Meiobenthic Assemblages in some Coral Reef Sites in Marsa Alam (Red Sea, Egypt) with Emphasis on Free Living Nematodes

Deyaaedin A. Mohammad

Department of Marine Science , Faculty of Science, Suez Canal University, Egypt.

deyaa_ismail@yahoo.com

ARTICLE INFO	ABSTRACT
	Meiofauna from three coral reef sites in Marsa Alam along the Egyptian Red Sea coast was quantitatively studied. Sediment samples were collected from a depth of 7 meters from the sand flat between the seagrass bed and the reef crest in each site. Water temperature and salinity were homogeneous, while the sediment's median grain sizes and total organic matter percentages varied. Total densities were higher in sites II and III and showed relatively similar sediment characteristics than that found in site I. Nematoda (38%), Copepoda (25%), and Polychaeta (22%) were the most common taxa at all investigated sites, with a maximum in August and a minimum in February. Spearman correlation coefficients showed significantly strong positive values between all meiofaunal taxa and temperature. A total of 10 nematode families were recorded. Among them, Chromadoridae, Cyatholaimidae, and Xyalidae were the most abundant (74%). Epi-growth feeding dominated all feeding types and accounted for 73% of total nematodes. The high similarities in the meiofaunal and nematofaunal composition among sites suggested the significance of sediment characteristics as a factor impacting community structure.

INTRODUCTION

Tropical and subtropical meiofauna have been studied in several regions all over the world; few studies have been carried out on the meiofauna of the coral reefs in Malaysia **(Renaud- Momant & Serone, 1967)**, French Polynesia **(Salvat & Renaud-Mornant, 1969; Renaud-Mornant *et al.*, 1971; Thomassin *et al.*, 1982)**, Bermuda **(Coull, 1970)**, the Indian Ocean **(Thomassin *et al.*, 1976; Rao & Misra, 1983)**, Lesser Antilles **(Renaud-Mornant & Gourbault, 1981, 1984; Gourbault *et al.,* 1985; Semprucci *et al,*. 2010)** and the Red Sea **(Grelet, 1985; Grelet *et al.,* 1987)**. Nematoda was the most dominant phylum in all these studies. Other groups such as copepods, ostracods, polychaetes, gastropods, kinorhynchs and foraminiferans were also well documented **(Renaud-Mornant & Serone, 1967; Hulings 1971; Herrera & del Valle, 1980; Ansari & Ingole, 1983; Guzman *et al.*, 1987)**.

There is a huge body of literature about the ecological patterns related to coral reefs **(Alongi, 1989)**. Nevertheless, little research has been carried out on the small- sized fauna living in this environment, and several remain unanswered. Ecological processes and patterns which determine the spatial distribution of the benthic fauna in coral reefs are connected to the physical scale wherever the organisms inhabit their niche. Hence, meiofauna are possibly ruled by diverse habitat architecture and abiotic limiting factors in comparison with other widely studied organisms **(Alongi, 1989)**.

Few studies on the meiofauna ecology have been conducted on Atlantic habitats associated with reef systems **(Boucher & Gourbault, 1990; Gamenick & Giere, 1994)**. Meiofaunal communities play an important ecological role in organic matter mineralization since they are considered as a link between higher food chain levels in tropical habitats and detritus **(Coull, 1999; Danovaro _et al_., 2004)**. The different advantages of meiobenthos as a measure of environmental health propose their use as a tool in the monitoring and detection of anthropogenic impacts **(Heip _et al_., 1988; Kennedy & Jacoby, 1999)**.

This is the first quantitative study on the meiobenthic assemblages and nematofauna of the coral reefs in the Red Sea in general, and in the Egyptian Red Sea in particular. Little is known about the diversity of tropical sublittoral nematodes around the world **(Alongi, 1987; Alongi, 1990; Tietjen, 1991; Boucher & Lambshead, 1995; Boucher, 1997)**. Since all the previous studies in the Red Sea dealt with meiobenthic assemblages in the littoral zones **(Ahmed _et al_., 2011; Hanafy _et al_., 2011; El-Serehy _et al.,_ 2015; El-Serehy _et al_., 2016; Sabeel and Vanreusel, 2015; Al-Sofyani and El-Sherbiny, 2018)** except **Hedfi _et al._ (2018)** who studied the sublittoral meiofaunal distribution in the eastern Red Sea coast (Jeddah, Saudi Arabia), the present study represent a short account on the subtidal meiofauna associated with the coral reef in Marsa Alam at the southern Egyptian Red Sea.

MATERIALS AND METHODS

Study area

Three sites were investigated along the western coast of the Egyptian Red Sea that represented the coral reef habitats at Marsa Alam: Marsa Egla (site I), Ras Samadi (site II) and Ras Dirra (site III). All sediment samples were collected from a depth of 7 meters from the sand flat between the reef crest and the seagrass bed in each site (Fig. 1).
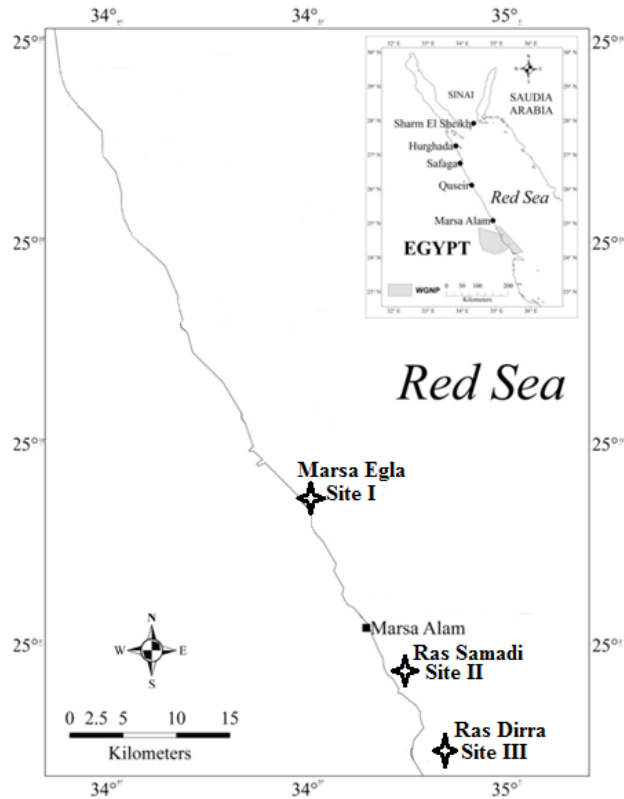
_____

Fig. 1. A map along the Egyptian Red Sea showing the studied sites

Sampling, sample processing and laboratory analysis

Sampling took place during the months of February and August 2021 (to represent winter and summer). YSI 650 multi-parameter instrument (YSI, Yellow Springs, OH, USA) was used to measure water temperature and salinity (TDS) in the field. Three sediment replicate samples were taken from each site via SCUBA diving using a cylindrical core of $10cm^2$ (3.5cm diameter, 10cm high). They were fixed in the field using 5% neutral formalin and placed in labeled plastic bottles. In the laboratory, samples were washed with tap water to remove excess formalin, and meiobenthic organisms were extracted using the decantation and elutriation technique **(Platt & Warwick, 1983)**. Floating contents were sieved through a 50μm mesh. Organisms retained in the sieve were collected in a pyrex petri dish for sorting, then transferred to glass vials containing 70% ethyl alcohol. All meiofaunal individuals were sorted into major groups and counted using a stereomicroscope (Prior S2000, magnification 100x). Nematodes were examined utilizing a compound microscope (Carl Zeiss 1000x magnification) and identified to the genus level by means of pictorial keys mentioned in the studies of **Tarjan (1980)**, **Platt and Warwick (1983)**, **Plat and Warwick (1988)** and **Warwick et al. (1998)**. All nematode individuals of the summer sediment samples were classified according to **Wieser (1953)** to one of the four trophic groups; namely, selective deposit feeders (1A),

non-selective deposit feeders (1B), epi-growth feeders (2A), and predators/omnivores (2B).

A random sediment sample from each location was collected for grain size analysis. Sediments were placed in labeled polyethylene bags and dried in an oven at 60°C overnight until complete dryness was obtained. Samples were shaken and sieved for 10 minutes through a set of sieves, with a mesh diameters of 4.0, 2.0, 1.0, 0.5, 0.250, 0.125, 0.064, 0.032 and <0.032mm, separating the sediment in fractions of gravel, pebbles, sand (very coarse, coarse, medium, fine and very fine sand), silt and clay. The sediments that retained on top of each sieve were weighed and analyzed according to the method of **Holme and McIntyre (1984)**.

From each sediment sample, 1g of fine sediment with mean grain size (Mz) = 200 μm was dried for 24 hours at 60°C in the laboratory. Total organic matter was assessed as the percentage weight loss in the samples after combustion at 550°C for 24 hours **(Jorgensen, 1977)**.

Data analysis

Difference of meiofaunal abundance and other major groups among different localities was analyzed using one-way analysis of variance (ANOVA) with 95% confidence limits. Spearman's correlation coefficient was estimated between the total meiofaunal abundance and the other major taxa with abiotic parameters. The above analyses were carried out using the statistical software SPSS 18.0 (2002).

RESULTS

1. Physico-chemical parameters and sediment characteristics

Water temperature was 19.2°C in winter and 29.2°C in summer at the study sites, while water salinity was 39.4‰ in winter and 40.5‰ in summer (Table 1). Sediment of site I exhibited the coarsest median grain size and the lowest TOMs (1.4%), while site II and III showed finer textures and slightly higher TOMs (Table 1).

Table 1. Water temperature, salinity, total organic matter percentage (TOMs) and sediment median grain size (Mz) at the investigated sites

Parameter\ season	Site I		Site II		Site III	
	winter	summer	winter	summer	winter	summer
Temperature°C	19.2	28.7	19.5	28.5	20	29.2
Salinity ‰	39.5	40.5	39.4	40.3	39.7	40.2
TOMs %	1.4	1.9	2.4	2.7	2.5	2.9
Mz (μm)	425 (Medium sand)		230 (Fine sand)		210 (Fine sand)	

2. Meiobenthic assemblage

Site III showed the highest overall mean value of meiofauna (112.14 ±118.06 individuals/ 10cm^2), followed by site II (109.5±117.8 individuals/ 10cm^2) and site I (82.35±84.58 individuals/ 10cm^2). The mean density of organisms in summer was twice than that recorded in winter (399.14±396.12 individuals/ 10cm^2 and 198.85±193.56 individuals/ 10cm^2, respectively). In terms of seasons and sites, the lowest density value was found in winter at site I, while the highest value was detected at site III in summer (Fig. 2). The analysis of variance (ANOVA) of meiofaunal taxa showed a non-significant variation among sites (F=0.81, *P*=0.446) and a highly significant variation among seasons (F =13.84, *P* <0.001).
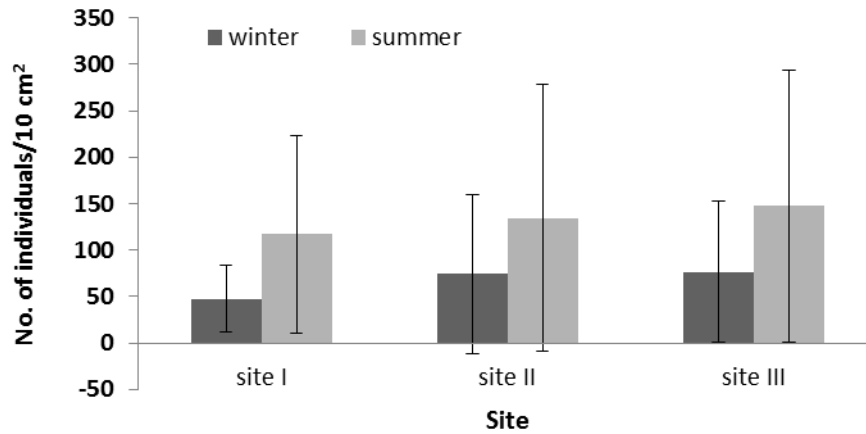

Fig. 2. Average total meiobenthic count in the studied sites and seasons.

Meiobenthic assemblages included six major taxa. Three of them contributed around 85% of the total meiobenthic organisms. Nematoda was the most abundant taxa representing 38%, followed by Harpacticoid copepoda (25%) and Polychaeta (22%) (Fig. 3). Different larval stages of other invertebrate groups accounted for 5% of total meiobenthic counts (Fig. 3).
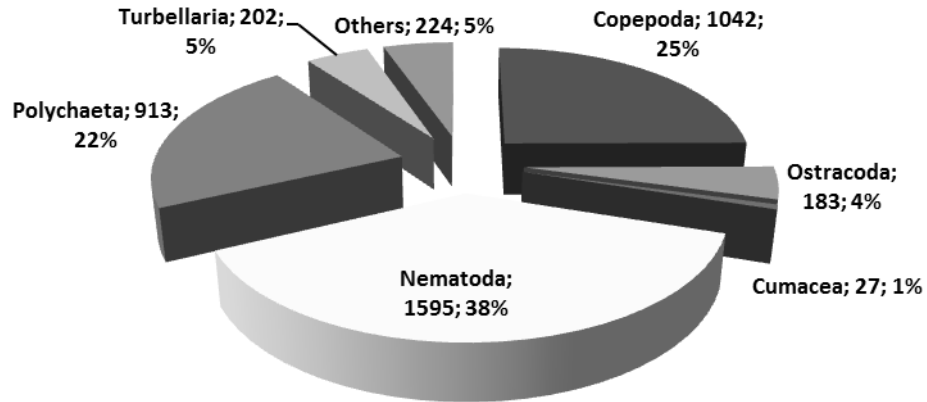
Fig. 3. Percentages of major meiobenthic taxa recorded in the study. Number of individuals is given for each group.

All six major taxa were recorded at all sites during the two seasons except cumaceans which were completely absent in site II and III. The highest density value was recorded for Nematoda in summer at site III, while the lowest was in winter for Cumacea at site I (Fig. 4). Regarding the total densities of major taxa in the different seasons, Nematoda exhibited the highest average density value in summer (356.6 ± 50.1 individuals/ $10cm^2$) followed by Copepoda (235 ± 27 individuals/ $10cm^2$). However, Cumacea showed the lowest average density value of 3.33 ± 5.77 individuals/ $10cm^2$ (Fig. 4).
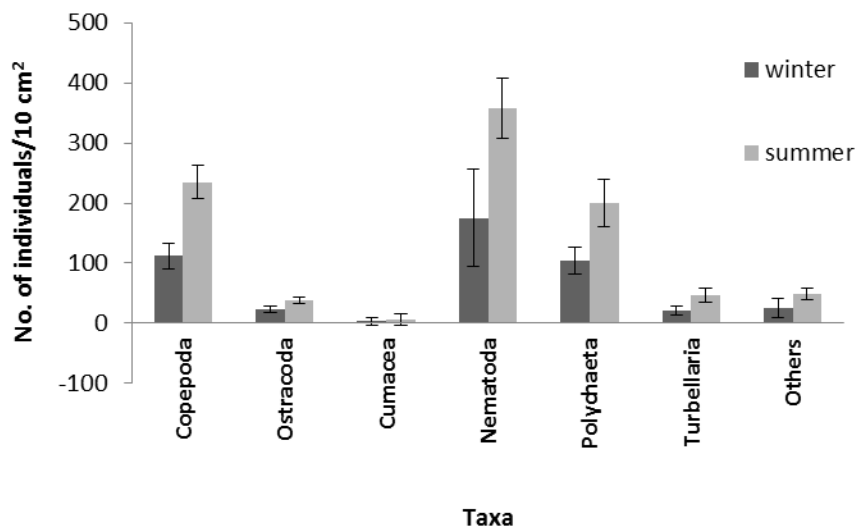

Fig. 4. Average count of meiobenthic taxa during the studied seasons

_____

All major taxa count was strongly positively correlated with water temperature, where the *r* value ranged between 0.85 and 0.95 with significantly high *P* values (Table 2). Other correlation coefficient values were not significant, except for Nematoda which showed positively strong correlation with TOMs ($r= 0.81$, $P= 0.05$) (Table 2).

Table 2. Spearman correlation coefficients of total meiofaunal count and the other major taxa with water temperature °C, TOMs % and sediment median grain size (Mz)

Parameter	Value	Total meiofauna	Copepoda	Ostracoda	Nematoda	Polychaeta	Turbellaria
Temperature	*R*	0.951	0.971	0.862	0.87	0.898	0.853
	P	0.004*	0.001*	0.027*	0.024*	0.015*	0.031*
TOMs %	*R*	0.743	0.693	0.086	0.81	0.789	0.331
	P	0.091	0.127	0.872	0.05*	0.062	0.521
Mz	*R*	0.555	0.475	-0.193	0.683	0.618	0.022
	P	0.253	0.341	0.715	0.135	0.191	0.966

*= significant value

3. Nematofauna

A total of 10 families were recorded at the investigated sites in summer. Chromadoridae, Cyatholaimidae and Xyalidae contributed for 74% of the total Nematode families, with percentages of 40%, 20% and 14%, respectively (Fig. 5). 18 genera were recorded, including *Chromadorita* (in site I) and *Ptycholaimellus* (in site III) exhibiting the highest abundance, while *Cobbia* and *Paramonhystera* showed the lowest density values (Table 3).
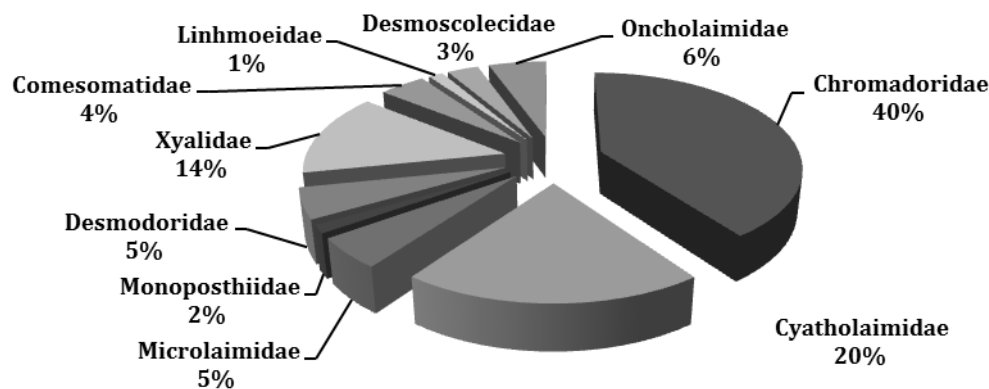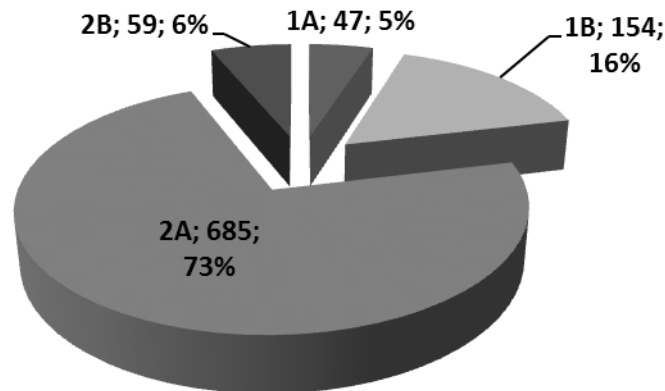

Fig. 5. Percentage of abundance for nematode families in the study area

Table 3. Feeding type and total individual count of the recorded nematode genera in the studied sites (expressed as no. of individual/ 10cm^2)

Family	Genus	Feeding type	site I	site II	site III
Chromadoridae	*Spilophorella*	2A	-	-	43
	Chromadorina	2A	12	34	-
	Chromadorita	2A	90	68	-
	Chromaspirina	2A	9	18	8
	Ptycholaimellus	2A	15	41	90
Cyatholaimidae	*Marylynnia*	2A	60	-	28
	Metacyatholaimus	2A	21	56	19
	Metadesmolaimus	1B	-	-	31
Xyalidae	*Cobbia*	2A	6	26	41
	Paramonhysterea	1B	6	38	-
	Stylotheristus	1B	-	-	32
Comesomatidae	*Sabatieria*	1B	12	19	16
Linhmoeidae	*Terschellingia*	1A	15	-	-
Microlaimidae	*Microlaimus*	2A	15	40	-
Monoposthiidae	*Monoposthia*	2A	-	15	-
Desmodoridae	*Paradesmodora*	2A	-	-	55
Desmoscolecidae	*Desmoscolex*	1A	-	20	12
Oncholaimidae	*Viscosia*	2B	39	-	20
	Total		**300**	**375**	**395**

All feeding habits were represented; A: selective deposit feeder, 1B: non selective deposit feeder, 2A: epi-growth feeder and 2B: predator/omnivore (Table 3). Epi-growth feeders (2A) was the main group in terms of number of genera (11) and individual count (73%), followed by non-selective deposit feeders (1B), which accounted for 16% and were represented by 4 genera (Fig. 6).

Fig. 6. Percentage of each type of nematode feeding habits in the study area. Number of individuals is given.

Viscosia was the only genus that represented the predator/omnivore feeders (2B). It was recorded at site I and accounted for 13% of all nematodes. The contribution of epi-growth feeders (2A) was the highest among all sites and varied between 72% in site III and 80% in Site II (Fig. 9). Non-selective deposit feeders group(1B) was ranked the second at site II and III (15% and 20%, respectively) (Fig. 7).
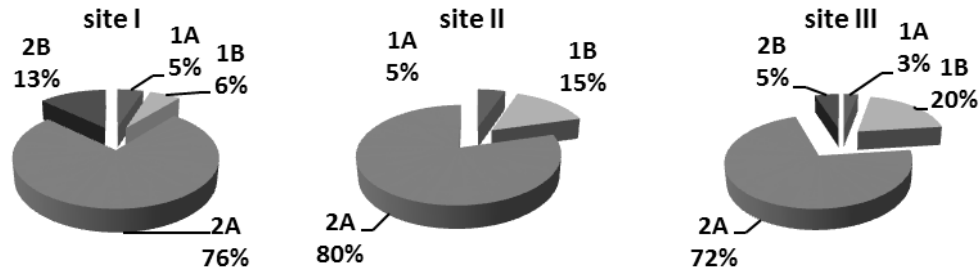

Fig. 7. Percentage of each nematode feeding habits at the studied sites

DISCUSSION

The meiofaunal count in this study showed lower values than that found by **Hedfi *et al.* (2018)** (in Eastern Red Sea, Saudi Arabia). Also, they found that total meiofaunal abundance was ranged between 218 ± 47 individual/10 cm^2 and 485 ± 134 individual/10 cm^2. This study found that the sediment characteristics of those studied sites exhibited high mud and organic matter contents (15-35% and 3-16%; respectively). In contrast, the sediment samples of the current study showed that the dominance of medium sand fractions and low organic matter contents (3-5%) in all sediment samples. Variations in total meiofaunal densities between the present study and the latter mentioned one might be attributed to the differences in sediment characteristics. **Smol *et al.* (1994) and Giere (2009)** reported that sediment characteristics play a significant role in the abundance and distribution of meiofauna. Also, they stated that high content of organic matter provides high meiofaunal densities.

The densities recorded in the present study showed high abundances of total meiofauna and other major taxa during summer. This finding is in agreement with those reported in similar areas and seasons and was related to water temperature **(Lopez-Canovas and Lalana (2001) in SW Cuba; Armenteros *et al*. (2009)** in the NW shelf of Cuba (Gulf of Mexico). **Rudnick *et al.* (1985)**; **Ansari and Parulekar (1993)**; **Hanafy *et al.* (2011)** stated that meio and macro-benthic fauna varied seasonally. They attributed that variation to the availability of food also suggested the excess of food resources is triggered by the high temperature during summer.

High meiofaunal densities were displayed more in site II and III than site I. This might be referred to their sediment characteristics in terms of TOMs and fine sediment texture. **Castel *et al*. (1989) and Giere (2009)** stated that density and distribution of meiofauna is function of the quantity of the available food sources and organic sediment content. **McLachlan *et al.* (1981)** found a positive correlation between the meiofaunal abundance and the detritus content of the sediment along the coasts of South Africa. The same correlation occurred in a Mediterranean beach, where relatively poor meiofauna was found in areas of low contents of organic matter **(Moreno *et al,*. 2006)**.

Nematoda was the most abundant taxa in all sites. That is in agreement with all the previous studies carried out around the world. **Renaud- Momant and Serone (1967)** in Malaysia; **Thomassin *et al.* (1982)** in French Polynesia, **Coull (1970)** in Bermuda; **Thomassin *et al.* (1976); Rao and Misra (1983); Renaud-Mornant and Gourbault (1981, 1984); Gourbault *et al.* (1985); Semprucci, *et al.* (2010)** in Indian Ocean and **Grelet (1985); Hedfi *et al*. (2018)** in the Red Sea; **Armenteros *et al.*(2009)** in Gulf of Mexico; **Boucher and kotta (2001)** in Pacific Ocean. **Grelet (1985)** and **Grelet *et al.* (1987)** indicated that, nematodes and copepods could be the most abundant organisms in the soft-bottom areas in the coral reefs of the Jordanian Red Sea coast (Gulf of Aqaba). **Giere (2009)** stated that, nematodes is the most frequent metazoan meiobenthos and usually dominate meiofaunal samples both in abundance and biomass due to their ability to adapt to live and survive in all substrates.

High similarity of the meiobenthic assemblages and the nematofauna of the studied sites were observed. This could be due to the homogeneity of the sediments at these sites, particularly in particle size composition. **Hodda (1990)** in the south east coast of Australia and **Armenteros *et al*. (2009)** in the NW shelf of Cuba reported high similarities in meiofaunal communities in sandy reefs, despite of the remarkable variations in topographical structure and dominant of megafaunal taxa. They proposed that micro-environments is significant in the distribution of meiofauna at very small scales.

Hall (1994) stated that particle size composition and hydrodynamic regime are the major ecological factors determining the faunal communities in soft bottom habitat. In the present study, it was difficult to discern which of these factors is the most influential in meiofauna abundance. In accordance with the **López-Cánovas and Lalana (2001)** results, I found that the density and proportion of copepods was high in habitats that are physically exposed (i.e. rocky flat and patch reef). This proposes that the negative impacts of sediment reworking may be less significant on the meiofauna than sediment oxygenation which is enhanced by well sorted sediments and caused by high water flow. On the other hand, the high input of organic matter as a result of sub-erosive water flow could be an element which enhances the occurrence of meiofauna **(Gamenick and Giere, 1994)**.

There is some evidence that, despite the widespread geographical separation between sites, nematode assemblages from the subtidal carbonate sediments of tropical seas are dominated by identical or closely related genera (Red Sea: **Grelet 1984; Australia: Alongi 1986; Tietjen 1991**; Caribbean Sea: **Boucher and Gourbault, 1990; Boucher and kotta, 2001**). This is true at the family level in the present study since the assemblages of nematofauna were dominated by members of the families Chromadoridae, Cyatholaimidae and Xyalidae. The Chromadoridae was the most abundant family that is in accordance with **Boucher (1997)** in the Western Pacific Ocean, **Tietjen (1991)** in the Great Barrier Reef and **Alongi (1986)** in Davis Reef.

Relatively high represented major taxa, nematode generic composition and different trophic habits were lowest in fine sands and highest in the medium-coarse ones (in the North Sea**: Heip *et al,*. 1985; Steyaert *et al*., 1999; Vanaverbeke *et al.*, 2002**). **Giere (2009)** stated that coarser sediments are richer in micro-niches and have relatively wide interstitial spaces and provide areas for sheltering and feeding as well as biofilms and microalgae which grow on the grain surfaces and are a rich food source for the meiobenthic organisms.

Epi-growth feeding nematodes were largely dominant in all samples in the current study. However, their distribution was insignificantly different between types of sediment. **Alongi (1986)** found that epi-growth feeders were very common in medium coarse sands with a very poor fine fraction in tropical habitats. **Boucher (1997)** in the Caribbean Sea; **Raes *et al.* (2007)** in Kenya and Zanzibar referred that to the occurrence of a high degree of benthic primary production in tropical ecosystems, diatoms great abundance and wide surfaces suitable for scraping off different biofilms.

In this study, *Viscosia* was only predator⁄omnivore nematode recorded in medium sands. This is probably because this genus feeds on other smallest meiofauna that take advantage of the high organic matter content which normally increases as grain size decreases that is in accordance to the findings in NE coasts of Brazil (**Netto *et al*.(1999a, 1999b)**). The low abundances of selective deposit feeders (1A) found in coarse sands herein are in accordance with the findings of **Alongi (1986)** in Austarlia; **Ndaro and Olafsson (1999)** in Zanzibar **Semprucci *et al.* (2010)** in Maldives, Indian Ocean. As expected, non-selective deposit feeders (1B) were frequently predominant in sediments dominated by fine fractions and are usually high in particulate detritus and bacteria (**Alongi, 1986**).

CONCLUSION

The compositions of the meiofaunal communities differed among sites with quite different sediment characteristics. Free living nematodes were the most abundant group and epi-growth feeding was the dominant feeding type. High water temperature during

summer might be important for structuring the meiofaunal communities in the coral reef sediments. The distribution patterns, community structures and other factors that might affect the associated coral reef meiofauna along the Egyptian Red Sea coast should be further investigated.

ACKNOWLEDGMENT

REFERENCES

Ahmed, A.; Mohammed, D. and Hanafy, M. (2011). Distribution and species composition of the littoral interstitial free living nematodes in the northern Red Sea, Egypt. Egypt. J. Aquat. Biol. & Fish., **15(2)**: 159-177.

Alongi, D. M. (1987). Intertidal zonation and seasonality of meiobenthos in tropical mangrove estuaries. Mar. Biol., **95**: 447-458.

Alongi, D. (1986), Population structure and trophic composition of the free-living nematodes inhabiting carbonate sands of Davies Reef, Great Barrier Reef, Australia. Aust. J. Mar. Freshwat. Res., 37: 609-619.

Alongi, D. (1989). The role of soft-bottom benthic communities in tropical mangrove and coral reef ecosystems. Rev. Aqua. Sci., **1**: 243-280.

Al-Sofyani, A. and Al-Sherbiny, M. (2018). Meiobenthic assemblage of the grey mangrove (*Avicennia marina*) along the Saudi Arabian coast of the Red Sea with emphasis on free-living nematodes. Oceanolo. and Hydrobiolo. Studies, 47(4): 359-375.

Ansari, Z. and Ingole, B. (1983). Meiofauna of some sandy beaches of Andaman Islands. Indian J. Mar. Sci., 12: 245-246.

Ansari, Z. and Parulekar, A. (1993). Environmental stability and seasonality of a harpacticoid copepod community. Mar. Biol., 115: 279-286.

Ansari, Z. and Parulekar, A. (1994). Meiobenthos in the sediments of seagrass meadows of Lakshadweep atolls, Arabian Sea. Vie Milieu., 44: 185-190.

Armenteros, M.; Creagh, B. and González-Sansón, G. (2009). Distribution patterns of the meiofauna in coral reefs from the NW shelf of Cuba. Rev. Invest. Mar., 30: 37-43.

Armenteros, M.; González-Sansón, G. and Lalana, R. (2003). Composición abundancia del meiobentos en un sector sublitoral de Ciudad de La Habana, Cuba. Rev. Invest. Mar., 24(1): 3-10. Berlin, 527 pp.

Boucher, G. and Kotta, J. (1996). Composition et diversite de la meiofaune du lagon de "Great Astrolabe Reef" (Fiji). In: L. Charpy, C, Charpy-Roubaud and P. Newell (eds,). The great Astrolabe Reef lagoon (Fiji): results of the French-Fijian

ASTTRO expedition. Oceanographie, Notes et Documents ORSTOM, 46: 47-52.

Boucher, G. (1990). Pattern of nematode species diversity in temperate and tropical subtidal sediments. P NS Z I. Mar. Ecolo., 11: 133-146.

Boucher, G. (1997). Structure and biodiversity of nematode assemblages in the SW lagoon of New Caledonia. Coral reefs**,** 16: 177-186.

Boucher, G. and Gourbault, N. (1990). Sublittoral meiofauna and diversity of nematode assemblages off Guadeloupe Islands (French West Indies). Bull. Mar. Sci.**,** 47(2): 448-463.

Castel, J.; Labourg, P.; Escaravage, V.; Auby, I. and Garcia, M. (1989). Influence of seagrass beds and oyster parks on the abundance and biomass patterns of meiobenthos and macrobenthos in tidal flats. Est. Coas. and Shelf sci., 28: 71-85.

Coull, B. (1970). Shallow water meiobenthos of the Bermuda platform. Oecologia, 4: 325-357.

Coull, B. (1999). Role of meiofauna in estuarine soft-bottom habitats. Austr. J. Ecol., 24: 327-343.

Danovaro, R.; Gambi, M.; Mirto, S., Sandulli, R. and Ceccherelli, V. (2004): Meiofauna. In: Mediterranean marine benthos: a manual of methods for sampling and study (Gambi, M. and Dappiano, M. eds.), Socie. Ital. Di Biolo. Mari., Geneva, 55-97 pp.

El-Serehy, H.; Al-Misned, F. and Al-Rasheid, K. (2015). Population fluctuation and vertical distribution of meiofauna in the Red Sea interstitial environment. Saudi. J. of Biolo.al Sci., (22): 459-465.

El-Serehy, H.; Al-Rasheid, K.; Al-Misned, F.; Al-Talasat, A. and Gewik, M. (2016). Microbial-meiofaunal interrelationships in coastal sediments of the Red Sea. Saudi. J. of Biolo. Sci., 23: 327-334.

Gamenick, I. and Giere, O. (1994): The microdistribution of coral sand meiofauna affected by water currents. Vie Milieu.*,* 44: 93-100.

Giere, O. (2009) Meiobenthology: The microscopic motile fauna of aquatic sediments (2nd ed.).Springer-Verlag, Berlin-Heidelberg.

Grelet, Y (1984). Peuplements meiobenthiques et structure de la nematofaunae du Golfe d Aqaba (Jordanie, Mer Rouge). These Doct. Spec., Oceanogr. Boil., Univ. Aix-Marseille II.

Grelet, Y. (1985). Vertical distribution of meiobenthos and estimation of nematode biomass from sediments of the Gulf of Aqaba (Jordan, Red Sea). Proc. 5th Int. Coral Reef Symp., **5**: 251-256.

Grelet, Y.; Falconetti, C.; Thomassion, B.; Vitiello, P.; Abu Hilal, A. (1987). Distribution of the macro- and meibenthic assemblages in the littoral soft-bottoms of the Gulf of Aqaba (Jordan). Atoll Resear. Bull., 308: 1-28.

Guzmán, H.; Obando, V. and Cortés, J. (1987). Meiofauna associated with a Pacific coral reef in Costa Rica. Coral Reefs, 6. 107-112.

Hall, S. (1994): Physical disturbance and marine benthic communities: life in unconsolidated sediments. Oceanogr. Mar. Biol. Annu., Rev**., 32:** 179-239.

Hanafy, M.; Mohammed, D. and Ahmed, A. (2011). Seasoanl distribution of the littoral interstitial meiofauna in the northern Red Sea, E*gypt.* Egypt. J. Aquat. Biol. and Fish., 15(2): 35-51.

Hedfi, A.; Ben Ali, M.; NourEl-Deen, A.; Albogami, B.; Hassan, M.; Saif., T. and Boufahja, F. (2018). Distribution and abundance of benthic meiofauna in the eastern Red Sea coasts (Jeddah, Saudi Arabia). Anim. Resear. and Rev. in Biolo., 26(2): 1-12.

Heip, C.; Vincx, M. and Vranken, G. (1985). The ecology of marine nematodes. Oceanogr. Mar. Biol. Annu. Rev., 23: 399-489.

Heip, C.; Warwick, R.; Carr, M.; Herman, P.; Huys, R.; Smol, N. and Holsbeke, K. (1988). Analysis of community attributes of the benthic meiofauna of Frierfjord/Langesundfjord. Mar. Ecol. Prog. Ser., 46: 171-180.

Herrera, A. and Valle, del. (1980). Caracteristicas de la meiofauna benthniea en la laguna y zona costera de Guayabal, en relacion con el grado de contaminacion. Rev. Cien. Biol**.,** 5: 29-45.

Hodda, M. (1990). Variation in estuarine littoral nematode populations over three spatial scales. Estuar. Coast. Shelf Sci**.,** 30: 325-340.

Holme, N. and McIntyre, A. (1984). Methods for the Study of Marine Benthos, Second ed. Blackwell, Oxford, pp. 387.

Hulings, N. (1971). A comparative study of the sand beach meiofauna of Lebanon, Tunisia and Morocco. Thalassia Jugosl, 7: 112-122.

Jorgensen, B. (1977). The sulfur cycle of a coastal marine sediment (Limfjorden, Denmark). Limnol. Oceanogr., 22: 814–832.

Kennedy, A. and Jacoby, C. (1999). Biological indicators of marine environmental health: Meiofauna - a neglected benthic component? Environ. Monit. Assess**.,** 54: 47-68.

López-Cánovas, C. and Lalana-Rueda, R. (2001). Benthic meiofauna distribution at three coral reefs from SW of Cuba. Rev. Invest. Mar.*,* 22: 199-204.

McLachlan, A.; Woolridge, T. and Dye. A. (1981). The ecology of sandy beaches in southern Africa. S. Afr. J. Zool., 16: 219-231.

Moore, C. (1979). Analysis of the associations of meiobenthic Copepoda of the Irish Sea. *J. Mar. Biol. Ass*. UK., 59: 831-849.

Moreno, M.; Ferrero, T.; Grandelli, V.; Marine, V.; Alebertelli, G. and Fabiano, M. (2006). Across-shore variability and trophodynamic features of meiofauna in a microtidal beach of the NW Mediterranean. Estuar. Coast. Shelf Sci., 66: 357-367.

Ndaro, S. and Olafsson, E. (1999): Soft-bottom fauna with emphasis on nematode assemblage structure in a tropical intertidal lagoon in Zanzibar, eastern Africa: I. spatial variability. Hydrobiol.**,** 405: 133-148.

Netto, S.; Attrill, M. and Warwick, R. (1999a). The effect of a natural water-movement related disturbance on the structure of meiofauna and macrofauna communities in the intertidal sand flat of Rocas Atoll (NE, Brazil). J. Sea Res., 42: 291-302.

Netto, S.; Warwick, R. and Attrill, M. (1999b). Meiobenthic Meiobenthic and macrobenthic community structure in carbonate sediments of Rocas Atoll (North-east, Brazil). Estuar. Coast. Shelf Sci., 48: 39-50.

Platt, H. and Warwick, R. (1983). Free living marine nematodes. Part I. British Enoplids. Synopses of the British Fauna No.28 (Eds. Kermack, D. and Barnes, R.) Cambridge University Press, Cambridge. 307 pp.

Platt, H. and Warwick, R. (1988). Free living marine nematodes. Part II. British Chromadorids. Synopses of the British Fauna No.38 (Eds. Kermack, D. and Barnes, R.) E. J. Brill/Dr Backhuys, Leiden. 502 pp.

Raes, M.; Troch, D.; Ndaro. M.; Muthumbi, M.; Guilini, A.; and Vanreusel, A. (2007). The structuring role of microhabitat complexity in coral degradation zones: a case study with marine nematodes from Kenya and Zanzibar. Coral Reefs, 26: 113–126.

Rao, G. and Misra, A. (1983). Meiofauna from Lakshadweep, Indian Ocean. Cah. Biol. Mar., 24: 51-68.

Renaud-Mornant, J. and Gourbault, N. (1984). Premières prospections meiofaunistiques en Guadeloupe II: Communautés des sables littoraux. Hydrobiol., 118: 113–118.

Renaud-Mornant, J. and Serbne, P. (1967). Note sur la microfaune de la cote orientale de la Malaisie. Cah. Pac., 11: 51-73.

Renaud-Mornant, J.; Salvat, B. and Bossy, C. (1971). Macrobenthos and meiobenthos from the closed lagoon of a Polynesian Atoll, Maturei Vavao (Tuamotu). Biotropica., 3: 36-55.

Rudnick, D.; Elmgren, R. and Frithsen, J. (1985). Meiofaunal prominence and benthic seasonality in a coastal marine ecosystem. Oecalogia (Berlin). 67: 157-168.

Ruttner-Kolisko, A. (1961). Biotop und Biozonose des Sandufers einiger osterreicischer Flusse. Verh. Int. Ver. Limnol.*,* 14: 362-368.

Sabeel, R. and Vanreusel, A. (2015). Potential impact of mangrove clearance on biomass and biomass size spectra of nematode along the Sudanese Red Sea coast. Marine Environmental Research, 103: 46-55.

Salvat, B. and Renaud-Mornant, J. (1969). Etude ~cologique du macrobenthos et du meiobenthos d'un fond sableux du Lagon de Mururoa (Tuamotu- Polynesie). Cah. Pac., 13: 159-179.

Semprucci, F.; Colantoni, P.; Baldelli, G.; Rocchi, M. and Balsamo, M. (2010). The distribution of meiofauna on back-reef sandy platforms in the Maldives (Indian Ocean). Mar. Ecol., 31: 592-607.

Smol, N.; Aillems, K.; Govaere, J. and Sandee, A. J. (1994). Composition, distribution and biomass of meiobenthos in the Ostrerschelde Estuary (SW Netherlands). Hydrobiol., 282/283: 197-217.

Steyaert, M.; Garner, N.; Gansbeke, D. and Vincx, M. (1999): Nematode communities from the North Sea: environmental controls on species diversity and vertical distribution within the sediment. J. Mar. Biol. Ass. UK., 79: 253-264.

Tarjan, A. (1980). Illustrated guide to the marine nematodes. IFAS, Univ. of Florida, Gainesville. 135 pp.

Tietjen, J. (1991). Ecology of free-living nematodes from the continental shelf of the Central Greet Barrier Reef province. Est. Coast. and shelf Sci., 32: 421-438.

Thomassin; B.; Vivier M. and Vitiello, P. (1976). Distribution de la méiofaune des sables corallines de la retenue d'eau épirécifale du Grand Récif de Tuléar (Madagascar). J. Exp. Mar. Biol. Ecol., 22: 31–53.

Vanaverbeke, J.; Gheskiere, T.; Steyaert, M. and Vincx, M. (2002). Nematode assemblages from subtidal sandbanks in the Southern Bight of the North Sea: effect of small sedimentological differences. J. of sea resear., 48 (3): 197-207.

Warwick, R.; Platt, H. and Somerfield, P. (1998). Free-living marine nematodes part III- Monhysterids. In: Barnes, D., Crothers, J. (Eds.), Pictorial key to world genera and notes for the identification of British species. The Linnean Society of London, London.

Wieser, W. (1953). Beziehungen zwischen Mundhöhlengestalt, Ernährungsweise und Vorkommen bei freilebenden marinen Nematoden. Arkiv För Zoologi., 2: 439-484.