

Growth rates of the two reef-building species, *Acropora humilis* and *Millepora platyphylla* at Hurghada, Red Sea, Egypt

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ABSTRACT

Linear growth rates were measured for two species of coral namely, *Acropora humilis* and *Millepora platyphylla* in Hurghada during the period from autumn 2006 to summer 2007. In addition, the rates of recovery in man-made lesion in *M. platyphylla* were estimated on seasonal basis. The linear growth rates of *A. humilis* varied significantly according to the sheltering condition, with an overall mean of 8.89 and 6.98mm/year in exposed and sheltered sites. The highest linear growth rate of *A. humilis* was estimated at the exposed site of Gotta Abu Ramada, being 9.17mm/year, while the lowest rate of 6.61mm/year was recorded at the sheltered site of El-Fanadir Reef. The seasonal linear growth rates of *M. platyphylla* were affected significantly by the sheltering condition, and non-significantly by seasons. The estimated annual growth rates of *M. platyphylla* at the exposed sites averaged higher value of 15.65mm/year compared to 11.29mm/year at the sheltered sites. On the seasonal level, the highest overall mean of growth rates was recorded in spring, while the lowest mean was in autumn, being 3.72 and 3.06mm/season, respectively.

The rates of diametric lesions recovery of *M. platyphylla* varied significantly according to seasons and non-significantly according to sheltering condition. The fastest recovery was recorded in summer, while the lowest recovery was in winter. For instance, the lesions of 3847mm² area each, recovered completely within 6 weeks in summer, while the same lesions area were not recovered completely after 12 weeks in winter.

Keywords: Growth rates, *Acropora humilis* and *Millepora platyphylla*, Hurghada Egypt

INTRODUCTION

Skeletal growth of stony corals is one of the important ecological and biological parameters, which essentially can help as an indicator for the calcification rate of the reef. Measurement of skeletal linear extension (LE) of coral within a distinct period by means of skeletal markers are one of the methods used (Rahav *et al.*, 1991; Dullo *et al.*, 1995). Several methods have been used such as, plastic coated wires (Oliver, 1984), Alizarin-Red-S-stain in order to stain the respective coral colonies alive (Gladfelter, 1984; Dullo *et al.*,

1995), spikes were also driven into the coral skeleton as markers (Shinn, 1976) and direct interval photograph of the coral colonies have been used (Rahav *et al.*, 1991) as well.

Along the Egyptian Red Sea coral reefs, few studies were achieved on some scleractinian growth. Kotb (1996) studied the linear growth rate of *Acropora granulose* and *Stylophora pistillata* by Alizarin Red method in southeastern coast of Sinai Peninsula. He also compared his data after 5 years (2001) in the same area, with the growth rate of another species (e.g. *P. damicornis*) by the same method. Al-Azri (1996) estimated the linear growth rate of *A. granulosa* and *S. pistillata* at Ras Mohammed. Ammar *et al.* (2000) made some measurements on transplanted *A. humilis* and *S. pistillata*, while Mohammed (2003) studied the linear growth rate of *A. humilis* and *S. pistillata* at the reef off Hurghada. More recently Aamer (2004) chosed four scleractinian species namely, *Acropora humilis*, *Pocillopora damicornis*, *Pacillopora verrucosa* and *Stylophora pistillata* to study the growth rate at six sites in Sharm El Sheikh.

The study of lesions recovery in corals is investigated fairly in many areas of the world except the Red Sea. Most of the research done on this subject has been carried out in Curacao (Meesters *et al.*, 1994, 1996; 1997 Nagelkerken and Bak, 1998), in Panama (Guzmán *et al.*, 1994), in Florida (Hayes and Bush, 1990), in the Red Sea (Oren *et al.*, 1998) and in Australia (Hall, 1997). Woesik (1998) compared the lesion healing capability in *Porites lutea* and *P. lobata* corals from Japan, but he found no differences in tissue regeneration between these two species.

This present study aimed to investigate the linear growth rates of the two species *Acropora humilis* and *Millepora platyphylla* and the rate of lesions recovery in *M. platyphylla*. In addition, the study attempted to study the environmental conditions (i.e. sheltering and exposure condition) on their growth rates during a whole year in *A. humilis* and in different seasons in *M. platyphylla*.

MATERIAL AND METHODS

The linear growth rates of the two coral species *Acropora humilis* (Dana, 1846) and *Millepora platyphylla* (Hemprich & Ehrenberg, 1834), as well as the recovery of man-made lesions in *M. platyphylla* were estimated on seasonal basis in Hurghada during the period from autumn 2006 to summer 2007. The linear growth rates for *A. humilis* were estimated at eight exposed and sheltered sites (namely; Gotta Abu Ramada, El Fanous, Carless Reef and Umm Gammer Is., as exposed sites and Small Giftun Is., Sabina Reef, Ishtta Reefs and El-Fanadir Reef, as sheltered sites), (Fig. 1). Except the two sites of Carless Reef and Umm Gammer Is., the linear growth rates in *M. platyphylla* were estimated in the other 6 sites.

At each site at 5m depth, five colonies of each species were selected and marked. In *A. humilis* five branches for each colony were selected randomly and

tagged by plastic string at approximately 1.5 – 2.0cm apart from the branch tip. In case of *M. platyphylla*, the plate of each selected colony was tagged by plastic string at 4.0–5.0cm apart from the plate tip.

The linear extensions (growth) of each branch or plate were measured annually in case of *A. humilis* and seasonally in *M. platyphylla* (between autumn 2006 and summer 2007). In both species, the linear extension was as shown in Fig. (2).

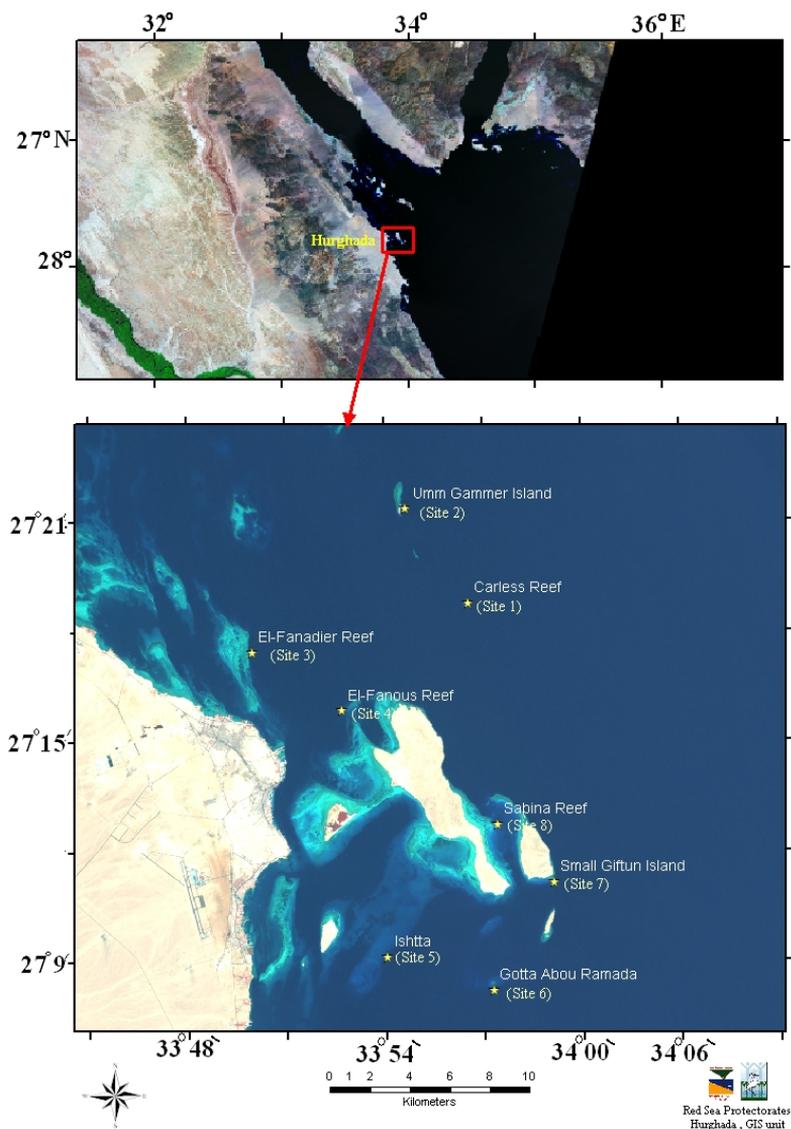


Fig. 1: Satellite map of the total eight studied sites around Hurghada area.

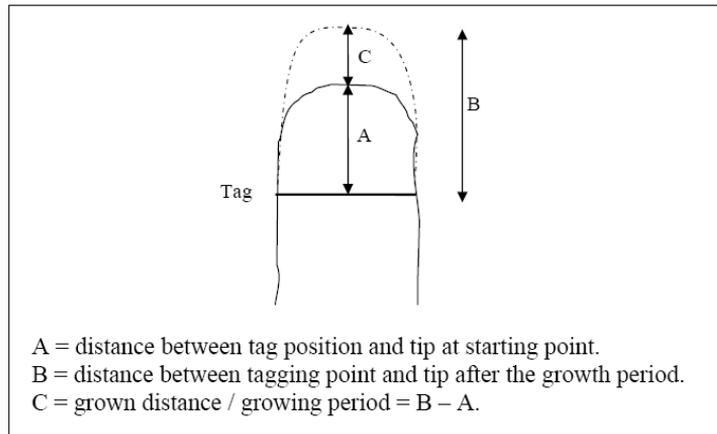


Fig. 2: Estimate of the linear growth rates in both species

An experiment was designed on seasonal basis to measure the rate of recovery in lost tissue in *M. platyphylla*, which could be occurred due to bio-erosion or potential damage as a result of divers contact. For this purpose, five colonies of *M. platyphylla* were selected at two sites (Gotta Abu Ramada and Sabina Reef) and at 5m depth. A circle lesion of 70mm diameter with 3847mm² areas was made artificially using sharp blade on a selected plate per colony. On bi-weekly intervals, the recovery rates were measured as the length of growing tissue on the diametric axis of the lesion, using a Verner caliper to the nearest 0.01mm, and as the area of grown tissue on the lesion (Fig. 3). To determine the seasonal variation on recovery, the experiment was repeated on seasonal basis starting from winter 2007 to autumn 2007.

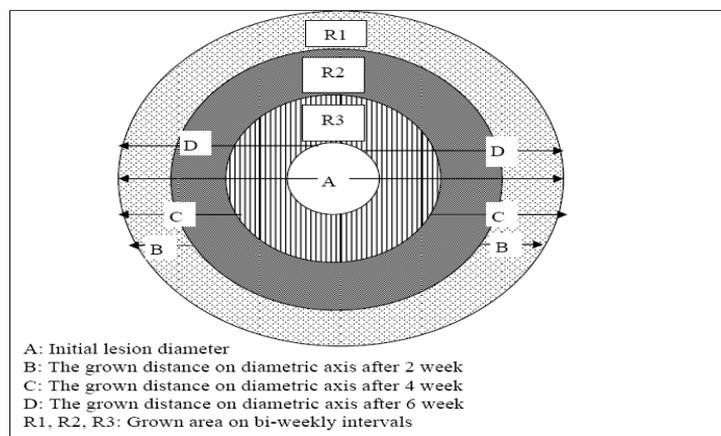


Fig. 3: Estimate of recovery rates in *M. platyphylla*

RESULTS

The linear growth rates of *A. humilis* varied significantly according to sheltering condition and sites, ($P < 0.001$). The estimated linear growth rate of *A. humilis* in the study area recorded higher values at exposed sites, with an overall mean of 8.89mm/year, compared to 6.97mm/year estimated for sheltered sites. In general, the highest linear growth rate of *A. humilis* was estimated at the exposed site of Gotta Abu Ramada, (9.17mm/year), while the lowest rate of 6.61mm/year was recorded at the sheltered site of El-Fanadir Reef (Table 1).

Table 1: Mean growth rates of *Acropora humilis* (mm/year) recorded at the selected exposed and sheltered studied sites

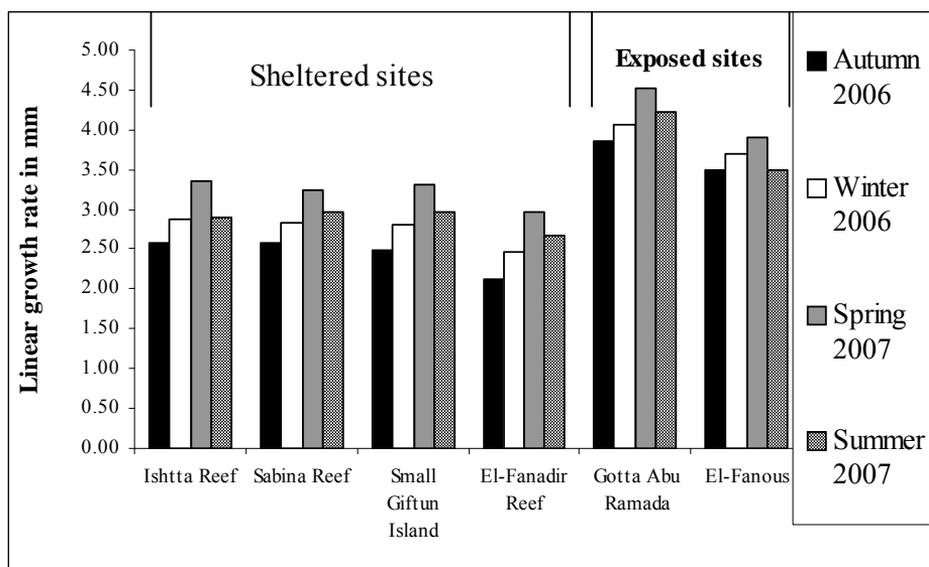
| Sites | Average linear growth rate mm/year |
|------------------------|------------------------------------|
| Exposed sites | |
| Gotta Abu Ramada | 9.17 |
| El-Fanous Reef | 8.91 |
| Carless Reef | 8.81 |
| Umm Gammer Island | 8.66 |
| Mean | 8.89 |
| Sheltered sites | |
| Small Giftun Island | 6.85 |
| Sabina Reef | 7.1 |
| Ishtta Reef | 7.35 |
| El-Fanadir Reef | 6.61 |
| Mean | 6.97 |

The seasonal linear growth rates of *Millepora platyphylla* were affected significantly by sheltering condition, ($p = 0.006$), and non-significantly by seasons, ($p = 0.292$). The annual growth rates of *M. platyphylla* at the exposed sites averaged higher value of 15.65mm/year rather than the value averaged at the sheltered sites (11.29mm/year) as given in Table (2).

On the seasonal level, the highest overall mean of growth rates was recorded during spring, while the lowest mean was during autumn (i.e. 3.72 and 3.06mm/season, respectively), (Table 2). Among all sites, the highest growth rates of *M. platyphylla* were recorded at the exposed reef of Gotta Abu Ramada site in all seasons (ranged between 3.85 and 4.53mm/season in autumn and spring, respectively). In comparison, the lowest growth rates were estimated at sheltered reefs of El-Fanadir Reef in all seasons (ranged between 2.13 and 2.97mm/season in autumn and spring, respectively (Table 2 and Fig. 4).

Table 2: Seasonal and annual linear growth rates (mm) of *M. platyphylla* recorded at the sheltered and exposed sites

| Sites | Autum 2006 /mm | Winter 2007 /mm | Spring 2007 /mm | Summer 2007 /mm | Annual growth rate mm/year |
|------------------------|----------------|-----------------|-----------------|-----------------|----------------------------|
| Exposed sites | | | | | |
| Gotta Abu Ramada | 3.85 | 4.08 | 4.53 | 4.23 | 16.69 |
| El-Fanous Reef | 3.50 | 3.70 | 3.90 | 3.50 | 14.60 |
| Mean | 3.68 | 3.89 | 4.22 | 3.87 | 15.65 |
| Sheltered sites | | | | | |
| Ishtta Reef | 2.58 | 2.88 | 3.35 | 2.90 | 11.71 |
| Sabina Reef | 2.58 | 2.83 | 3.25 | 2.98 | 11.64 |
| Small Giftun Island | 2.50 | 2.80 | 3.30 | 2.97 | 11.57 |
| El-Fanadir Reef | 2.13 | 2.47 | 2.97 | 2.67 | 10.24 |
| Mean | 2.45 | 2.75 | 3.22 | 2.88 | 11.29 |
| Overall means | 3.06 | 3.32 | 3.72 | 3.37 | 13.47 |

Fig. 4: Mean linear growth rates (mm/season) of *M. platyphylla* estimated for different seasons at different study sites.

The progress in the recovery of the artificially made lesions on the plates of *M. platyphylla* is shown in Fig. (5). The seasonal rate of recovery varied significantly according to seasons, ($p < 0.001$) and non-significantly according to sheltering condition, ($p = 0.834$). According to seasons, the highest recovery rates at the two sites occurred during summer, where all lesions recovered in six weeks. In contrast, the lowest recovery rates were recorded during winter, where

there was no complete recovery after a trial period of 12 weeks (Fig. 6 and Table 3). This allowed algae to be grown in center of the lesions.

In winter, the diametric recovery rates of *M. platyphylla* at sheltered site of Sabina Reef was found to be higher during the first 10 weeks than that recorded at the exposed site of Gotta Abu Ramada. During the last two weeks, there was no recording for growth at both sites (Fig.6). The higher bi-weekly diametric recovery rates at both sites recorded in the eighth week were 15.99 and 16.83mm at Gotta Abu Ramada and Sabina Reef respectively (Table 3).

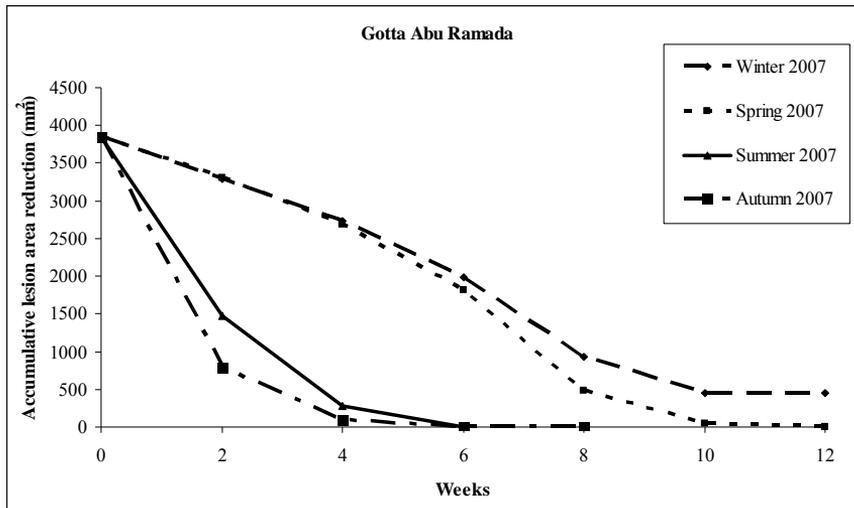


Fig.6: The recovery progress in artificially made lesions on the plates of *M. platyphylla*

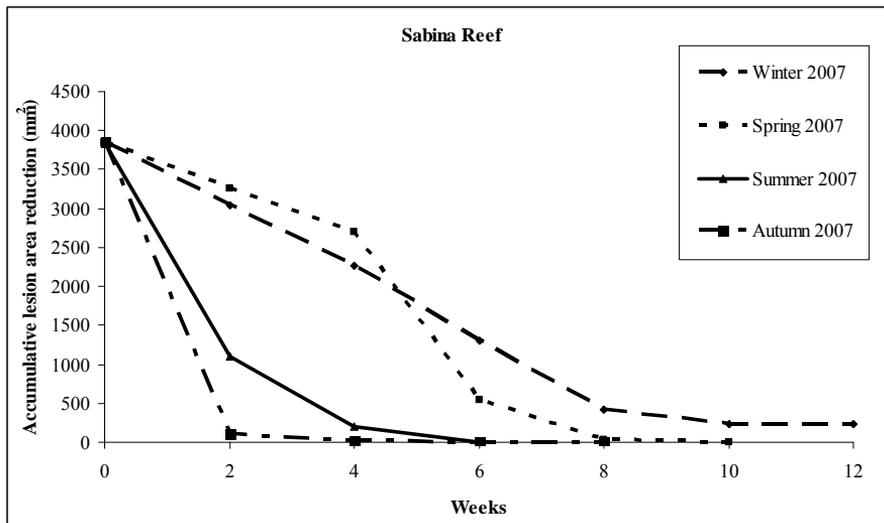
Table 3: Seasonal diametric recovery rates in artificially made scars on *M. platyphylla* plates measured bi-weekly. (Initial lesion 70mm diameter)

| Seasons | Sites | Rate of recovery (weeks) | | | | | |
|-------------|------------------|--------------------------|-------|-------|-------|-------|------|
| | | 2 | 4 | 6 | 8 | 10 | 12 |
| Winter 2007 | Gotta Abu Ramada | 5.35 | 5.76 | 8.76 | 15.99 | 10.36 | 0.00 |
| | Sabina Reef | 6.45 | 6.96 | 10.67 | 16.83 | 8.18 | 0.00 |
| Spring 2007 | Gotta Abu Ramada | 5.12 | 6.72 | 10.90 | 23.64 | 15.98 | 7.64 |
| | Sabina Reef | 5.56 | 5.79 | 33.39 | 20.07 | 5.19 | |
| Summer 2007 | Gotta Abu Ramada | 26.80 | 24.33 | 18.87 | | | |
| | Sabina Reef | 32.53 | 21.31 | 16.16 | | | |
| Autumn 2007 | Gotta Abu Ramada | 39.15 | 20.57 | 7.58 | 2.71 | | |
| | Sabina Reef | 58.42 | 7.96 | 3.08 | 0.54 | | |

Lesion recovery in spring at Sabina Reef was found to be faster than at Gotta Abu Ramada as it took ten weeks to recover the entire lesion at Sabina Reef, while it took 12 weeks at Gotta Abu Ramada (Fig.6). The bi-weekly diametric recovery rates were recorded with higher value in the sixth week at Sabina Reef and in the eighth week at Gotta Abu Ramada, being 33.39 and 23.64mm, respectively (Table 3).



(A)



(B)

Fig. 5: Accumulative reduction in the area of artificially made lesions on *M. platyphylla* bi-weekly during different seasons at Gotta Abu Ramada (A) and Sabina Reef (B)

During summer, complete recovery of the lesions occurred within 6 weeks at both sites, (Fig.6). The higher bi-weekly diametric recovery rates at the two sites were recorded in the second week being 26.80 and 32.53mm at Gotta Abu Ramada and Sabina Reef, respectively, with an average value of 23.3mm/2weeks (Table 3).

The recovery during autumn took eight weeks to recover the entire lesion at both sites. The diametric recovery rate of *M. platyphylla* in Sabina Reef was found to be slightly higher than at Gotta Abu Ramada (Fig.6). Higher bi-weekly diametric recovery rates at both sites were recorded in the second week, being 39.15 and 58.42mm at Gotta Abu Ramada and Sabina Reef, respectively, with an average value of 17.5mm/2weeks (Table 3).

DISCUSSION

Coral growth rate is variable between different species on all accessible time scales; hours to days, weeks to months and seasons to years (Goreau, 1959). It is known that annual coral growth can be affected by different physical factors such as temperature (Gladfelter, 1984; Wellington & Dunbar, 1995; Kotb, 2002; Aamer, 2004), light and depth "as a function of light intensity" (Fricke & Schumacher, 1983; Wellington and Glynn, 1983; Strömngren, 1987; Dullo *et al.*, 1995; Aamer, 2004), salinity (Glynn, 1993), sedimentation rates (Charuchinda and Hylleberg, 1984; Hodgson & Carperter, 1995; Aamer, 2004). In addition, water motion exerts a control over reef corals in various ways. Enhanced circulation (flushing) caused by waves, tides and currents modifies many important environmental factors (e.g. Plankton, dissolved nutrients, gases, sediment, water clarity, substrata, salinity, and temperature) which influence the coral growth and distribution (Graus *et al.*, 1977; and Brown *et al.*, 1985).

The linear growth rates of *A. humilis* varied significantly according to the sheltering condition, ($P=0.001$) and sites, ($P=0.001$). The annual mean growth rates of *A. humilis* ranged between 6.61mm/year and 9.17mm/year. Slightly lower rates of 6.8 and 7.4mm/year were recorded by Mohammed (2003) for the same species on selected reefs off Hurghada. Ammar *et al.* (2000) estimated growth rates of 3 to 7mm/year in the transplanted *A. humilis* at the same localities. Aamer (2004) concluded that sites or location influenced significantly the linear growth rates of *A. humilis* at Sharm El-Shiekh which ranged between 6.17mm/year and 9.80mm/year, while Davies, (1989) found that *A. humilis* in Caribbean Sea varied between 2-13.3mm/year at 2m depth.

The linear growth rates of *A. humilis* were affected by the sheltering condition, where higher growth rates were recorded at the exposed sites of Gotta Abu Ramda. This likely results from water movement which is higher in exposed sites than in sheltered sites, which provided food (nutrients and plankton) to corals in exposed condition rather than corals in sheltered condition. Riegl and Velimirov (1994) and Riegl and Piller (1997) studied the structure of the coral communities at Hurghada in northern Red Sea and concluded that,

coral communities are dominated by *A. hyacinthus*, *A. humilis*, *Millepora* sp. and *Stylophora pistilata* at 10m depth of the exposed reefs, while the sheltered sites were dominated by *Porites* sp. Exposed reefs, dominated by *Acropora* sp. have been described from the central Red Sea in Sudan (Mergner & Schuhmacher 1985; Head, 1987), from the Indian Ocean in Chagos (Sheppard, 1980) and in Madagascar (Pichon, 1978) and from the Pacific in the Great Barrier Reef (Wallace, 1978; Done, 1982).

The linear growth rates of *M. platyphylla* were influenced significantly by sheltering condition. Very few studies were carried on *M. platyphylla* growth rates, and some of these studies showed that *M. platyphylla* are built of well calcified basal plates of the colonies, which are strengthened by multiple fusions (Riegl and Piller, 1997; 1999). This may support the finding of this study, where higher growth rates of *M. platyphylla* were recorded at the exposed sites than in shelter sites. Also Riegl and Velimirov (1994) found that one of the most dominant species of exposed sites in the Red Sea was *Millepora* sp. In the Caribbean Sea, Geister (1983) found coral framework in the sites frequently exposed to high hydrodynamic forces dominated by *Acropora* sp. and *Millepora* sp.

The present results show non-significant differences at the seasonal variation. The highest average growth rates were recorded at spring. Soonge and Cho (1998) demonstrated the release of medusae of three hydrozoan fire corals namely, *Millepora dichotoma*, *M. murrayi* and *M. platyphylla* at three sites in southern Taiwan from February 1994 to July 1995. All the three species were gonochoristic, which developed and released several batches of medusae between April and May and the earliest medusae appearing in March. For the plate-like *M. platyphylla* at Wanlton, the first batch of medusae, averaging 0.26mm in diameter, was observed in tissues on April 7, 1995. The medusa reached an average maximum diameter of 0.62mm by the end of April.

The rate of recovery of *M. platyphylla* varied significantly according to seasons, and non-significantly according to sheltering condition. The highest recovery rates at both sites occurred during summer and the lowest during winter. This is likely to be related to the expected higher temperature, light and food availability during summer time. Generally the growth of corals depends on temperature and light (Loya, 1985; Dotan, 1990; Kotb 1996; Ammar *et al.*, 2000; Mohammed, 2003; and Aamer, 2004). The temperature increases the recovery of coral and reduces the growth of algae on the artificially made lesions. Cr quer *et al.* (2002) concluded that the recovery of *Montastraea annularis* (Faviidae) reaches its maximum with high temperature.

Serour (2004) estimated the potentially physical damage to corals by a diver at a rate of 3.87 incidents/dive. In 2008, almost more than 8 million dives have been recorded in the Egyptian coast of the Red Sea (Center for information and decision support in Red Sea Governorate). This means that, in total 30.9 millions potentially damaged incidents to corals occurred in 2008. Therefore, in

conclusion, *M. platyphylla* has the ability to regenerate damaged tissue fairly rapidly. In area such as reefs off Hurghada, where most reefs are heavily used by divers, such finding is so fortunate. It is indicated that the physical damage caused by divers for the plates of *M. platyphylla* can be recovered completely within 6 weeks in summer and 12 weeks or slightly more in winter.

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