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Distribution of Soft Corals in the Egyptian Coasts of the Red Sea and Gulf of Aqaba

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Abstract:
Red Sea is a resource-rich area with a distinctive coral reef ecosystem where soft corals represent the most diverse species. Knowledge of soft coral biodiversity and its distribution in the Egyptian coast of the Red Sea and Gulf of Aqaba are limited, so this study aimed to elucidate soft coral distribution and abundance at these areas. Eight sites along these areas were surveyed using transect of25-meterlength of the point intercept transect (PIT) in three depths; (0-5m), (5-10m) and (10-15m) in all sites during summer 2015and only two sites; Lighthouse and MarsaEgla, were additionally surveyed in winter. Eleven genera belong to three families were recorded. Of them the five genera; *Sinularia, Sarcophyton, Lobophytum, Nephthea* and *Xeniawere* considered the most common at all selected sites. Xenia represented the most abundant genus (112ind./trans.) at Gulf of Aqaba, while Sinularia (71ind./trans.) were common at the Red Sea, but *Lobophytum* showed the rare genus in this study. The diversity and abundance of soft corals decreased from north to south might be due to topography of the Red Sea and the increase of human impacts.

Keywords: Alcyonacea- soft coral- Red Sea- Gulf of Aqaba

I. INTRODUCTION

Octocorals are distributed worldwide and especially in the Indo-Pacific region. Soft corals and sea fans (octocorals) within the Order Alcyonacea are23 families with 90 genera described from the tropical Indo-Pacific, so they are considered diverse and widespread benthic groups within coral reefs in that area(Dinesen, 1983;Benayahu, 1997;Benayahu et al., 2004).

Although octocorals don't contribute much to the formation of limestone reef structure asscleractinians, they are important component of reef ecosystems (Fabricius and Alderslade, 2001). Although many studies were conducted on stony corals and other reef organisms in the Red Sea, they had not given much attention to soft corals despite their important ecosystem function as filter feeders (Cary, 1931). Moreover, the high diversity of soft corals in the Red Sea were confirmed by many studies (Forskål, 1775; Savigny, 1817; Ehrenberg, 1834; Klunzinger, 1877; Kükenthal, 1902, 1904 and 1913; Thomson and McQueen, 1907; Gohar, 1940; Mohammed, 2012). Soft corals were addressed in little researches (Reinicke, 1997; Benayahuet al., 2002; Perkol-Finkel and Benayahu, 2004) due to their difficult taxonomy and the low number of experts who capable of identifying octocorals.

Greater part on more recent identifications and revisions of soft corals dictated to report that Alcyoniidae and Xeniidae are highly diverse families in the Red Sea than other soft coral families (ca. 200 species; e.g., Benayahu, 1985, 1990; Reinicke, 1997; van Ofwegen, 2000).

Previous studies in the Red Sea reported that eight genera were common; *Xenia, Heteroxenia, Sarcophyton, Lobophytum, Litophyton, Sinularia, Nephthea*, and *Dendronephthea* (Gohar, 1940; Roushdy, 1954; Bermetand Ormond, 1981; Vine, 1986). Unfortunately, alcyonaceacoral reef are vulnerable to the many potential threats facing coral reefs globally including reduction in water quality (Holmes et al., 2000; Norström et al., 2009), coastal development, overexploitation, destructive fishing, pollution and climate change (Burke et al., 2011).Many physical factors have great effects on soft coral abundance and distribution especially, the sedimentation and temperature increase could have led to the decline of the reef community in terms of abundance and species richness (Chou et al., 1994). High or low temperatures cause zooxanthellae removal of soft coral that have led to bleaching.

The present study aimed to document the diversity and distribution of soft corals occupied shallow water (□ 15m) in the western coast of the proper Red Sea and Gulf of Aqaba to provide baseline information for the soft corals distribution in these areas.

II. MATERIALS AND METHODS

Study area

In a trial to cover the most area of the Egyptian Red Sea coast, eight sites were selected along the western coast of the proper Red Sea and Gulf of Aqaba to be surveyed in this study. Three of them are located in the Gulf of Aqaba; they are Ras Abu Galum, Lighthouse and Marsa Ghozlani, from north to south. Other five sites are situated in the western coast of the proper Red Sea (Abu Monkar Island, Safaga, El-Hmrawin, Marsa Egla and Shalatein) (Fig.1).

The coordinates of sites as well as the oceanographic parameters are represented in Table (1).The sites were selected to include inshore and submerged offshore reefs and to represent different levels of human impact on corals such as phosphate shipment, coastal leveling and landfilling, snorkeling/diving tours, recreational fishing trips, hotels, restaurants and marine protected areas also.

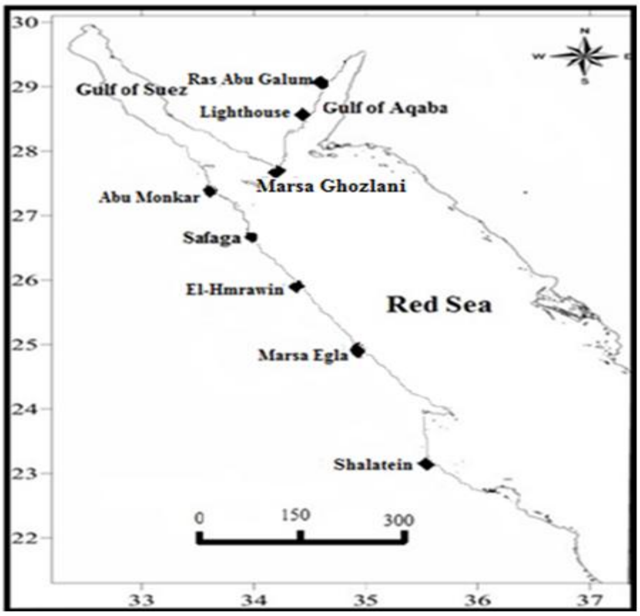

Figure.1. Map showing selected sampling sites along the Egyptian coast of the Red Sea

Survey method

All studied sites were surveyed in summer 2015 and only two sites, Lighthouse (in the northern Gulf of Aqaba,) and MarsaEgla (in the southern Red Sea), were additionally surveyed in winter 2015. All surveys were carried out using SCUBA. Semi-quantitative traditional method, point intercept transect (PIT) described by Obura(2014) was used to assess the abundance of soft coral genera at 3 depths; 0-5m, 5-10m and 10-15m. A transect of 25m length was laid parallel to the reef contour and marked every 50cm. Three line transects were set in a single file row and separated by a 1 m inter-transect space. Soft coral species under each point located at 50cm intervals along a 25 m transect were recorded. The total number of transects from all sites were 72 transects. The abundance of each genus of soft coral was calculated as an average number of recorded genus in the three transects and represented as a number of individual/transect (ind./trans.). Soft corals were identified in this study to generic placement according to Fabricius and Alderslade (2001) withfocusing on 5soft coral genera; *Sinularia*, *Sarcophyton*, *Lobophytum*, *Xenia* and *Nephthea*. Temperature and salinity were measured using hydro- thermometer andsalino-meter, respectively.Surface water temperature was measured in summer only at all selected sites except at Lighthouse and MarsaEgla, in which water temperature was measured in both summer and winter at three depths.

Statistical analysis

Data of abundance of soft corals were represented as mean and one-way and two-way ANOVA were performed upon original or transformed data using SPSS (V.19). Data of non- normal distribution, even after transformation, were subjected to non-parametric tests (Kruskal-Wallis and Mann-Whitney test).

III. RESULTS

Seawater temperature and salinity

The amplitude of surface water temperature was 7°C throughout studied sites in summer with a maximum value of 32.5°C at Shalatein and a minimum of 25.5°C at Abu Monkar (Tables1). Variations of water temperature at MarsaEgla and lighthouse in winter at three depths are shown in Table (2). Water temperature decreased gradually with increasing depth. Salinity values did not show spatial or seasonal variation at all sites, ranging between 40 ‰ and 41.1 ‰ (Tables 1 and 2).

Table.1. Positions and some oceanographic parameters at the studied sites during summer.

Site	Position		Temperature (°C)	Salinity (‰)
	Latitudes	Longitudes		
Ras Abu Galum	28°43'45.06″	34°37'32.88″	27.3	41
Lighthoue	28°29.944'N	34°31.182'E	25	40.7
MarsaGhozlani	27°43'20″ N	34°15'14″ E	26	41.1
Abu Monkar Island	27° 2'47.14" N	33°53'29.43" E	25.5	40
Safaga	26° 33'05.89" N	34° 11'32.52" E	29.7	40.1
El-Hmrawin	26⁰ 15' 15" N	34⁰12' 10" E	29.8	40
MarsaEgla	25° 10' 17.8" N	34° 50' 27.5 "E	27.4	40.1
Shalatein	23⁰ 09' 10" N	35⁰ 36' 58" E	32.5	40.2

Table.2. Seawater temperature at Lighthouse and MarsaEgla in different depths. Diversity of soft corals

T (°C)	Summer				Winter			
	T (°C)			Salinity (‰)	T (°C)			Salinity (‰)
Site/Depth (m)	0-5	5-10	10-15		0-5	5-10	10-15	
Lighthouse	27.4	27.2	27	41	22.9	22.8	22.5	40.40
MarsaEgla	32	31.8	31.6	40.15	23.1	23	22.8	40

Diversity of soft corals:

Eleven soft coral genera were observed atall selected sites along the western coast of the proper Red Sea and Gulf of Aqaba; *Alcyonium*, *Capanella*, *Lobophytum*, *Litophyton*, *Heteroxenia*, *Xenia*, *Cladiella*, *Sarcophyton*, *Sinularia*, *Dendronephthea* and *Nephthea* (Fig. 2).Marsa Ghozlaniwas the most diverse site in the area as it harbouredall genera of soft coralswhereas5 mutual generawere found in all sites and considered as a minimum number present at studied sites as recorded at Shalatien, MarsaEgla and Lighthouse (Fig.3).

Figure.2.Recorded soft corals at the selected studied sites

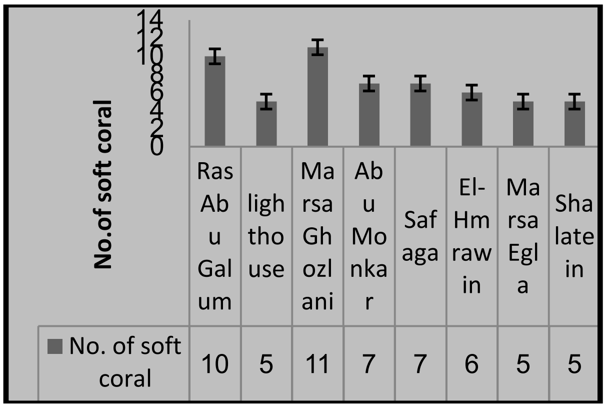

Figure.3.Diversity of soft coral genera at selected sites

Soft coral abundance:

Of a total 11genera of recorded soft corals, five genera were mutual in all sites; *SinulariaSarcophyton*, *Lobophytum*, *Xenia* and *Nephthea*, so they were chosen to investigate their abundance at selected sites (Fig.4). For each site; a total sum of soft coral individuals at three depths were considered to evaluate spatial abundance. Spatial abundance of soft coralin the Gulf of Aqaba represented by 3 sites (285 ind./trans.) was higher than that recorded in the proper Red Sea (197 ind./trans.) whichrepresented by 5 sites (Table3). Variation in soft coral abundance between two areas showed significant difference ($p<0.05$). In the proper Red Sea, the decrease in soft coral abundance was related to the increase in seawater temperature where El-Hmrawin harbored the lowest abundance (16 ind./trans., temp: 29.8°C). *Sinularia*existed atall sites with different values, Xenia was the dominant genus specially at Ras Abu Galum, Lighthouse and MarsaEgla, (60, 30 and 20ind. /trans., respectively) (Table3). *Sarcophyton* and *Nephthea* showed approximately similar distribution in the same trend approximately throughout all sites except at Shalatein. *Lobophytum* and *Xenia* were not recorded at El-Hmrawin, and showed the lowest abundance with similar values (1ind./trans.) at Shalatein.

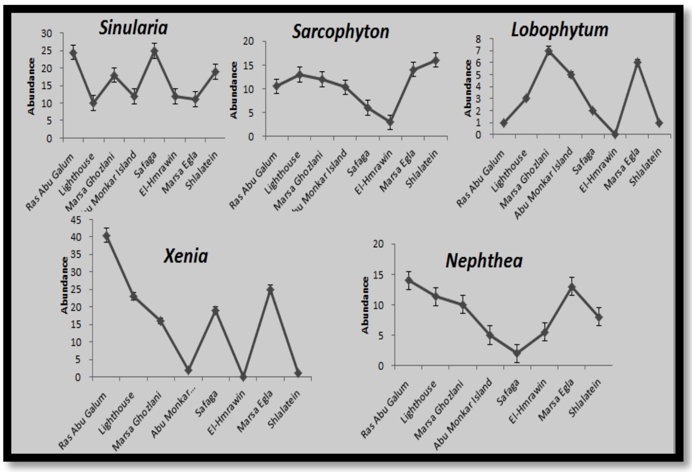

Figure.4. Abundance of five soft coral genera at each site in three depths during summer

Table.3. Abundance soft corals at selected sites during summer

Soft coral /site	Ras Abu Galum	Lighthouse	MarsaGhozlani	Gulf of Aqaba	Abu Monkar Island	Safaga	El-Hmrawin	MarsaEgla	Shalatein	Red Sea
Sinularia	25	15	22	62	12	25	12	7	17	71
Sarcophyton	15	20	12	47	10	6	3	10	14	43
Lobophytum	1	5	7	13	5	2	0	6	1	14
Xenia	60	30	22	112	2	19	0	20	1	42
Nephthea	18	16	17	51	5	2	6	9	8	27
Total	119	88	80	285	34	54	21	52	41	197

Seasonal variation:

Seasonal variation of soft coral abundance in the two sites (Lighthouse and MarsaEgla) in three depths showed insignificant variation ($p> 0.05$). Although average of sea water temperature in Lighthouse was less than Marsa Eglaabout (>3°C), there was no real variation in soft coral abundance at sites (Fig. 5). Soft coral exhibited an increase in its abundance in summer than winter with a very low difference between the two sites giving a maximum value (45ind./trans.) at Lighthouse in summer. This increasing in abundance synchronized with the increase in seawater temperature (Fig. 5).

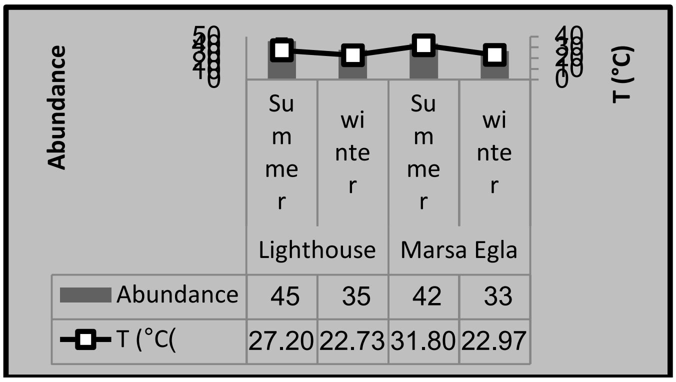

Figure.5. Soft coral abundance and seawater temperature during summer and winter at Lighthouse and MarsaEgla

In summer, Xenia was a dominant genus during summer and winter (~14.17and 13.17ind./trans., respectively). *Lobophytum* displayed the lowest abundance with similar values during summer at the two sites (~1.78ind./trans.)(Fig.6).

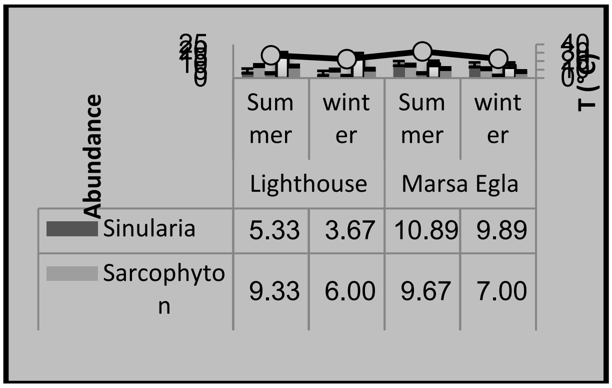

Figure.6. Seasonal abundance of the five soft coral genera and seawater temperature at Lighthouse and Marsa Egla in three depths

Variation within depths:

The variation of soft coral abundance in the three depths at two sites was significant ($p<0.05$). The abundance of soft coral increased gradually with depth showing the same pattern for two sites, giving the highest value in the Gulf of Aqaba (34ind./trans.) at (10-15m).In the Gulf of Aqaba, the abundance of soft corals ranged from 17ind./trans. In the surface to 34ind. /trans. at deepwater at, while it ranged from 7ind./trans. to 21ind./trans. in the Red Sea (Fig. 7). A little difference in abundance between the surface and mid waters was noticed in the Gulf, while it was considerable between mid and deep waters. Conversely, in the Red Sea great variation in the abundance appeared between the surface and mid waters. Abundance of all soft coral genera displayed a consistent trend of increasing values with depths at two sites, except Xenia and Sinularia which showed a reverse trend with depth; the first at Gulf of Aqaba with the highest value (11.33ind./trans.) in (0-5m) and the second showed highest value in (5-10m) (6.4ind./trans.) (Table 4).

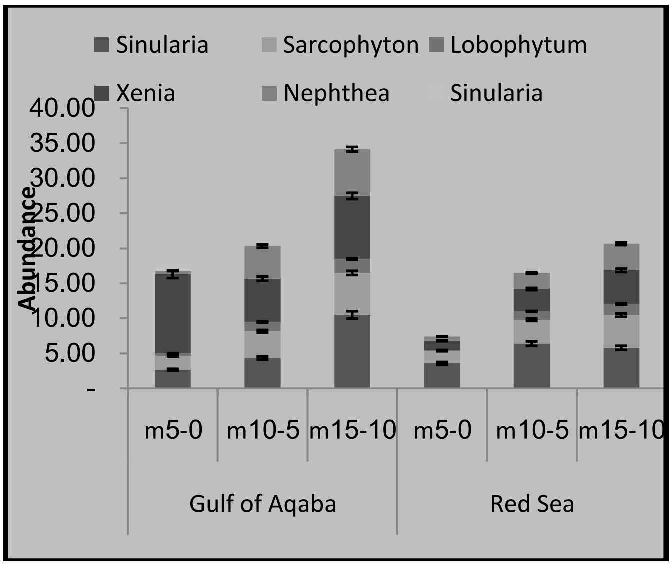

Figure.7. Abundance of soft coral genera at the Gulf of Aqaba and the proper Red Sea during summer in three depths

Table.4. Soft coral genera at two areas in different depths during summer

Soft coral Genera/Depth	Gulf of Aqaba			Red Sea			Average		
	0-5	5-10	10-15	0-5	5-10	10-15	0-5	5-10	10-15
Sinularia	2.67	4.33	10.50	3.60	6.40	5.80	3.14	5.37	8.15
Sarcophyton	2.00	3.83	6.00	1.80	3.40	4.67	1.90	3.62	5.34
Lobophytum	0.33	1.33	2.00	-	1.20	1.60	0.33	1.27	1.80
Xenia	11.33	6.17	9.00	1.40	3.20	4.80	6.37	4.69	6.90
Nephthea	0.44	4.67	6.67	0.60	2.30	3.80	0.52	3.49	5.24
Total	17.00	20.00	34.00	7.00	17.00	21.00	12.00	18.00	27.00

IV. DISCUSSION

The main aim of this study was to investigate soft coral distribution and relative abundance along the western coast of the proper Red Sea and Gulf of Aqaba. Different variables were taken in consideration to assess the status of soft coral in these two areas; these variables include site variation, season and depth. Water temperature and salinity were measured in order to relate these parameters to our findings. A total of eight sites were selected to cover both the Gulf (Ras Abu Galum, Lighthouse and MarsaGhozlani) and the Red Sea (Abu Monkar Island, Safaga, El-Hmrawin, MarsaEgla and Shalatein). There were some differences in diversity between sites; the highest number of soft coral genera recorded in this study was 11genus at Marsa Gghozlani in the Gulf of Aqaba followed by Ras Abu Galum (10), the cause made them the healthiest site in the study area, but Lighthouse in the same area occupied 5 genera. These differences can be explained by different stressor factors which influenced this area; the damage triggered by low protection in the past creates sufficient substrates (of dead corals and rocks), besides recruiting fragments that initiates the diversity rising (Ammar, 2011). Surprisingly, 7 genera were the maximum number which expressed the diversity of soft coral at the western Red Sea. This was as a result of the coast exposure to human activities such as; land filling and overfishing processes and sedimentation due to the reject water of the desalination plant that cause a low water quality (Rogers, 1990; Mohammed, 2003; Thomas *et al.* 2003). Abundance of soft coral responded significantly ($p<0.05$) to these damaging factors in these areas; it was (285ind./trans.)at the Gulf of Aqaba that revealed the healthy conditions as enough time had been taken to manage and improve their distribution and diversity, moreover the low values or absence of sponges, ascidians, anemones, broken corals, echinoderms and algae (Voogd et al. 2004; Pawlik et al. 2007). On the other hand, Red Sea coast recorded low abundance (197ind./trans.) as a result of high sedimentation rates and water turbidity occurred in the area which led to clear degrading in coral distribution and biodiversity (Mohammed and Mohamed, 2005). The most abundant genus in this study was *Xenia* (112ind./trans.) at Gulf of Aqaba, while *Sinularia* was (71ind./trans.) at the Red Sea, never the less *Lobophytum* show approximately same lowest recorded genus at the Gulf (14ind./trans.) and at the Red Sea(13ind./trans.). As *Xenia* spp. can colonize successfully, besides their high fecundity and several dispersal modes (Benayahu&Loya, 1985). It is very flexible for growth for example; (Fox et al. (2003) assumed locally high abundance *Xenia* spp. than other soft corals (up to 80%) on coral rubble patches after chronic blast fishing practices in the Komodo National Park in eastern Indonesia). *Sarcophyton* and *Nephthea* distributed in the same trend approximately at all sites except Shalatien as the ability of both to reproduce asexually, allowing them to spread over an area in which they are already present when competitors are removed (Fabricius & Alderslade, 2001). El-Hmrawin was exposed to huge infringements what reflected the lowest abundance of soft coral (16ind./trans.) such as; phosphate shipment and it also harmed the marine environment in Safaga. Although Ammar (2011) assumed that South Nuweiba showed the least healthy of all sites because of the illegal destructive fishery overexploitation, RasabuGalum showed highest abundance of soft coral (119ind./trans.) in this study. In terms of seasonal variation, two sites were selected to study seasonal variation of soft corals during summer and winter (Lighthouse in the Gulf of Aqaba) and (MarsaEgla in the Egyptian coast of the Red Sea). Average of sea water temperature in Lighthouse decreased from MarsaEgla by (>3°C), however soft coral abundance varied insignificantly during seasons and increased during summer as the fecundity of soft coral was greater during the summer than during the rest of the year (Ben-David-Zaslow, 1999).

These results disagree with Grossowicz, (2008), Grossowicz &Benayahu, (2015) in term of soft coral abundance and distribution. Soft coral abundance distributed significantly across bathymetric area (from 0 to 15m)at two areas ($p<0.05$).It increased with depth and it was against to other studies (Michalek-Wanger, K. and B.l.Willis, 2000). However, light penetration decreased owing to sedimentation and water turbidity by organic and inorganic materials disposed in the Red and the hard filtration of food. Stinging cells called "Nematocysts" in the outer layer of their tissue (ectodermis) contained by soft corals were used for prey capture that couldn't be captured during filtration (Fabricius*et al.*, 1995) moreover; the distinct topography of the Red Sea may influence the bathymetric distribution of soft corals. Further studies are required on how light intensity controls the bathymetric distribution of soft corals in the Red Sea and to understand how different environmental factors influence their diversity. We should learn how to appreciate the importance of coral reefs and realize their role in the livelihoods of millions of people in developing countries. Finally, more effective coral reef management is absolutely required.

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