SPATIAL RANGE OF MEIOBENTHIC FAUNAL DENSITY IN INTERTIDAL ZONE OF PORT DICKSON, MALAYSIA

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Abstract: The study was carried out to determine the spatial range and the composition of the meiobenthic community in intertidal zone along Port Dickson coast, facing the Straits of Malacca. Three beaches were chosen for the study areas, which were Saujana Beach (St1) (02º29.803' N, 101º50.213' E), Teluk Pelanduk (St2) (02º25.050' N, 101º53.631' E), and Teluk Kemang (St3) (02º27.744' N, 101º51.072' E). A PVC hand-corer with 4 cm inner diameter was used to collect the sediment samples during low tide. The sediment samples were collected within three quadrates (Q1, Q2, and Q3) that were placed along 12 metre transect lines starting at the upper-tide level. Six meiobenthic taxa found within three beaches at Port Dickson, were Nematoda, Harpacticoida Copepod, Polychaeta, Tanaidacea, Ostracoda, and Cumacea. The highest mean total density of meiobenthos was found in St3 (36.7 to 57.39 ind.10cm^{-2}) followed by St1 (35.54 to 46.46 ind.10cm^{-2}) and the lowest was in St2 (8.27 to 44.45 ind.10cm^{-2}). Nematodes were the most dominant in St1 and St3 with a mean density ranging from 6.47 to 38.83 ind.10cm^{-2} and 21.43 to 36.28 ind.10cm^{-2} respectively. In St2, harpacticoid copepods were the most dominant group with the mean density ranging from 5.19 to 25.03 ind.10cm^{-2}. Harpacticoid copepods showed relatively low density with only 0.21 to 2.86 ind.10cm^{-2} (5%) and 2.5 to 8.7 ind.10cm^{-2} in St1 and St3. Salinity was found to be correlated significantly with the benthic meiofaunal distribution (Pearson correlation r = 0.899, n = 9, P<0.05). Analysis of similarity demonstrated a significant difference (ANOSIM, R: -0.169, P: 0.85) in the communities of meiobenthos among the three sampling stations.

KEYWORDS: Meiobenthos, density, Port Dickson, intertidal zone

Introduction

Meiobenthos occur in both freshwater and marine habitats. They also occur from the splash zone on the beach to the deepest sediments in the sea (McIntyre and Warwick, 1984). Benthic community structures can be influenced by various environmental factors (Fabi *et al*., 2002; Moura *et al*., 2007). According to Giere (1993), the distribution of meiobenthos strongly depends on the abiotic and biotic factors such as structure of the sediments, temperature, salinity and dissolved oxygen (Giere, 1993).

Intertidal areas are subject to flooding due to tidal cycle, which will impose stress to the meiobenthos (Soetaert *et. al,* 1994). Apart from desiccation stress, the absence of the buffering capacities of the overlying water will induce more extreme fluctuations (for example, temperature and salinity) in the upper layers, and this will create unfavourable conditions to meiobenthos. However, the meiobenthos present in these layers are usually adapted to tolerate considerable salinity changes (Nybakken, 2001).

The spatial-distribution patterns of species are often greatly influenced by spatially-structured environmental or biological process (Glockzin and Zettler, 2008). According to

Montagna (1983) and Blanchard (1990), the occurrence of diatoms,which is the food source for naidid oligochaetes, determines their spatial and seasonal microscale distribution in tidal flats.

Port Dickson is located near the Straits of Malacca with a coastline stretching up to 18 km. Port Dickson beach, which is known as a place for recreational activities in Malaysia, has always been an attraction for locals in need of a convenient holiday spot. The study was conducted in order to determine the density and composition of the meiobenthos community and, thus, indicate the spatial range of the meiobenthic fauna community over the three intertidal zone areas along the Port Dickson coast.

Materials and Methods

Study site

Sampling session was conducted in the intertidal zone beaches along Port Dickson coast on 7th April 2008 during the low tide. Three sampling stations (Fig. 2.1) were selected along the Port Dickson coast: Saujana Beach (St1), Teluk Pelanduk (St2), and Teluk Kemang (St3). GPS reading of the sampling stations were recorded (Table 2.1).

Samples collection and processing

A transect was laid from the uppermost to the low-tide level of the beach at each station. Three frame quadrates were placed on the transect following the point of uppermost, mid and low-tide level. A PVC hand-corer with an inner diameter of 4cm was used to collect the sediment sample. Triplicate of sediments were obtained in each quadrate by inserting a hand-corer on the sediment down to 10cm depth (Troch *et. al*, 2001).

Core samples were then transferred into yellow screw-cap bottles and immediately fixed using 10% formalin solution (Monthum and Aryuthaka, 2006). Additional sediment samples at each sampling station also were taken and brought back to the laboratory for the particle-size analysis. Environmental parameters of the water fill in a dug hole with 10 cm depth (such as temperature, salinity, dissolved oxygen concentration, pH, and conductivity) were measured *in situ* at each station using YSI 556 Multiprobe-parameter. The GPS reading was recorded at each sampling stations.

In the laboratory, sample decantation (McIntyre and Warwick, 1984) was conducted for each sample to extract meiobenthos. Sediment samples was placed in a glass cylinder, filled with water, inverted and allowed to settle for 15 seconds. The supernatant was then sieved onto a 63 µm sieve. The organisms retained on the 63 µm sieve were preserved in labelled bottles containing 5% neutralised formalin mixed with Rose Bengal stain. All the samples of meiobenthos were sorted and enumerated into different taxa under a stereomicroscope. Sediment for grain-size analysis was first air dried. The analysis was done following dry-sieving method (Buchanan, 1984) as more than 95% of the particles were found to be sand.

Data analysis

The density of meiobenthos was estimated as number of individuals (N) per unit area (10 cm^2) and the composition of meiobenthic groups in the percentage of the total meiobenthos. One-way ANOSIM using PRIMER (Plymouth Routines in Multivariate Ecological Research) software package was utilised to determine if there were significant differences between groups of meiobenthic samples. Possible correlation between the meiobenthos density with environmental factors was determined through Pearson’s correlation analysis.

Results and Discussion

Environmental parameters

The value of dissolved oxygen varies between quadrates in different tide levels measured (Fig. 3.1). In Teluk Kemang (St3), the range values of dissolved oxygen of water column was high from the uppermost towards low-tide level. A low value of dissolved oxygen in Q1 located at uppermost-tide level (1.83 mg/L) indicates poor water quality in this beach area which is well known as a recreational area and a site for local inhabitants. Recreational water is generally polluted with common activities such as industrial processes, farming activities, wild life, sewage effluents and indigenous microorganisms (WHO, 1998). Meanwhile, in low-tide level towards open ocean, dissolved oxygen measured was high (11.04 mg/L). In Teluk Pelanduk (St2) dissolved oxygen ranged from 7.61 to 8.67 mg/L and Saujana Beach (St1) showed the lowest value of dissolved oxygen which ranged from 4.7 to 8.52 mg/L. The variation in pH of surface water was small and found to be alkaline within three stations.

The highest mean pH was in Teluk Pelanduk (St2) at 8.64, followed by Teluk Kemang (St3) with a pH of 8.61 and lowest in Saujana Beach (St1) with mean value 8.19. However, the salinity and temperature vary significantly between quadrates located in different tide levels in three stations. In St1, the salinity in the first quadrates was low, with only 3.3 psu and increased as the quadrates move towards ocean with 29.97 psu. While in St2, the values were almost similar within the three quadrates with 28.8 psu in Q1, 30.5 psu in Q2, and 29.6 psu in Q3. Same as in St1, St3 showed lowest salinity in Q1 with only 4 psu and increased in Q2 and Q3 with 31 psu. St1 had the lowest temperature which ranged from 32.7 to 34.3 ºC, followed by St3 (33.3 to 35.2 ºC) and St2 had the highest value of temperature which ranged from 33 to 38.7 ºC.

Sedimentary parameters

The grain-size parameters include sorting, skewness and kurtosis obtained is shown in Table 3.1. Sediment characteristics such as grain size, grain shape, sorting, and pore space are known to directly or indirectly affect the numbers and types of species found in soft-bottom environments (Gray, 1974). Sediments in all stations showed a fine sand type with the mean particle size ranging between 1.78 and 2.62 phi. A second aspect of sieve analysis is sorting or the degree of scatter. Most of the area had a well-sorted condition with the sorting coefficient ranging between 0.37 and 0.46. Almost all of the samples of sediment were positively skewed.

Density and composition of meiobenthos

There were six meiobenthic taxa (Fig 3.2) found in Port Dickson, Negeri Sembilan within three sampling sites. The taxa found were Nematoda, Harpacticoida Copepod, Polychaeta, Tanaidacea, Ostracoda, and Cumacea. In all sampling stations, the dominant meiobenthos was nematodes with a mean density ranging from 11 to 68 ind.10 cm^{-2} in St1, 20 to 26 ind.10 cm^{-2} in St2 and 38 to 64 ind.10 cm^{-2} in St3. Harpacticoid copepods were the second dominant group in St2 and St3 with a mean density ranging from 9 to 44 ind.10 cm^{-2} and 5 to 15 ind.10 cm^{-2} respectively. However, in St1, harpacticoid copepods showed relatively low density with only 1 to 5 ind.10 cm^{-2} which contributed 5% of the total meiobenthos. A few other groups found in sampling stations appeared occasionally in very low numbers. Referring to Figure 3.3, Nematoda and Harpacticoida contributed about 62% and 20% respectively to the total community in the study area. The two groups are well known for their abundance in most aquatic environments (McIntyre, 1969). Their high dispersal rate must have helped them to easily establish new populations in the study area Commito and Tita (2002).

The abundant of both groups within stations may result from the sediment type, which was fine sand. Sediment grain size is the primary factor affecting the abundance and species composition of meiobenthos (Coull, 1988). This could be a reasonable explanation when Giere (1993) reported the fine sands in shallow sea bottoms, with their varying and rich food supply, harbour the highest number of nematodes. The highest harpacticoid abundance was also encountered in shallow flats with fine sand and some mud enriched with detritus.

Figure 3.4 shows patterns of the distribution of meiobenthos in all stations from upper to lower-tide level. According to Kim and Montagna (2009), salinity is one of the most influential environmental variables affecting meiobenthic communities. In St1 and St3, the salinity in upper-tide level (Q1) with only 3.3 psu and 4 psu respectively results in low meiobenthos density compared with other tide levels and increase of density with the increasing salinity towards the sea. It might be due to upper-tide level of St1 and St3 being more influenced by the freshwater runoff that both stations have very low salinity. There was a direct relationship between freshwater inflow and salinity on benthic communities (Yamamuro, 2000). The number of marine species increases with increasing salinity in water more than 7 psu (Remane and Schlieper, 1971). Significant correlation between salinity and meiobenthos density in the study area further support the idea of negative impact of low salinity towards meiobenthos density as found in St1(Pearson correlation $r = 0.899$, $n = 9$, $P>0.05$).

Meiobenthos found in the present study showed lower density than reported elsewhere in Malaysia and some other tropical regions (Table 3.2) and this situation might be caused by several factors. McLachlan (1978) found that desiccation is an important factor besides oxygen content controlling vertical distribution of meiobenthos in beaches. The distribution of meiobenthos as shown in Figure 3.4 in all stations slightly increased in density as the location of the quadrates move towards sea but decreased towards the beach where the upper sand layers were almost dry. Meiobenthos are known to be sensitive to low pore water content (Jansson, 1968) and as sand dries at low tide, the fauna face desiccation stress. In addition, the water temperature reading of the day was higher (38.8 ºC) at upper tide level which could be a factor of decreasing in the meiobenthos density. McLachlan (1977) reported the vertical migration was reduced at night, probably in response to cooler night temperatures at low tide and less desiccation and this could possibly explain the lower densities of meiobenthos obtained in field sampling using a hand-corer as the sampling was carried out during the day time with a high temperature reading.

Tourism and recreational activities have been known to represent disturbances and have been linked to pollution, industrialisation and erosion (Dronkers and de Vries, 1999) that may affect spatial heterogeneity, and consequently the structure and dynamics of natural assemblages (Sousa, 1984). Impacts caused directly by recreational activities are emerging as significant environmental issues (Schlacher *et al*., 2008). Gheskiere *et. al* (2005) in their study reported tourism-related activities are particularly affecting the sandy-beach meiobenthos in the upper-beach zone. Tourist upper beaches are characterised by a lower percentage of total organic matter (% TOM), lower densities and diversities of meiobenthos compared to non-tourists locations. Low dissolved-oxygen concentrations indicate poor water quality and also results in low density of meiobenthos in sampling area. Oxygen gradients influence the biogeochemical properties of sediments and the structure and distribution of bacterial, meio-, macro- and megafaunal communities are fully explained in (Rosenberg *et. al*, 1983; Mullins *et. al*, 1985; Arntz *et. al*, 1991; Levin *et. al*, 2000).

The similarity analysis using the Bray-Curtis cluster analysis estimated similarities in community structure between the different sampling stations for meiobenthos. The Bray-Curtis cluster and MDS analysis shows (Figure 3.5) two major groups of meiobenthic community produced at 73% similarity level. The first group representing Teluk Pelanduk (St2) with a 80% similarity level which indicates the highest similarity among themselves compared with the other two stations. The second group comprises St3 and St1 forming a 78% similarity level. There were significant differences in communities of meiobenthos between stations (ANOSIM, R: 0.48, P: 0.004), while there were no significant differences of the community structure between quadrates in different tide levels for each station (ANOSIM, R: -0.169, P: 0.85).

Conclusion

The highest mean density of meiobenthos was found in Teluk Kemang (St3), ranging from 36.7 to 57.39 ind./10cm^2 followed by Teluk Pelanduk (St2), ranging from 35.54 to 46.46 ind./10cm^2 and the lowest was in Saujana Beach (St1) with the density ranging from 8.27 to 44.45 ind./10cm^2. Nematode and harpacticoid dominated in all stations and a few other groups were recorded in low numbers. This study demonstrates the meiobenthos distributions in study areas are affected by the environmental parameters measured, particularly in the upper tide-level zone. Salinity was found to be significantly correlated (Pearson correlation $r = 0.899$, n = 9, $P<0.05$) with the meiobenthos distribution found to be significantly different between stations (ANOSIM, R: -0.169, P: 0.85).

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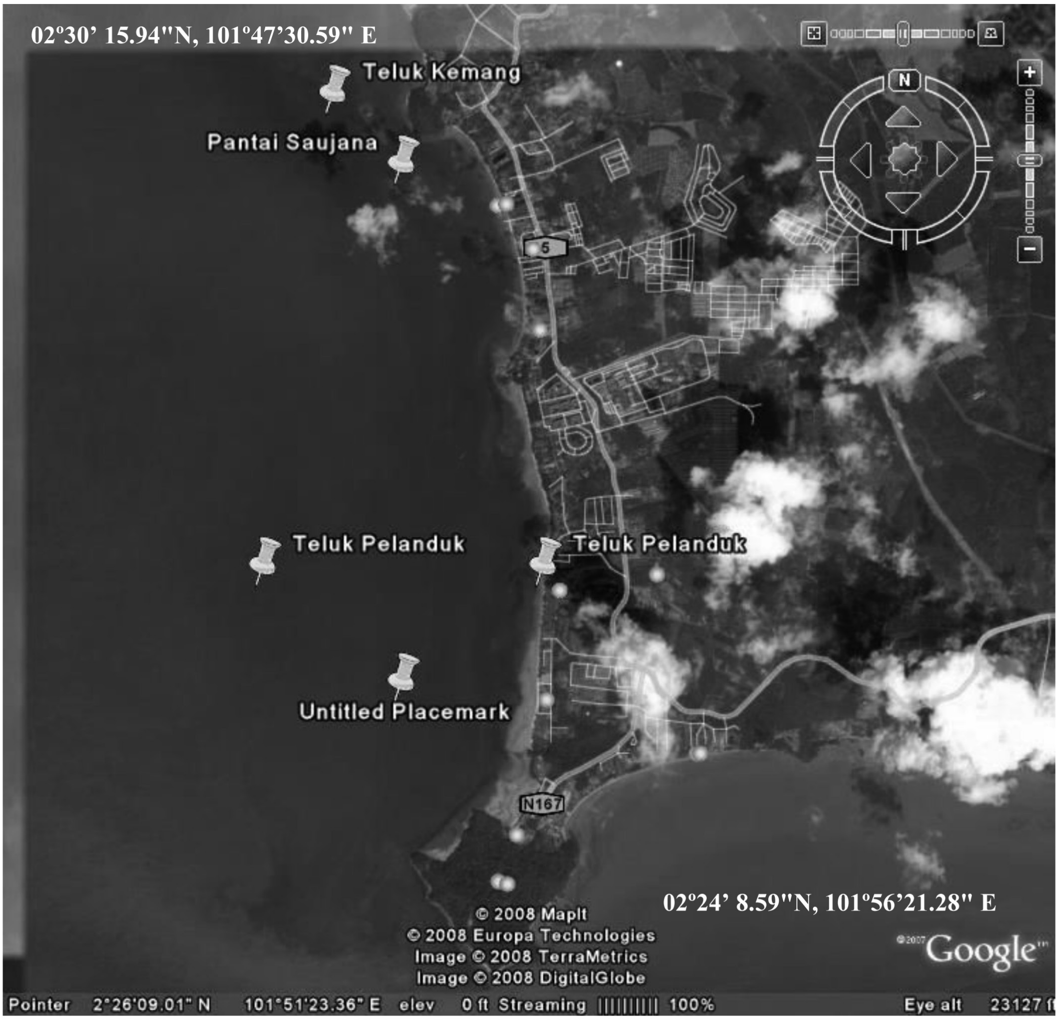


Figure 2.1: Map of the three sampling stations in Port Dickson.

Table 2.1: GPS reading of the sampling stations

Stations	Latitude (N)	Longitude (E)
Saujana Beach (St1)	02º29.803'	101º50.213'
Teluk Pelanduk (St2)	02º25.050'	101º53.631'
Teluk Kemang (St3)	02º27.744'	101º51.072'

Table 3.1: Mean particle size of sediments in sampling stations

Station	St1Q1	St1Q2	St1Q3	St2Q1	St2Q2	St2Q3	St3Q1	St3Q2	St3Q3
Parameter	Phi	Phi	Phi	Phi	Phi	Phi	Phi	Phi	Phi
Mean (x)	1.779	2.62	2.44	1.877	1.96	1.94	2.11	2.56	2.18
Sorting	0.14	0.53	0.45	0.37	0.42	0.38	0.38	0.46	0.42
Skewness	4.56	-0.73	0.45	2.53	1.86	1.61	0.62	-0.49	0.73
Kurtosis	25.17	4.78	2.95	11.55	6.25	7.60	2.40	2.59	3.85

Table 3.2: Comparisons of mean density of meiobenthos with previous studies

Investigation	Habitats	Meiobenthic density
Shabdin and Zainuddin (1990)	Coral reef at Pulau Manukan, Sabah, Malaysia	675 – 882 ind./10cm^2
Zaleha *et. al* (2003)	Bottom sediment in Perhentian Island, Malaysia	874 – 1231 ind./10cm^2
Troch *et. al* (2001)	Seagrass beds, Gazi Bay, Kenya	457 – 2619 ind./10cm^2
Dye (2006)	Mangrove sediments, Botany Bay, Sydney, Australia	747- 886 ind./10 cm^2

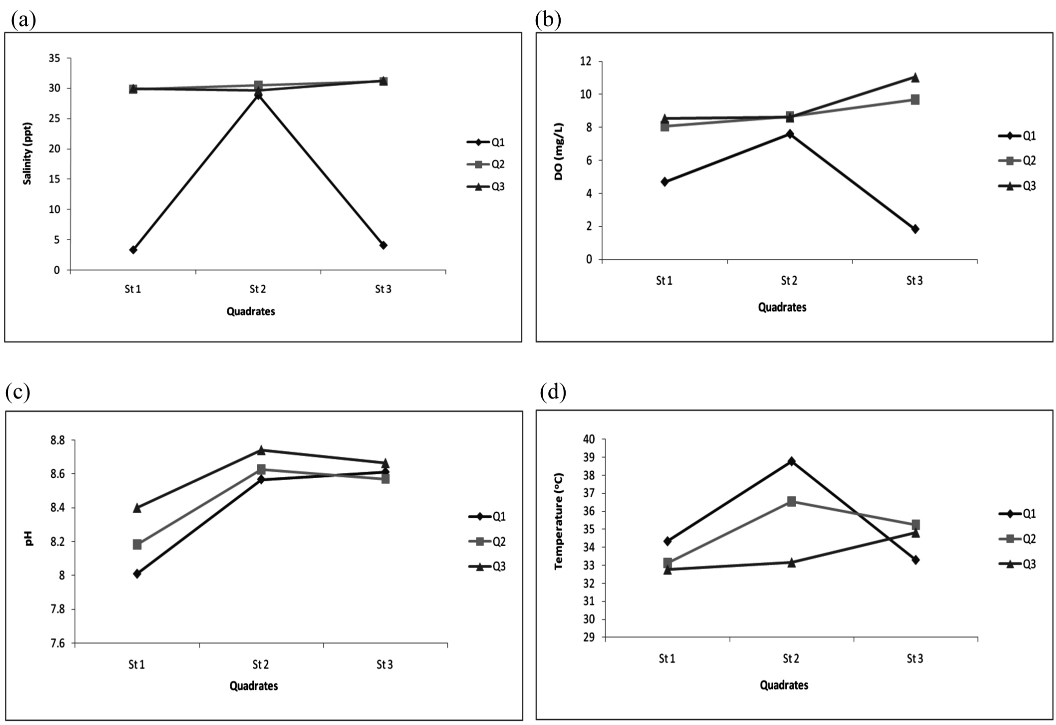


Figure 3.1: Environmental parameters in each station (Saujana Beach (St1), Teluk Pelanduk (St2) and Teluk Kemang (St3)), (a) Salinity (ppt), (b) DO (mg/L), (c) pH (d) Temperature (ºC)

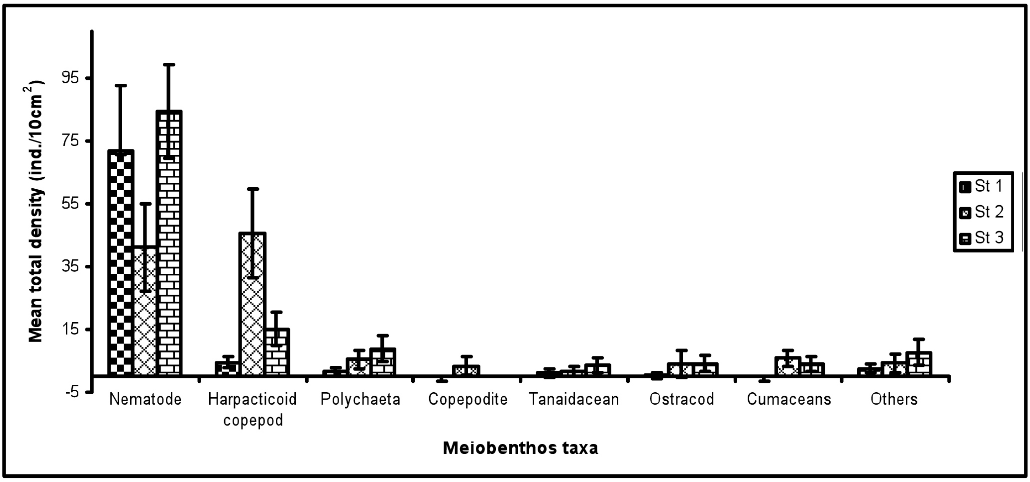
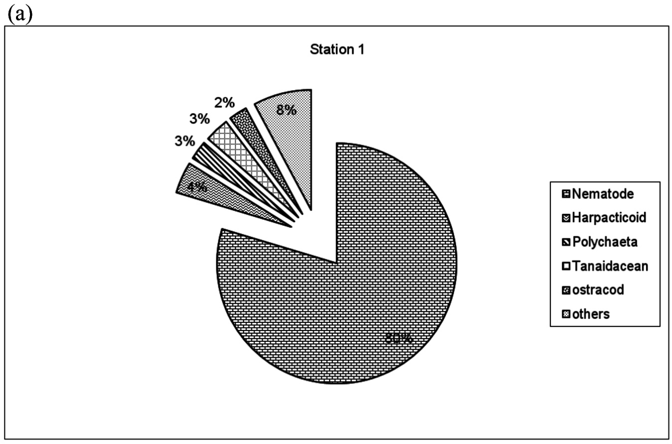
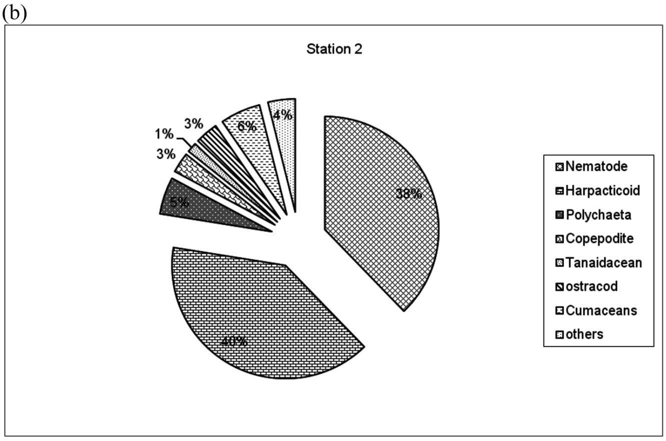


Figure 3.2: The mean total density (ind. /10 cm^2) of meiobenthos in three beaches (Saujana Beach (St1), Teluk Pelanduk (St2), Teluk Kemang (St3)) in Port Dickson, Negeri Sembilan

(a)



(b)



(c)

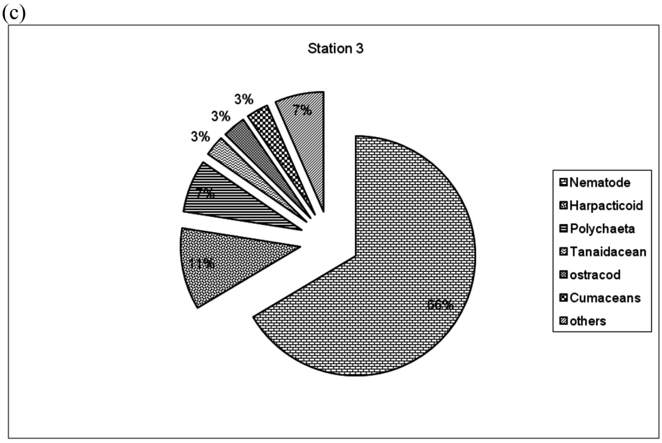


Figure 3.3: Composition of meiobenthos taxa in three stations a) Saujana Beach (St1), b)Teluk Pelanduk (St2), c) Teluk Kemang (St3) in Port Dickson, Negeri Sembilan

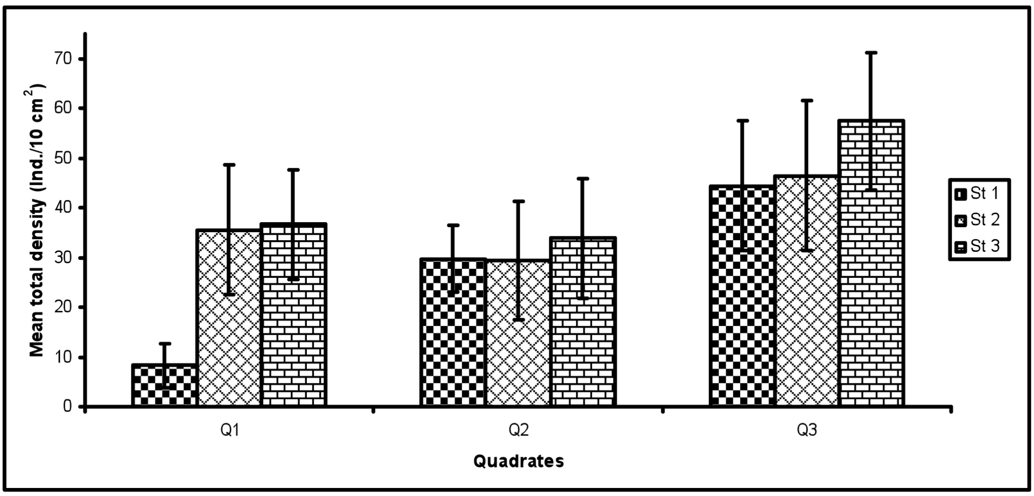
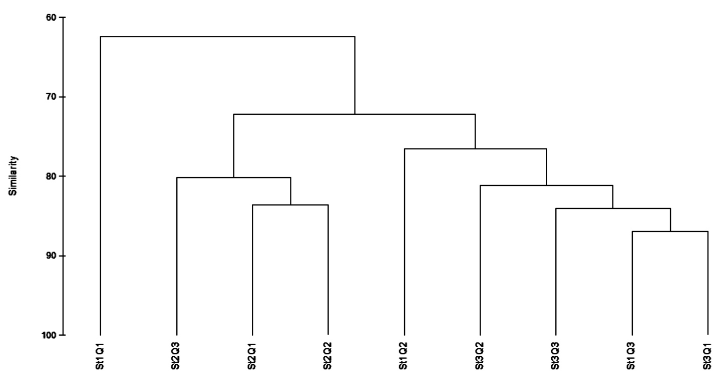


Figure 3.4: Mean density (ind./10 cm^2) of meiobenthos (a) in Saujana Beach (St1), (b) in Teluk Pelanduk (St2), and (c) in Teluk Kemang (St3)



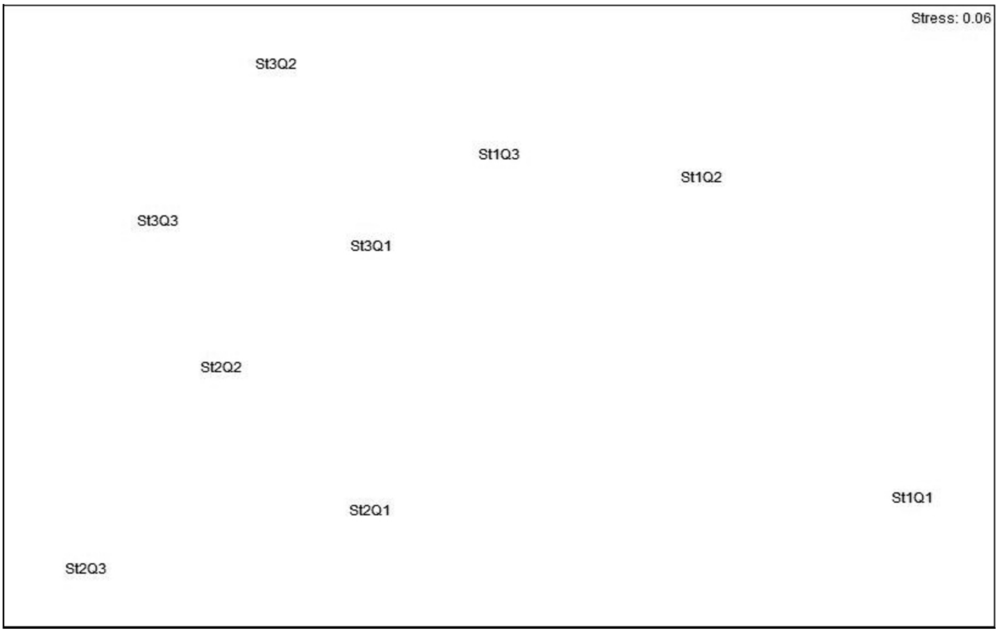


Figure 3.6: Cluster analysis dendrogram of Bray-Curtis similarity and MDS analyses for meiobenthos at three sampling stations ((Saujana Beach (St1), (b) in Teluk Pelanduk (St2), and (c) in Teluk Kemang (St3))