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SPATIAL AND TEMPORAL VARIATIONS IN GROWTH RATES AND SKELETAL DENSITY OF THE BRANCHING CORALS, *ACROPORA HUMILIS AND STYLOPHORA PISTILLATA* (SCLERACTINIAN: CNIDARIA) FROM GULF OF SUEZ AND NORTHERN RED SEA, EGYPT

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ABSTRACT

Scleractinian corals consider one of the most important reef builders in tropical and subtropical regions around the world including Red Sea. This study aimed to estimate the linear growth rates and skeletal densities for the most dominant coral species, *Acropora humilis* and *Stylophora pistillata* at the Suez Gulf and northern Red Sea during the period from summer 2015 to spring 2016. The present results showed that, *A. humilis* has an annual growth rate averaged 6.08±0.551 mm/y, and was low compared with *S. pistillata* which averaged7.37±3.488 mm/y. These rates showed seasonal and spatial variations. *A. humilis* recorded its highest average of 1.74±0.11 and 1.74± 0.9 mm during both autumn and winter (cold seasons), respectively, but it declined to 1.11± 0.22 mm during spring. On the other hand, *S. pistillata* recorded its highest average of 2.40±1.14 mm in winter and the minimum (1.08±0.74 mm) during summer. For spatial variations, the highest annual growth rate of *A. humilisa* veraged 6.67 mm/y at site III, declined gradually northwards to 5.99±1.28 and 5.58±1.42 mm/y at sites, II and I respectively. On contrast, *S. pistillata* recorded the highest annual average of 10.16±2.66 mm/y at site II but declined to 8.49 mm/y at site I and reached the lowest average of 3.46 mm/ y at site III. For skeletal densities, the annual averages recorded 1.85±0.13 $g.cm^{-3}$and 2.09±0.17 g. $cm^{-3}$for*A. humilis* and *S. pistillata*, respectively. These values declined to 1.71±0.24 g/cm3 and 1.90±0.26 $g/cm^3$for the two species, respectively, at site II, but increased to 1.95±0.13 $g/cm^3$for *A. humilis* at site III and reached to2.20±0.25g/cm^3 for *S. pistillata* at site I. The seasonal fluctuations were also detected, recorded highest average of 2.18±0.312g/cm^3 for *A. humilis* during winter at sites I and minimum average of 1.47±0.35g/cm^3during summer at II; while *S. pistillata* reached the highest average of 2.51±0.21g/cm^3 during autumn at site I, and minimum average of 1.62±0.33g/cm^3 during summer at site II.

Keywords**:** Stony corals, Red Sea, Gulf of Suez, Growth rate, skeletal density.

INTRODUCTION

Coral reefs in the Red Sea constitute unique environmental communities and consider as the most famous and fantastic corals in the world. Taxonomy, biology, diversity and distribution in addition to coral growth rates and skeletal densities for certain species had been treated in several studies along the Egyptian coasts (Kotb, 1996; Al-Azri, 1996; Mohamed *et al*., 2007; Al- Hammady, 2011; Sharaka, 2011; Attalla *et al*. 2011; Hussein, 2016).

As it well known that, the calcification process of scleractinian corals is one of the most important features of this group, allows producing an exoskeleton composed of calcium carbonate. Therefore, scleractinian corals consider the major reef builders while the coral reefs are the result of a complex interaction of constructive processes that build solid framework (Sheppard and Sheppard, 1991). Consequently, growth and skeletal growth of stony corals are one of the most important ecological and biological subjects, which essentially can use as an indicator for the calcification rate of the reefs and an increase in size of coral colonies (Ammar *et al*., 2005). This phenomenon depends mainly on several environmental factors included position and location, latitudes, light availability, depth (Head, 1987; Kotb, 1996; Al-Azri, 1996; Mohamed *et al*., 2007), exposing or sheltering from wave actions (Attalla *et al*., 2011; Sharaka, 2011), effects of pollution and availability of nutrients levels (Al-Hammady, 2011; Hussein, 2016) as well as presence of associated crabs (Salem, 2017).

As all other life organisms, stony corals increase in size with variable growth rates according to the sites position, latitudes, availability of nutrients and favorable environmental conditions (Head, 1987). Measurements of growth rates represented by skeletal linear extension (LE) of corals within a distinct period by means of skeleton markers are one of the methods used by several authors (Charuchinda and Hylleberg, 1984; Gladfelter, 1984; Logan and Tomascika, 1991; Rahav *et al.,* 1991; Dullo *et al*., 1995). These markers indicate the beginning of the newly grown skeletal extension during the time interval.

In the Red Sea and its associated gulfs, Suez and Aqaba, fringing reefs are the basic type occurring along most of the coastal lengths, but tend to be well developed in the central and northern Red Sea (Head, 1987). However, fringing reefs of the western coast of the Gulf of Suez are more developed, forming remarkable stretches from Ain Sukhna (about 50 km south of Suez) to southwards. These reefs extend between 30 to 40 m offshore, sloping from 1 to 5 m in depth. According to Head (1987), there are 53 genera and 177 species of zooxanthellate corals so far known in the Red Sea and its gulfs, the largest genera are *Acropora* and *Stylophora* were the dominant genera.

Along the Egyptian Red Sea, several studies were carried out on coral reefs, but few were focused on the growth rate of zooxanthellate corals, particularly at northern limits of the Suez Gulf. The most prominent studies on linear growth rates of stony corals were carried out by Kotb (1996) on *Acropora granulosa* and *Stylophora pistillata* using Alizarin- red method along the southeastern coast of Sinai Peninsula, Kotb (2001) in the same area and by the same method, but at different depths (5m, 15m and 30m) on another three branching coral species comprised: *Pocillopora damicornis*, *S. pistillata;* and *A. granulosa* and Al-Azri (1996) used plastic coated copper wire for studying the linear extensions growth rates for *A. granulosa* and *S. pistillata* at Ras Mohammed (the entrance of the Gulf of Aqaba).

Furthermore, other studies on coral growth were carried out at the first decade of the 21[ist] century. Mohammed (2003) studied the linear growth rate of *A. humilis* and *S. pistillata* at the offshore reef of Hurghada. Ammar (2004) estimated the growth rate of *A. humilis*, *P.damicornis*, *P. verrucosa* and *S. pistillata* at Sharm El Sheikh. Mohamed *et al.* (2007) studied seasonal variations in growth rates of *A. humilis* and *S. pistillata* at three sites at Hurghada. Al-Hammady (2011) studied the extension growth rates for *A. humillis* and *S. pistillata* along the western coast of the Red Sea at El-Hmraween Harbor. While Attala *et al*. (2011) and Sharaka (2011) studied the linear growth rates of the two reef-building species, *A. humilis* and *Millepora platyphylla* at sheltered and exposed conditionson the offshore reefs facing Hurghada, Red Sea. Recently, Hussein *et al*. (2016) estimated the linear extension growth rates for *Pocillopora verrucosa* and *Acropora hemprichii* in four sites along the northern western coast of the Red sea including the southern limit of Suez Gulf. While, the impacts of associated crab species (*Trapezia cymodoce* and *Tetralia glaberrima*) on the linear extensions growth rates of *A. humilis* and *S. pistillata* were studied by Salem (2017) at three sitesalong the Gulf of Aqaba.

On the other hand, the skeletal density of stony corals is represented as a function of increase in weigh and volume of the newly grown skeleton (i.e. density = weigh /volume). It had been studied by many authors such as Oliver (1984). Along the Egyptian Red Sea coasts, Kotb (2002) studied the skeletal density for *S. pistillata*, *A. granulose* and *P. damicornis*at three depths (5 m, 15 m and 30 m) in the northern Red Sea by using Alizarin-Red stain. Dar and Mohamed(2009 studied seasonal variations in skeletal thickness and specific density for *A. humilis* and *S. pistillata* in three sheltered, intermediate and exposed localities along the Red Sea coast under different natural and anthropogenic stresses. While Ammar *et al.* (2005) measured the skeletal density for *Acropora hycinthus, Porites solida*, and *Pocillopora verrucosa* by using Archimedean's principle along the coastline of the Res Sea at Wadi EL-Gemal (flooding site laying south Marsa Alam) and a non-flooding site (North Wadi Qala'an). On the other hand, Al-Hammady (2011) reported the highest skeletal densities for *A. humillis* at El-Hmraween Harbor, compared with the lowest densities recorded at Ras-El-Behar. In contrast, S. *pistillata* showed its maximum skeletal densities, none expectedly at Ras-El- Behar and the minimum densities at Kalawy Bay. While Hussein (2016) found that, the skeletal densities for *A. hemprichii* and *P.verrucosa* reached highest average values at the oil pollution and phosphate shipping impacted sites and lowest values at the impacted site by petroleum products; but have moderate averages at the other non-impacted sites as small Gifton Island and Abu Ramada Island.

In spite of the previous studies, no detailed information on the growth rates and skeletal densities of stony corals at the Suez Gulf were available. Therefore, this study through light on the annual and seasonal growth rates as well as skeletal densities for the branched corals, *A. humilis* and *S. pistillata* at the selected areas.

MATERIAS AND METHODS

A- Linear growth rate:

The annual and seasonal linear growth rates of the stony corals *Acropora humilis* (*Dana*, 1846) and *Styllophora pistillata* (*Esper*, 1795) from the Gulf of Suez and Northern Red Sea were estimated during the period from summer 2015 to spring 2016. The present study was carried out on three sites(Figure, 1), arranged from north to south as: site I (Ain Sokhna, 65km south Suez City, Gulf of Suez) which lies at 29˚ 33' 27.1" N and 32˚ 21' 38.5" E, site II (South Ain Sokhna, 85Km south Suez City, Gulf of Suez), lies at 29˚ 28' 46.75" N and 32˚ 26' 57.38 E) and site III (NIOF at Hurghada) represents the northern part of the Red Sea and lies at 27˚ 17' 4.19" N and 33˚ 46' 19.97" E. These sites were chosen based on the anthropogenic effects of human on coral reefs at the selected sites. At Hurghada (NIOF) coral reefs have low effects and disturbance and considered as a control site. While those chosen at Ain Sokhna (sites I and II) lie at the western part of Gulf of Suez, and suffer from high anthropogenic impacts (Figures,1).

At each site, the linear growth rates for three distinct and marked colonies of each *A. humilis* and *Stylophora pistillata* were measured at 3m depth according to English *et al*. (1997), as well as those applied in the Red Sea coral colonies growth by Attala *et al*. (2011), Sharaka (2011), and Hussein (2016). From each colony, three branches were chosen randomly and tagged by plastic string about 1.5 - 2.0 cm apart from the tip of the branch. The linear extension was measured seasonally using caliper vernier as the length of the tagged branch from the plastic string to the tip of the branch (Figure, 2).

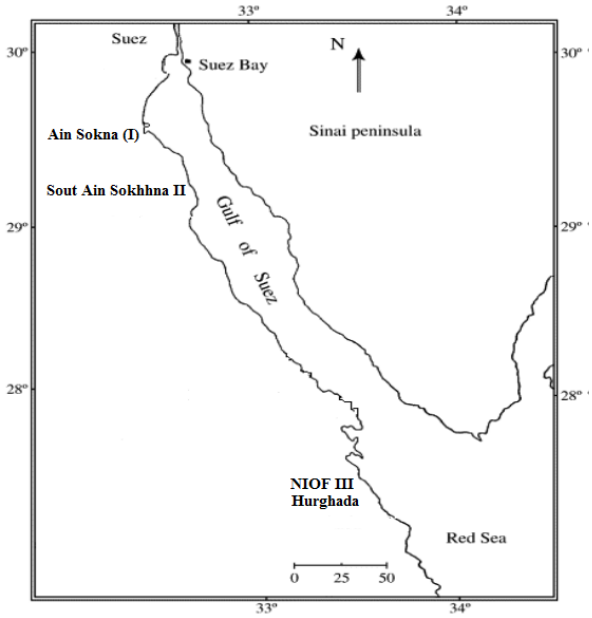


Figure (1): Map showing sites of collection during the present study.

B- Skeletal density:

For measuring the skeletal densities of *A. humilis* and *S. pistillata*, three pieces (2-3 cm length) from coral branches were cutting using a peelers from each one of the chosen colonies at the three sites during the period of this study. The collected samples were washed with seawater, cleaned and dried in the air. The skeletal densities of the dried samples were estimated using Archimedeans' principle by weighting them first in air and then suspended briefly from an analytic balance into water according to Graus and Mascintyre (1982) and Al-Hammady (2011). The skeletal density was estimated as dry weight divided by volume as following:

$$\text{Density } (g/cm^3) = \frac{\textit{Weight of dried coral}}{\textit{Volume of suspended corals}}$$ (Graus and Mascintyre, 1982)

The seasonal and spatial variations in the average values of skeletal densities for the two chosen coralspecies were calculated. Statistical analyses (T-test and ANOVA) were used to evaluate the seasonal and spatial differences using SPSS program (Version 2010).

RESULTS

A- Coral growth rates:

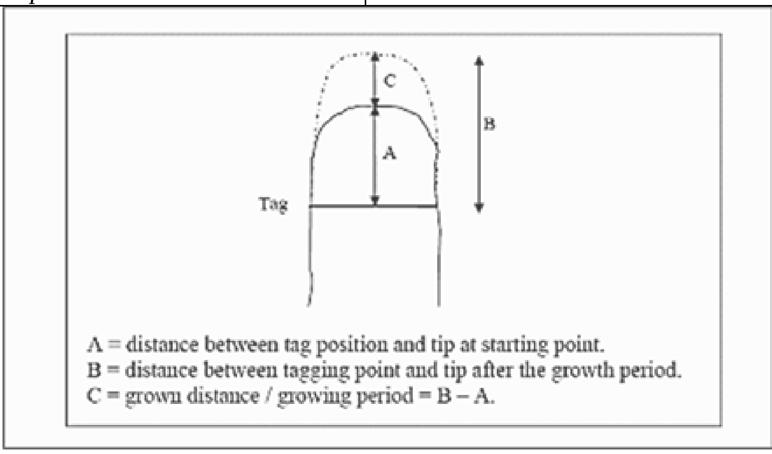
1- The annual growth rates of *A.humilis and S. pistillata*:

The results of linear growth rates of the two scleractinian corals, *A.humilis* (Dana, 1814) and *S.pistillata* (Esper, 1795) are given in Table (1) and graphically illustrated in Figures (3-5). These results showed that, the annual growth rates averaged 7.37 ± 3.49 and 6.08 ± 0.55 mm/y at all sites for *S. pistillata* and *A. humilis*, respectively. The value of annual rate is relatively higher in *S. pistillata* than *A. humilis*. However, these values showed spatial variations between different sites. *S. pistillata* displayed higher grates at Suez Gulf, and measured10.16 ± 2.65 and 8.49± 2.82 mm/y at sites II and I, respectively, but declined sharply into 3.47 ± 1.51 mm/y at site III (northern Red Sea).

In contrast, *A. humilis* recorded its highest

Acropora humilis

Stylophora pistillata



Linear extension

Figure (2): Live colonies of tagged with plastic strip as start point for measurements and linear extension (After Sharaka, 2011).

growth rate (6.67 ± 0.98 mm/y) at site III (northern Red Sea), but decreased gradually northwards into 5.99 ± 1.276 and 5.58 ± 1.4213 mm/y at sites II and I, respectively (Table 1 & Figures, 3&4).

2- Seasonal changes in growth rates of *A.humilis and S. pistillata*

Results in Table (1) and Figure (4) illustrated the seasonal growth rates of *A. humilis* measured during different seasons at the three studied sites. It was noticed that, the growth rates fluctuated seasonally, recorded lowest average of 0.88±0.07, 1.13±0.09 and 1.31±0.17 mm during spring at sites I, II and III, respectively. On the other hand, the highest growth rates recorded 1.65±0.12, 1.79± 0.14 and 1.83±0.18 mm during winter, autumn and winter at the same sites, respectively.

On the other hand, the growth rates of *S.pistillata* showed the same pattern like as *A. humilis*. The lowest averages of seasonal growth rates were 2.05±1.73, 2.30±0.27 and 0.98±0.09 mm, recorded during spring; while these rates increased to the highest averages of 2.70±1.73, 2.72±0.46 and 1.14±0.10 mm during winter, autumn and winter at sites, I, II and III, respectively (Table, 1 and Figure, 5).

B-Skeletal densities of *A. humilis and S.pistillata*

1- The annual skeletal density of *A.humilis and S. pistillata*:

Results of skeletal densities of *A. humilis* and *S. pistillata* are given in Table (2) and illustrated in Figure (6). The annual average of skeletal densities reached 1.85±0.13 g/cm^3 for *A. humilis* at all sites and increased to 2.09±0.17 g/cm^{3}for*S. pistillata*. However, there were spatial variations in the skeletal densities of these corals species. For *A. humilis*, the lowest annual average was 1.71±0.244 g/cm^{3}recorded at site II; then it increased to the highest one, recorded 1.95±0.13 g/cm^3 at site III. At the same time, the reverse was detected for *S. pistillata*, recorded its highest average of 2.20±0.25g/cm^{3}at site I, but decreased to the lowest average of1.90±0.26 g/cm^3 at site II.

2- Seasonal changes in skeletal density of *A.humilis and S. pistillata*:

There are also remarkable seasonal and spatial fluctuations in the average values of skeletal densities for these species. The skeletal density of *A. humilis* recorded its highest average of 2.18±0.312 g/cm^3 during winter at sites I, declined sharply to the lowest average

Table (1): The averages growth rates (mm/y) of *A. humilis* and *S. pistillata* at the studied sites.

Seasons		Sites & species	*A. humilis* I	*A. humilis* II	*A. humilis* III	X′± SD	*S. pistillata* I	*S. pistillata* II	*S. pistillata* III	X′ ± SD
Autumn	mm	X	**1.61**	**1.79**	**1.81**	**1.74**	**2.59**	**2.72**	**1.04**	**2.12**
		S.D	0.08	0.014	0.06	0.11	1.77	0.460	0.06	0.930
	mm/day	X	0.018	0.02	0.02	0.019	0.03	0.03	0.012	0.02
		S.D	0.001	0.0002	0.001	0.001	0.020	0.005	0.001	0.010
Winter	mm	X	**1.65**	**1.73**	**1.83**	**1.74**	**2.7**	**3.35**	**1.14**	**2.40**
		S.D	0.12	0.14	0.18	0.09	1.730	0.3	0.1	1.140
	mm/day	X	0.018	0.019	0.02	0.019	0.03	0.037	0.013	0.027
		S.D	0.001	0.002	0.002	0.001	0.019	0.003	0.001	0.013
Spring	mm	X	**0.88**	**1.13**	**1.31**	**1.11**	**2.05**	**2.30**	**0.97**	**1.77**
		S.D	0.07	0.09	0.17	0.22	0.32	0.270	0.09	0.71
	mm/day	X	0.01	0.013	0.02	0.012	0.023	0.03	0.011	0.020
		S.D	0.001	0.001	0.002	0.002	0.004	0.003	0.0001	0.008
Summer	mm	X	**1.44**	**1.33**	**1.72**	**1.50**	**1.15**	**1.79**	**0.31**	**1.08**
		S.D	0.16	0.05	0.04	0.20	0.086	0.550	0.28	0.74
	mm/day	X	0.02	0.02	0.02	0.017	0.013	0.02	0.003	0.012
		S.D	0.002	0.001	0.001	0.002	0.001	0.006	0.003	0.008
Annual site growth rate (mm/year, n=9)			**5.58**±1.42	**5.99**±1.28	**6.67**±0.98		**8.49**±2.82	**10.16**±2.66	**3.47**±1.51	
Annual X+SD			**6.08±0.55**				**7.37±3.488**			

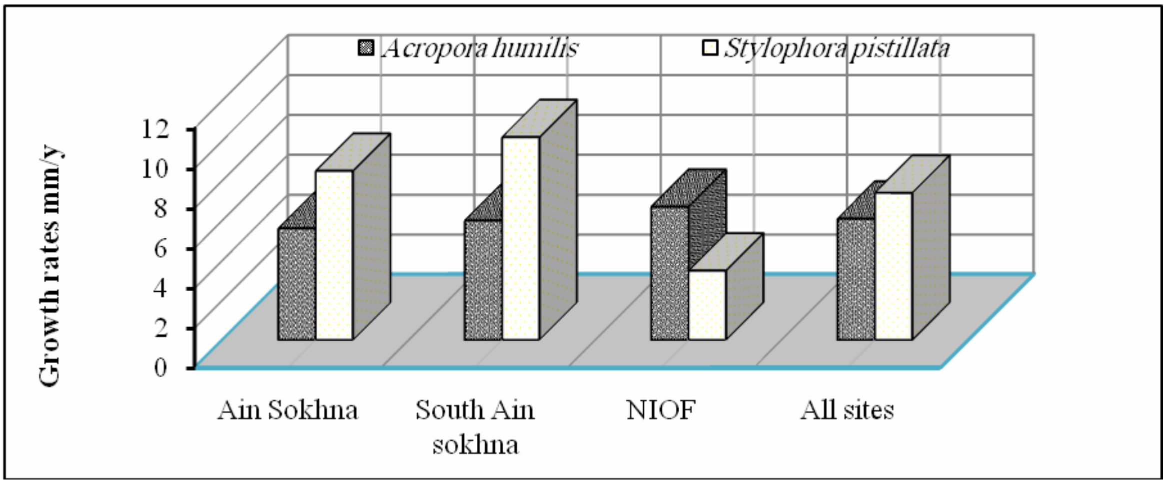
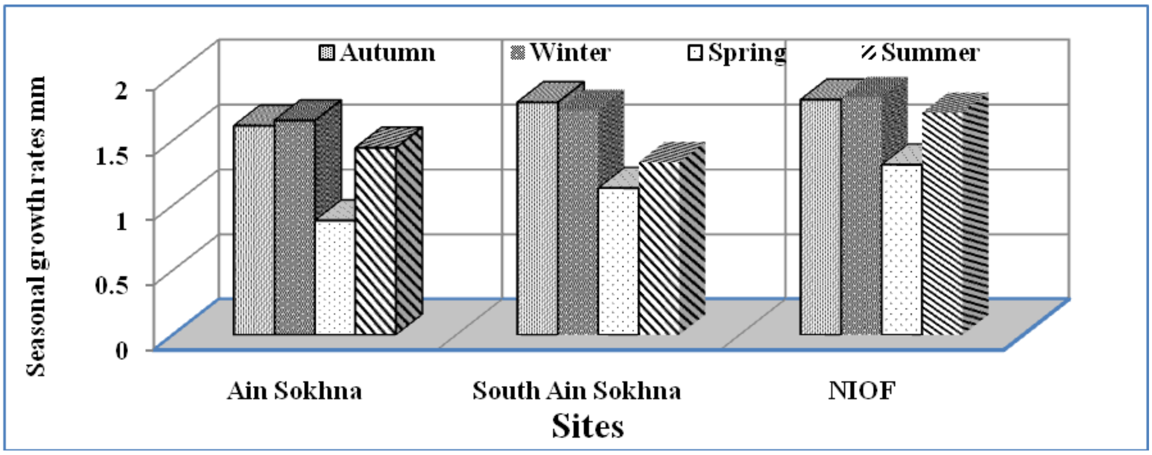


Figure (3): Sows the annual average growth rates (mm) of *A. humilis* and *S. pistillata* at the study sites.



Figures (4): Shows the seasonal changes in growth rates (mm) of *Acropora humilis* at the studied sites.

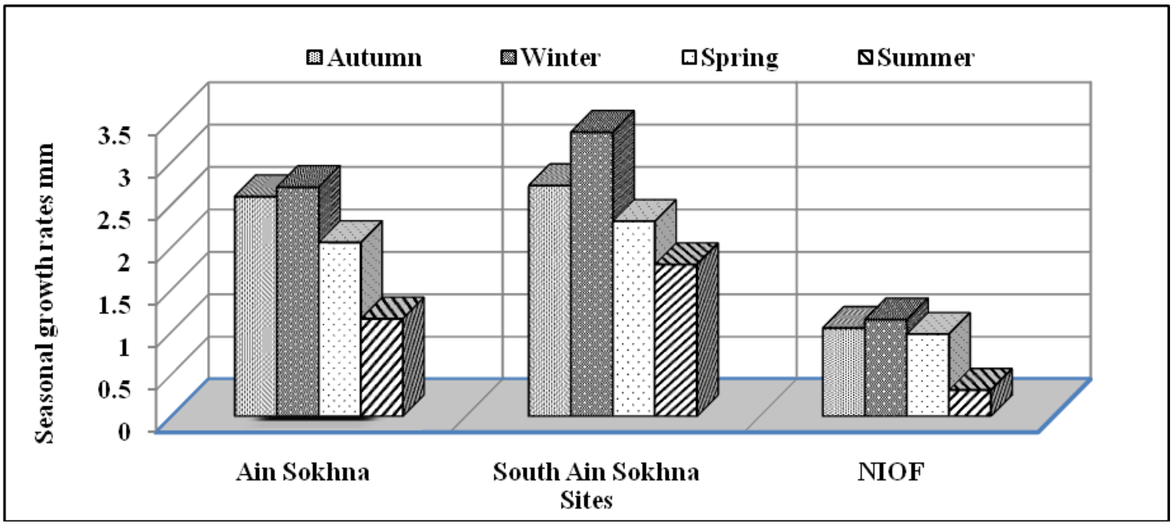


Figure (5): Seasonal growth rates (mm)of *S. pistillata* at the studied sites.

of 1.47±0.35 g/cm^{3}during summer at site II. However, there was a gradual increase in skeletal densities from summer reaching the highest values during winter at sites I and II but declined again during the following spring. At site III, the densities increased through summer reaching the high values during autumn but declined slightly during the following winter and spring (Table, 2 and Figure, 7).

For *S. pistillata*, the skeletal densities recorded the highest average of 2.51±0.21 g/cm^3 during autumn at site I, declined to the lowest average (1.62±0.33 g/cm^3) during summer at site II (Table, 2 & Figure, 8). These results indicated that, the highest values were recorded during autumn at site I and winter at sites II and III. On the other hand, all the lowest values recorded at all sites during summer. It was noticed that, a gradual increases from summer to winter were detected at sites II and III, followed by decline during the following spring. While at site I, a gradual decline was started in winter and continued through spring and the following summer.

Table (2): The average values of skeletal densities (g/cm^3) of the *A. humilis* and *S. pistillata* at the studied sites.

Species	Seasons \ Sites	Site 1	Site 2	Site 3
A. humilis	Summer	1.56±0.20	1.47±0.35	1.88±0.5
	Autumn	2.11±0.23	1.71±0.36	2.14±0.17
	Winter	2.18±0.31	2.04±0.08	1.86±0.47
	spring	1.675±0.33	1.60±0.08	1.91±0.46
	Average ± S. D	**1.88±0.3**	**1.71±0.244**	**1.95±0.13**
	Grand average± SD	**1.85±0.13**		
S. pistillata	Summer	1.93±0.06	1.62±0.33	1.79±0.13
	Autumn	2.51±0.21	1.99±0.06	1.97±0.22
	Winter	2.29±0.16	2.21±0.20	2.50±.54
	Spring	2.09±0.24	1.77±0.42	2.41±0.95
	Average± SD	**2.2±0.25**	**1.90±0.26**	**2.17±0.34**
	Grand average± SD	**2.09±0.17**		

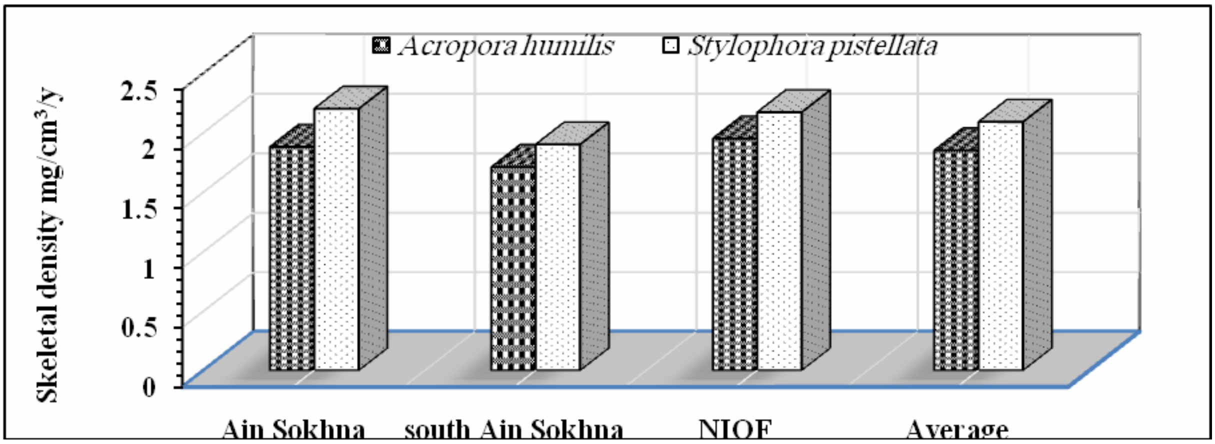


Figure (6): Shows the annual averages of skeletal densities (g/cm^3) of*A. humilis* and *S. pistillata* at the studied sites

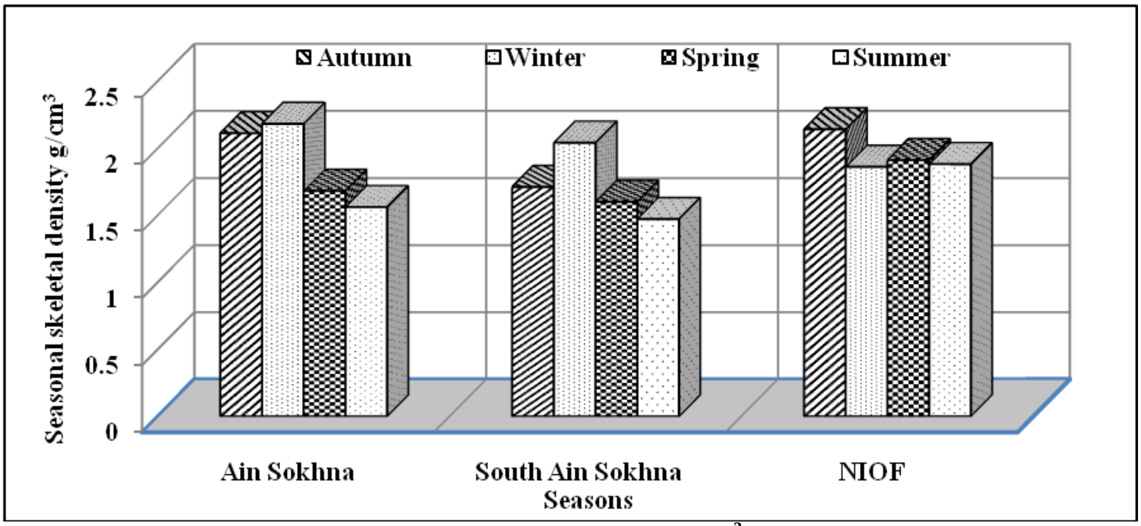


Figure (7): Shows the seasonal averages of skeletal density (g/cm^3) of *A.humilis* at the studied sites.

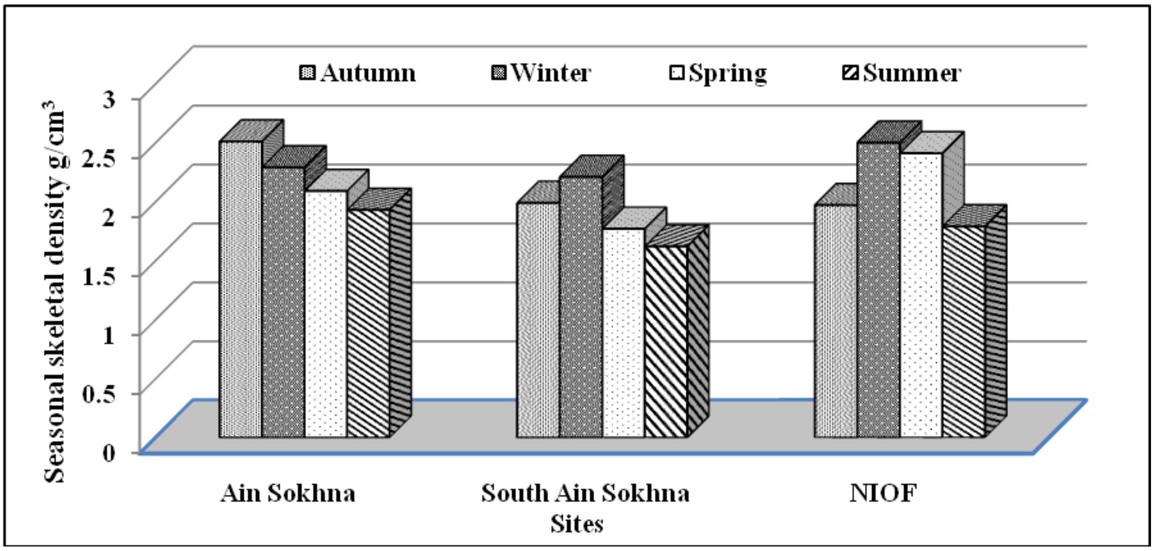


Figure (8): Shows the seasonal averages of skeletal density(g/cm^3) of *S.pistillata*at the studied sites.

DISCUSSION

At the present study the linear growth and skeletal density for the most common specie, *Acropora humilis* and *Stylophora pistillata* distributed in the northern Red Sea and western coast of the Suez Gulf were studied. The obtained results during this study showed that, there are remarkable differences in the annual rate of growth and skeletal density for the two species, in addition to spatial and seasonal variations in the average values of these rates. The present results indicated that, *S. pistillata* had higher annual growth rates at all sites than *A. humilis*, which averaged 7.37±3.488 mm/ y for the first species and 6.08±0.55 mm/ y for the latter one. These results are in well agreement with that reported by Kotb (1996) for the same species studied at three depths (5, 10 and 30 m) at Na'ama Bay, Sharm El-Sheikh, and that reported by Al-Hammady *et al*. (2011) for corals colonies at 5 m depth along the Red Sea coasts from El-Hamarween to Ras El-Bahr(Ras Gharib). But the present results are in contrast to that reported by Mohamed *et al*. (2007) for coral colonies at three offshore reefs facing Hurghada and Sharaka(2011) for coral colonies inhabited both of exposed and sheltered reefs offshore Hurghada City, in which *A. humilis* had growth rates higher than that obtained during the present study.

Moreover, Mohamed *et al*. (2007) studied the growth rate of *Acropora humilis* and *Stylophora pistillata* at offshore reefs facing Hurghada. They found that, the mean annual growth of *A. humillis* and *S.pistillata* were7.07 and 6.22mm/y respectively. Their data are much higher than that recorded at the present work for the same species (6.67 and 3.46mm/y, respectively). Also, the earlier findings of Isdale (1977) and Stromgren (1987) on the colonies of the same species explained that, the differences in growth rates at the same depth and time, depending on the surrounding conditions. Moreover, the lowest annual growth rates for *S. pistillata* from Na'ama Bay were recorded by Kotb (2001). He found that, the annual growth rate of *S.pistillata* averaged 6.34 mm/y at 5m depth, which was higher than that recorded for the same species (3.46 mm/y) at site III but much lower compared with 8.49 and 10.16 mm/y recorded at sites I and II, respectively. This difference may be due to increasing in latitudes and surrounding conditions especially temperature. Similar results were recorded by Glynn (1977) for *P.damicornis*within 7m depth in the Gulf of Panama and the Gulf of Chiriqui (Pacific coast of Panama) which averaged annual growth of 3.08 and 3.86mm/y respectively and related the higher growth to the higher temperature in the Gulf of Chiriqui

On the other hand, there were remarkable spatial variations between growth rates of the two studied coral species during this study. The highest annual growth rates for *S. pistillata* were recorded at sites I and II (Gulf of Suez), but declined remarkably at site III (northern Red Sea). In contrast, *A. humilis* reached its highest growth rate atsite III (northern Red Sea), but decreased gradually northwards at sites II and I(Gulf of Suez). These results are very similar to that recorded by Kotb (1996) on *S. pistillata* from Na'ama Bay (Sharm El–Sheikh) which had higher growth rates averaged 6.51, 7.48 and 9.24 mm/y at 5, 15 and 30 m depths compared with lower rates varied from 5.89 to 6.86 mm/ y at three reefs facing Hurghada, and with Al-Hammady (20011) with exception only Ras El Behar which had 14.79mm/y. However, the growth rates for this species were significantly higher than reported by Al- Azri (1996) which averaged only 0.36 mm/y.

For *A. humilis,* the annual growth rates were nearly similar to that previously estimated for all the northern Red Sea inhabiting colonies reported by Mohamede *et al.* (2007) which averaged 6.86, 7.49 and 6,87mm/y at Gotta El-Erg, Abu Qalawa and El Fanadir (northern Red Sea), and Al- Hammady (2011) which varied from 6.21 to 7.23 mm/y; but were much lower than reported by Sharaka (2011) in both exposed and sheltered reefs which varied from 6.61 to 9.17 mm/y, showing higher rates at exposed than sheltered reefs.

Spatial variations in the annual growth rates of the two studied corals, *A. humilis* and *S. pistillata* may be attributed either to increasing nutrients as demonstrated by Al-Hammady (2011) for coral colonies at El Hamraween and Hussein (2016) at Old Al-QuseirHarbour, or due to effects of wave actions as explained by Sharaka (2011) for those species inhabiting exposed reefs, or to differences in latitudes and human impacts as shown during the present results(Kotb, 1996; Al-Hammady, 2011; Hussein, 2016).

On the other hand, the present results showed that, there are obvious seasonal fluctuations in growth rates of the studied species. The lowest averages were recorded during spring for the two species, compared with the highest averages recorded during winter and autumn. These results are in contrast with that reported by Kotb *et al*. (2007) and Al-Hammady (2011) on the same species from the northern Red Sea. Mohamed*et al*. (2007) recorded the highest seasonal growth rates in summer (warm season), declined slightly in spring and reached the minimum averages in winter (cold season), while Al-Hammady (2011) obtained the same results on the same species, but the lowest average were recorded in autumn. The same results were also reported by Loya (1985). He studied the LE of S. *pistillata* in the northern Gulf of Aqaba and recorded higher length extension (LE) was almost 0.003mm/day in summer, declined to the lowest LE, averaged 0.001 mm/day in winter at 5m depth. However, these results are much lower than those recorded in the present study which averaged 0.012 and 0.0267 mm/day for summer and winter, respectively.

On the other hand, Hussein (2016) found that the highest rates were recorded during summer and spring for both *Acropora hemperchii* and *Pocillopora verrucosa* compared with the lowest rates recorded in autumn. But for *Milleporaplatyphyla*, Sharaka Attala *et al*. (2011)reported higher rates in spring followed by summer, and lowest rates were reported in autumn. Tunnicliffe (1983) reported that, in general all members of family Acroporidae have higher linear extension rate than other scleractinian corals. While, Davies (1983) found that, in some coral species the growth rate varied from 2.5 to 26.6 cm/y in length in *Acropora* for Atlantic Ocean, but decline to vary between 0.81 to 2.5 cm/y in *Montastrea annularies*.

The present results showed that, the skeletal densities of *A. humilis* and *S. pistillata* had annual averages of 1.85±0.13 and 2.09±0.17 g/cm^3 for the two species, respectively. These results exhibited spatial variations and showed skeletal density for *S. pistillata* higher than those of *A. humilis* at all sites. These results are being slightly lower than that reported by Kotb *et al*. (2002). They estimated skeletal densities for *S. pistillata* and *A. granulosa* at 5m depth and found that, these densities averaged 1.98 mg/mm^3/y for the first species and 2.35 mg/mm^3/y for the latter one.

On the other hand, the skeletal densities of *A. Humillis* recorded at NIOF (1.95 ±0.13g/cm^3) is slightly higher than that recorded by Al-Hammady (2011) which averaged 1.83 g/cm^3 at El-Hamraween, but being slightly lower at site II and nearly similar to that recorded at site I. For *S. pistillata* its densities ranged from 1.62±0.33 to 2.51±0.21g/cm^3 which is agreement with Al-Hammady (2011) on the same species which ranged from 1.24 to 2.56 g/cm^3.These results are also very similar to that recorded by Hussein (2016) on *Pocillopora verrucosa* which had skeletal density higher than *Acropora hemprichii* at all studied sites except at El Hamraween affected with phosphates. On the other hand, relatively higher average of skeletal densities were recorded during winter and autumn for *A. humilis* and in winter and spring for *S. pistillata*, with minimum values during summer for both species. This may be coincide with increasing growth rates during cold seasons and decreasing these rates during warm seasons for the two species, respectively.

REFRENCES

Al-Azri, A.N.A. (1996): Some ecological studies on coral reefs of the Gulf of Aqaba (South Sinai) Red Sea, Egypt. *B.Sc. Thesis, Sultan Qaboos University*,133 Pp.

Al-Hammady, M.A.M. (2011): Patterns of bleaching and fertility in the two corals Red Sea *Stylophora pistillata* and *Acropora humillis*, as biomonitors of environmental impacts at Red Sea, Egypt. *Ph. D. Thesis, Zool., Dept., Faculty of Science, Al-Azhar Univ., Assuit, Egypt*,481Pp.

Ammar, M.A.A. (2004): The role of zooplankton and water quality on some biological and ecological aspects of corals along the Egyptian Red Sea coast. *Ph.D. Thesis, Suez Canal University, Ismailia, Egypt*, 325 Pp.

Ammar, M.S.A., Mohamed, T.A. and Al-Hammady, M.A.M. (2005): Skeletal density (Strength) of some corals in an activity flooding and a non-flooding site, South MarsaAlam, Red Sea, Egypt. *J. Egypt. Ger. Soc. Zool. Vol.*, (46D).125-139 pp.

Attala, T. M.; Hanafy, M.H. and Aamer, M.A. (2011): Growth rates of the two reef-building species, *Acropora humilis* and *Millepora platyphylla*at Hurghada, Red Sea, Egypt.*Egypt J. Aquat. Biol. & Fish.*, Vol.15(2): 1- 15.

Charuchinda, M. and Hylleberg. J. (1984): Skeletal extension of *Acropora formosa* at a fringing reef in the Andaman Sea. *Coral Reefs*,3: 215-219.

Davies, P. J. (1983): Reef growth, Pp. 69-106. In: Barnes, D. G. (Ed.) Perspectives on coral reefs. *AIMS Contribution No*. 200.

Dar, M. A. and Mohammed, T. A. (2009): Seasonal variations in the skeletogensis process in some branching corals of the Red Sea. *Inter.l J. Mar. Sci.*, 25 (1): 31-44.

Dullo, W.;Gektidis,M.; Golubic, S.; Heiss, G. A.; Kampmann, H.; Kiene, W.; Kroll, D. K.; Kuhrau, M. L.; Radtke, G.; Reijmer, J. G.; Reinicke.G. B.; Schlichter, D.; Schuhmacher, H.; Vogel, K. (1995): Factors controlling Holocene reef growth: An interdisciplinary approach.*Facies*,52:145-188.

English, S.; Wilkinson, C. and Baker, V. (1997): Survey manual fir tropical marine resources 2nd Edition, 385 pp.

Gladfelter, E.H.(1984): Skeletal development in *Acropora cervicornis*: III- A comparison of monthly rates of linear extension arid calcium carbonate accretion measured over a year. *Coral Reefs*, 3:51-57.

Glynn, P. W. (1977):Coral growth in upwelling and non upwelling areas off the Pacific coast of Panama. *J. Mar. Res*., 35 (3): 567-585.

Graus, R.R. and Macintyre, I.G. (1982): Variation in growth forms of the reef coral *M. annularis* (Ellis & Solander): A quantitative evaluation of growth response to light distribution using computer simulation. In: Rutzelr, K. and Macintyre, I.G. (ed).The Atlantic Barrier reef Ecosystem at Carrie Bow Cay, Belize. I. Structure and communities. *Smithson. Mar. Sci*., 12:441-464.

Head, S.M. (1987): Corals and coral reefs of the Red Sea. In: Key environments Red Sea (Edwardes, A. J and Head, S.M. eds.) *Pergamon Press, Oxford*, 128-151.

Hussein, H.N.M. (2016): The effect of some pollutants on coral reef reproduction and growth at Hurghada-Al-Qusier sector, Red Sea, Egypt. *Ph.D. Thesis, Al-Azhar Univ., Egypt*, 148 Pp.

Isdale, P. J. (1977): Variation in growth rate of hermatypic corals in a uniform environment. *Proc. 3rd Int. Coral Reef Symp*., 2: 403-408.

Kotb, M. A. (1996). Ecological and biological studies on the coral reefs at southern Sinai coasts, Red Sea, Egypt. *Ph. D. Thesis. Marine Science Dept. F. Scie.Suez Canal Univ*., 174 Pp.

Kotb, M.M.A. (2001): Growth rates of three reef-building coral species in the northern Red sea, Egypt. *J. Aquat. BioL& fish.* No.4 VoL 5,:165 -185.

Kotb, M.M.A. (2002): Skeletal density of three reef-building coral species in the northern Red sea, Egypt. *J. Egypt. Ger. Soc. Zool*. VoL 39 D,:1 -16.

Mohamed, T.A;Kotb, M.M.A.; Ghobashy, A. and El-Deek, M. (2007):Reproduction and growth rate of two scleractinian coral species in the northern Red Sea, Egypt. *J. Aquac. Res*., 33(2), 70-86.

Logan, A. and Tomascik, T. (1991): Extension growth rates in two coral species from high-latitude reefs of Bermuda. *Coral Reefs*, 10:155-160.

Loya.Y. (1985): Seasonal changes in growth rate of a Red Sea coral population. *Proc. 5th Int. Coral Reef Cong., Tahiti*., 5:187-191.

Mohamed, T.A. (2003): Study of growth and reproduction of some corals at Hurghada region with reference to the effect of some pollutants in the area. *Ph.D. Thesis, Fac. Suez Canal Univ., Egypt*.

Oliver, J.K. (1984): Intra-colony variation in the growth of *Acropora formosa*: Extension rates and skeletal structure of white (zooxanthellae-free) and brown tipped branches. *Coral Reefs*,3:139-147

Rahav, O.; Ben-Zion, M.; Achituv, Y. & Dubinsky, Z. (1991):A photographic, computerized method for in situ growth measurements in reef building cnidarians. *Coral Reefs*, 9:204-...

Salem, E.S.E.(2017): Aspects of growth and reproduction of *Tetralia glaberrim*a and *Hapalocarcinus marsupialis* and their relationship with coral reef at Gulf of Aqaba, Red Sea, Egypt. *Ph. D. Thesis, Al-Azhar Univ., Cairo, Egypt*292 Pp.

Sharaka, T.M.A. (2011): Assessment study on natural and human impacts on the coral reefs of the Red Sea, Egypt. Ph. D. Thesis. *Marine Science Dept. F. Scie.Suez Canal Univ*.254Pp.

Sheppard, C.R.C and Sheppard, A.L.S. (1991): Corals and coral communities of Arabia, p. 3-170. In: W. Buttiker and Krupp (eds.) *Fauna of Saudi Arabia Vol .12. Natural History Museum, Basle, Switzerland*, 419pp.

Stromgren, T. (1987): The effect of light on the growth rate of intertidal *Acropora pulchra* (Brook) from Phuket, Thailand, lat. 8°K . *Coral Reefs*, 6: 43-47.

Tunnicliffe, V. (1983): Caribbean Staghorn coral population: per-hurricane Allen Condition in Discovery Bay, Jamaica. *Bull. Mar. Sci*., 33:132-151.

الملخص العربي

التغيرات المكانية والزمنية في معدلات نمو وكثافة الهيكل في الشعاب المرجانية أكروبورا هيوميليس واستيلوفورا بيستيلاتا (المراجين الكلسية: اللاسعات) من خليج السويس وشمال البحر الأحمر، مصر

تعتبر المراجين الكلسية (الحجرية) واحدة من أهم بانيات الريف في المناطق الاستوائيه وتحت الاستوائية حول العالم ومن ضمنها البحر الأحمر لذا تهدف هذه الدراسة الى تقدير معدلات النمو وكذلك كثافة الهيكل لنوعين من المراجين السائدة في خليج السويس وشمال البحر الأحمر هما أكروبورا هيوميليس واستيلوفورابيستيلاتا.

أظهرت النتائج الحالية لهذه الدراسة ان المتوسط السنوي لمعدلات النمو لمرجان أكروبورا هيوميليس منخفض(0.001 ± 6.08 مم/ سنه) بالمقارنه مع المتوسط السنوي لمعدلات نمو مرجان استيلوفورا بيستيلاتا(3.49 ±7.37مم/ سنه)، بالإضافه إلى ذلك فقد اظهرت الدراسه تباين موسمى فى معدلات النمو حيث سجل مرجان أكروبورا هيوميلس أعلى متوسط لمعدلات النمو(1.74 مم) خلال موسمى الشتاء والخريف(المواسم البارده) ثم انخفض إلى0.22±1.11مم خلال موسم الربيع. من ناحيه أخري سجل مرجان استيلوفورا بيستيلاتا أعلى متوسط له (1.14± 2.40 مم) خلال موسم الشتاء ثم انخفض ليصل الى أقل متوسط (0.74 ± 1.08مم) خلال موسم الصيف.وقد أوضحت الدراسه أن هناك تباينا مكانيا في معدلات النمو حيث سجل مرجان أكروبورا هيوملیس أعلى متوسط لمعدلات النمو بلغ0.98±6.76مم عند الموقع الثالث ثم انخفض تدريجيا باتجاه الشمال ليسجل 1.28 ±5.99 مم و1.42 ±5.58مم عند الموقعين الثانى والأول على الترتيب. وفى نفس السياق سجل مرجان استيلوفورا أعلى متوسط سنوي ± 10.16 (2.66مم/سنه) عند الموقع الثانى ثم انخفض إلى 8.49مم/ سنه في الموقع الأول ليصل لأقل متوسط له 3.46 (مم/ سنه) في تجمعات الشعب بالموقع الثالث.

كما بلغ المتوسط السنوي لكثافة الهيكل في نوعي المرجان أكروبورا هيوميليس واستيلوفورابستيلاتا0.13 ± 1.85جم/سم ^{3} و 0.17±2.09 جم/سم ^{3}على الترتيب، إلا أنها أظهرت تباينا في المواقع المختلفة حيث انخفضت هذ القيمهفي مرجان اكروبورا هيوميليس إلى0.24±1.71 جم/سم ^{3} عند الموقع الثانى ثم عاودت الزياده لتصلإلى 0.13±1.95جم/سم ^{3} عند الموقع الثالث. بينما أظهر مرجان استيلوفورا نتائج معاكسه حيث بلغ متوسط كثافة الهيكل0.25±2.20جم/سم ^{3} عند الموقع الأول وتناقص إلى 0.26±1.90جم/سم ^{3} عند الموقع الثانى. ومن ناحيه أخرى فقد أظهرت الدراسه وجود تباين موسمي لكثافة الهيكل في النوعين فقد سجل مرجان أكروبورا هيوميليس أعلى متوسط له(0.31 ± 2.18جم/سم ^{3}) خلال موسم الشتاء عند الموقع الأول ثم انخفض إلى أدنى مستوياته (0.35 ±1.74جم/سم ^{3})خلال موسم الصيف عند الموقع الثانى، بينما سجل أعلى متوسط لكثافة الهيكل في مرجان استيلوفورا بيستيلاتا (±2.51 0.21جم/سم ^{3}) خلال موسم الخريف عند الموقع الأول غير أنه تناقص إلى أدنى متوسط له (0.33±1.62جم/سم ^{3}) خلال موسم الصيف عند الموقع الثانى.