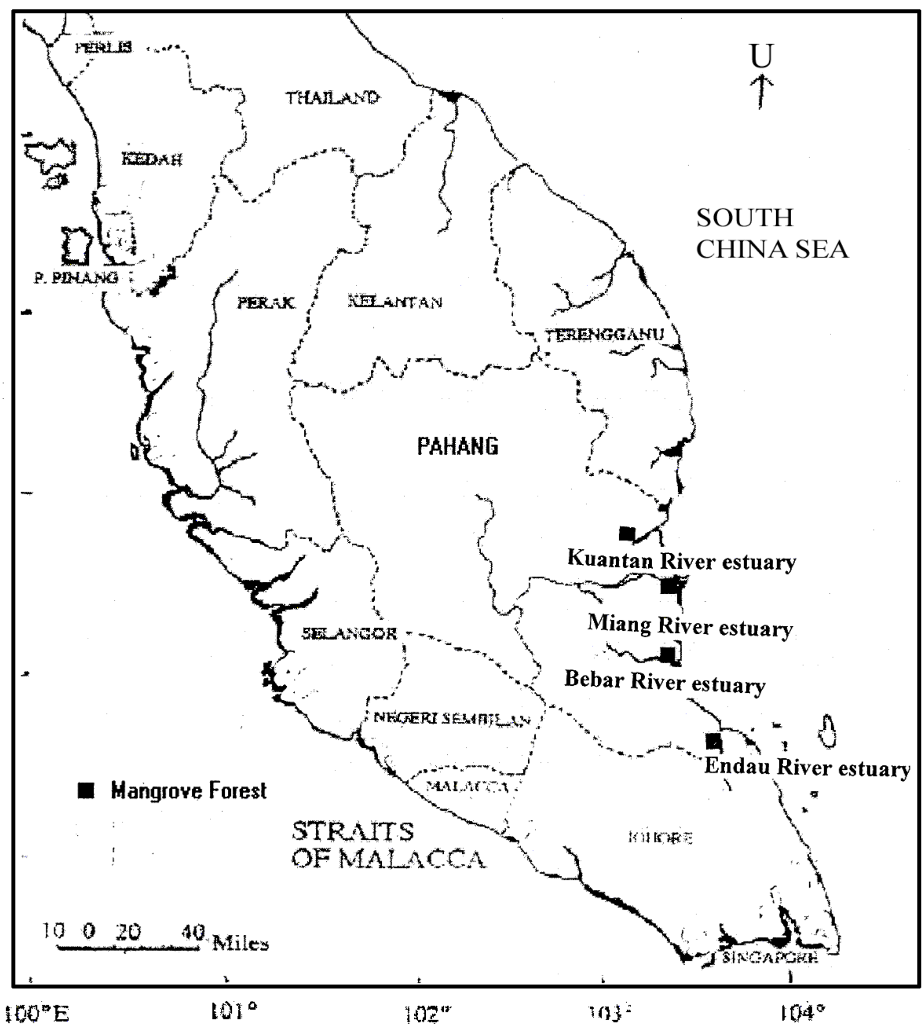

Figure 2. Density distribution of planktonic copepods in mangroves of Pahang, Malaysia

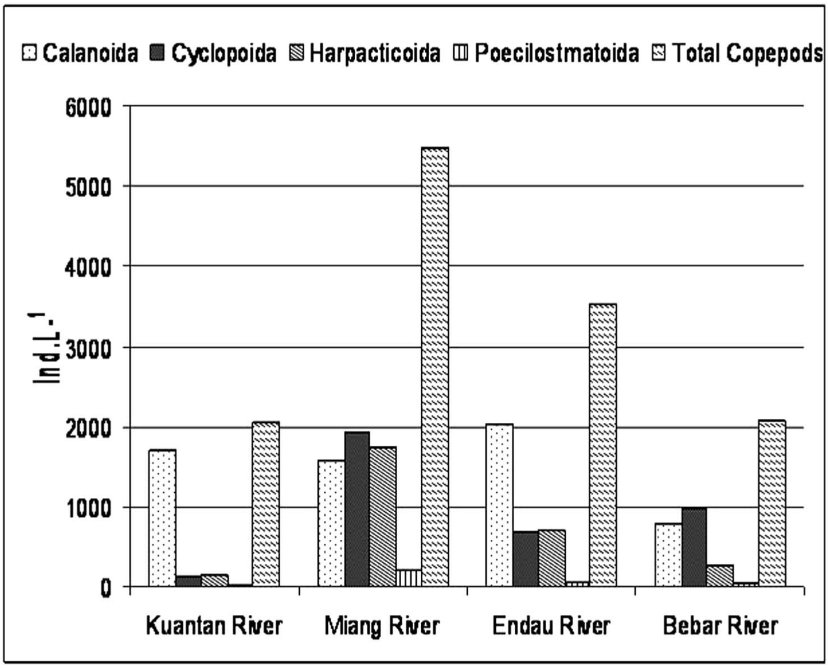

Figure 3a. Density distribution of planktonic copepods in estuarine mangroves in Kuantan River

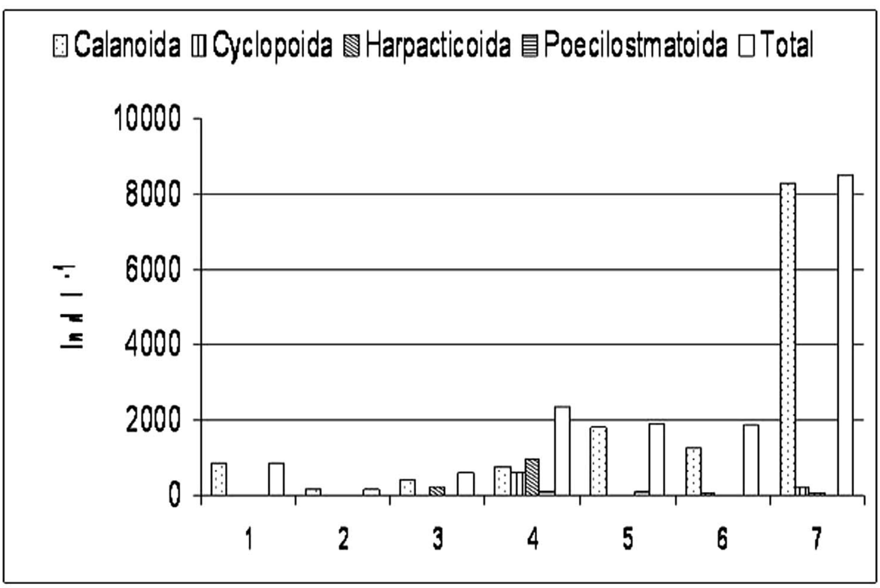

Figure 3b. Density distribution of planktonic copepods in mangroves of Miang River

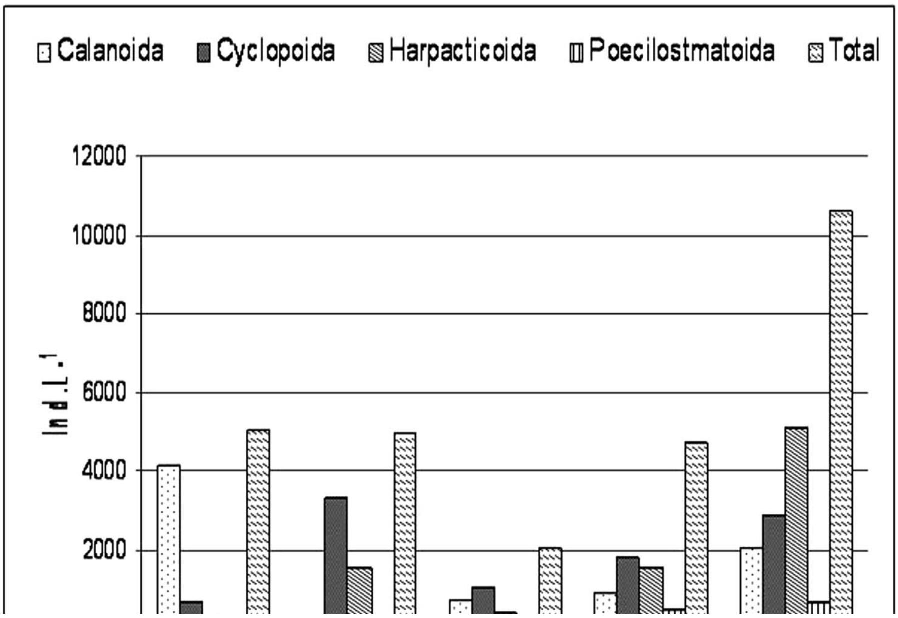

Figure 3c. Density distribution of planktonic copepods in mangroves of Endau River

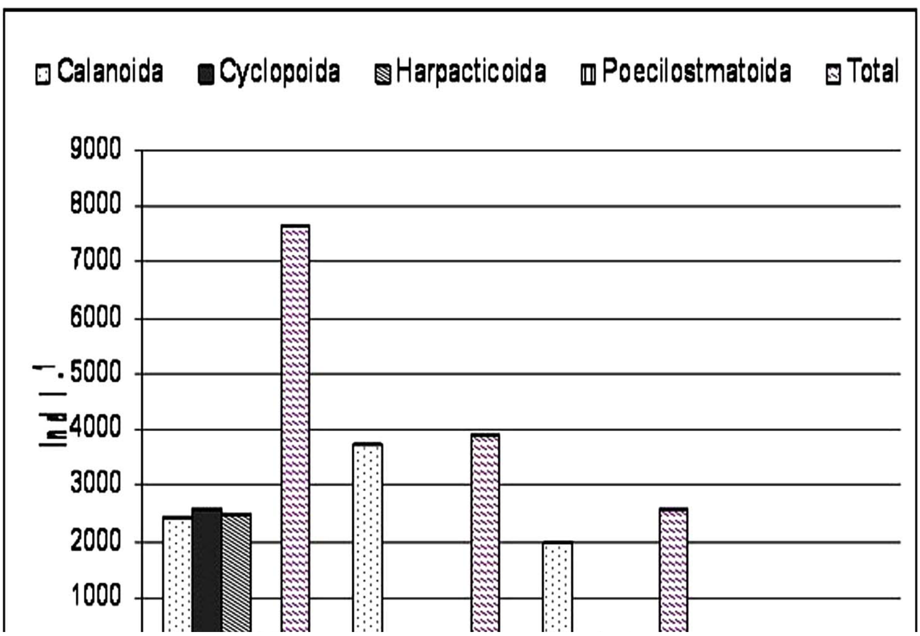

Figure 3d. Density distribution of planktonic copepods in mangroves of Bebar River

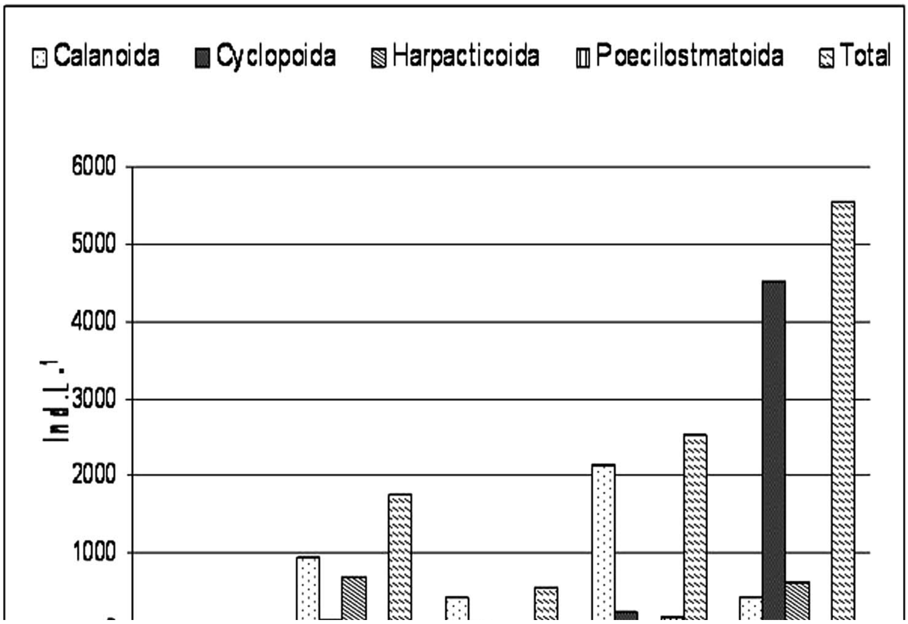

Figure 4. Dendogram of the 21 stations from four estuaries in Kuantan, Miang, Bebar and Endau River, using group-average clustering from Bray-Curtis similarities on abundances. (K: Kuantan; M: Miang; B:Bebar;E:Endau)

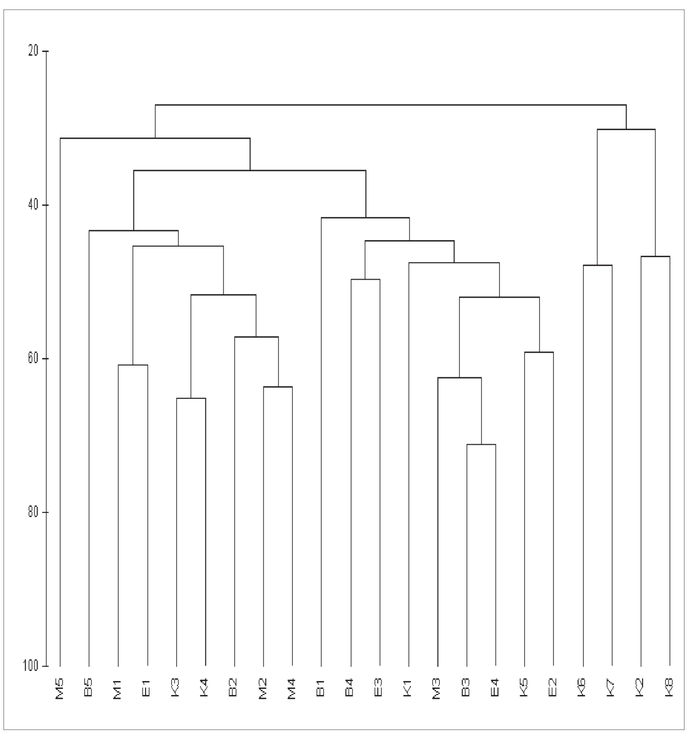

Figure 5. 2-Dimensional MDS configuration of the 21 stations from four estuaries in Kuantan, Miang, Bebar and Endau River, using group-average clustering from Bray-Curtis similarities on abundances. (KTN: Kuantan;MNG: Miang; BBR: Bebar; END: Endau)