CORAL REEFS QUANTITATIVELY ASSESSMENT ALONG THE EGYPTIAN RED SEA COAST

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ABSTRACT

Coral assessment and distribution have been studied along the Egyptian Red Sea coast from north Hurghada with 5km to Shalateen illustrating the most important factors that affect the coral distribution and abundance at the selected sites. The cover percentage of the coral reef community was estimated at each locality by using the standard method (the line intercept transect). During the present investigation, 68 coral species were recorded at seven coastal sites along the Egyptian Red Sea; forty-nine species of them were hard corals and the other 19 species were soft corals. North Hurghada site (NIOF) recorded the least cover of the living coral (66.23%) while Abu-Dabab area recorded the maximum coverage percent (91.50%). In spite NIOF site recorded the least cover, it measured the maximum species diversity (3.54) due to the maximum recorded number of species (48 species); while Shalateen recorded the least diversity (1.97) due to the least number of coral species (24 species).

The highest hard coral cover *Pocillopora damicornis* (15.6%) at El Sharm El-Bahari and the highest soft coral is *Sarcophyton glaucum* (10.18%) at North Qula’an. Some environmental characteristic variations and biological interaction between benthos, the anthropogenic activities, overfishing, tourism developments, as well as petroleum and phosphate production, Sedimentation processes, bottom topography and geomorphology are the main controlling factors of coral distribution at the studied areas.

Key words: Coral assessment, diversity, community distribution, evenness index, Red Sea, Egypt.

RESUMEN (Evaluación cuantitativa de arrecifes de coral a lo largo de la costa egipcia del Mar Rojo)

Se ha estudiado la distribución de corales a lo largo de la costa egipcia del Mar Rojo desde el norte de Hurghada hasta 5 km de Shalateen, relacionándolo con los factores mas importantes que afectan la distribución y abundancia de corales en los sitios seleccionados. El porcentaje de cobertura de los corales en la comunidad de arrecifes se estimó en cada localidad mediante el uso del método estándar (transecto de interceptación). Los resultados arrojaron 68 especies de coral en siete sitios a lo largo de la costa egipcia del Mar Rojo, siendo cuarenta y nueve especies de corales duros mientras se encontraron 19 especies de corales blandos. El lugar de muestreo del Norte de Hurghada (NIOF) registró la menor cobertura de coral vivo (66,23%) mientras que el área de Abu-Dabab registró la cobertura máxima en porcentaje (91,50%). Aunque la cobertura mínima se encontró en NIOF, apareció la máxima diversidad específica (3,54) debido a la cantidad máxima registrada de especies (48 especies); mientras que Shalateen registró la menor diversidad (1,97) debido al menor número de especies de corales (24 especies).

La mayor cobertura de coral duro *Pocilloporadamicornis* (15,6%) se registró en Sharm El-Bahari y la más alta de corales blandos fue *Sarcophytonglaucum* (10,18%) en el Norte de Qula’an. Los principales factores que controlan la distribución de los corales en el área de estudio fueron, además de algunas variaciones ambientales, las interacciones bentónicas, efectos antropogénicos como la pesca excesiva, el incremento del turismo, la producción de petróleo y la liberación de fosfato, además de procesos sedimentarios, la topografía del fondo y la geomorfología.

Palabras clave: distribución de corales, diversidad, distribución de la comunidad, índice de uniformidad, Mar Rojo, Egipto.
INTRODUCTION

The Red Sea is still one of the most important areas that contains beautiful coral communities and are widespread throughout the tropical Indo-Pacific area. The abundance and the ecology of the hard and soft corals have been studied by many authors in the Red Sea and the Indo-Pacific regions (Cray, 1931 and Crossland, 1938) and in the central Great Barrier Reef (Diensten, 1983; Dai, 1990 and Fabricius, 1997). Moreover, the coral distribution in some localities of the Red Sea have been studied generally referring to the community structure of coral reefs (Ammar & Nawar, 1998; Ammar, 2003 and 2004), ecology and biology (Loya, 1972; Kotb, 1996; Kotb et al., 2001; Mohammed, 2003 and 2006), the interaction of many factors that affecting the distribution and affect the coral bleaching (Mohammed and Mohamed, 2005), the affecting factors as sedimentation, overfishing, tourist activities, as well as petroleum and phosphate production (Mohammed et al., 2009), geographical relationship and geomorphological observations of coral reefs at the northern Red Sea (Scheer, 1971) and the basis of topographical characteristics of the reef (Loya, 1972). However, all of these factors had significant influencing on the distribution of corals among coral reefs at the studied areas. On the other hand, the biology and ecology of soft corals have been shown by Gohar (1940), Fishelson (1970 & 1973) Benayahu and Loya (1981) and Merganer & Schumacher (1981).
Mohammed (2006) and Mohammed et al. (2009) concluded that, many factors could affect the distribution of coral reefs and their structure and abundance such as the biological interaction between the benthos fauna, the bottom topography and geomorphology (Adjeroud et al., 2000; Kotb et al., 2001; Ouillon et al., 2004; Andréfouët and Guzman, 2005) as well as the physical factors and anthropogenic activities (Ammar and Nawar, 1998 and Mohammed, 2003). These activities include phosphate shipping smoothers and navigation activities, landfill and dredging, mining operations and overfishing (Daby 2003). These areas are controlled by; water depth, temperature variation (Rogers, 1990), tidal range and the degree of exposing, salinity and water mixing (Babcock and Davies, 1991), light penetration, geographic occurrence, the geomorphologic nature (Kotb, 2001; Abou Zaid and Kotb, 2000) and bottom sediment nature, turbidity and terrestrial inputs.

The present work aims to evaluate, assess quantitatively and compare the corals distribution, diversity and abundance along the Egyptian Red Sea Coast during January 2009 to February 2010. However the study will illustrate the different ecological factors that affect the coral diversity and richness as well as to explore the human threats on coral communities at each site.

MATERIALS AND METHODS

Area of study

During the present investigation seven sites were selected northern Red Sea along the Egyptian coast to evaluate and calculate the coral community, diversity and abundance referring to the most important factors affecting the coral diversity and distribution (Figure 1). These sites are highly influenced by different factors and activities; such as phosphate shipment at Safaga and El-El-Hmrawin; overfishing at Shalateen; touristic activities (diving and snorkeling) at NIOF, Sharm El-Naq, El-Sharm El-Bahari and Abu-Dabab; coastal leveling and landfiling at NIOF; the effect of an active valley at Qula’an and. The features and characteristics of the selected stations, as well as the oceanographic parameters were listed in table (1). The program of samples collection is based on the NIOF field trips, starting in the June 2009 and ended March 2010, covering seven different distributed areas located at the Egyptian coast of Red Sea.

Methods

Studied sites were surveyed using the line intercept transect (LIT) methods (English et al., 1997) 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 neighbor 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 24 transects were surveyed from all of the studied sites, where the percentage cover and number of soft and hard corals were estimated. Also, the living corals (soft, hard) and dead corals were calculated. The percentage covers of other taxa including algae, sponges, gorgonians, sea anemones and sand with rocks were also estimated. The coral samples were brought to the laboratory for identification. They were preserved in 4% formalin in seawater, rinsed in fresh water after 24 h, and then transferred to 70% ethyl alcohol. Sclerites or spicules (endoskeleton) were obtained by dissolving soft coral tissues in 10% sodium hypochlorite. The soft corals (Alcyonacea) were identified according to Macfadyen (1929), Thomson & Dean (1931), Verseveldt (1982), and Fabricius & Alderslade (2001). Moreover, the hard corals

![Figure 2: The species number of corals at the investigated sites.](image1)

![Figure 3: The percentage covers of the hard and soft corals at the investigated sites.](image2)
were identified according to Sheppard & Sheppard (1991) and Veron (2000).

The percentage cover was calculated from the following formula:

\[
\text{Percentage cover} = \frac{\text{Intercept length}}{\text{Transect length}} \times 100
\]

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).

\[
\text{Hs} = - \sum_{i=1}^{s} \frac{P_i}{s} \ln \frac{P_i}{s}
\]

where, \( s \) = Total species, \( i \) = Each species

\[
P_i = \frac{\text{Number of colonies species (i)}}{\text{Number of total colonies}}
\]

ii) Pielou’s evenness index (J).

\[
J = \frac{\text{H}}{\ln s}
\]

where, \( s \) = number of species.

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

RESULTS

Coral distribution along the coastal area:

During the present study a total of 68 coral species belonging to 35 genera were surveyed during the present investigation where, 49 species of them were hard corals (belonging to 23 hard coral genera) and 19 species (belonging to 12 genera) were soft corals (Table 2) in addition to the other species that observed and not intercepted in the line transects. Hurghada site recorded the highest number of Species (48 species), while the lowest number (24 species) was recorded at Shl ateen (Figure 2). So, Hurghada illustrated the highest diversity than any other studied sites. The highest percentage cover of the hard corals has been recorded at El Sharm El-Bahari and reached about 80.25% whereas; the lowest percentage cover has been recorded at Hurghada in front of the NIOF Red Sea Branch (Marine Biological Station, MBS) with 45.87 %. On the other hand, El Sharm El-Bahari recorded the least cover of the soft corals (0.27%) and the highest value was recorded at North Quła’an (24.84%). The dead corals ranged between 2.59% at El Sharm El-Bahari and 13.09% at NIOF (Figure 3).

*Pocillopora demicornis* and *Stylophora pistillata* recorded the highest percentage cover of the hard coral species (15.60 at El Sharm El-Bahari and 13.28 at Shl ateen respectively); moreover, *Sarcophyton glaucum* and *S. leptoclados* recorded the highest soft coral species (10.18 and 6.67%) at North Quła’an and Sharm El-Naqa respectively (see table 2). Moreover, *Acropora*, *Favites*, *Favia*, *Millipora*, *Porites*, *Pocillopora* and *Stylophora* are the most frequent and common hard coral genera; while, *Nephthea*, *Sarcophyton*, *S. leptoclados* and *Xenia* are common and abundant soft coral genera.

Community structure and biodiversity of corals:

During the present investigation, the coral community recorded its highest cover of living corals (91.5%) at Abu-Dabab locality followed by North Quła’an, Sharm El-Naqa and El Sharm El-Bahari (85.06%, 83.20% and 80.52% respectively). While the lowest cover was demonstrated at NIOF (66.23%), which recorded the highest percent of dead corals (13.09%), while El Sharm El-Bahari has the lowest percent of dead corals and reached about 2.59% (Table 3 and figure 3). On the other hand, El Sharm El-Bahari recorded the highest
value of hard coral cover (80.25%) and the least soft corals (0.27%). But NIOF recorded the least hard corals (45.87%), while North Qula’an had the maximum soft coral cover that reached 24.84% (Table 3 & figure 4). NIOF and Shlateen sites recorded a high diversity of living organisms (11% and 22.48%) that associated with coral communities.

NIOF area recorded the highest species number and diversity (48 species and 3.54) followed by Abu-Dabab which recorded 35 coral species and its diversity reached 2.84 followed by North Qula’an (34 species and the diversity was 2.54. while Shlateen demonstrated the least diversity (1.97) and the recorded number of species was decreased to 24 (Table 4 and figure 5). On the other hand, the evenness index is the maximum vale at NIOF (0.9) and is related to coral diversity while the minimum value was detected at Shlateen and reached about 0.62.

Acropora humilis, Favites sp., Favia favus, Porites solida, Pocillopora sp. and Stylophora pistillata are the most frequent and repetitive hard species along the studied sites; while, Sarcophyton sp and Sinularia sp. are the most common soft corals.

Data analysis:

On the other hand, one way ANOVA illustrated that, there are no significant differences between the different sites and their diversity and evenness index (Table 5). Whenever, the cluster analysis illustrated that, there are two clusters, the first concerned with the number of species at the studied sites. This cluster (Figure 6) pointed out the similarity among El-Hmrawin, El Sharm El-Bahari, Sharm El-Naqa and Shlateen as they have an equal or sub-equal numbers. Another similarity between Abu-Dabab and North Qula’an; while NIOF has

<table>
<thead>
<tr>
<th>Site</th>
<th>Latitudes</th>
<th>Longitudes</th>
<th>Depth</th>
<th>Temperature</th>
<th>Salinity</th>
<th>pH</th>
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<td>NIOF</td>
<td>27° 17’ 13” N</td>
<td>33° 46’ 43” E</td>
<td>3</td>
<td>29.32</td>
<td>41.7</td>
<td>7.89</td>
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<tr>
<td>Sharm El-Naqa</td>
<td>26° 53’ 39” N</td>
<td>33° 58’ 22” E</td>
<td>8</td>
<td>27.34</td>
<td>40.54</td>
<td>8.14</td>
</tr>
<tr>
<td>El-Hmrawin</td>
<td>26° 15’ 15” N</td>
<td>34° 12’ 10” E</td>
<td>4.5</td>
<td>27.11</td>
<td>40.24</td>
<td>8.09</td>
</tr>
<tr>
<td>El Sharm El-Bahari</td>
<td>25° 52’ 04” N</td>
<td>34° 24’ 57” E</td>
<td>6</td>
<td>31.54</td>
<td>40.74</td>
<td>8.3</td>
</tr>
<tr>
<td>Abu-Dabab</td>
<td>25° 20’ 19” N</td>
<td>34° 44’ 26” E</td>
<td>8</td>
<td>26.57</td>
<td>40.53</td>
<td>8.14</td>
</tr>
<tr>
<td>North Qula’an</td>
<td>24° 21’ 35” N</td>
<td>35° 17’ 47” E</td>
<td>5</td>
<td>32.84</td>
<td>41.23</td>
<td>8.3</td>
</tr>
<tr>
<td>Shlateen</td>
<td>23° 09’ 10” N</td>
<td>35° 36’ 58” E</td>
<td>4</td>
<td>30.26</td>
<td>41.12</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Table 1: The latitude, longitude and the some oceanographic parameters at the studied sites.

Dendrogram using Average Linkage (Between Groups)

Figure 6: Growth of Heterosigma akashiwo exposed to various fractions of Skeletonema costatum filtrate fractionated by solid-phase extraction and to corresponding negative controls (modified SWM-3).
Table 2:  
The percentage cover of coral species at the studied sites.

<table>
<thead>
<tr>
<th>Specis</th>
<th>NI OF</th>
<th>Sharm El-Naqi</th>
<th>Sharm El-Hmrawin</th>
<th>El-Sharm El-Bahari</th>
<th>Abu-Dabab</th>
<th>North Qu'lan</th>
<th>Shlateen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acropora humilis</td>
<td>2.35</td>
<td>3.5</td>
<td>6.85</td>
<td>7.78</td>
<td>8.65</td>
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<td>A. squarrosa</td>
<td>0.33</td>
<td>0</td>
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<td>1.80</td>
<td>3.15</td>
<td>3.57</td>
<td>0</td>
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<td>A. hemipranchi</td>
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<td>2.2</td>
<td>2.25</td>
<td>1.35</td>
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<td>2.66</td>
<td>3.61</td>
</tr>
<tr>
<td>A. pharaonis</td>
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<td>2.5</td>
<td>6.4</td>
<td>1.43</td>
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<td>A. cytherea</td>
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<td>3.5</td>
<td>2.85</td>
<td>2.58</td>
<td>0.00</td>
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<td>A. digitifera</td>
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<td>1.55</td>
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<tr>
<td>A. grandulosa</td>
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<td>0.76</td>
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<td>Acropora sp.</td>
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<td>0</td>
<td>1.33</td>
<td>2.10</td>
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<td>Echinopora fruticolosa</td>
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<td>4.2</td>
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<td>0.00</td>
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<td>3.21</td>
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<tr>
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<td>0</td>
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<td>3.45</td>
<td>2.84</td>
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<td>0.00</td>
<td>2.55</td>
<td>3.15</td>
<td>5.15</td>
<td>4.64</td>
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<td>0.00</td>
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<tr>
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<td>0</td>
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<td>0.51</td>
<td>0.00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Stylophora pistillata</td>
<td>8.18</td>
<td>4.2</td>
<td>1.35</td>
<td>1.18</td>
<td>3.35</td>
<td>4.98</td>
<td>13.28</td>
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<tr>
<td>Stylophora wellsi</td>
<td>0.62</td>
<td>0.00</td>
<td>0.00</td>
<td>1.35</td>
<td>1.21</td>
<td>3.21</td>
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<tr>
<td>Seriatopora hisrix</td>
<td>1.21</td>
<td>0.00</td>
<td>0.00</td>
<td>0.22</td>
<td>2.05</td>
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<td>0</td>
</tr>
<tr>
<td>Siderastrea savignyana</td>
<td>0.00</td>
<td>0</td>
<td>0.14</td>
<td>0.13</td>
<td>1.88</td>
<td>0.00</td>
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<td>Turbinaria mesenterina</td>
<td>0.17</td>
<td>2.1</td>
<td>0.00</td>
<td>0.00</td>
<td>2.94</td>
<td>0.00</td>
<td>0</td>
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<tr>
<td>Cosenaria</td>
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<td>0</td>
<td>1.22</td>
<td>2.25</td>
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<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Cycloseris sp</td>
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<td>2.2</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Cycloseris marginata</td>
<td>0.23</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.89</td>
<td>1.44</td>
<td>0</td>
</tr>
<tr>
<td>Cenactis echinata</td>
<td>0.38</td>
<td>2.83</td>
<td>0.25</td>
<td>0.00</td>
<td>0.33</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>Fungia fungites</td>
<td>0.55</td>
<td>0.12</td>
<td>0.00</td>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
<td>1.85</td>
</tr>
</tbody>
</table>
a significant difference due to higher recorded number of diverse species. The second cluster is representing the species diversity and evenness index at the surveyed sites which haven’t significant differences.

**DISCUSSION**

The Red Sea is biogeographically divisible into Northern, Central and Southern regions, where the central has the greatest concentration of coral reefs and the highest diversity of hard corals (Sheppard et al., 1992 and Veron 1995). Shlakeen area is affected by a high density of over-fishing processes and the reject water of the desalination plant that present in the area. These factors are leading to increase the turbidity and settlement of sediment on the coral communities which causes the over growth of macroalgae on corals and overgrowth of many sponge species in the area. So, the species diversity decreased (1.97) in the area and percentage cover decreased to 70.99%. On the other hand, the NIOF site is not affected by sedimentation processes resulted from the previous landfilling processes north Hurghada and the interaction between many factors as temperature and direct exposure to sun light (Mohammed and Mohamed, 2005). These reasons are the main factors affect the coral cover causing their decrease to about 66.23%, while the species diversity was the maximum values and recorded 3.54 compared to Shlakeen which recorded 1.97. This may be attributed to many factors affecting these areas, such as landfilling and sedimentation processes (at NIOF) and overfishing processes and sedimentation due to turbidity resulting by the reject water of the desalination plant (at Shlakeen). This is in agreement with Rogers (1990); Mergner et al. (1992); Ammar and Nawar (1998); Mohammed (2003); Thomas et al. (2003). Mohammed and Mohamed (2005) were illustrated that the high sedimentation and turbidity rates in the sheltered areas of the northern Red Sea increases the particulate sediment over and around the coral communities, subsequently the coral distribution and biodiversity are degraded.

<table>
<thead>
<tr>
<th>Specie</th>
<th>NIOF</th>
<th>Sharm El-Naga</th>
<th>El-Hmrarwin</th>
<th>El Sharm El-Bahari</th>
<th>Abu-Dabab</th>
<th>North Qula’an</th>
<th>Shlakeen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcyonium sp</td>
<td>1.50</td>
<td>0.08</td>
<td>0</td>
<td>0</td>
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<td>0.00</td>
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<tr>
<td>Heteroxenia fuscescens</td>
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<td>2.75</td>
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<td>0.00</td>
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<td>Lobophytum pauciflorum</td>
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<td>Nephthea gracilima minor</td>
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<td>0.00</td>
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<td>0</td>
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<tr>
<td>Nephthea mollii</td>
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<td>0</td>
<td>0</td>
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<td>Nephthea sp</td>
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<td>0.9</td>
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<td>1.5</td>
<td>0.11</td>
<td>0</td>
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<tr>
<td>Sarcophyton glaucum</td>
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<td>0.75</td>
<td>0.16</td>
<td>0.00</td>
<td>10.18</td>
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<td>0</td>
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<tr>
<td>Sarcophyton spongiosum</td>
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<td>0</td>
<td>0.00</td>
<td>2.88</td>
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<td>0</td>
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<td>Sarcophyton sp.</td>
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<td>0.00</td>
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<tr>
<td>Sinularia polysdactyla</td>
<td>3.34</td>
<td>0.95</td>
<td>0.00</td>
<td>3.49</td>
<td>2.13</td>
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<tr>
<td>Sinularia leptolados</td>
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<td>6.67</td>
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<td>1.02</td>
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<td>Sinularia gardineiri</td>
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<td>Tubipora musica</td>
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<td>Xenia macrscopicula</td>
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<td>0.00</td>
<td>0.65</td>
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<td>Anthella simplex</td>
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<td>Paralemnalia thyroides</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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<td>Capenella fungiformis</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>0.90</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dead corals</td>
<td>13.09</td>
<td>8.35</td>
<td>6.75</td>
<td>2.59</td>
<td>6.10</td>
<td>7.08</td>
<td>5.13</td>
</tr>
<tr>
<td>Rocky bottom</td>
<td>0.33</td>
<td>2.11</td>
<td>11.69</td>
<td>4.38</td>
<td>0.87</td>
<td>1.25</td>
<td>0.18</td>
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<tr>
<td>Sandy bottom</td>
<td>9.35</td>
<td>2.55</td>
<td>0.94</td>
<td>6.88</td>
<td>0.18</td>
<td>0.88</td>
<td>1.22</td>
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<td>Echinodermis</td>
<td>2.31</td>
<td>0.12</td>
<td>1.6</td>
<td>1.12</td>
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<td>0.00</td>
<td>0.19</td>
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<td>Algae</td>
<td>7.54</td>
<td>0.74</td>
<td>1.23</td>
<td>1.25</td>
<td>0.00</td>
<td>0.00</td>
<td>7.49</td>
</tr>
<tr>
<td>Tridacna</td>
<td>0.11</td>
<td>2.35</td>
<td>2.25</td>
<td>3.26</td>
<td>1.35</td>
<td>2.75</td>
<td>0.22</td>
</tr>
<tr>
<td>Sponge</td>
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<td>0</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>14.58</td>
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<td>Black Sponge</td>
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<td>0.58</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>2.98</td>
</tr>
</tbody>
</table>

Continue of Table 2:

*The percentage cover of coral species at the studied sites.*
On the other hand, Abu Dabab area recorded the maximum coral cover (91.50%) as it is managed by environmental protectorate affairs agency which mainly act to protect the marine environment and coral communities, where its diversity reached to 2.84. Sharm El-Naqa and Sharm El-Bahri recorded a sub-equal values of coral cover (83.20% and 80.52% respectively), where they are relatively affected by tourist activities that may slightly affect the species diversity and reached to 2.92 (at Sharm El-Naqa) and 3.03 (at Sharm El-Bahri), where Mohammed et al. (2009) illustrated that, the tourist activities and anthropogenic impacts affect the coral distribution, diversity and coverage percent.

El-Hamrawin area is affected by phosphate harbor, mining processes and overfishing processes that may affect the coral cover and species diversity where the living corals covered about 75.54% of the area and their diversity reached 2.68. This is in agreement with Mohammed (2003), Ammar (2004), Mohammed (2006) and Mohammed et al., (2009); where, they illustrated that these activities are completely destroyed the benthic communities in the shallower areas. North Qula’an area is away from the coastal human affects but lies under the effect of the direct floods from the active valleys. In spite of this factor, but the coral cover reached to 85.06% and its diversity is 2.54. This site is protected by a dense area

Table 3: The percentage cover of different taxa at the studied sites.

<table>
<thead>
<tr>
<th>Taxa</th>
<th>NIOF</th>
<th>Sharm El-Naqa</th>
<th>El-Hamrawin</th>
<th>El-Sharm El-Bahri</th>
<th>North Qula’an</th>
<th>Abu-Dabab</th>
<th>Shlakeen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard corals</td>
<td>45.87</td>
<td>66.85</td>
<td>67.14</td>
<td>80.25</td>
<td>60.22</td>
<td>79.55</td>
<td>69.21</td>
</tr>
<tr>
<td>Soft corals</td>
<td>20.36</td>
<td>16.35</td>
<td>8.40</td>
<td>0.27</td>
<td>24.84</td>
<td>11.95</td>
<td>1.78</td>
</tr>
<tr>
<td>Dead corals</td>
<td>13.09</td>
<td>8.35</td>
<td>6.75</td>
<td>2.59</td>
<td>7.08</td>
<td>6.10</td>
<td>5.13</td>
</tr>
<tr>
<td>Sand and rocky bottom</td>
<td>9.68</td>
<td>4.66</td>
<td>12.63</td>
<td>11.26</td>
<td>2.13</td>
<td>1.05</td>
<td>1.40</td>
</tr>
<tr>
<td>Other living things</td>
<td>11.00</td>
<td>3.79</td>
<td>5.08</td>
<td>5.63</td>
<td>5.73</td>
<td>1.35</td>
<td>22.48</td>
</tr>
</tbody>
</table>

Table 4: Summery of the statistical analysis of the surveyed communities at the different stations.

<table>
<thead>
<tr>
<th>Station</th>
<th>NIOF</th>
<th>Sharm El-Naqa</th>
<th>El-Hamrawin</th>
<th>El-Sharm El-Bahri</th>
<th>North Qula’an</th>
<th>Abu-Dabab</th>
<th>Shlakeen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity</td>
<td>3.54</td>
<td>2.92</td>
<td>2.68</td>
<td>3.03</td>
<td>2.54</td>
<td>2.84</td>
<td>1.97</td>
</tr>
<tr>
<td>Evenness</td>
<td>0.9</td>
<td>0.89</td>
<td>0.81</td>
<td>0.92</td>
<td>0.72</td>
<td>0.68</td>
<td>0.62</td>
</tr>
<tr>
<td>colony no.</td>
<td>124</td>
<td>105</td>
<td>97</td>
<td>119</td>
<td>96</td>
<td>86</td>
<td>53</td>
</tr>
<tr>
<td>sp. No.</td>
<td>48</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>34</td>
<td>35</td>
<td>24</td>
</tr>
<tr>
<td>Hard coral species</td>
<td>31</td>
<td>22</td>
<td>19</td>
<td>25</td>
<td>26</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>Soft coral species</td>
<td>17</td>
<td>5.00</td>
<td>8.00</td>
<td>2.00</td>
<td>8.00</td>
<td>7.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 5: One way ANOVA of the coral diversity of the studied sites.

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>148.691</td>
<td>6</td>
<td>24.782</td>
<td>0.078</td>
<td>0.998</td>
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<tr>
<td>Within Groups</td>
<td>4452.996</td>
<td>14</td>
<td>318.071</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>4601.687</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
of mangrove plant which protects the coral communities from the flood water of the valley.

The difference among the studied sites may be affected by many other natural factors as the difference in the geographic distribution as well as bottom topography (Kotb et al., 2001; Ouillon et al., 2004) and geomorphology of the sites (Bak, 1975; Adjeroud et al., 2000; Andrefouët and Guzman, 2005) and the interaction between physical and biological factor (Mohammed, 2006) that influenced the distribution, zonation and diversity of corals, as well as the interaction between physical and biological factors influences the identity, distribution and abundance of coral species and macro-benthic organisms in the area; moreover, longitudes and latitudes may be another factor affect the coral distribution and diversity. Finally, the differences in coral diversity and evenness index between the different localities can be attributed to the interactions between the environmental conditions in the different sites such as surface temperature, salinity, dissolved oxygen and turbidity (Sheppard et al., 1992), where the temperature is ranging between 27°C -29°C at different sites and lies in the range 26°C -32°C pointed out by Klein et al. (1997). There are no significance differences between the diversity in the different sites using ANOVA test.

CONCLUSION

1. Anthropogenic activities (landfilling and over-fishing) are responsible for decreasing the coral community’s distribution, diversity and number of species at most localities as NIOF and Slateen.
2. The bottom topography, geomorphology, geographic distribution, longitudes and latitudes are major factors controlling the coral distribution and differences in diversity of species and their numbers.
3. Competition as well as complex interaction between biotic and abiotic factors are another factors influencing the corals distribution and diversity.
4. Acropora humilis, Favites sp., Favia favus, Porites solida, Pocillopora sp., Stylphora pistillata, Sarcophyton sp and Sinularia sp. are the most common and frequent coral species along the Red Sea Coast.

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