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Distribution patterns of hard and soft corals along the Egyptian Red Sea Coast

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Abstract

Distribution, diversity and evenness indices of hard, soft coral forms and genera relative to the geographic distribution as well as local oceanographic conditions were studied in twelve sheltered and exposed localities along the Egyptian Red Sea Coast, starting from Ras Al-Behar in the north to Shlateen in the south. Distribution of hard and soft corals was controlled by many factors such as water temperature, turbidity and oxygen content. In the exposed areas, hard corals formed the highest percentage cover being 28.37% - 47.65%; 6.93% - 42.85%; 0.0% - 13.82%; 0.0% - 6.19% for the branching, massive, hydrocorals and solitary forms, respectively. The sheltered areas, on the other hand recorded the highest percentage cover for the branching forms being 22.07% - 71.24%. Among the soft corals, the finger shape as well as the dendrites had the highest percentage cover in the exposed areas being 0.00 – 12.29%; 0.19 – 39.56% for the finger shape and dendrites, respectively while the mushroom and carpet forms were highly distributed in the sheltered areas indicating that branching hard corals as well as mushroom and carpet soft corals were more adaptable to the high polluted sites in the sheltered zones. The other hard and soft coral forms were more flourished and can survive the intensive surge waves in the exposed areas. Among the branching forms, *Acropora* spp. recorded the highest percentage covers in the sheltered areas being 7.32 – 37.74% followed by *Pocillopora* sp (0.00 – 35.87%) while *Stylophora* spp. recorded the highest values (3.62 – 43.19%) in the exposed areas. *Porites* corals were the dominant massive genus in both exposed and sheltered areas being 3.62 – 26.94%; 2.11 – 21.38%, respectively. *Sarcophyton* was the dominant soft corals in the sheltered areas being 0.20 – 15.35% while *Heteroxenia* was common in the exposed areas being 0.00 – 24%. Evenness index (J) recorded its highest values in sheltered and exposed areas at Safaga and El-Fanadir being 0.95 and 0.99, respectively indicating a northward increases in quantity and diversity of corals.

Keywords: Coral forms, community structure, distribution, diversity, Red Sea, Egypt.

1. Introduction

Many shallow areas are stressed along the Red Sea coast due to the increased urbanization density, overexploitation and unplanned human activities (Ammar *et al*., 2007; Jameson *et al*., 1999; Mohammed, 2006) such as phosphate shipping, landfill and dredging, mining and overfishing (Daby, 2003). Benthos differentiation between the different areas are controlled by water depth and temperature variation (Rogers, 1990; Ammar and Müeller, 2001); tidal range and the degree of exposing, salinity and water mixing (Babcock and Davies, 1991; Ammar and Mahmoud, 2006); light penetration, geographic occurrence, the geomorphologic nature (Abou Zaid and Kotb, 2000; Kotb, 2001) as well as bottom sediment nature, turbidity and terrestrial inputs (Mohammed, 2010). However, coral reefs have attracted the attention of many authors with respect to many aspects like geographical relationship and geomorphological observations of coral genera at the northern Red Sea (Scheer, 1971), the basis of topographical characteristics of the reef (Loya, 1972) as well as the effect of sedimentation on coral reef distribution (Ammar, 2003; Ammar and Mahmoud, 2006; Mohammed, 2003, 2006, 2010; Mohammed *et al*., 2009).

Distribution of coral community structure in the Red Sea have been studied by Ammar and Nawar (1998) and Ammar (2003 and 2004). The ecology and biology have been documented by Merganer and Schumacher (1981), Kotb (1996) and Kotb *et al*. (2001), Mohammed (2003). The interaction of many factors influencing the distribution and bleaching of corals as well as the physical factors and anthropogenic activities have also been documented by Mohammed and Mohamed (2005), whereas the biological interaction between the benthos fauna, the bottom topography and geomorphology has been described by

Adjeroud *et al*. (2000), Kotb *et al*. (2001), Ouillon *et al*. (2004), Andréfouët and Guzman (2005). The purpose of this study is to assess and compare the assemblages and distribution of coral reef forms in some exposed and sheltered sites along the Egyptian Red Sea Coast and attempts to determine the factors affecting the coral biodiversity as well as the most abundant genus in each coral community at the studied sites.

2. Materials and methods

2.1. Area description

Twelve sites along the northern Egyptian Red Sea coast were surveyed to evaluate and calculate the percentage cover of the different forms, community and diversity referring to the most important factors affecting the coral diversity, assemblages and distribution. These sites and their positions are shown in Figure 1. They are divided into two sections; exposed and sheltered related to the water currents as shown in Table 1. The sites are highly influenced by different factors and activities such as phosphate shipping at Safaga, El-Quaih and El-Hmrawin; overfishing at Ras El-Behar, Ras El-Esh and Shlateen; touristic activities (diving and snorkeling) at El-Fanadir, Sharm El-Naga, El-Sharm El-Bahari and Abu-Dabab; coastal leveling and landfilling at National Institute of Oceanography and Fisheries (NIOF) at Hurghada; the effect of an active valley at Qula'an.

The study was performed using the line intercept transect (LIT) methods according to English *et al*. (1997). A 20m. long tape was used as a transect to evaluate the percentage cover of corals in the area relative to the other benthos using SCUBA diving equipments. Each transect has 20 m length and 2 m gap between the neighbouring transects. Three replicate transects were counted and averages were calculated at sub-equal depths from 3 to 7 meters for all the selected sites. A total of 36 transects were surveyed allover the studied sites where the percentage cover of both soft and hard coral forms were estimated in relation to the total coral cover. Coral samples were brought to the laboratory for identification. They were preserved in 4% formalin in seawater, rinsed in freshwater for 24 h. then transferred to 70% ethyl alcohol. Sclerites or spicules (endoskeleton) were obtained by dissolving soft coral tissues in 10% sodium hypochlorite. The soft corals (Alcyonaria) were identified according to Macfadyen (1929), Thomson & Dean (1931), Verseveldt (1982), as well as Fabricius and Alderslade (2001). While, hard corals (Madreporaria) were identified according to Sheppard and Sheppard (1991) as well as Veron (2000).

Percentage cover was calculated from the following formula:

$$\text{Percentage cover} = \frac{\text{Intercept length}}{\text{Transect length}} \text{X } 100$$

Diversity (H`) and evenness index (J) was calculated in each lagoon according to Shannon-Wiener (1948) and Pielou (1966):

i) Shannon-Wiener species diversity (Hs').

$$Hs = - \sum_{i=1}^{s} Pi \ln Pi$$

s = Total species, (i) = Each species

$$Pi = \frac{\text{Number of colonies species}^{(i)}}{\text{Number of total colonies}}$$

ii) Pielou`s evenness index (J). $J = \frac{H}{\ln s}$,

where, s = number of species.

Temperature, salinity, and dissolved oxygen were directly measured at each site by hydrolab instrument (model Surveyor 4, 1997).

3. Results

3.1. Oceanographic parameters

The sheltered sites were characterized by high water temperature and salinity, while in the exposed sites to the current from the open sea decreasing the water temperature and salinity. The surface water temperature is fluctuated between 21.94 °C (NIOF) and 34.28 °C (North Qula'an) at the sheltered sites and between 22.00 °C (Ras El Behar) and 30.99 °C (Shlateen). The recorded salinity was maximum at the sheltered site North Qula'an (43.27psu) and the minimum value measured at the exposed site Ras El-Behar (42.59). Moreover, pH is ranged between 7.70 at El-Hmrawin site (Sheltered) and 8.90 at shlateen (exposed), while the dissolved Oxygen is fluctuated between 3.13 mg/l at NIOF and 5.90 mg/l at Hmrawin (Table 1 and Figures 2 & 3).

3.2. Coral assemblages at the studied sites

A total of 46 genera were recorded allover the 12 studied sites, of which 26 and 20 genera belonged to hard and soft corals, respectively were distributed among the sheltered and exposed sites whereas the branching coral genera gave the maximum cover at most of the sheltered and exposed sites. The sheltered sites comprised 37 coral genera among them, 24 belonged to hard corals and the rest were soft corals. The exposed sites comprised 43 coral genera among them 25 were hard and 18 were soft corals.

The hard coral genus *Acropora* spp. formed the highest cover representing 21.46%, 10.90%, 18.44%, 37.74%, 24.90% and 14.28 of the total recorded corals at Ras El-Esh, NIOF, Safaga, El-Hmrawin, El-Fanadir and Sharm El-Naga, respectively (Tables 2 & 3). Whereas *Stylophora* sp. formed 43.19% and 23.49% of

Table 1: Some physical parameters of the investigated sites and their position.

Areas		temp.			Salinity			D.Oxygen			pH		
		Min	Aver	Max	Min	Aver	Max	Min	Aver	Max	Min	Aver	Max
Shelter areas	Ras El-Esh	----	28.7	-----	-----	41.34	-----	----	5.60	-----	----	-----	-----
	NIOF	21.94	24.95	26.9	40.71	41.23	41.61	3.13	4.57	5.58	8.60	8.6	8.6
	Safaga	28.33	29.01	29.7	40.04	14.38	42.72	4.78	5.03	5.27	----	-----	-----
	El-Hmrawin	25.57	27.94	29.03	40.88	41.84	42.15	----	5.90	-----	7.70	7.91	8
	El-Sharm El-Bahari	30.25	30.47	30.95	41.47	41.68	41.99	-----	-----	-----	7.91	8.02	8.07
	North Qula'an	33.16	33.78	34.28	42.28	42.55	43.27	----	5.70	-----	7.97	8.04	8.1
Exposed areas	Ras El-Behar	21.5	22.86	24	41.67	41.91	42.59	4.17	4.36	4.73	7.89	7.93	8.06
	El-Fanadir	25	25.66	26.5	41.06	41.11	41.22	4.61	4.88	5.21	7.95	7.99	8.08
	Sharm El-Naga	27.21	27.4	28.08	40.48	40.57	40.74	----	-----	-----	8.14	8.15	8.19
	El-Quaih	-----	29.8	-----	40.66	40.84	40.91	4.26	4.95	5.58	7.45	7.99	8.11
	Abu-Dabab	26.55	26.6	26.72	40.49	40.50	40.56	----	-----	-----	8.14	8.14	8.15
	Shlateen	29.68	30.12	30.99	40.75	40.92	41.19	----	-----	-----	8.09	8.22	8.9

Table 2: The percentage cover of Madreporaria genera in the sheltered sites

Specis	Ras El-Esh	NIOF	Safaga	El-Hmrawin	Sharm El-Bahari	North Qula'an
Acropora	21.46	10.90	18.44	37.74	33.73	7.32
Stylophora	6.63	13.29	16.67	1.79	1.47	7.28
Seriatopora	6.11	1.83	0.36	0.00	0.00	2.41
Pocillopora	2.63	1.39	4.21	19.70	35.87	0.00
Favia	1.89	6.04	4.92	4.43	4.61	4.44
Favites	0.64	2.64	1.63	2.05	4.78	7.82
Montipora	1.26	5.04	1.63	0.00	0.97	0.26
Porites	2.11	3.90	11.89	21.38	6.68	10.26
Platygyra	3.13	6.21	3.45	0.00	3.17	8.11
Goniastrea	1.58	0.59	2.91	0.00	0.00	2.06
Goniopora	0.82	0.00	0.49	0.00	0.00	0.00
Galaxea	3.65	6.02	0.00	0.00	0.00	0.78
Echinopora	3.83	3.77	3.67	0.00	0.00	6.16
Cyphastrea	0.00	0.00	1.03	0.00	0.00	0.00
Turbinaria	0.00	0.26	0.00	0.00	0.00	3.46
Gyrosmilia	0.00	0.00	0.00	0.00	0.00	0.00
Coscinaraea	1.68	0.00	1.63	0.00	1.52	0.00
Millepora	1.49	2.08	5.38	1.46	5.00	0.14
Fungia	2.42	0.83	1.09	0.00	0.11	0.00
Ctenactes	0.00	0.57	0.23	0.33	0.00	0.00
Siderastrea	0.00	0.00	0.00	0.00	0.17	2.21
Lobophyllia	0.00	3.55	0.00	0.00	0.00	2.85
Pavona	0.00	0.00	0.00	0.00	1.59	4.20
Cycloseries	0.00	0.35	0.00	0.00	0.00	1.05

Table 3: The percentage cover of Madreporaria genera in the exposed sites

Specis	Ras El-Behar	El-Fanadir	Sharm El-Naga	El-Quaih	Abu-Dabab	Shlateen
Acropora	3.70	24.90	14.28	11.10	19.89	12.64
Stylophora	43.19	3.62	4.65	23.49	5.14	23.23
Seriatopora	0.00	5.99	0.00	5.73	0.38	0.00
Pocillopora	0.00	1.50	7.20	4.09	6.68	0.00
Favia	0.00	3.51	3.87	3.60	2.90	11.68
Favites	0.67	5.01	0.55	2.29	4.26	5.04
Montipora	0.27	0.00	0.00	0.00	0.35	15.09
Porites	3.62	12.20	15.06	15.30	26.94	4.51
Platygyra	1.19	2.34	0.00	0.00	3.44	6.54
Goniastrea	0.00	5.53	0.00	3.19	1.84	0.00
Goniopora	1.07	1.81	0.00	0.00	0.00	0.00
Galaxea	0.00	0.00	0.00	0.00	0.27	0.00
Echinopora	0.52	0.00	6.86	0.54	0.00	4.52
Cyphastrea	0.00	3.30	0.00	0.00	0.00	0.00
Turbinaria	0.00	0.00	2.32	0.00	0.00	0.00
Gyrosmilia	0.00	0.00	0.00	0.00	0.00	0.00
Coscinaraea	0.00	0.00	0.00	0.00	2.46	0.00
Millepora	0.00	1.88	12.73	3.34	11.11	6.13
Fungia	0.00	0.77	0.13	0.57	0.00	2.61
Ctenactes	0.00	0.45	3.13	0.00	0.36	0.00
Lobophyllia	0.00	0.00	0.00	0.00	0.00	3.49
Hydnophora	0.00	0.00	0.00	0.00	0.36	0.00
Pavona	0.00	0.00	0.77	0.00	0.00	0.00
Plesiastrea	0.00	0.00	0.00	0.00	0.56	0.00
Cycloseries	0.00	0.00	2.44	0.00	0.00	2.03

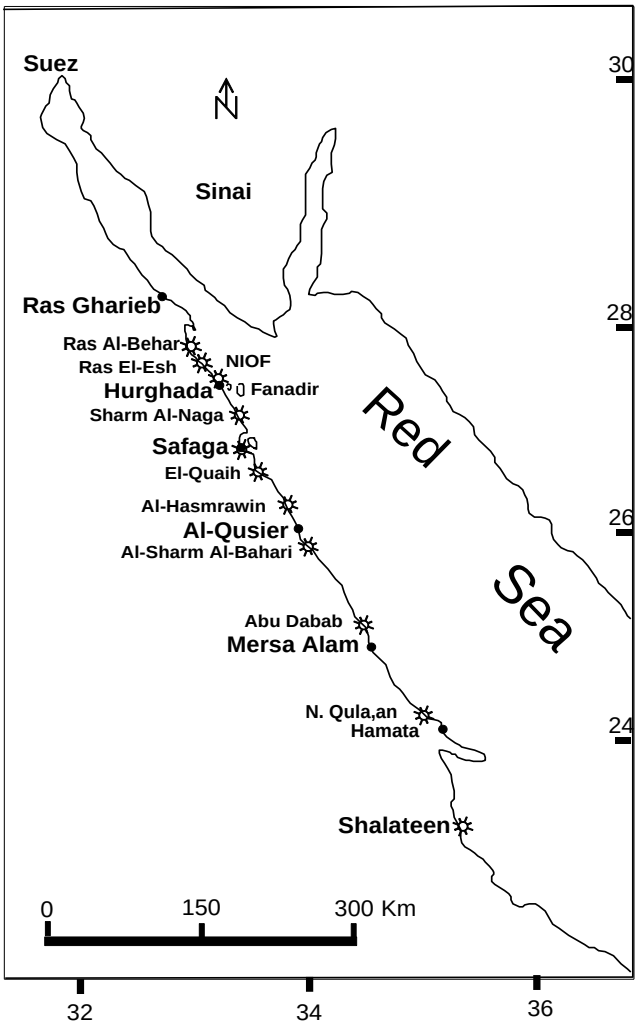

Figure 1: Location map of the studied sites along the Red Sea

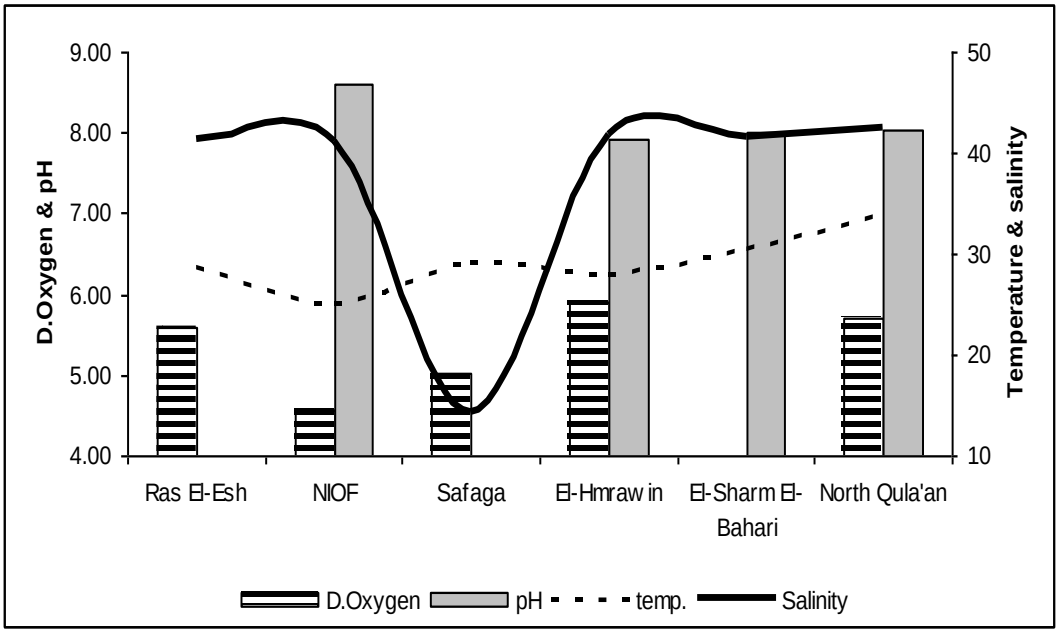

Figure 2: Temperature, salinity, pH and dissolved oxygen variations in the sheltered sites.

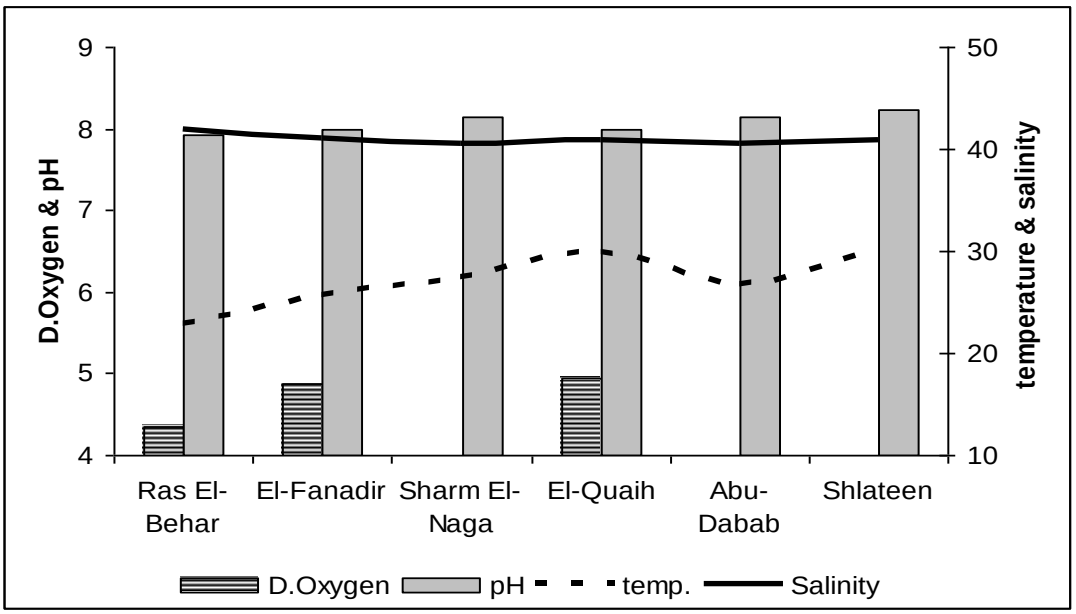

Figure 3: Temperature, salinity, pH and dissolved oxygen variations in the exposed sites.

the total recorded corals at Ras El-Behar and El-Quaih, respectively (Table 3). *Pocillopora* sp. covered 35.87 at Sharm El-Bahari. On the other hand, the massive coral *Porites* sp. recorded the highest abundance 26.94% and 21.38% of the total recorded corals at Abu-Dabab and at El-Hmrawin respectively.

At the sheltered sites, the dominance of soft coral genera were recorded for *Xenia* sp. (12.11%) at Ras El-Esh, *Heteroxenia* sp. (3.64%) at El-Hmrawin, *Sarcophytun* sp. (15.35%) at North Qula'an, *Sinularia* sp. (9.15% and 12.17%) at NIOF and Safaga respectively while at Sharm El-Bahari a very traces of *Sarcophytun* and *Nephthea* were only recorded having 0.2, 0.14 % of the recorded corals (Table 4). On the other hand, at the exposed sites, the soft coral *Sinularia* sp. recorded the highest values highest values at El-Quaih (10.92%), El-Fanadir (10.32%), Sharm El-Naga (8.04%), Abu-Dabab (3.81%) and Shlateen (1.44%) respectively (Table 5). At Ras El-Behar, *Heteroxenia* sp. recorded the highest value allover the surveyed soft corals being 24.35%. Moreover, *Lobophyton* sp. recorded the highest soft corals at Sharm El-Naga, El-Quaih and Abu Dabab being 847, 7.86 and 4.14% respectively (Table 5). In general, the sheltered sites recorded relatively high number of genera whereas NIOF site is having the highest number of genera (30 genera). On the other hand, El-Hmrawin is the site having the lowest recorded genera (14). On contrary, the exposed sites (El-Quaih and Shlateen to Ras El-Behar) recorded a relatively lower range than the sheltered sites being 16 to 27 genera (Table 6).

3.3. Coral forms and community structure related to diversity of sites

Table (7) reveals the percentage cover of different forms of hard and soft corals in the sheltered and exposed sites. Branching corals were the most dominant at the studied sites except at North Qula'an, Abu-Dabab and Shlateen at which the massive forms recorded the highest percentage cover being 37.93%, 40.92% and 42.85% respectively. These three sites were located at the most southern side of the Egyptian Red Sea (Figures 4 & 5). Generally, branching and massive coral forms occupied the highest percentage cover among the hard corals allover the surveyed sites and show a regular pattern in their distribution. Contrary soft corals showed irregular pattern of distribution and dominance. In fact, at the sheltered sites the highest percentage cover (19.41% and 7.73%) were represented by dendrite forms at Ras El-Esh and NIOF, respectively; mushroom forms (15.34%) at North Qula'an and the encrusting forms (11.21% & 12.18%) at NIOF and Safaga respectively. At the exposed sites, the highest percentage cover was represented by the dendrites which formed 39.56% of the total cover at Ras El-Behar, followed by finger shape (12.29% and 5.87%) at El-Quaih and Sharm El-Naga, respectively and encrusting forms (10.73, 10.52% and 8.02%) at El-Quaih , El-Fanadir and Sharm El-Naga respectively. Moreover, soft corals were found in minute traces at El-Sharm El-Bahari (Figures 6 & 7).

Coral diversity recorded its highest value 3.54 at the sheltered site NIOF and the minimum was 2.54 at North Qula'an. The exposed sites, on the other hand, recorded low diversity; from 1.78 at Ras El-Behar to 2.92 at Sharm El-Naga. The evenness index of corals varied from 0.72 to 0.95 at the sheltered sites and between 0.62 and 0.99 at the exposed sites (Table 8, Figures 8 & 9).

4. Discussion

The present study illustrated a general pattern in the distribution of hard and soft corals allover 12 sites in the Red Sea, where the main trend showed that, hard corals cover areas greater than that of soft corals. This agrees with the results of Loya (1972), Vine (1986), and Ammar and Mahmoud (2006) who pointed out that, hard corals almost dominate soft ones. Maximum values of massive corals over branching ones in Shlateen, Abu-Dabab and Qula'an are associated with turbidity, overfishing, diving and swimming at these three sites (Schleyer and Tomalin, 2000; Ammar and Mahmoud, 2006). The same authors illustrated that, the susceptibility of branching corals to breakage caused by trampling, diving and swimming leads to an increasing massive forms cover.

The dominant branching genera are *Acropora*, *Stylophora* and *Pocillipora* while the massive forms are represented mainly by *Porites* which is the most, dominant and fast growing one on the flood sediments area. These results agree with those of Ammar and Emara (2004) and Ammar and Mahmoud (2006). Temperature is an important factor affects the coral coverage, where the dramatic variations of temperature from the optimum values (25-29°C) cause high mortality rates of corals (Brown, 2000 and Mohammed and Mohamed 2005). The relatively high salinity at both sheltered and exposed sites may be responsible for the decrease in coral cover in general due to the expected increase in coral bleaching and mortality (Glynn, 1993). Water temperature generally increases southward while water salinity decreases southward (Morcos, 1970); nevertheless, the sheltered sites were affected by different impacts (such as human activities as fishing, diving and swimming and anthropogenic impacts) causing variations in the physical and chemical formations compared to the exposed sites. In contrast to the hard coral pattern, soft corals showed no certain trend in the distribution depending on the local conditions and impacts at each site. However, the increasing coverage values of dendrites form at Ras El-Esh, El-Hmrawin and Ras El-Behar over other soft forms may be related to their ability for acclimatization with the effect of oil pollution at these sites.

Table 4: The percentage cover of Alcyonaria genera in the sheltered sites.

Specis	Ras El-Esh	NIOF	Safaga	El-Hmrawin	Sharm El-Bahari	North Qula'an
Xenia	12.11	1.98	0.00	0.99	0.00	3.00
Heteroxenia	3.80	1.99	0.00	3.64	0.00	2.52
Sarcophytun	10.23	8.47	4.81	0.99	0.20	15.35
Sinularia	3.17	9.15	12.17	1.26	0.00	6.57
Dendronephthea	2.05	0.00	0.73	0.00	0.00	0.00
Anthella	0.00	0.65	0.00	0.00	0.00	0.00
Paralemnalia	0.00	0.48	0.00	0.00	0.00	0.00
Alcyonium	0.85	2.26	0.00	0.00	0.00	0.00
Capenella	0.42	0.59	0.00	0.00	0.00	0.00
Cladiella	1.60	0.77	1.22	0.00	0.00	0.00
Nephthea	1.48	2.63	0.00	2.71	0.14	1.76
Lobophyton	2.96	1.77	1.44	0.86	0.00	0.00
Tubipora	0.00	0.00	0.00	0.66	0.00	0.00

Table 5: The percentage cover of Alcyonaria genera and sea anemones in the exposed sites.

Specis	Ras El-Behar	El-Fanadir	Sharm El-Naga	El-Quaih	Abu-Dabab	Shlateen
Xenia	13.11	2.13	0.00	0.00	0.71	0.00
Heteroxenia	24.35	0.00	0.00	0.00	0.00	0.00
Sarcophytun	1.27	4.09	4.86	0.00	0.00	0.92
Sinularia	0.00	10.32	8.04	10.92	3.81	1.44
Anthella	0.00	0.42	0.72	0.00	0.00	0.00
Lemnalia	0.00	1.85	0.23	0.00	0.00	0.00
Paralemnalia	0.00	0.86	0.23	0.00	0.00	0.00
Alcyonium	0.00	0.00	0.00	0.13	0.00	0.00
Cladiella	0.00	1.64	0.74	0.00	0.00	0.00
Nephthea	1.46	0.42	1.72	5.73	3.05	0.15
Lobophyton	0.00	3.07	8.47	7.86	4.14	0.00
Pararythropodium	0.92	0.00	0.00	0.00	0.00	0.00
Lobularia	0.67	0.00	0.00	0.00	0.00	0.00
Stereonephthya	0.79	0.00	0.00	0.00	0.00	0.00
Microspicularia	1.59	0.00	0.00	0.00	0.00	0.00
Tubipora	0.00	0.58	0.37	2.13	1.34	0.00
Gorgoneans	0.00	0.97	0.00	0.00	0.00	0.00
sea anemones	1.59	0.84	0.62	0.00	0.00	0.00

Table 6: The number of coral genera in the studied exposed and sheltered sites

Sheltered sites	Ras El-Esh	NIOF	Safaga	El-Hmrawin	El-Sharm El-Bahari	North Qula'an
	26	30	22	14	15	22
Exposed sites	Ras El-Behar	El-Fanadir	Sharm El-Naga	El-Quaih	Abu-Dabab	Shlateen
	27	26	23	16	21	16

Table 7. Percentage cover of hard and soft corals in the exposed and sheltered sites along the Red Sea coast.

Sites	Hard corals					Soft corals				
Sheltered sites	*Branching*	*Encrusting*	*Massive*	*Non-scleractinian*	*Solitary*	*Finger*	*Dendrites*	Mushroon (Funnel)	Encrusting (carpet)	*Massive*
Ras El-Esh	36.84	5.51	15.1	1.49	2.43	5.82	19.41	10.23	3.17	0
NIOF	29.95	4.03	29.44	2.08	1.75	5.34	7.73	8.47	11.21	0.00
Safaga	39.68	6.33	26.92	5.38	1.31	2.66	0.73	4.81	12.18	0.00
El-Hmrawin	59.23	0.00	27.87	1.46	0.33	0.86	7.35	0.99	1.26	0.65
El-Sharm El-Bahari	71.24	1.51	21.80	5.00	0.11	0.00	0.14	0.20	0.00	0.00
North Qula'an	22.07	9.62	37.93	0.14	1.05	0.00	7.28	15.34	6.57	0.00
Exposed sites	Hard corals					Soft corals				
Ras El-Behar	47.65	0.53	6.93	0.00	0.00	0.68	39.56	2.91	1.74	0.00
El-Fanadir	36.67	3.36	30.97	1.91	1.24	4.79	5.79	4.16	10.52	0.59
Sharm El-Naga	28.37	9.98	22.00	13.82	6.19	5.87	4.21	0.00	8.02	1.54
El-Quaih	40.09	0.49	22.02	3.01	0.52	12.29	3.87	6.49	10.73	0.49
Abu-Dabab	32.09	2.46	40.92	11.11	0.37	4.14	3.76	0.00	3.81	1.34
Shlateen	39.36	4.52	42.85	6.13	4.63	0.00	0.19	0.92	1.40	0.00

Table 8: Coral diversity and evenness index in the exposed and sheltered sites along the Red Sea Coast.

Station	Ras El-Behar	Ras El-Esh	NIOF	El-Fanadir	Sharm El-Naga	Safaga	El-Quaih	El-Hmrawin	El-Sharm El-Bahari	North Qula'an	Abu-Dabab	Shlateen
Diversity	1.78	2.7	3.54	2.86	2.92	2.57	2.23	2.68	3.03	2.54	2.43	1.97
Evenness	0.64	0.93	0.9	0.99	0.89	0.95	0.93	0.81	0.92	0.72	0.68	0.62

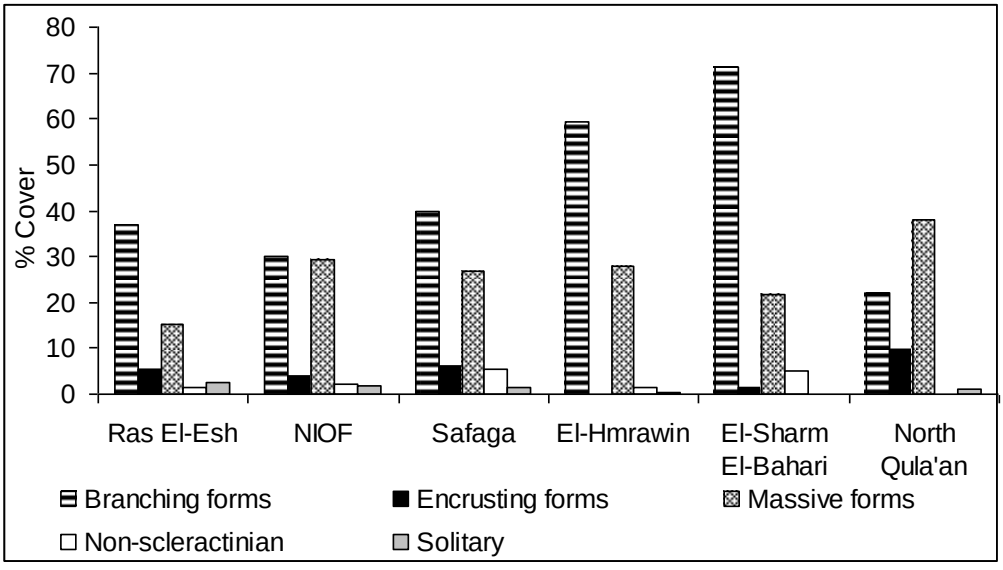

Figure 4: Hard coral forms for each locality of the sheltered sites

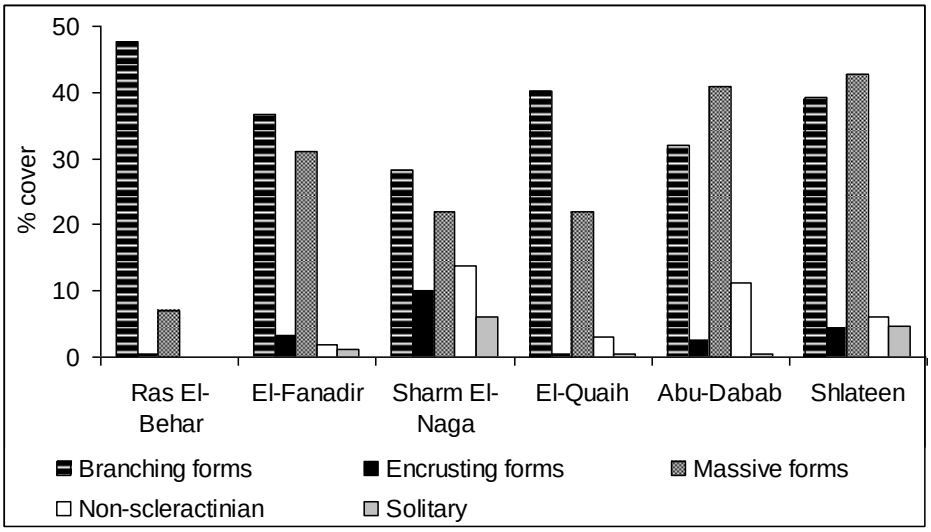

Figure 5: Hard coral forms for each locality of the exposed sites

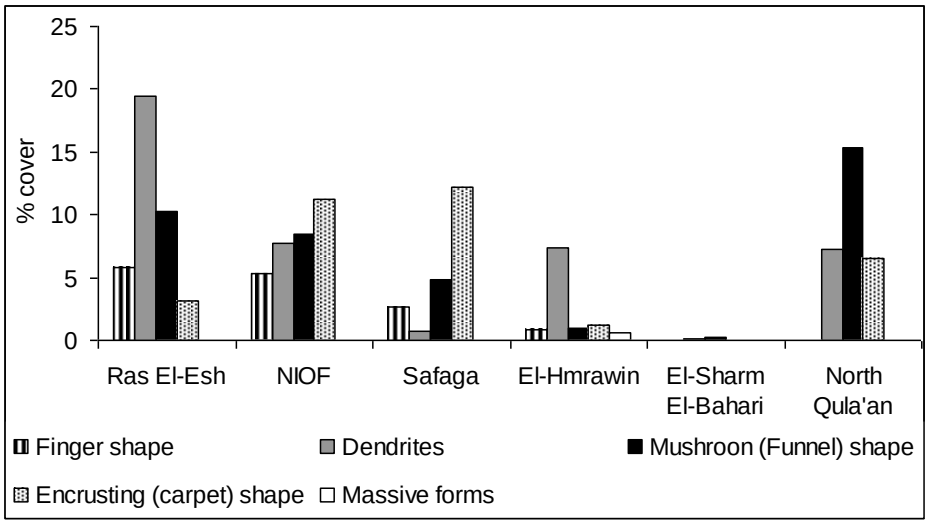

Figure 6: Soft coral forms for each locality of the sheltered sites

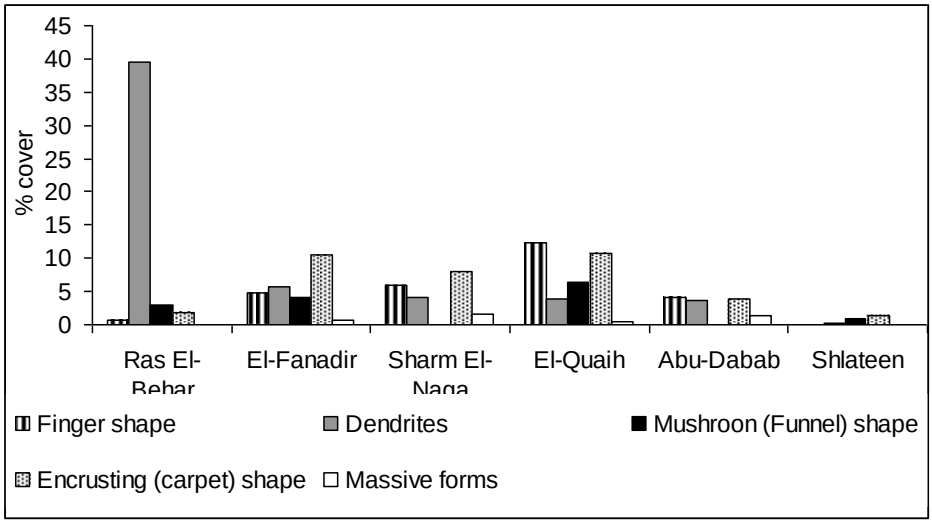

Figure 7: Soft coral forms for each locality of the exposed sites

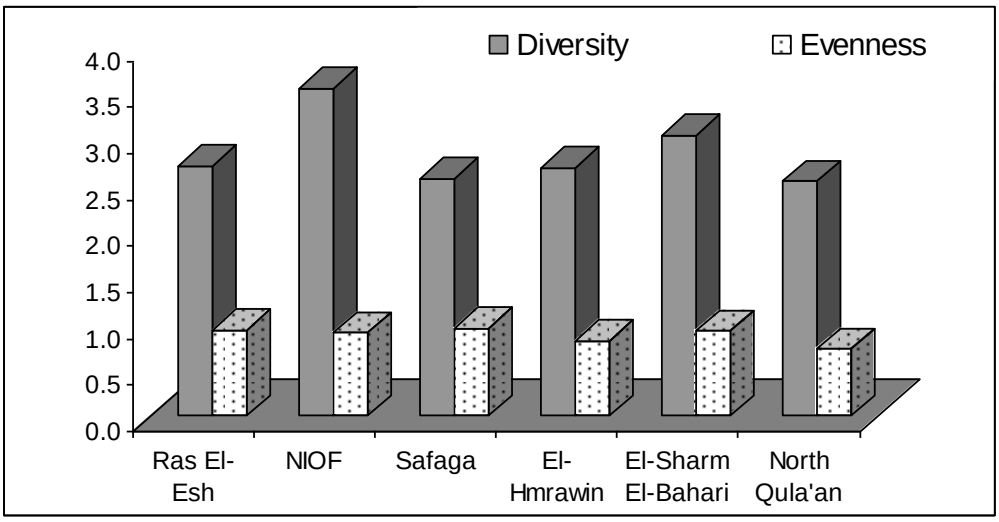

Figure 8: The diversity and evenness index of coral genera at the sheltered sites

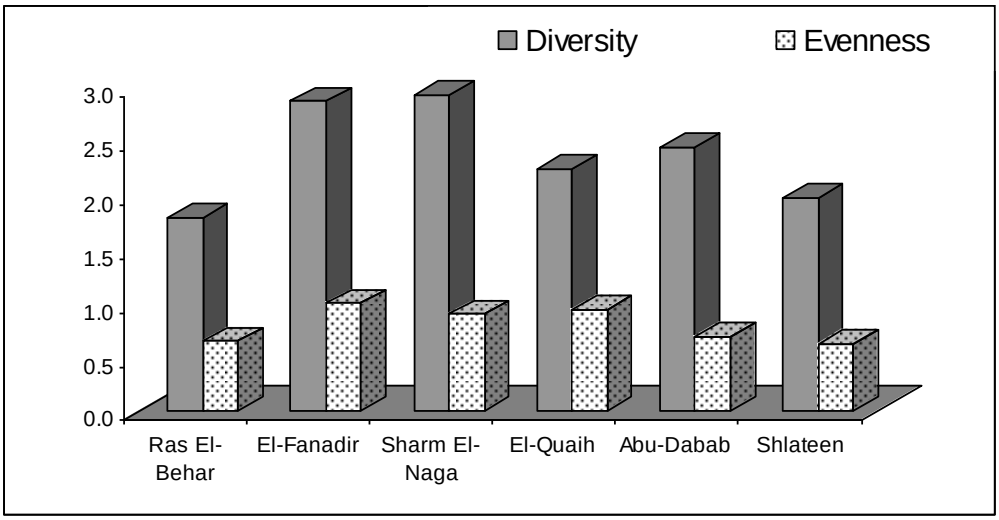

Figure 9: The diversity and evenness index of coral genera at the sheltered sites

The encrusting forms having high recorded covers of soft corals at NIOF, Safaga, El-Fanadir and Sharm E-Naga can grow fast and tolerate the human activities like fishing, diving and swimming (Ammar and Mahmoud, 2006). In general, soft corals appear to be increasing at the polluted areas, probably due to their ability to tolerate such effects and impacts. The encrusting forms (mainly *Sinularia*), dendrites shapes (mainly *Heteroxenia* and *Xenia*) and mushrooms (mainly *Sacrophyton*) indicate remarkable tolerances to harmful impacts and the human activities. Clearly tourist diving, overfishing and phosphate mining processes have adverse effect on the soft corals at El-Hmrawin, El-Sharm El-Bahari, Sharm El-Naga, Abu-Dabab and Shlateen (Kotb *et al*., 1991 and Mohammed, 2010).

Geographic position and geomorphology are other limiting factors for coral dominance beside the main factors (Temperature, turbidity, landfilling, algal blooming and overgrowth) that affect the distribution and growth (Mohammed, 2006 & 2010). This conclusion may help in clarifying the current results that, the northern localities are characterized by a high percentage of branching forms followed by massive corals. The southern sites have a higher covers than the branching forms especially North Qula'an, Abu-Dabab and Shlateen. In addition to geomorphology (Adjeroud *et al.*, 2000; Andréfouët and Guzman, 2005 and Mohammed *et al*., 2009), the interaction between the physical, biological factors (Porter, 1972) and geographic position may lead to the differences in coral form distribution (Kotb *et al*., 2001; Ouillon *et al*., 2004 and Mohammed, 2010). On the other hand, the present study illustrated that, diversity is depending on geographic position, where the sheltered sites showed a relatively high diversity and evenness index compared to the exposed sites which recorded a low values. Finally, it was observed that, the number of genera may

be associated with latitudes and longitudes, where, the maximum number of genera was recorded in the northern sites (both sheltered and exposed sites) while the lowest number was recorded in the south.

5. Conclusion

During the present study, the interaction of many factors such as sedimentation, bottom topography and geographic position affect the distribution of corals along the Egyptian Red Sea coast:

1. The oceanographic conditions and anthropogenic activities (landfilling, sedimentation and over-fishing) may affect and cause their decrease in some affected localities.
2. The bottom topography, geomorphology, geographic position (longitudes and latitudes) were major factors controlling coral forms distribution, diversity, evenness and number of genera in sheltered and exposed sites as well as northern and southern sites.
3. *Acropora*, *Pocillopora*, *Stylophora* and *Porites* spp. are the most common hard corals while *Sarcophyton* and *Sinularia* spp. are the most common soft corals along the Red Sea Coast.
4. There is no potent deviation in the effect of physical parameters (water temperature, salinity, D. O. and pH) on coral reef distribution.

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أنماط توزيع الشعاب المرجانية الصلبة والرخوة بطول ساحل البحر الأحمر المصرى

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تم دراسة التوزيع ومؤشر التنوع وعدالة التوزيع لأجناس وأشكال الشعاب المرجانية بالنسبة للتغير الجغرافى (المتمثل فى العوامل الهيدروجرافية) فى 12 موقع على طول الساحل المصرى للبحر الأحمر ما بين مواقع محمية ضحلة ومواقع مكشوفة، بدءا من رأس البحار شمالا وحتى الشلاتين جنوبا. وقد اثرت كل من درجة الحرارة والعكارة والمحتوى الأكسجينى الذائب على توزيعات المراجين حيث أن الأشكال المتفرعة فى المناطق المعرضة للتيارات وكذا فى الناطق المحمية سجلت أعلى نسبة للمراجين الصلبة (وسجلت الأشكال أعلى نسبة صلبه بلغت ما بين 22.07-71.24%). أما بالنسبة الى المراجين الرخوة فقد سجلت الأشكال الأصبعية (صفر - 12.29%) والشجيرية (0.19- 39.56%) أعلى نسبة فى المناطق المعرضة للتيارات بينما سجل شكل عش الغراب والمنبسط أعلى نسبة فى المناطق المحمية مما يدل على أن الأشكال المتفرعة (الصلبة) وعش الغراب والمنبسطة (الرخوة) هى أكثر الأشكال تأقلما فى المناطق المحمية أما باقى الأشكال فقد ازدهرت وتأقلمت مع الظرف البيئية المختلفة فى المناطق المعرضة للتيارات البحرية. وبصفة عامة فقد سجلت *أكروبورا* أعلى نسبة بين الأشكال المتفرعة (7.32-37.74%) فى المناطق الضحلة، بينما سجلت البوسيلليبورا نسبة اقل (صفر – 35.87%)، وسجلت *أستيلوفورا* أعلى نسبة (3.62-43.19%) فى المناطق المعرضة للتيارات البحرية. وقد كان *بورايتس* هو السائد بالنسبة للأشكال الكتلية الموجودة فى المناطق المعرضة للتيارات البحرية (3.62- 26.94%) وكذلك المحمية (2.11 – 21.38%). أما المرجان الرخو *ساركوفيتون* فكان أكثر المراجين الرخوة شيوعا فى المناطق المحمية (0.2 – 15.35%) وكان المرجان الرخو *هتيروزينيا* هو الشائع فى المناطق المعرضة (صفر - 24%). ولقد سجلت منطقتي سفاجا والفنادير (شمالا) أعلى عدالة توزيع مرجانى وبلغت قيمتها 0.95 و 0.99 على التوالى مما يشير لزيادة التنوع المرجانى فى مناطق الشمال.