Benthic community associated with coral reefs in the coastal area of Gulf of Aqaba, Red Ses, Egypt

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ABSTRACT

Benthic community associated with coral reefs was investigated at four sites along the coastline of Gulf of Aqaba, Red Sea Egypt. The four sites (Taba, Nuweiba, Dahab and Sharm El-Sheikh) are important popular spots for recreational activities and the reefs of these sites are of fringing type. *Drupella cornus* and *Trochus maculatus* were the most important gastropods associated with coral reefs. Taba and Sharm El-Sheikh showed high occurrence of worm shells (Gastropoda) *Dendropoma maximum* (up to 30 individuals / colony). Concerning the abundance of bivalves (Mollusca), Taba showed greater abundance of *Spondylus varium* and *Pteria penguin*, whereas Sharm El-Sheikh had the greatest abundance of *Tridacna maxima* (up to 40 individuals/10m). The studied sites exhibited high density of Echinoderms, particularly the sea urchins *Diadema setosum*, *Tripneustes gratilla* and *Heterocentrotus mammillatus*. The study revealed selective associations between mollusc species and coral growth forms. The bivalve *Pteria penguin* was found to be attached with plate-like coral *Mellipora platyphylla* and the branching coral *Millepora dichotoma*. The vermetid gastropod *Dendropoma maximum* was also found to be inserted into the Melliporid coral colonies. Aggregates of *Drupella cornus* were observed attached with branching corals, especially *Acropora* spp. and *Stylophora* spp. In contrast to the *Drupella cornus*, the corallivore gastropod *Coralliphila neritoidea* and the bivalve *Tridacna maxima* were predominantly preying on the massive corals of *Porites* spp. The distribution of coral growth forms was compared. In general, massive, branched and plate-like colonies were the dominant growth forms of corals in the area of study. Massive colonies were dominant in the reef flat area, reef margin and the deep parts of the outer reef slope. Branching coral colonies were flourishing on the fringing reef flat, the barrier reef flat and the outer reef slope until 10m depth (upper layers of outer reef slope), their importance declined with depth. All plate-like coral colonies in the area of study belong to Hydrocorals (Milleporidae); *Millepora platyphyla*. They are abundant in the reef edge and upper zone of outer reef slope (the reef zone exposed to high wave action). The considerable abundance of macroalgae in the coral communities of the sampling sites were probably resulting from increased levels of nutrients caused by enhanced terrestrial runoff of sewage and sediments concomitant with increased human pressure in the area and coastal development for tourism expansion. The present study attracts the attention to the problem that the benthic community undergoes adverse influences of enhanced human pressure concomitant with growth of coastal cities and intensive constructions for tourism development in the Gulf of Aqaba. This is indicated by increased boring organisms, coral bioeroders and abundance of macroalgae.

Keywords: Benthos, coral reefs, Gulf of Aqaba, Red Sea, Egypt

INTRODUCTION

The Gulf of Aqaba is one of the unique ecosystems with highly diversified marine life including coral reefs and associated organisms. Geographically Gulf of Aqaba marks the northernmost outpost of the Indian Ocean. The coral reef system of the Gulf of Aqaba supports an exceptional biodiversity and particularly vulnerable to the effects of pollution due to its low rate of water exchange with the main body of the Red Sea (Fishelson, 1995). The contrast provided by the biodiversity of the coral reefs in the Gulf of Aqaba and the adjacent desert is a unique attribute valued by tourists visiting the Gulf. About one-third of the visitors to the Gulf participate in water sports, including snorkeling and SCUBA diving, which both depend on and impact the state of the reefs (Hawkins and Roberts, 1994).

A coral reef constitutes probably the most complex community of the marine environment. It is actually an association of several thousand species of different kinds of animals which occupy various ecological niches. Corals constitute the basic framework and substrate for many other organisms which penetrate the skeletal mass (sponges, algae, polychaetes, sipunculides, bivalves and gastropods). Coral also provide shelter for many fishes as well as various species of polychaetes, crustaceans, molluscs and echinoderms.

Benthos is important in the ecosystem because they comprise a wide variety of species mainly polychaete worms, Mollusca, Echinoderms, crustaceans and macroalgae. They provide food source for many species of commercially exploited fish and crustaceans and for many species of seabirds. Molluscs are the main category of benthic community at the intertidal zone of the Red Sea. A total of 950-1000 species of marine shells are living in the Red Sea, only 637 species are recorded from the Gulf of Aqaba. The molluscan fauna of the Red Sea is entirely of Indo-Pacific origin, with estimation of less than 5% that are endemic. The rapid growth of coastal cities and associated human activities for tourism development create multiple stresses on the benthic community in the Gulf of Aqaba.

The present study aimed to examine the benthic community associated with coral reefs at four coastal sites in the Egyptian side of the Gulf of Aqaba. So, the future changes in community structure due to natural and anthropogenic influences can be monitored through further studies. The study investigates also the relationships between mollusc species and coral growth forms.

MATERIALS AND METHODS

Four reef sites distributed along the Egyptian coast of Gulf of Aqaba were selected including Taba, Nuweiba, Dahab and Sharm El-Sheikh (Fig. 1) for the study of benthic organisms associated with the coral reefs during 2006/2007. The reefs of the study sites are of fringing type with, scleractinian corals as the most important hermatypic organisms.

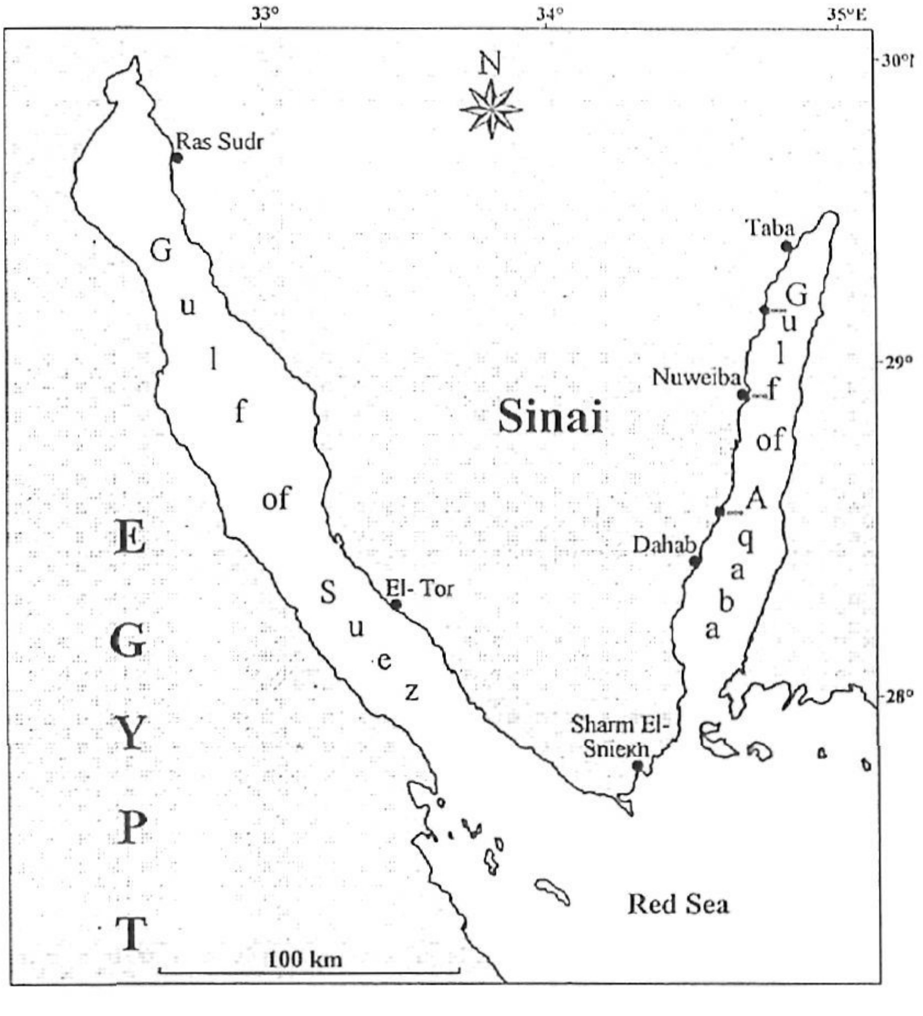

Fig. 1. Map of the Gulf of Aqaba showing the sampling localities.

The benthic communities were sampled using Line transect method (Loya, 1978). Four line transects of 10-m length were surveyed at each site and run underwater parallel to the shoreline using SCUBA diving. All benthic organisms under the line transect were recorded and identified to species or generic levels. The coral growth forms were also recorded as encrusting, branching, submassive, massive, digitate, tabulate, foliaceous, and plate-like. Whenever confronted with the identification of a certain species, a colour photograph was taken by underwater camera and a sample was collected underwater and placed in a plastic bag carrying an identification number for further identification in the laboratory. The percentage living covers of total hard corals and the different coral growth forms were calculated. The intersected length of any coral species underlying the line is recorded to the nearest centimeter.

Percentage cover = total length of coral tissue intersected on the transect / total transect length) x 100

At each sampling site the quantitative survey of the macro-benthic communities in the upper layer of reef sediment was performed by using Van Veen grab sampler (equivalent to 0.1 m^2). The collected samples were washed through a sieve with mesh size 1 mm and the residue was preserved with 5-10 % formalin solution.

RESULTS AND DISCUSSION

Benthic community composition:

In the area of study, several species of corals are found together with their symbiotic partners such as fishes, gastropods, bivalves, echinoderms, crustaceans...etc. The abundance of benthic organisms encountered during this survey is shown in Table 1.

A total of 33 invertebrate species representing 25 species of Mollusca (18 Gastropoda, 6 Bivalvia and 1 Polyplcophora), 5 species of Echinodermata, 2 species of Cirripedia (Crustacea) and 1 species of Bryozoa were recorded during sampling of this study. 21 species and genera of marine algae were also recorded in the present study including 4 species and 2 genera of green algae, 9 species of brown algae, and 3 species and 3 genera of red algae (Table 1).

Gastropods represented 54.55% of the total invertebrate species, whereas *Trochus maculates,Tectus dentatus*, *Drupella cornus* and the worm shell *Dendropoma Maximum* were the most common species associated with coral reefs in the area of study (Table 1). Taba and Sharm El-Sheikh (Ras umm Sidd) supported the higher density of *Dendropoma Maximum*, which was inserted into coral colonies and coral rocks. *Tectus dentatus* and *Drupella cornus* were most abundant at Sharm El-Sheikh, while higher abundance of *Coralliphila neritoidea* was reported at Taba. Antonius and Riegl (1997) reported high density of *Drupella cornus* (up to 100 individuals/scan) at Sharm El-Sheikh (Ras umm Sidd) and correlated the high abundance of *Drupella cornus* with the outbreak of coral diseases (mostly White Syndrome). The greatest abundance of *Planaxis sulcatus* and *Drupa ricinus* were registered at Dahab and Nuweiba, respectively (Table 1). Nuweiba was characterized by the moderate occurrence of *Clanculus pharaonis*.

Table 1. Abundance of benthic organisms associated with coral reefs in the studied locations during 2006/2007.

Species	Taba	Nuweiba	Dahab	Sharm El-Sheikh
Algae:				
A) Green algae				
1) *Codium* sp.	-	+	+++	-
2) *Dictyota* sp.	-	++	+	-
3) *Halimeda tuna*	+	++	+++	+
4) *Caulerpa racemosa*	-	++	++	-
5) *Caulerpa serrulata*	+	++	++	-
6) *Cladopdropsis zolingerie*	-	+	++	+++
B) Brown algae				
1) *Padina pavonica*	+++	++	+	++
2) *Cystoseira barbata*	+	-	+	+
3) *Cystoseira myrica*	-	+	+	+
4) *Saragassum dentifolium*	-	+++	+++	-
5) *Saragassum latifolium*	-	+++	++	-
6) *Colpomenia sinuosa*	+	+	+++	++
7) *Hydroclathrus clathratus*	++	+	+++	++
8) *Turbinaria elatensis*	++	+	+	+
9) *Stypopodium zonale*	-	-	++++	-
C) Red algae				
1) *Hypnea* sp.	-	+	-	+
2) *Liagera* sp.	+	+	+	+
3) *Jania* sp.	+	+	+	+
4) *Laurencia pinnatifida*	++	+	+	-
5) *Ceramium rubrum*	-	-	+	-
6) *Galaxura* sp.	++	+	+	-
Mollusca:				
A) Polyplacophora				
1) *Acanthopleura haddoni*	-	-	-	+++
B) Bivalvia				
1) *Pinctada radiata*	+	-	+	-
2) *Tridacna maxima*	++	+++	+++	++++
3) *Brachidontes variabilis*	+	+	+	++
4) *Modiolus auriculatus*	+	+	+	-
5) *Pteria penguin*	++++	-	+	+
6) *Spondylus varium*	+++	+	+	+

Table 1. Continued

Species	Taba	Nuweiba	Dahab	Sharm El-Sheikh
C) Gastropoda				
1) *Trochus maculatus*	+++	+++	+++	++
2) *Tectus dentatus*	++	++	++	+++
3) *Fusus marmoratus*	-	-	+	+
4) *Conus textile*	-	-	+	-
5) *Conus coronatus*	++	++	++	-
6) *Conus virgo*	-	+	-	-
7) *Cerithium erythraeonese*	-	-	+	-
8) *Patella caerulea*	-	-	+	-
9) *Nerita polli*	-	-	+	++
10) *Turbo radiata*	-	++	+	++
11) *Planaxis sulcatus*	-	++	+++	-
12) *Cerithium caerulum*	+	-	++	-
13) *Drupella cornus*	++	++	++	++++
14) *Drupa ricinus*	+	+++	++	-
15) *Morula granulata*	-	-	+	+
16) *Clanculus pharaonis*	-	++	-	-
17) *Coralliphila neritoidea*	+++	-	-	+
18) *Dendropoma maximum*	++++	+++	++	++++
Echinodermata:				
1) *Diadema setosum*	+++	++++	++++	+++
2) *Tripneustis gratilla*	++++	++	++	++
3) *Holothuria edulis*	-	-	+	-
4) *Heterocentrotus mammillatus*	++++	++++	+++	++
5) *Asthenosoma varium*	++	-	-	-
Crustacea:				
A) Cirripedia				
1) *Balanus* spp.	-	-	+	-
2) *Tetraclita squamosa*	-	-	-	+++
Bryozoa:				
1) *Bugula neritina*	-	-	+	-

—: Absent   + : Rare   ++ : Moderate   +++ : Frequent   ++++ : Abundant

Bivalves constituted 18.18% of the total of invertebrate species reported in the present survey. *Tridacna Maxima* (Family: Tridacniidae) was the moat abundant bivalve in the area of study (Table 1). Sharm El-Sheikh showed the greatest abundance of *Tridacna Maxima*, whereas Taba had the greatest abundance of Penguin's wings *Pteria penguin* and the oyster *Spondylus varium* that were often attached to coral colonies.

It was noted an increase in the bioindicator species *Acanthopleura haddoni* (Mollusca: Polyplacophora), *Tetraclita squamosa* (Crustacea: Cirripedia) and *Brachiodontes variabilis* (Mollusca: Bivalvia) were found in Sharm El-Sheikh (Table 1).

The echinoderms constituted 15.16% of the total invertebrate species encountered in this survey, including 5 species representing 5 important families, 4 belonging to Echinoidea (Sea Urchins): *Diadema setosum* (Family: Diadematidae), *Tripneustes gratilla* (Family: Toxopneustidae), *Heterocentrotus mammillatus* (Family: Echinometridae) and *Asthenosoma varium* (Family: Echinothuridae), and 1 belonging to Holothuroidea (Sea Cucumber): *Holothuria edulis* (Familty: Holothuriidae). *Diadema setosum*, *Tripneustes gratilla* and *Heterocentrotus mammillatus* were the dominant echinoderms in the area of study (Table 1). The sea urchin *Diadema setosum* was the main coral bioeroder (Bak, 1994). Bioerosion by urchins includes excavation and all abrasive activities including spine abrasion, which result in forming of cavities and burrows, reducing overall reef consolidation. Bioerosion also weakened the bases of large massive coral colonies, making them less resistant to storms and exposed to dislodgement and increased the susceptibility of corals to some diseases. The highest abundance of *Heterocentrotus mammillatus* was obtained at Taba and Nuweiba, while the largest abundance of *Tripneustes gratilla* was reported at Taba. The scarcity of Sea Cucumbers in the area of study (Table 1) was probably ascribed to the overexploitation of Sea Cucumbers in the last five years for food and medical purposes (Hasan, 2005).

The higher abundance of macroalgae, particularly Green and brown algae recorded at Dahab and Nuweiba (Table 1) was possibly due to increased nutrient loading and sedimentation associated with recreational activities and sewage outflows from adjacent coastal cities and recreational resorts. High nutrient levels induce the rapid growth of algae which overgrow and kill the hard corals (Wielgus *et al*., 2004). Dahab supported the greatest abundance of the brown algae *Stypopodium zonale*, *Colpomenia sinuosa* and *Hydroclathrus clathratus*, and green algae *Codium* sp.and *Halimeda tuna*, while Nuweiba supported the greater abundance of the brown alga *Saragassum latifolium*. On the other hand, Sharm El-Sheikh and Taba showed the higher abundance of the turf green alga *Cladopdropsis zolingerie* and the brown alga *Padina pavonica*, respectively (Table 1).

Coral cover and growth forms:

The percentage covers of living hard corals and coral growth forms are given in Table 2. The term coral cover refers to the amount of substrate occupied by the organism and often expressed as percent. The highest coral cover was recorded at Sharm El-Sheikh, while the lowest cover was recorded at Nuweiba. This may be partially attributed to the soft sandy bottom (loose substrate) in Nuweiba which is unfavorable for the settlement of coral larvae, preventing new recruits of corals. Coral planulae larvae are unable to settle and survive on an unconsolidated soft substrate which has been covered with loose, shifting sediments (Te, 1992).

Table 2. Percentages cover of live hard corals and coral growth forms at the sampling sites.

Species	Taba	Nuweiba	Dahab	Sharm El-Sheikh
Live coral cover (%)	37.50	28.25	39.43	40.62
Coral growth forms (%)				
1) Branching	7.55	5.64	8.61	5.25
2) Digitate	1.50	3.50	2.94	4.18
3) Submassive	4.30	2.45	1.85	4.34
4) Massive	10.25	6.75	11.35	12.55
5) Encrusting	1.75	2.56	3.50	2.40
6) Plate-like	7.91	3.20	6.40	7.76
7) Foliaceous	0.80	0.60	1.20	–
8) Tabular	3.44	3.55	3.68	4.14

Figures 2 and 3 show the percent contributions of different hard coral growth forms to the total live hard coral cover at the investigated stations and at each station. In general, massive, branching and plate-like colonies were the dominant growth forms of corals in the area of study. Massive colonies were dominant in the reef flat area, reef margin and the deep parts of the outer reef slope. They are related mainly to the genera *porites*, *Favites*, *Favia*, *Goniastrea*, *platygyra* and *Hydnophora*, *Goniopora*, *Leptoria*. Branching colonies were flourishing on the fringing reef flat, the barrier reef flat and the outer reef slope until 10m depth (upper layers of outer reef slope, where their abundance declined with depth. The hard corals *Acropora* spp., *Mellipora dichotoma*, *Pocillopora damicornis* and *Stylphora pistillata* are the common branching colonies in the Gulf of Aqaba. All plate-like coral colonies in the area of study belong to Milleporid coral *Millepora platyphyla*. It is abundant in the reef edge and upper zone of outer reef slope (the reef zone exposed to high wave action). *Millepora platyphylla* is able to withstand strong currents. Previous researches suggest that corals in exposed area can have denser skeletons and hence may be more resistant to breakage than those in more sheltered areas (Brown *et al.*, 1985).

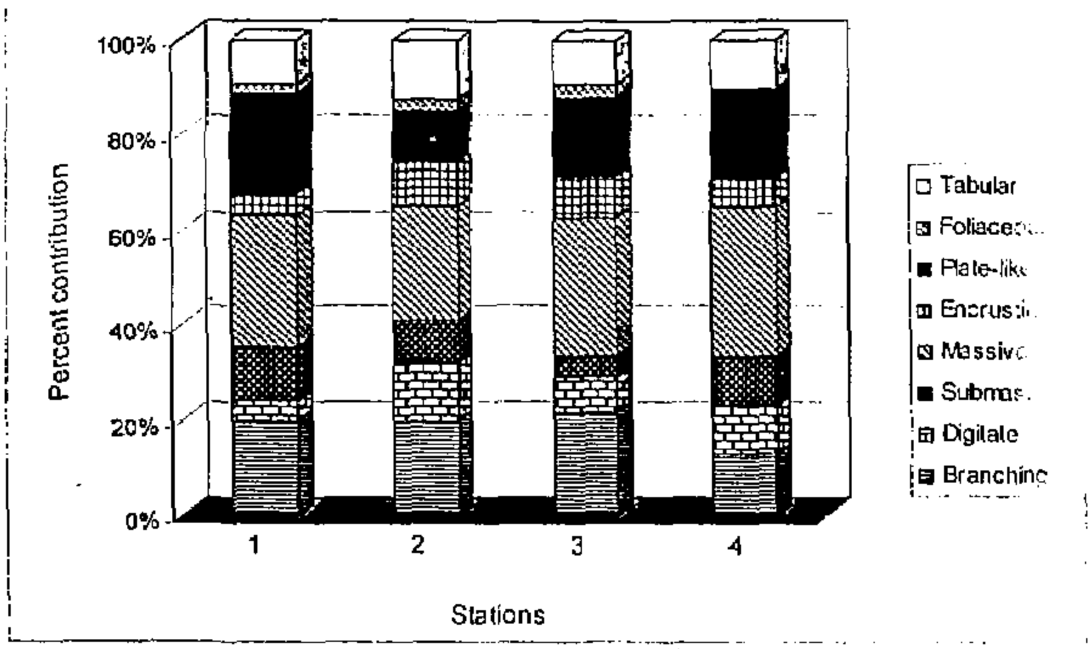

Fig. 2. Percent contributions of different hard coral growth forms to the total live hard coral cover at the investigated stations.
Stations: 1 = Taba, 2 = Nuweiba, 3 = Dahab, 4 = Sharm El-Sheikh

The possible reasons for the higher percentage of massive corals in the studied reef sites might be: 1) good illumination with high amount of light that penetrates to the coral colonies (Transparency 12-18.5m, EIMP, 2005); 2) Massive corals are robust growth forms, showing high resistance to breakage, that is the main cause of coral damage observed along the Egyptians side of the Gulf of Aqaba. 3) Massive corals, particularly the species of *Platygyra*, *Leptoria*, *Favia*, *Favites* and *Porites* displayed greater tolerance to the sedimentation and unexpected severe low tide (Fishelson, 1973; Abdel-Salam and Porter, 1988). Although the branching corals are fragile, delicate and most vulnerable to mechanical damage, they showed high percentage cover. This may be attributed to the fact that most of branching corals in the area of study belong to *Acropora* spp., *Millepora dichotoma*, *Pocillopora damicornis* and *Stylophora pistillata*, where these corals have generally high growth rates, often regenerate rapidly after fragmentation (i.e. "r" strategy) and are swift colonizers of bare substrate (Endean, 1976; Pearson, 1981).

Relationship between coral growth forms and molluscs:

It was observed that some of mollusc species (gastropods and bivalves) preferred to associate with certain coral growth forms. At Taba, it was found that *Coralliphila neritoidea* (gastropod) attached to the massive coral *Porites lutea* (Al-Moghrabi, 1997; Abou Zeid *et al.* 1999), while the bivalve *Spondylus varium* was incorporated with most of massive coral growth forms.

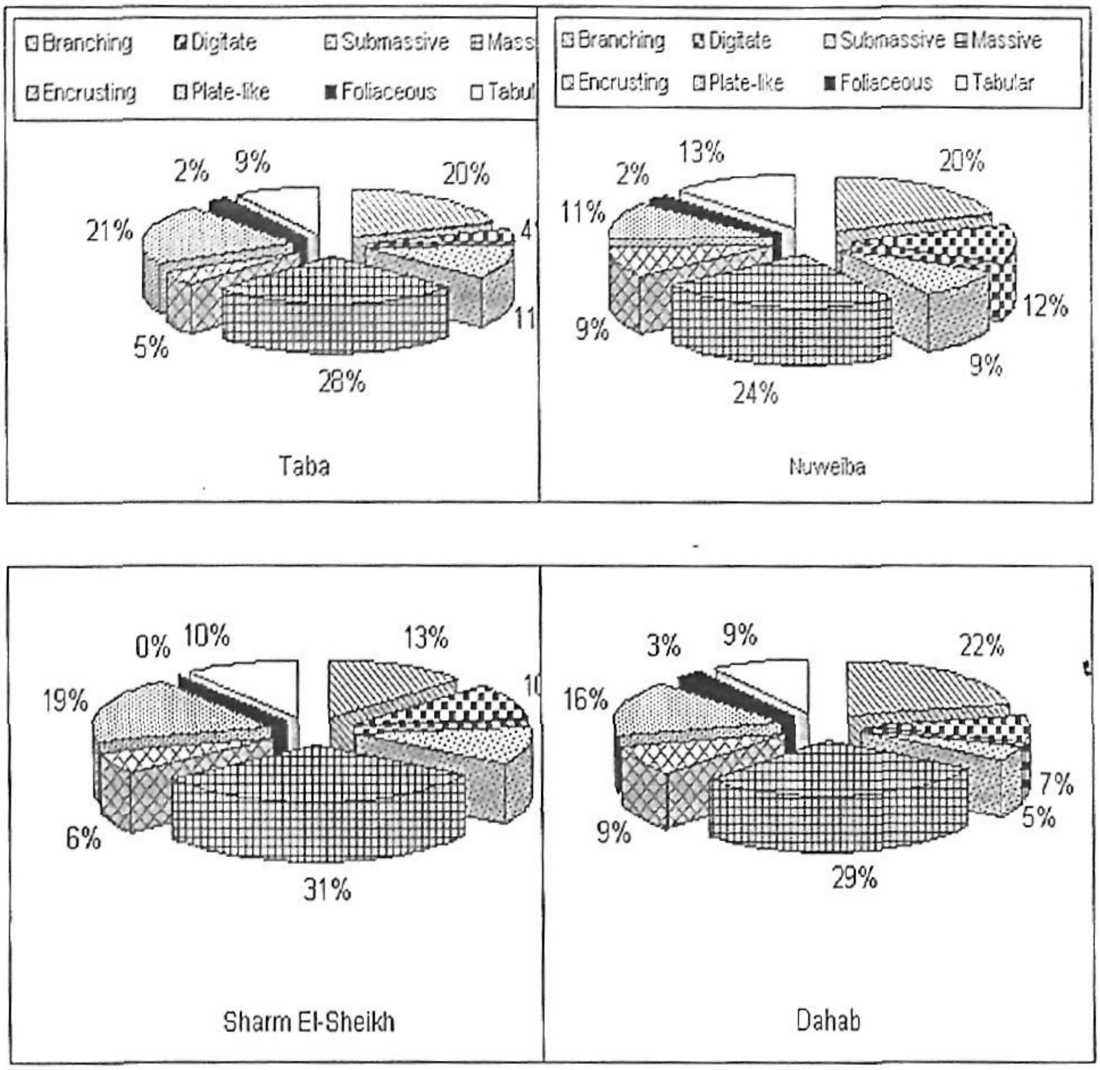

Fig. 3. Percent contributions of different hard coral growth forms to the total live hard coral cover at each investigated stations.

On the other hand, the bivalve *Pteria penguin* (Penguin's wings) was found to be attached to the plate-like Hydrocoral: *Mellipora platyphylla* and the branched Hydrocoral: *Millepora dichotoma* in high density (10-15 individuals/colony) at Taba station. It is suggested that *Pteria penguin* is probably able to tolerate the painful burning effect of fire Melliporid corals. Also, the high density of the vermetid gastropod shell *Dendropoma maximum* was predominantly incorporated with *Millepora platyphylla* (30-35 individuals/colony) and *Millepora dichotoma* (20-25 individuals/colony) at Taba and Sharm El-Sheikh.

In contrast to *Coralliphilia neritoidea*, the aggregation of the gastropod *Drupella cornus* was mainly found in living branched corals, particularly *Acropora* spp. and *Stylophora pistillata*. Al-Moghrabi (1997) observed that the gastropod *Drupella cornus* was mainly found as aggregates on living coral colonies, predominantly on *Acropora* species (branching growth forms). The most abundant reef-building branching coral at Sharm El-Sheikh (Ras umm Sidd), *Acropora hemprichi* is suffering from population explosion of *Drupella cornus* (Antonius and Riegl, 1997).

Along the Gulf of Aqaba, particularly at Sharm El-Sheikh, high density of *Tridacna maxima* (bivalve) was observed to be inserted into massive coral colonies.

There is another evidence for the selective association between mollusc species and coral growth form in the coast of Japan and Philippine. The adult snails of *Drupella rugosa* (> 28 mm in shell length) were found to be most common on tabular corals of the genera *Acropora* and *Montipora* (Mayer *et al.* 1982), while juveniles (< 28 mm in shell length) were found almost exclusively on digitate species of *Acropora* (Johnson *et al.* 1993).

In the past, the Egyptian coast of the Gulf of Aqaba was recognized as clean area, but in recent decades, it became exposed to intensive pressure from increased human activities, construction for tourism development and recreational marine sports. As a result, the benthic community in the Gulf of Aqaba began to decline due to the pollution accompanied with these activities. This view is reinforced by the appearance of the bivalves *Brachiodontes variaiblis* and *Modiolus auriculatus* as well as the barnacles *Balanus* spp. and *Tetraclita squamosa* (Crustacea: Cirripedia), where these species are identified as biomonitors for pollution, in addition to increased abundance of macroalgae.

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