Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(4): 785 – 805 (2021)
www.ejabf.journals.ekb.eg

Impact of tourism and fishing on the coral reef health along the west coast of the Gulf of Aqaba, Red Sea, Egypt

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ARTICLE INFO
Article History:
Received: Aug. 18, 2021
Accepted: Aug. 23, 2021
Online: Aug. 30, 2021

Keywords:
Benthic cover
Coral reef
Key invertebrates
Tourism
Overfishing
Dahab
Nuweiba'a
Red Sea
Egypt

ABSTRACT

To assess the anthropogenic impact on the Egyptian coast of the Gulf of Aqaba, particularly the tourism and fishing influences. Eighteen sites were surveyed from November 2019 to February 2020. At each site, coral cover was determined using Point Intercept Transect (PIT) method, at depths of 3 and 8 m. Also, abundances of invertebrate species were determined by belt transect method at the same depths for each site. Mean of cover percentages of corals (hard and soft) at Dahab sector ranged from 16.7 to 64.0 % at 3m, and from 3.3 to 56.0 % at 8m. At Nuweiba'a, it ranged from 7.3 to 55.3 % at 3m and from 4.0 to 30.0 % at 8 m. Statistical analyses confirmed that there were significant differences in coral assemblage in relation to depth and sites. A total of 78 invertebrate species were recorded and counted from the two depths at the two sectors. Of which, the molluscan, *Tridacna* sp. and the echinoderms, *Echinometra mathaei* and *Diadema setosum* were found to be the most abundant species at the two sectors as well as at both depths. In addition, the abundance and assemblages of recorded key invertebrate species were varied among the sectors. Comparison of the influences of tourism and fishing showed several observations suggested a moderate decline in coral cover and key invertebrate species, with a notable increase of total algal cover in the Nuweiba'a sector.

INTRODUCTION

Coral reefs that supply and preserve the services for around 500 million people now impacted by natural or human disturbance such coastal expansion, newly added metropolitan areas, random fisheries, and pollution that can damage coral resilience and cause mortality **(Hughes *et al.*, 2017; Adjeroud *et al.*, 2018; Lamb *et al.*, 2018; Hughes *et al.*, 2018a; McWilliam *et al.*, 2020).** The decreases in coral coverage and increased sponge or algal coverage have a diminishing impact on the services provided **(Done 1992; Norstro¨m *et al.*, 2009; Bell *et al.*, 2013)**.

Protected areas with temperate tolerant corals are of crucial importance; this unusual feature, with warm water up to 28 degrees **(Abdelmongy & El-Moselhy, 2015; Rasul *et al.*, 2015).** The Gulf of Aqaba showed most rates of temperate ranging of the Red Sea **(Chaidez *et al.*, 2017).** The Gulf has not been covered by a coral mass bleaching, that might be attributed to the most heat tolerated corals since it contains a particular gene of exceptional heat resistance that may be helpful against bleaching around the planet **(Fine *et al.*, 2013; Osman *et al.*, 2018).** Despite the fact of the Gulf of Aqaba is shielded from climate change, there is another dangerous element may alter a mass of corals, which is a consequence of rising human stress due to excess of coastal development and overfishing **(Rinkevich, 2005; Naumann *et al.*, 2015).** Intensive fishing, snorkeling and coastal development have investigated and showed detrimental influences on the coral health of the gulf **(Zakai & Chadwick-Furman, 2002; Hasler & Ott, 2008; Naumann *et al.*, 2015).** A previous research showed that there is a link between increasing the algal coverage and an increasing of the quantity of nutrients **(Bahartan *et al.*, 2010; Naumann *et al.*, 2015).**

Algae are the natural space competitors for corals, with increases algal cover, coral cover declined, and hence related fish recruitment **(Rasher & Hay, 2010; Dixson *et al.*, 2014).** Algal consuming organisms (represented by fish, urchins, and other crustaceans) are required to make competition balance to secure the space that coral need to recruit and grow. However, when those algal consumers decrease in an area due to anthropogenic disturbances specially overfishing, algal cover increases, and disturb coral recruit and growth, which cause corals degradation and shifting associated communities **(Williams & Polunin, 2001; Bellwood *et al.*, 2004; Burkepile & Hay, 2008; Hoey & Bellwood, 2011; Sandin & McNamara, 2012)**.

MATERIALS AND METHODS

1. Study sites

Eighteen sites were selected at Dahab and Nuweiba'a sectors **(Table 1)** to study the influences of the two main human activities tourism and fishing on the coral coverage and their associated invertebrate fauna during the period from November 2019 to February, 2020. Nine sites were selected in Dahab sector **(Fig. 1a)** to study the influences of tourism and another nine sites in the Nuweiba'a sector **(Fig. 1b)** to study the effect of fishing on coral coverage. All selected sites were surveyed, so that any effect of anthropogenic impacts on coral reef and their associated invertebrates might be apparent.

Table 1: The coordinates and names of the selected study sites at Dahab and Nuweiba'a ectors

Sector	Site name	Latitude	Longitude
Dahab	Caves	28°25'0.06"	34°27'22.52"
	Moray Garden	28°26'15.86"	34°27'32.78"
	Ecotel hotel	28°27'26.63"	34°28'18.65"
	Lighthouse	28°29'56.07"	34°31'11.55"
	Eel Garden	28°30'19.19"	34°31'12.49"
	Ras Abu Helal	28°32'32.04"	34°31'0.14"
	Ras Abu Talha	28°32'53.05"	34°31'4.89"
	Canyon	28°33'17.17"	34°31'15.73"
	Tiger Reef	28°34'3.15"	34°31'59.02"
Nuweiba'a	El-Sokhn north	28°45'31.46"	34°37'24.30"
	Wadi Miran	28°48'22.39"	34°37'29.62"
	Megeizer	28°50'2.66"	34°37'14.43"
	Big Stone	28°51'6.56"	34°37'52.02"
	Wadi Hobiq	28°52'38.55"	34°38'46.38"
	Hobiq North	28°53'43.59"	34°38'56.96"
	Mazariq South	28°54'53.67"	34°38'40.69"
	Wadi El Faraa	28°56'2.69"	34°38'46.48"
	El Hognah	28°57'15.09"	34°38'27.82"

2. Coral surveys

Benthic composition was determined using the point intercept transect (PIT) method **(Hill & Wilkinson, 2004).** A transect of 25 m long was laid parallel to the shoreline at two selected depths (3m and 8m) which representing the main topographic zones (reef face and reef slope). Benthos categories lying under a point of the transect line were recorded and counted every 50 cm along the transect length. This step was repeated three times at each depth of each site. Classification of hard (Scleractinia) coral forms, done according to their morphology, as this is an important in coral functioning and in coral reef structural complexity **(Darling *et al.,* 2012)**. Ten substrate categories which covered all benthic biotic and abiotic elements were determined.

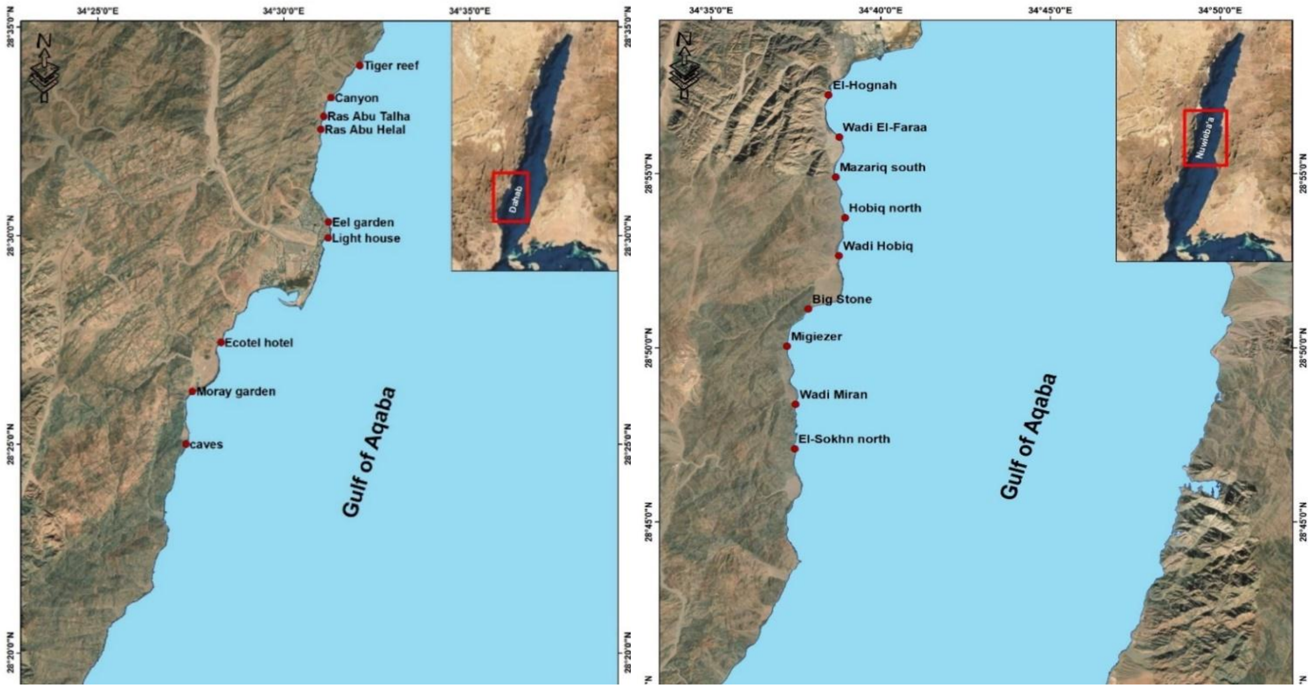

Fig. (1): Maps of the Southern Sinai Peninsula showing the locations of the studied sites at Dahab sector (left) and Nuweiba'a sector (right)

3. Associated Invertebrates census

Associated invertebrates with corals were estimated using underwater visual census at the two depths by applying two transects of 100 m long. All invertebrate species belonging to Mollusca and Echinodermata were recorded and counted within 2.5 m on both sides of the transect route, yielding a measured area of 1000 m^2 per site. Also, some key invertebrate species such as crown of thorns, starfish, *Acanthaster planci;* grazer urchins, (longspined urchins belonging to *Diadema* and *Echinotrix* genera); pencil urchin, *Heterocentrotus mammillatus;* collector urchin, *Tripneustes gratilla;* giant clams, *Tridacna* spp; and corallivorous snails, *Drupella* spp and *Coralliophila* spp were identified and counted.

4. Data analysis

Means and standard deviations of percentage cover of each benthic substratum type were calculated for each depth at each site. Moreover, a mortality index using the ratio of dead hard coral to live hard coral (dead coral divided by all coral coverage) was determined to assess the health of hard coral communities as it independent of actual coral cover. So, the value of 0.5 indicates an equal amount of live and dead coral cover. While values more than 0.5 indicate dead coral cover is higher than live coral cover with relatively more unhealthy coral communities where the index approaches to one. Whereas the values less than 0.5 indicate higher live coral cover than dead coral cover, i.e., relatively more healthy coral communities as the index approaches to zero **(Gomez *et al*.,1994).** Multivariate analyses of invertebrates' assemblages were conducted using the PRIMER software package **(Clarke, 1993; Clarke & Warwick, 2001).** Analysis of variance (ANOVA) using Fisher LSD method to refuse the null hypnosis and confirm the presence of significant differences between different measurements, the analysis become available using Sigma Plot V12.5 and MiniTab V18.1 software.

RESULTS AND DISCUSSION

Substrate composition

The substrate at Dahab and Nuweiba'a sectors consists of ten categories these are hard live corals (Scleractanian only) includes branching hard coral, columnar, tabular, massive, encrusting, foliose, solitary (mushroom corals, Fungiidae); dead corals; hydrocorals, genus *Millepora* including *Millepora dichotoma* and *Millepora platyphylla*; soft corals including Alcyoniidae, Xeniidae, Nephtheidae, Tubipora spp., and zoanthids; macro algae; turf algae; crustose coralline algae; other life forms including ascidians, sea grasses and sponges; abiotic elements including sand, silt and rock; and rubble. At three meters depth, hard live coral had the highest average percentage cover at both sectors, being 41.4 $\pm$ 16.4 % and 31.0 $\pm$ 16.1 % at Dahab and Nuweiba'a respectively, followed by abiotic elements with average percentage of 27.9 $\pm$ 17.1 % and 19.6 $\pm$ 13.4 % at both sectors respectively. The other life forms had very low average percentage cover at both sectors being 2.0 %, while the remaining substrate categories had moderate average percentage cover **(Fig. 2)**. In contrast, at eight-meters depth, the other life forms had the highest average percentage cover of 64.7 $\pm$ 19.8 % at Nuweiba'a while it was very low at Dahab, being only two. Abiotic elements came next after other life forms with average of 45.9 $\pm$ 29.4 and 38.6 $\pm$ 18.3 %, followed by hard live coral with average of 29.2 $\pm$ 17.7 and 14.7 $\pm$ 8.9 % at Dahab and Nuweiba'a respectively. The other substrate categories had very low average values and most of them with average percentage cover under10.0 % **(Fig. 3)**.

Coral abundance and mortality index:

At Dahab sector, the overall average of hard live coral cover was 41.4 $\pm$ 16.4 % at 3 m depth and 29.2 $\pm$ 17.7 % at 8 m depth. At 3 m depth, the highest coral cover was 64.0 $\pm$ 8.7% recorded at Ras Abu Talha site, while the lowest one was 16.7 $\pm$ 7.6 recorded at Ecotel Hotel site. The coral cover at the other sites varied from 18.0 $\pm$ 10.6 % to 59.3 $\pm$ 10.3 % at Moray Garden and Eel Garden sites respectively. Whereas, at 8 m depth, the lowest coral cover was 3.3 $\pm$ 1.2 % recorded at Ecotel Hotel site and the highest coral cover was 56.0 $\pm$ 12.2 % at Ras Abu Talha site. The coral cover at the other sites varied from 5.3 $\pm$ 2.3 % to 46.0 $\pm$ 7.2 % at Moray Garden and Eel Garden sites respectively **(Table 2** and **Fig. 4)**.

On the other hand, at Nuweiba'a sector, the overall average of hard live coral cover was 31.0 $\pm$ 16.1 % at 3 m depth and 14.7 $\pm$ 8.9 % at 8 m depth. At 3 m depth, the highest coral cover was 55.3 $\pm$ 10.1 % recorded at Wadi Hobique, while the lowest one was 7.3 $\pm$ 3.1 recorded at El Faraa site. The coral cover at the other sites varied from 12.0 $\pm$ 5.3% to 47.3 $\pm$ 9.9 % at El Hognah and Wadi Miran sites respectively. Whereas, at 8 m depth, the lowest coral cover was 4.0 $\pm$ 2.8 % recorded at El Hognah site and the highest coral cover was 30.0 $\pm$ 5.3 % at Wadi Hobique site. The coral cover at the other sites varied from 6.0 $\pm$ 0.0 % to 20.0 $\pm$ 6.0 % at Megiezer and Mazarique sites respectively **(Table 2** and **Fig. 5)**.

The mortality index of hard coral across Dahab sector revealed that at 3 m depth, the hard coral losses was very low at all sites. The values of the index at this depth varied from 0.05 at Eel Garden site to 0.20 at Ecotel Hotel site. On the other hand, at 8 m depth the mortality indices were low and slightly higher than those recorded at 3 m depth at all sites except at Moray Garden and Ecotel Hotel sites. It varied from 0.10 at Eel Garden site to 0.22 at Canyon site; whereas the mortality indices at the latter two sites mentioned above were considerably high being 0.43 and 0.32 respectively **(Fig. 6)**. At Nuweiba'a sector, the mortality index of hard coral at El Faraa site equal one at 8 m depth, this means there is no live coral, also at the same depth, the live coral coverage was markedly low at Wadi Miran site and equal only 40.0 % of all coral coverage where the mortality index equal 0.6. In contrast, at Megiezer site all corals were live and there is no dead coral where the mortality index equal zero at 8 m depth. At the remaining sites the mortality indices were moderately low and varied from 0.09 at Big Stone site to 0.45 at Mazarique site at depth of 8 m. On the other hand, at 3 m depth in the same sector, the live corals are in good health where the mortality indices were markedly low al all sites and fluctuated between 0.09 at Wadi Hobique site and 0.37 at Hobique North site **(Fig. 7)**.

Hard coral cover was found to decreases with the increasing in depth across the Dahab and Nuweiba'a sites, this is consistent with previously recorded results from the Red Sea **(Loya & Slobodkin, 1971; Loya, 1972; Kotb, 1996; Kotb *et al*., 1996; Medio, 1996; De Vantier, 2000; Tilot *et al*., 2000, Tilot *et al*., 2008, Reverter *et al.*, 2020).** Although the hard coral cover was varied among the studied sites, the more the depth got shallower, the more the sand can accumulate between the bottom substrate structure, this leading to decreasing the chances of coral larvae to settle and grew to form a new colony **(Sheppard, 1982** and **Kotb, 1996).** The present results indicated that there was no relationship between intensity of tourism and coral cover. For instance, without segregation of tourism sites that was used heavily by tourists, and those with lighter tourists the present results confirm the findings by **Tilot *et al.* (2008).** However, while the low intensity of human activity in the southern part of the Nuweiba'a region, there was a decreasing in the hard coral cover, which took a steep slope, may be because the reef slope was very shallow and that was clear in some stations. In addition, the fishing methods of the Bedouin fishermen could have caused severe damage, as seen in certain sites left entangled nets with corals. The analysis of variance data revealed that at Dahab sector, the differences between results of sites and substrate categories and their interaction were statistically highly significant, while in case of depth, the results were not significant. Whereas at Nuweiba'a sector, the differences between results of substrate and depth and their interaction were highly significant and differences between sites results were not significant.

Coral assemblages:

The hard corals recorded from the two sectors can easily recognized into five forms these are branching, tabulate/or laminar, massive, foliaceous and encrusting coral. At 3 m depth, the mean percentage of branching coral cover at Dahab is higher than those recorded at Nuweiba'a sector at the same depth being, 55.9 % and 44.7 % respectively. However, massive coral cover exhibited the same pattern as branched corals at the two sectors with percentage cover of 51.3 % and 49.5% respectively. The mean percentage of other coral forms at the same depth were represented by low coverage ranged from 2.4 % for tabulate coral at Dahab to 19.6 % for encrusting coral at Nuweiba'a sector. On the other hand, at 8 m depth, the highest mean cover percentage was 34.7 % for branching coral at Dahab sector whereas, it was 29.9 % at Nuweiba'a sector. While the massive coral cover is slightly lower than branched corals and represented by 25.2 and 19.0 % at both sectors respectively. Again, the other coral forms had very low mean cover percentage at the same depth from both sectors (Table 3 and Figure, 8).

Regarding to studied sites, at Dahab sector, the mean values of cover percentage of branching coral were high at both depths and ranged from 13.3 % at 8 m depth at Ecotel Hotel site to 94.6 % at 3 m depth at Canyon site. While the mean values of massive coral coverage were slightly higher than those for branching corals particularly at 3 m depth at some sites and varied from 17.2 % at Moray Garden site to 80.0 % at Ecotel Hotel site. Encrusting corals had moderately values of coral cover and ranged from 6.9 % to 46 % at 3 m depth at Tiger Reef and Moray Garden sites respectively. However, the other two coral forms, tabulate and foliaceous, were detected at some sites and represented by very low values of coral coverage (Table, 3). On the other hand, at Nuweiba'a sector, the mean values of branching corals cover at 3 m depth were markedly higher than those recorded at 8 m depth at all sites and varied from 7.0 % to 82.4 % for 3 m depth and from 15.6 % to 47.1 % for 8 m depth. Again, the mean values of massive coral at 3 m depth were markedly higher than those recorded at 8 m depth it ranged from 15.0 % at Wadi Mirant site to 81.8 % at El Hognah site for the former depth and varied from 7.3 % at Hobique North site to 40.6 % at Wadi Hobique site for the second depth. Encrusting corals had moderately values of coral cover with highest value of 46.4 % at El Sokhn site and the lowest one of 1.3 % at Wadi Miran site at 3 m depth. However, foliaceous corals were detected only at two sites (Megiezer and El Faraa) from 3 m depth with very low coral cover being, 21.1 and 9.1 % respectively (Table, 3). The distribution of the coral forms in general follows the same pattern found by Loya and Slobodkin (1971), Kotb (1996), Kotb *et al*. (1996) and Tilot *et al*. (2008) which indicate that the relative abundance of branched corals tends to decrease with depth, as same as massive at the studied sites (Table 3 and Fig. 8).

By using analysis of variance (ANOVA) among sectors, the analysis of variance data revealed that at Dahab sector, the differences between results of sites, depths, and coral forms as well as their interaction were statistically highly significant. On the other hand, at Nuweiba'a sector, the differences between results of coral forms and depths as well as their interaction were statistically significant, while differences between sites results were non-significant. However, there was a significant variation between Dahab and Nuweiba'a at 8 m depth which might be attributed to the difference of the reef slope as a topographic zone between the two sectors.

Table (2). Mean cover percentage and standard deviation of substrate categories at studied sites at two depths from Dahab and Nuweiba'a sectors.

Sector	Site	Depth	Substrate categories									
			Hard live coral	Soft coral	Millipora	Macro algae	Coralline algae	Turf algae	Other life forms	Abiotic elements	Rubble	Dead coral
Dahab	CAV	3 m	43.3 ± 14.5	10.0 ± 2.8	20.0 ± 2.8			7.3 ± 4.2		27.3 ± 17.9		6.0
		8 m	32.0 ± 14.0	4.0 ± 3.5	2.0 ± 0.0	2.0 ± 0.0		8.0 ± 0.0		49.3 ± 4.2		10.0 ± 0.0
	MOG	3 m	18.0 ± 10.6	3.0 ± 1.4	4.0 ± 0.0	2.0		9.3 ± 4.2		63.3 ± 18.1		6.0 ± 2.8
		8 m	5.3 ± 2.3						22.0	84.7 ± 13.3		4.0 ± 0.0
	ECH	3 m	16.7 ± 7.6	3.0 ± 1.4	21.3 ± 14.2			10.7 ± 2.3		42.7 ± 11.4		10.0 ± 2.8
		8 m	3.3 ± 1.2	3.0 ± 1.4				4.0		91.3 ± 4.2		3.0 ± 1.4
	LIH	3 m	34.7 ± 3.1	2.7 ± 1.2	3.0 ± 1.4	2.0	10.7 ± 1.2	3.3 ± 1.2	5.0 ± 4.2	35.3 ± 3.1	3.0 ± 1.4	5.3 ± 2.3
		8 m	26.0 ± 13.1	5.0 ± 4.2	3.0 ± 1.4	3.0 ± 1.4	13.3 ± 6.1	3.3 ± 1.2	4.0 ± 2.8	34.0 ± 12.5	10.0 ± 2.8	6.7 ± 4.2
	EEG	3 m	59.3 ± 10.3	2.0	8.0 ± 5.3	2.0	9.3 ± 2.3	4.7 ± 3.1	2.0	10.7 ± 6.1	6.0	4.0 ± 2.0
		8 m	46.0 ± 7.2	12.0 ± 5.3	6.0 ± 2.8	6.0	9.3 ± 4.6	4.0 ± 2.0	2.0	13.3 ± 7.6	2.0 ± 0.0	7.3 ± 3.1
	RAH	3 m	48.7 ± 1.2	9.3 ± 4.6	2.0		16.0 ± 8.7	2.7 ± 1.2		12.7 ± 3.1	2.0	9.3 ± 5.0
		8 m	43.3 ± 6.1	15.3 ± 7.0			13.3 ± 5.0	2.0		15.3 ± 5.0	2.0	11.3 ± 2.3
	RAT	3 m	64.0 ± 8.7	3.3 ± 1.2	4.7 ± 2.3	2.0 ± 0.0	4.7 ± 2.3	2.0	2.0	13.3 ± 4.6		11.0 ± 1.4
		8 m	56.0 ± 12.2	3.0 ± 1.4		2.0	6.7 ± 2.3	7.3 ± 5.8		14.7 ± 9.2	2.7 ± 1.2	10.0 ± 7.2
	CAN	3 m	38.7 ± 17.0	4.0 ± 2.8	6.0 ± 5.3		16.0 ± 3.5	8.0	2.0	25.3 ± 13.6	8.0 ± 2.8	4.0 ± 0.0
		8 m	22.0 ± 7.2	8.0			3.3 ± 1.2	4.7 ± 4.6		52.0 ± 10.6	6.7 ± 1.2	8.7 ± 4.2
	TIR	3 m	49.3 ± 4.2	6.0 ± 0.0	2.0 ± 0.0		4.7 ± 1.2	14.0 ± 13.1	1.0 ± 1.4	20.7 ± 12.1	2.0	4.7 ± 2.3
		8 m	28.7 ± 7.0			2.0 ± 0.0	5.0 ± 1.4	5.0 ± 1.4	4.0	58.7 ± 9.9	2.0	4.0 ± 2.8
	All mean at 3 m		41.4 ± 16.4	4.8 ± 3.0	7.9 ± 7.5	2.0 ± 0.0	10.2 ± 5.1	6.9 ± 4.1	2.4 ± 1.5	27.9 ± 17.1	4.2 ± 2.7	6.7 ± 2.7
	All mean at 8 m		29.2 ± 17.7	7.2 ± 4.8	3.7 ± 2.1	3.0 ± 1.7	8.5 ± 4.2	4.8 ± 2.0	8.0 ± 9.3	45.9 ± 29.4	4.2 ± 3.4	7.2 ± 3.0
Nuweiba'a	SOK	3 m	36.7 ± 20.5	2.0	6.7 ± 5.0	3.0 ± 1.4	3.3 ± 1.2	5.3 ± 4.2		30.7 ± 20.4	4.0 ± 2.8	12.0 ± 4.0
		8 m	18 ± 3.5				2.7 ± 1.2	12.0 ± 3.5		41.3 ± 5.8	14.7 ± 5.8	11.3 ± 1.2
	WDM	3 m	47.3 ± 9.9	2.0			8.0 ± 0.0	14.7 ± 4.2		14.7 ± 2.3		17.3 ± 6.4
		8 m	8.0 ± 4.0		6.0 ± 0.0		4.7 ± 1.2	33.3 ± 14.0		24.7 ± 11.7	3.0 ± 1.4	21.3 ± 5.0
	MGZ	3 m	19.3 ± 7.6		4.0	16.0 ± 2.0	2.0 ± 0.0	36.0 ± 2.0		7.0 ± 7.1	13.3 ± 9.5	8.0 ± 2.0
		8 m	6.0 ± 0.0	8.0 ± 2.8				6.7 ± 5.0		77.3 ± 4.2	7.0 ± 1.4	
	BGS	3 m	36.7 ± 2.3		14.7 ± 8.1		2.7 ± 1.2	14.0 ± 5.3		13.3 ± 9.2	6.7 ± 4.2	12.0 ± 5.3
		8 m	20.0 ± 10.6	10.7 ± 3.1			2.0 ± 0.0	13.3 ± 1.2		44.7 ± 13.3	8.0 ± 5.3	3.0 ± 1.4
	WDH	3 m	55.3 ± 10.1	6.0	5.0 ± 1.4		4.0 ± 2.0	11.3 ± 4.2		17.3 ± 4.2		6.7 ± 2.3
		8 m	30.0 ± 5.3	6.7 ± 4.6	2.0 ± 0.0		4.0	17.3 ± 8.1		29.3 ± 9.0	3.0 ± 1.4	11.3 ± 2.3
	HBN	3 m	25.3 ± 11.4	2.0 ± 0.0	3.0 ± 1.4	2.0	6.7 ± 4.2	25.3 ± 14.7		16.7 ± 9.2	6.0 ± 0.0	18.0 ± 10.4
		8 m	11.3 ± 4.6			12.0		28.0 ± 6.0		42.7 ± 5.0	9.3 ± 3.1	4.7 ± 3.1
	MZQ	3 m	39.3 ± 6.4	4.0	5.0 ± 1.4		6.0	18.0 ± 10.6		21.0 ± 1.4	3.3 ± 1.2	18.7 ± 6.4
		8 m	20.0 ± 6.0		4.0			19.3 ± 6.4		26.0 ± 14.4	14.0 ± 11.1	19.3 ± 8.1
	FRA	3 m	7.3 ± 3.1		3.3 ± 2.3	28.0 ± 5.7		15.3 ± 9.9		49.3 ± 23.2	2.7 ± 1.2	3.3 ± 2.3
		8 m						2.0	50.7 ± 31.9	47.3 ± 30.1	2.0	2.0
	HGN	3 m	12.0 ± 5.3	2.0	20.7 ± 20.8			22.7 ± 18.1	2.0	6.0 ± 5.7	30.0 ± 8.0	9.3 ± 4.2
		8 m	4.0 ± 2.8					8.0	78.7 ± 12.9	14.0 ± 8.7	2.0	2.0 ± 0.0
	All mean at 3 m		31.0 ± 16.1	3.0 ± 1.7	7.8 ± 6.4	12.3 ± 12.3	4.7 ± 2.5	18.1 ± 8.9	2.0	19.6 ± 13.4	9.4 ± 9.7	11.7 ± 5.4
	All mean at 8 m		14.7 ± 8.9	8.5 ± 2.0	4.0 ± 2.0	12.0	3.4 ± 1.2	15.5 ± 10.1	64.7 ± 19.8	38.6 ± 18.3	7.0 ± 5.0	9.4 ± 7.7

CAV= Caves; **MOG**= Moray Garden; **ECH**= Ecotel Hotel; **LIH**= Light House; **EEG**= Eel Garden; **RAH**= Ras Abu Helal; **RAT**= Ras Abu Talha; **CAN**= Canyon; **TIR**= Tiger Reef; **SOK**= El Sokhn; **WDM**= Wadi Miran; **MGZ**= Megiezer; **BGS**= Big Stone; **WDH**= Wadi Hobique; **HBN**= Hobique North; **MZQ**= Mazarique; FRA= El Faraa; **HGN**= El Hognah

Table (3). Mean cover percentage of different coral forms recorded at different sites at two depths from Dahab and Nuweiba'a sectors.

Sector	Site	Coral forms									
		Branching		Tabulate/Laminar		Massive		Foliaceous		Encrusting	
		3 m	8 m	3 m	8 m	3 m	8 m	3 m	8 m	3 m	8 m
Dahab	CAV	45.5	27.3	1.8		54.5	25.5	3.6	5.5	12.7	29.1
	MOG	28.7	17.2			74.7	17.2	5.7		46.0	11.5
	ECH	66.7	13.3			80.0	20.0			20.0	
	LIH	49.5	38.3	4.5	4.5	45.0	24.8			18.0	15.8
	EEG	35.4	39.2		3.8	68.4	32.9			8.9	11.4
	RAH	55.1	53.6			26.1	23.2		2.9	24.6	13.0
	RAT	50.0	39.9	1.1	1.1	47.8	41.1		3.3	7.8	8.9
	CAN	94.6	54.1	2.3		22.5	15.8			11.3	
	TIR	77.6	29.3			43.1	25.9			6.9	17.2
	Mean	55.9	34.7	2.4	3.1	51.3	25.2	4.7	3.9	17.4	15.3
Nuweiba'a	SOK	36.6	36.6			51.2	17.1			46.4	12.2
	WDM	7.0	16.9	0.3		15.0	12.0			1.3	
	MGZ	31.6	26.3		5.3	73.7	15.8	21.1		26.3	
	BGS	82.4	47.1	2.4	2.4	25.9	18.8			18.8	2.4
	WDH	12.5	15.6			80.0	40.6			12.5	14.1
	HBN	76.4	40.0	10.9		36.4	7.3			14.5	14.5
	MZQ	56.2	38.2	11.2		44.9	22.5			20.2	6.7
	FRA	45.5				36.4		9.1		9.1	
	HGN	54.5	18.2			81.8	18.2			27.3	
	Mean	44.7	29.9	6.2	3.9	49.5	19.0	15.1		19.6	10.0

CAV= Caves; **MOG**= Moray Garden; **ECH**= Ecotel Hotel; **LIH**= Light House; **EEG**= Eel Garden; **RAH**= Ras Abu Helal; **RAT**= Ras Abu Talha; **CAN**= Canyon; **TIR**= Tiger Reef; **SOK**= El Sokhn; **WDM**= Wadi Miran; **MGZ**= Megiezer; **BGS**= Big Stone; **WDH**= Wadi Hobique; **HBN**= Hobique North; **MZQ**= Mazarique; **FRA**= El Faraa; **HGN**= El Hognah

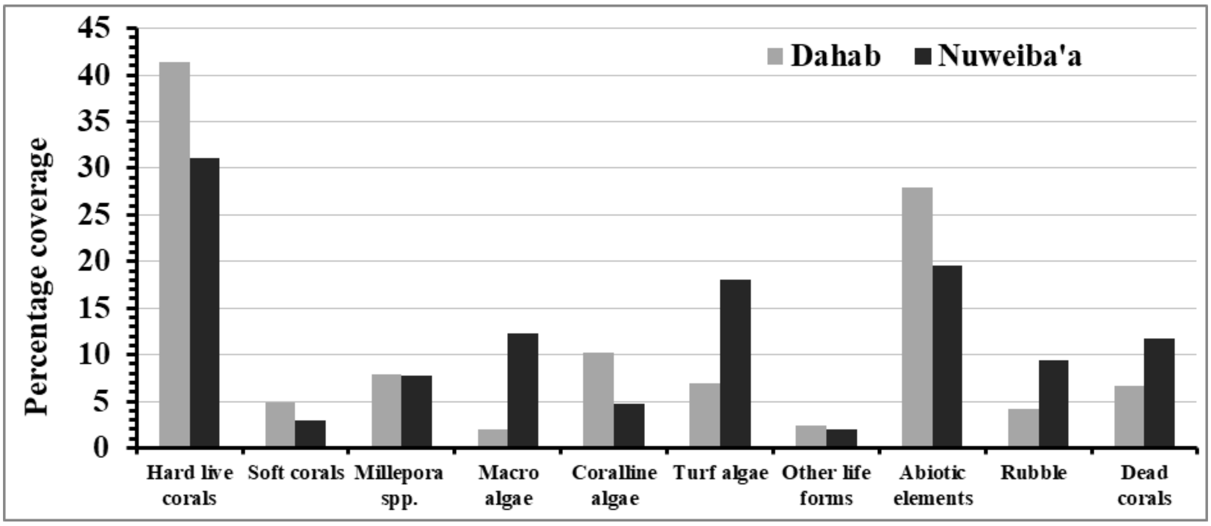

Fig. (2). Showing the average percentage cover of substrate categories at three meter depth at Dahab and Nuweiba'a sectors.

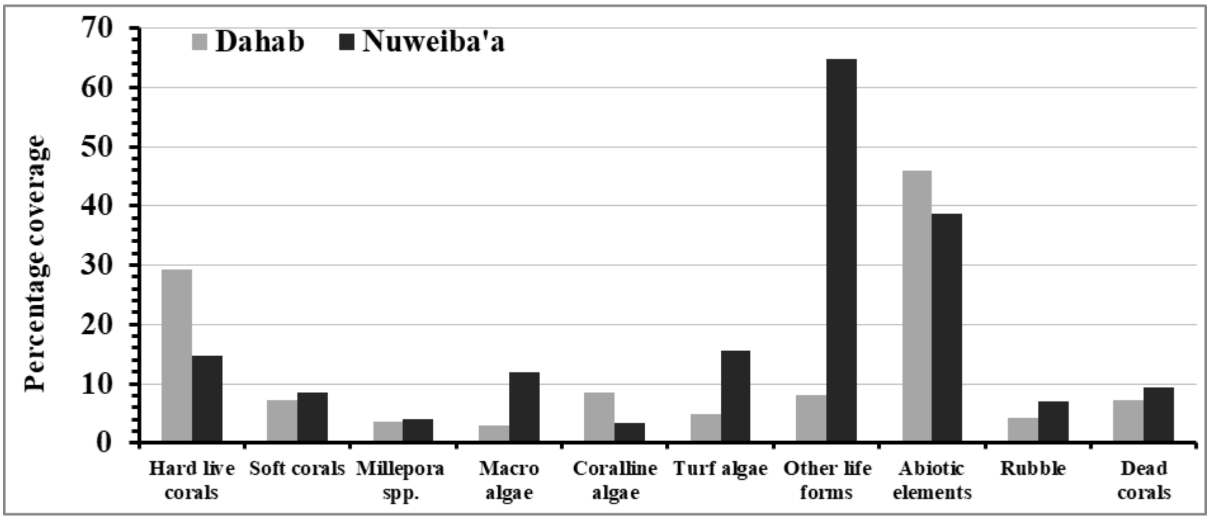

Fig. (3). Showing the average percentage cover of substrate categories at eight-meters depth at Dahab and Nuweiba'a sectors.

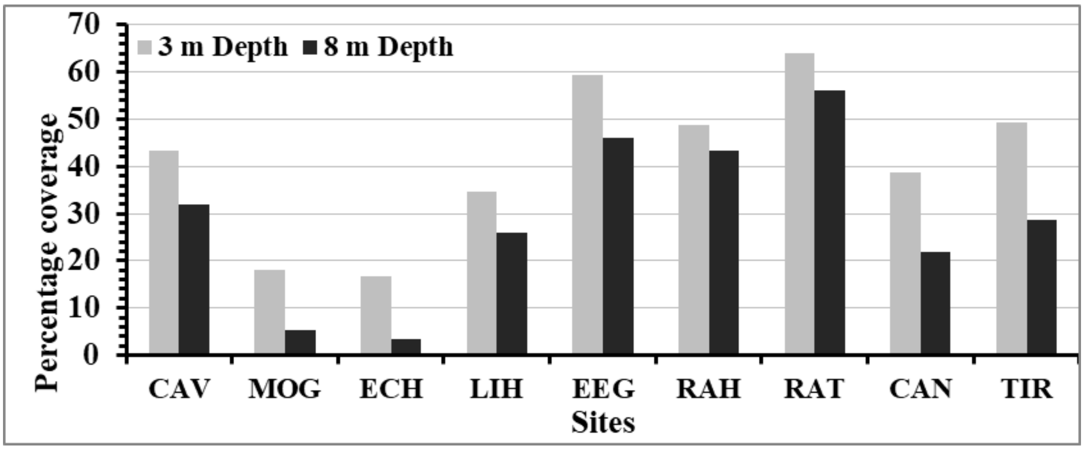

Fig. (4). Showing the average percentage cover of hard live coral at studied sites from Dahab sector. (Note: the abbreviations of site name are mentioned under Table, 2).

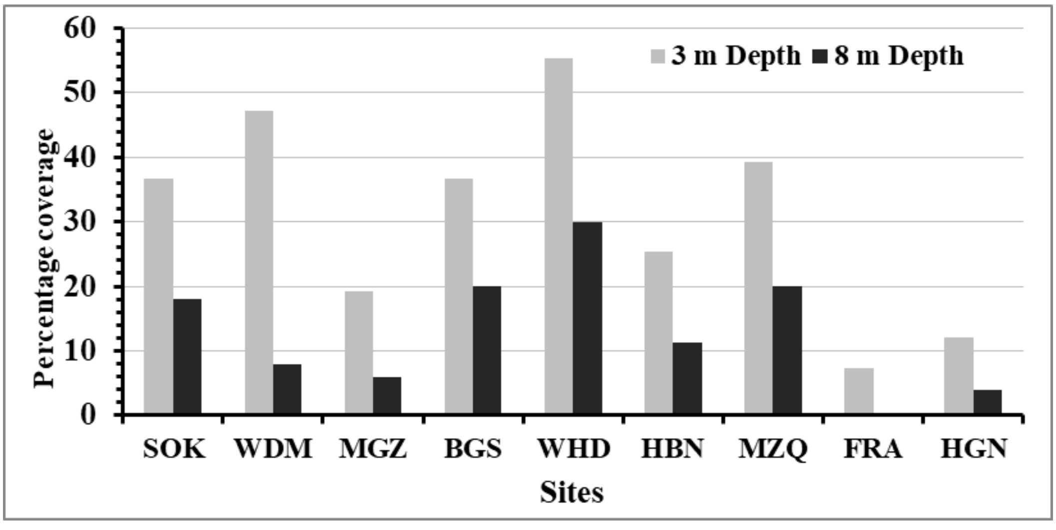

Fig. (5). Showing the average percentage cover of hard live coral at studied sites from Nuweiba'a sector. (Note: the abbreviations of site name are mentioned under Table, 2).

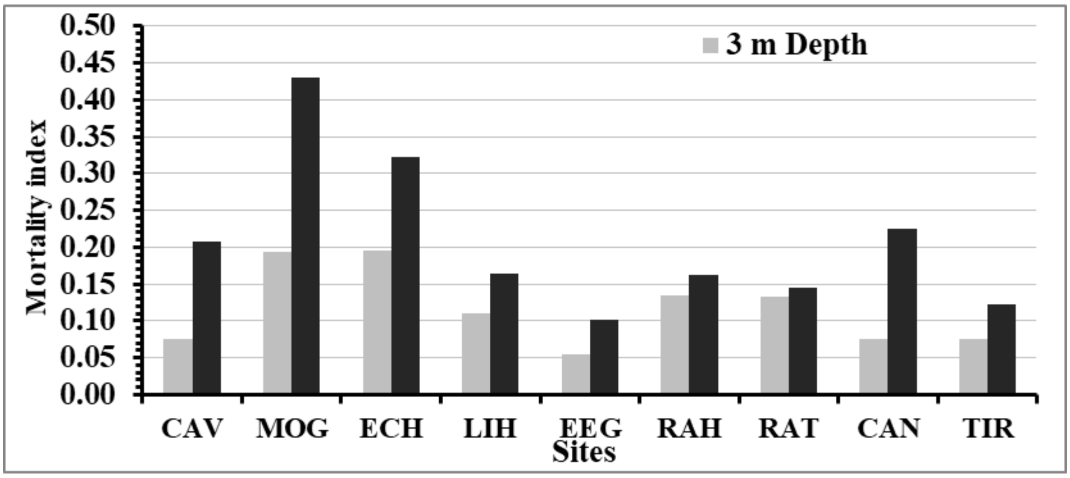

Fig. (6). Showing the mortality indices of hard coral recorded at two depths at studied sites from Dahab sector. (Note: the abbreviations of site name are mentioned under Table, 2).

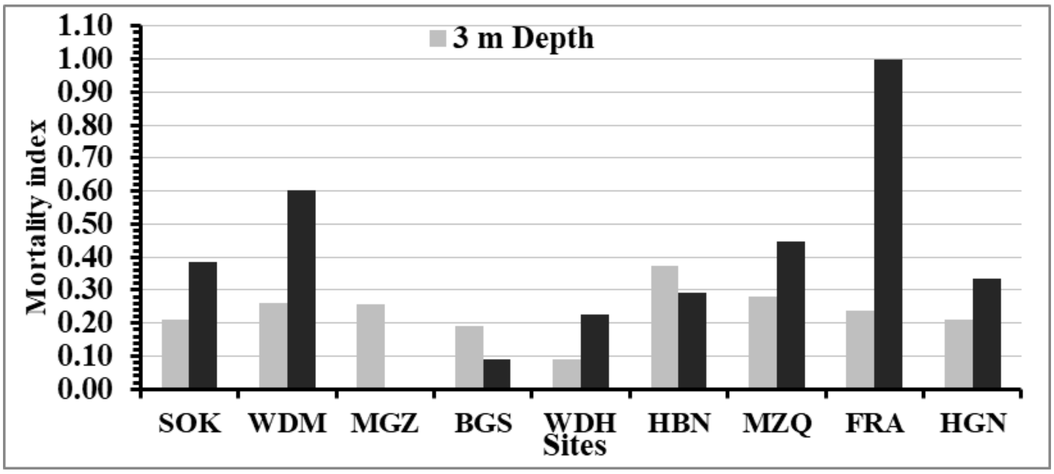

Fig. (7). Showing the mortality indices of coral recorded at two depths at studied sites from Nuweiba'a sector. (Note: the abbreviations of site name are mentioned under Table, 2).

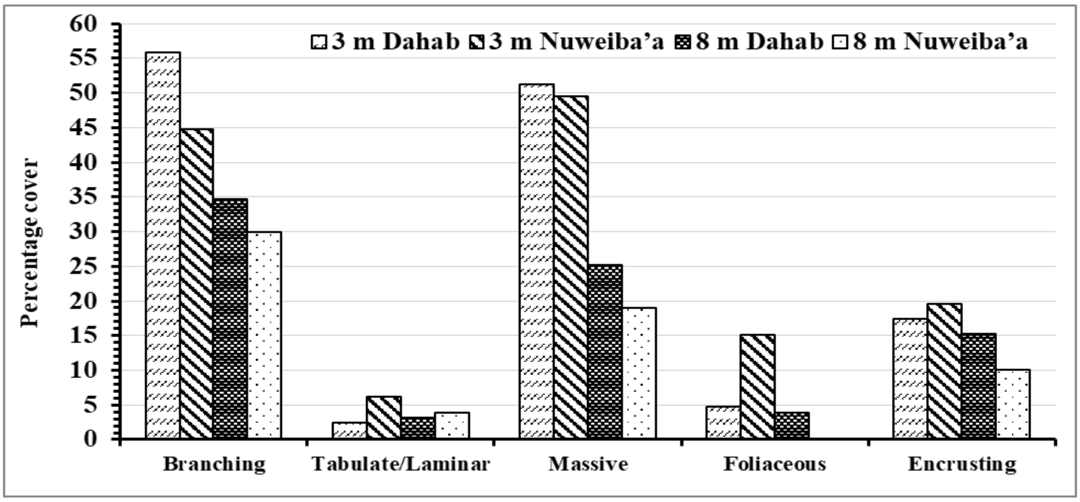

Fig. (8). Showing mean cover percentage of different coral forms at two depths from Dahab and Nuweiba'a sectors.

Algal cover:

Algal cover was detected at all sites in both sectors and including macro and turf algae. At Dahab sector, the highest average percentage cover was 14.0 % at Tiger Reef site at 3 m depth; then it decreased to 11.33 % at the same depth at Moray Garden site and 10.0 % at 8 m depth at Caves sites. Algal cover at the remaining sites had markedly low percentage cover ranged from 2.0 % at 8 m depth at Ras Abu Helal site to 8.0 % at 3 m depth at Canyon site **(Fig. 9)**. On the other hand, at Nuweiba'a sector, the values of mean percentage of algal cover at studied sites were considerably higher than those recorded at Dahab sector. The highest value was 52.0 % at 3 m depth and recorded at Megiezer site; then it decreased to 43.0 % at the same depth at El Faraa sites and to 40.0 % at 8 m depth at Hobique North site. However, at the remaining sites, the algal coverage values were moderately low at both depths and varied from 8.0 % at 8 m depth at El Hognah site to 33.33% at the same depth at Wadi Miran site **(Fig. 10)**.

Algae may damage corals and other species via toxicity (**Rasher & Hay, 2010),** covering **(Box & Mumby, 2007),** grazing **(McCook *et al*., 2001).** Recent research has shown that algal growths (e.g., macroalgae and benthic cyanobactroids) can disruptive coral microbioms, leading to increased coral mortality **(Haas *et al*., 2016** and **Zaneveld *et al*., 2016).** The increases of algal interference within coral reefs are considered to be the consequence of several interconnected causes, such increasing nutrient content and loss of top control because to overfishing or disease **(Rasher *et al.*, 2012** and **Jessen *et al*., 2013).** Fishing can thus have a role in reducing herbivorous fish at some study sites and so increasing algal coverage. The major component in macroalgal growth in studies indicating herbivory suppression **(Rasher *et al.*, 2012).** Although nutrient levels in this study were not assessed, a prior brief study in the region have shown an increase in phosphates and ammonium, positively linked to increases in turf algae **(Naumann *et al*., 2015).** Whereas the increasing in nutrients in addion, higher water temperatures would promote the growth of cyanobacterial mats over macroalgae (**Kuffner & Paul, 2001; de Bakker *et al*., 2017** and **Beltram *et al*., 2019).**

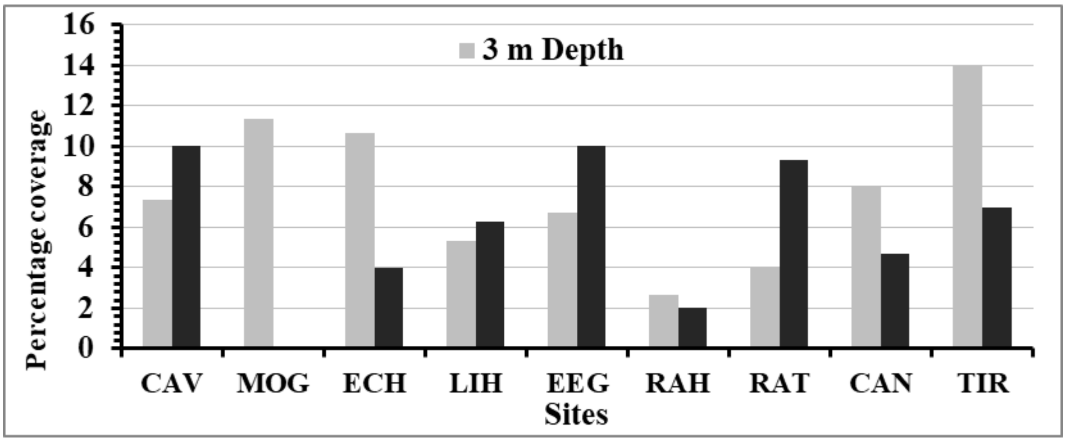

Fig. (9). Showing average percentage covers of algae at two depths at studied sites from Dahab sector. (Note: abbreviations of site name are mentioned under Table 2).

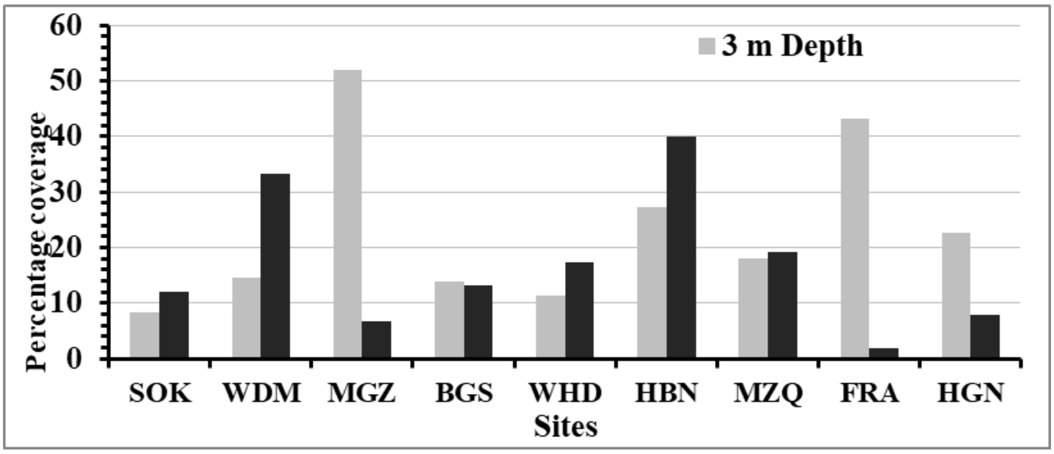

Fig. (10). Showing average percentage covers of algae at two depths at studied sites from Nuweiba'a sector. (Note: abbreviations of site name are mentioned under Table, 2).

Invertebrate distribution, abundance, and diversity:

A list of recorded invertebrate species at two depths from the two sectors was given in **Table (4)**. A total of 78 species belonging to molluscs and echinoderms were recorded, these species are lie under 8 classes, 20 orders and 36 families. Of which there was 52 species (66.7 % of total species) were molluscs and the remaining 26 species (33.3 %) were echinoderms. The molluscan gastropods are more diverse than bivalves and represented by 43 species while the echinoderms sea urchins and sea cucumber were the more diverse than other echinoderm groups and represented by 10 species each. Generally, out of 78 species there are 49 species (62.82 %) were recorded from Dahab sector from which there 20 species were not detected from Nuweiba'a sector. However, there are 58 species (74.36 %) were recorded from Nuweiba'a sector of which 50 % were not detected from Dahab sector. Also, there are 66 species were recorded from 3 m depth from both sectors of which 26 species are not detected from 8 m depth whereas, there are 52 species were recorded from 8 m depth from both sectors of which only 12 species are not detected from 3 m depth **(Table 4)**.

Regarding to species abundance, at Dahab sector, there are four species had the highest percentage abundance, among them the gastropod, *Tridacna* sp. came in first rank of abundance with percentage abundance of 22.61 % and 29.07 % at 3 m and 8 m depth respectively. The sea urchin, *Echinometra mathaei,* came in the second rank with percentage abundance of 26.75 % and 17.05 % at the same depths, followed by the bivalve, *Spondylus spinosus*, with percentage abundance of 5.15 % and 9.82 % at the two depths respectively. The sea urchin, *Diadema setosum* had the fourth rank of abundance with 1.06 % and 3.75 % at the same depths. The other species recorded from this sector had very low values of percentage abundance fluctuated from 0.04 % to about 1.5 % **(Table 5)**. In contrast, at Nuweiba'a sector, the percentage abundance values for most species were markedly higher than those recorded for the same species from Dahab sector. The sea urchin, *Diadema setosum* had the highest percentage abundance of 43.26 % and 9.94 % at 3 m and 8 m depth respectively, followed by *Echinometra mathaei* with percentage abundance of 13.76 % and 23.76 % at the same depths. However, *Tridacna* sp had the first rank in Dahab sector it came in the third rank of abundance at Nuweiba'a sector with abundance of 18.14 % and 15.47%, followed by the urchin, *Echinothrix diadema* with abundance of 6.88 % and 12.71 % at both depths respectively. The other species recorded from this sector had markedly low values of abundance ranged from 0.05 % to 2.5 % **(Table 4)**.

At Dahab sector, the diversity of species at 3 m depth was higher than that recorded at 8 m depth, where 40 species (81.6 % of all species at Dahab) and 32 species (65.3 %) were recorded at the two depths respectively. The highest species diversity values were 14 and 13 species recorded at Moray Garden and Canyon sites from 3 m depth and 11 and 10 species recorded at Eel Garden and Canyon sites at 8 m depth. Whereas the other sites comprise low number of species varied from 5 species at Ras Abu Helal sites at 8 m depth to 10 species at Eel garden site at 3 m depth. The abundance values at 3 m depth markedly higher than those at 8 m depth at all sites, it varied from 80 individuals at Moray Garden to 692 individuals at Ras Abu Talha site for the former depth and it varied from 11 to 315 individuals at the same sites respectively for the latter depth. The values of Shannon-Weaver diversity index (H) were ideal with index figured 1.0 – 3.5 **(Murugan *et al.*, 1998)** at Caves and Moray Garden sites only at 3 m depth being, 1.65 and 2.18 respectively. Also, the values of “H” were ideal with index values at Caves, Moray Garden, Ecotel Hotel, Eel Garden and Canyon sites at 8 m depth being 1.84, 1.64, 1.57, 1.87 and 1.85 respectively. In contrast, at other sites the values of “H” were under the index value. Specie Richness index (d) values markedly fluctuated from site to another and varied from 1.0 at Tiger Reef to 2.97 at Moray Garden site at 3 m depth. However, at 8 m depth the values of this index varied from 1.01 at Ras Abu Helal to 2.53 at Eel Garden site. Species Evenness index (j) values showed that there is no equality in abundance between species at Light House and Tiger Reef sites only at 3 m depth where, the values under 0.5. In contrast, at other all sites at both depths there is good equality in abundance between species where the values of “j” varied from 0.52 at Canyon site at 3 m depth to 0.91 at Moray Garden site at 8 m depth **(Table 5)**.

At Nuweiba’a sector, the diversity of species at the two depths exhibited the same pattern as in Dahab, where 47 species (81.0 % of all species at Nuweiba’a) and 37 species (63.8%) were recorded at 3 and 8 m depth respectively. The highest species diversity values were 18, 16 and 15 species recorded at El Hognah, El Faraa and Big Stone sites from 3 m depth and 13 species recorded at Wadi Miran, Hobique North and Mazarique sites at 8 m depth. Whereas the other sites comprise low number of species varied from 3 species at El Faraa site at 8 m depth to 10 species at Hobique North site at 3 m depth. The abundance values exhibited the same pattern as in at Dahab sector at all sites, it varied from 113 individuals at Wadi Hobique site to 468 individuals El Hognah site at 3 m depth and it varied from 4 individuals at El Faraa site to 67 individuals at Mazarique site for at 8 m depth. The values of “H’” index at 8 m depth were ideal with the index figured and slightly higher than those at 3 m depth, it varied from 1.73 at Hobique North to 2.18 at Wadi Miran sites for the former depth and it varied from 1.52 at Hobique North site to 1.84 at Megiezer site for the latter depth. However, the values of “H” were under the index values at Big Stone and El Faraa at both depths. Specie Richness index (d) values were high at most sites at both depths, it fluctuated from 1.9 at Wadi Hobique to 2.76 at El Hognah site at 3 m depth. However, at 8 m depth the values of this index varied from 1.18 at Wadi Hobique to 3.13 at Wadi Miran site. Species Evenness index (j) values showed that there is no equality in abundance between species at Big Stone, El Faraa and El Hognah sites only at 3 m depth, where the values under

0.5. In contrast, at other all sites at both depths there is very good equality in abundance between species where the values of "j" varied from 0.57 at Big Stone site to 0.97 at Megiezer site **(Table 5)**.

Although the molluscan species, *Tridacna sp* was the most abundant species among sites from Nuweiba'a sector, but the number of the individuals of this species was much less than those recorded from Dahab that might be attributed to over collecting by the Bedouin local fishermen. In coral reefs, *Tridacna* spp had several ecologically driven roles, such as increased topography, acting as a zoosanthellae reservoir (Symbiodiniaceae) and reducing eutrophic effects through water filtering **(Neo *et al.*, 2015).** In his experimental research **Cabaitan *et al.* (2008)** indicated that the clams had considerable positive effects on fish species and invertebrate diversity and abundance, presumably through functioning as an essential food source**.** The present study showed that there is markedly decreasing in number of long spines urchins, *Echinothrix* spp and *Diadema setosum* at Dahab, likewise at Nuweiba'a except for only two sites in just one depth (3m). These results came with that reported by **Reverter *et al*. (2020).** *Diadema* and *Echinometra* urchins and some molluscs species are very successful in controlling algae growth (including cyanobacteria) and providing space for corals to settle **(Sandin & McNamara, 2012** and **Capper *et al.*, 2016).** In the Caribbean, in the 1980s, *Diadema antillarum* decreasing was in fact one of the major causes for algal proliferation **(Carpenter, 1990)** and the recent recovery of that urchin at some sites fostered the recovery and growth of corals.

Additional studies indicate that interactions among corallivories and other stressors such as overfishing and nutrient pollution can also impact coral resilience **(Rice *et al.*, 2019).** *Drupella* spp, *Coralliophila violacea* are corallivore snails, these species are considered major cause of loss of coral tissue and decreased growth if they are present in large quantity **(Hamman, 2018).** A prior relationship was proposed in the Red Sea between coral diseases and *Drupella* snail abundance **(Antonius & Riegl, 1998)** more up-to-date research have also shown *Drupella* spp as efficient vectors of ciliate in the Great Barrier Reef responsible for brown band disease **(Nicolet *et al.*, 2013).** However, in their investigation **Reverter *et al.* (2020)** showed that there is no notable increase in coral snail numbers between 2009 and 2019. In the present study, there was no record for any outbreak of the crown of thorns starfish, *Acanthaster planci,* throughout the time of this study and this result confirmed the observation that recorded by **Reverter *et al.* (2020).** However, the crown of thorns has been recorded with very little individual number from the Egyptian Red Sea coasts **(Hellal *et al.*, 1995; Ammar *et al*., 2006** and **Tilot *et al.*, 2008)**.

Table (4). List and percentage abundance of recorded invertebrate species belonging to phylum Mollusca and Echinodermata at two depths (3 and 8 m) from Dahab and Nuweiba'a sectors.

Phylum, class and species			Dahab		Nuweibaa	
			3 m depth	8 m depth	3 m depth	8 m depth
Mollusca	Bivalvia	*Modiolus auriculatus* (Krauss, 1848)	1.8	0.39		
		Spondylus spinosus Schreibers, 1793	5.15	9.82	0.5	0.55
		Pinctada margaritifera (Linnaeus, 1758)			1.13	4.97
		Pinna muricata Linnaeus, 1758	0.09	0.65	0.41	
		Pinna saccata Linnaeus, 1758	0.09	0.78		
		*Pteria aegyptiaca (*Dillwyn, 1817)			0.14	2.21
		*Pteria penguin (*Röding, 1798)	0.13		0.63	0.55
		*Pinctada margaritifera (*Linnaeus, 1758)	0.26	1.42		
	Cephalopoda	*Octopus sp.*			0.05	
	Gastropoda	*Tridacna* sp.	22.61	29.07	18.14	15.47
		Cerithium adansonii Bruguière, 1792			0.59	3.59
		Cerithium echinatum Lamarck, 1822		0.39	0.81	3.59
		Cerithium columna Sowerby I, 1834	0.13			
		Cerithium rueppelli Philippi, 1848				0.55
		Turritella maculata Reeve, 1849			0.05	0.55
		Mauritia grayana Schilder, 1930	0.04		0.14	
		Nassarius concinnus (Powys, 1835)		0.13		
		Monoplex aquatilis (Reeve, 1844)			0.05	0.55
		Canarium erythrinum (Dillwyn, 1817)			0.09	0.28
		Gibberulus gibberulus (Linnaeus, 1758)				0.28
		Lambis truncata (Lightfoot, 1786)	0.09		0.09	
		Morula aspera (Lamarck, 1816)	0.04			
		*Tricornis tricornis (*Lightfoo, 1786)				0.55
		*Engina mendicaria (*Linnaeus, 1758)			0.27	
		Columbella sp.			0.05	
		Conus arenatus Hwass in Bruguière, 1792		0.13	0.14	0.55
		Conus generalis Linnaeus, 1767				0.55
		Conus miliaris Hwass in Bruguière, 1792	0.04			
		Conus namocanus Hwass in Bruguière, 1792			0.05	
		Conus pennaceus Born, 1778	0.04			
		Conus sanguinolentus Quoy & Gaimard, 1834	0.04			
		Conus taeniatus Hwass in Bruguière, 1792				1.1
		Conus tessulatus Born, 1778				0.55
		Conus textile Linnaeus, 1758		0.13		0.28
		Conus virgo Linnaeus, 1758	0.09			
		*Vexillum aureolatum (*Reeve, 1844)			0.09	
		Vexillum pardale (Küster, 1840)			0.05	
		Turrilatirus turritus (Gmelin, 1791)	0.09			
		Chicoreus virgineus (Röding, 1798)			0.05	

Table (4): Continued.

Phylum	Class	Species	Dahab 3 m depth	Dahab 8 m depth	Nuweibaa 3 m depth	Nuweibaa 8 m depth
Mollusca	Gastropoda	*Coralliophila violacea (* Kiener, 1836)	32.82	28.04		
		Drupa morum Röding, 1798		0.13	0.09	
		Drupa ricinus lischkei (Hidalgo, 1904)	0.26	0.26	0.41	1.1
		Morula aspera (Lamarck, 1816)			0.32	
		Oxymeris crenulata (Linnaeus, 1758)	0.09	0.13		
		Vasum turbinellus (Linnaeys, 1758)	0.04	0.13		1.1
		Haliotis varia Linnaeus, 1758			0.14	
		Tectus dentatus (Forsskål in Niebuhr, 1775)	0.04		0.05	1.38
		Tectus virgatus (Gmelin, 1791)				0.28
		Clanculus pharaonius (Linnaeus, 1758)	0.04		0.05	0.28
		Turbo radiatus Gmelin, 1791	0.13	0.13	0.27	0.28
		Trochus erithreus Brocchi, 1821	0.04			
		Trochus maculatus Linnaeus, 1758	0.26	0.52	0.95	1.93
Echinodermata	Asteroidea	*Fromia ghardaqana* Mortensen, 1938			0.05	
		Fromia monilis (Perrier, 1869)	0.04			
		Linckia multifora (Lamarck, 1816)			0.05	
	Crinoidea	*Heterometra* sp.	0.57	0.13	1.04	
	Echinoidea	*Echinometra mathaei* (Blainville, 1825)	26.75	17.05	13.76	23.76
		Heterocentrotus mamillatus (Linnaeus, 1758)	2.24	0.65	5.07	
		Heterocentrotus trigonarius (Lamarck, 1816)	0.09			
		Tripneustes gratilla (Linnaeus, 1758)	0.18			
		Phyllacanthus imperialis (Lamarck, 1816)	1.41	1.42	0.59	0.55
		Prionocidaris baculosa (Lamarck, 1816)			0.09	
		Diadema setosum (Leske, 1778)	1.06	3.75	43.26	9.94
		Echinothrix calamaris (Pallas, 1774)		0.26		
		Echinothrix diadema (Linnaeus, 1758)	1.72	0.65	6.88	12.71
		Asthenosoma varium Grube, 1868			0.05	
	Holothuroidea	*Synapta maculata* (Chamisso & Eysenhardt, 1821)	0.04	0.13		
		Actinopyga miliaris (Quoy & Gaimard, 1834)	0.04	0.26	0.27	1.1
		Bohadschia steinitzi Cherbonnier, 1963		0.26		0.55
		Bohadschia subrubra (Quoy & Gaimard, 1834)			0.23	2.21
		Holothuria atra Jaeger, 1833	0.04		0.32	2.49
		Holothuria edulis Lesson, 1830	0.53	0.9		0.28
		Holothuria fuscogilva Cherbonnier, 1980			0.09	0.28
		Holothuria leucospilota (Brandt, 1835)	0.04	0.26	0.27	
		Pearsonothuria graeffei (Semper, 1868)			0.41	0.28
		Stichopus pseudohorrens Cherbonnier, 1967		0.26		
	Ophiuroidea	*Ophiocoma erinaceus* Müller & Troschel, 1842		0.26	0.09	
		Ophiocoma pica Müller & Troschel, 1842	0.75	1.55	1.76	2.76

Table (5). Number of species (S), overall invertebrates abundance (N), Species Richness Index (d), Evenness Index (J), and Shannon- Weiner Index (H') for invertebrates (molluscs and echinoderms) recorded at two depths (3 and 8 m) at studied sites from the two sectors.

Sector	Sites	3 m depth					8 m depth				
		S	N	d	J	H'	S	N	d	J	H'
Dahab	CAV	9	171	1.56	0.75	1.65	8	39	1.91	0.88	1.84
	MOG	14	80	2.97	0.82	2.18	6	11	2.08	0.91	1.64
	ECH	8	147	1.4	0.7	1.47	9	53	2.01	0.72	1.57
	LIH	9	277	1.42	0.35	0.76	8	132	1.43	0.55	1.13
	EEG	10	314	1.57	0.54	1.24	11	52	2.53	0.78	1.87
	RAH	8	88	1.56	0.64	1.32	5	52	1.01	0.54	0.87
	RAT	8	692	1.07	0.67	1.4	8	315	1.21	0.67	1.39
	CAN	13	107	2.57	0.52	1.34	10	45	2.36	0.8	1.85
	TIR	7	397	1	0.45	0.88	8	75	1.6	0.68	1.42
	Total	40	2273	5.05	0.49	1.81	32	774	4.6	0.57	1.98
Nuweiba'a	SOK	11	152	1.99	0.75	1.8	11	45	2.26	0.73	1.76
	WDM	13	148	2.4	0.67	1.74	13	46	3.13	0.85	2.18
	MGZ	13	169	2.33	0.72	1.84	9	13	3.11	0.97	2.13
	BGS	15	444	2.29	0.36	0.98	6	52	1.26	0.57	1.03
	WDH	10	113	1.9	0.68	1.58	5	29	1.18	0.68	1.1
	HBN	10	123	1.87	0.66	1.52	13	66	2.86	0.67	1.73
	MZQ	13	264	2.15	0.64	1.64	13	67	2.85	0.83	2.13
	FRA	16	329	2.58	0.32	0.88	3	4	1.44	0.94	1.03
	HGN	18	468	2.76	0.45	1.32	9	40	2.16	0.84	1.85
	Total	47	2210	5.97	0.5	1.95	37	362	6.11	0.73	2.66

CAV= Caves; **MOG**= Moray Garden; **ECH**= Ecotel Hotel; **LIH**= Light House; **EEG**= Eel Garden; **RAH**= Ras Abu Helal; **RAT**= Ras Abu Talha; **CAN**= Canyon; **TIR**= Tiger Reef; **SOK**= El Sokhn; **WDM**= Wadi Miran; **MGZ**= Megiezer; **BGS**= Big Stone; **WDH**= Wadi Hobique; **HBN**= Hobique North; **MZQ**= Mazarique; **FRA**= El Faraa; **HGN**= El Hognah

ACKNOWLEDGMENT

The work was supported by the Egyptian Environmental Affairs Agency (EEAA). We thank the (EEAA) for facilitating the work, and express our gratitude to their senior staff, including Dr. Muhamad Salem, Dr. Khaled Allam, Muhamad Kotb, Yasser Awad Allah. We also thank Essam Saad Allah, Khaled Al Haddad, Ahmad Al Sadeq, Emad Abdu Allah, and Muhamad Ali for their help in the field.

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الملخص العربي

تحديد عواقب السياحة و الصيد على صحة الشعاب المرجانية على الساحل الغربي لخليج العقبة، البحر الأحمر، مصر

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لتقييم ودراسة تأثير الأنشطة البشرية على الساحل المصري لخليج العقبة، وخاصة أنشطة السياحة و الصيد،تم مسح ١٨ موقع فى الفترة من نوفمبر ٢٠١٩ الى فبراير ٢٠٢٠ . في كل موقع تمت دراسة غطاء الشعاب المرجانية والطحالب عن طريق استخدام طريقة المقطع متعدد النقاط عند عمقين ٣ متر و٨ متر، كما تمت دراسة اللافقاريات الموجودة عند ذات العمقين عن طريق استخدام طريقة المقطع الحزامي.

بينت الدراسة أن متوسط نسبة غطاء الشعاب المرجانية ويشمل الشعاب الصلبة والرخوة في منطقة دهب تراوحت من ١٦.٧% الى ٦٤.٠ % عند عمق ٣ متر ومن ٣.٣ % الى ٥٦.٠ % عند عمق ٨ متر. وفي منطقة نويبع كانت نسبة الغطاء تترواح من ٧.٣ % الى ٥٥.٣ % عند عمق ٣ متر بينما تراوحت من ٤.٠ % الي ٣٠.٠ % عند عمق ٨ متر. وأكدت التحليلات الإحصائية للنتائج في المنطقتين فرضية ان وفرة الشعاب وتجمعاتها تتأثر بالعمق والموقع.

تم تسجيل 78 نوعا من اللافقاريات من المنطقتين، وتبين ان أكثر الأنواع انتشارا هم *Tridacna* sp. و*Diadema setosum* و*Echinometra mathaei* في كلا العمقين، كما تنوعت الوفرة العددية والتجمعات لأنواع اللافقاريات بين المنطقتين.

وبمقارنة تأثير السياحة والصيد تبينت بعض المشاهدات مثل التراجع في نسب غطاء الشعاب المرجانية بمنطقة نويبع (منطقة الصيد) عن منطقة دهب (السياحة) وأيضا تراجع لبعض أنواع اللافقاريات الدليلة لصحة الشعاب مع زيادة واضحة للغطاء الطحلبي في منطقة نويبع عن منطقة دهب.