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ECOLOGICAL OBSERVATIONS ON THE ABUNDANCE, DISTRIBUTION OF HOLOTHUROIDS (ECHINODERMATA: HOLOTHUROIDEA) IN THE RED SEA COAST, EGYPT

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ABSTRACT

Deposit-feeding holothurians are prominent members of many shallow and deep benthic communities. Increasing attention is being given to the effects of international trade on the environment, especially in situations where biodiversity conservations is opposed to exploited industries such as fisheries. Effect of habitat conditions on abundance, distribution and population structure of three important holothurian species in Red sea Hurghada area were studied. Individual of *Holothuria atra* population were found to vary between 9.5 and 28.5 cm length with a model length of 21.5 cm. It was abundant during winter and spring in algal and sea grass habitats. *Holothuria hawaiiensis* Individuals were found to vary between 15.5 cm & 43.5 cm in length. Its frequent length categories starting from 25.5 cm to 41.5 cm. This species was abundant during winter and spring in sandy habitat with algae, as well as living and dead coral with a clear occurrence in site III. *Bohadshia vitiensis* individuals had length range varying between 14.0 & 42.0 cm length with most frequent categories varying from 21.5 up to 35.5 cm length. A narrow seasonal fluctuation in abundance was noted. The distribution of this species was found to be correlated with sand, algae and sea grass habitats. There was a high correlations between the gut sediment contents of the studied species and the sediment composition of the surrounding sites. The continuation of this study on all the other areas of Red Sea world make it possible to introduce sustainable management measures.

1. INTRODUCTION

In the Egyptian marine habitat, invertebrates including sea cucumbers are among the most valuable inshore fisheries resources. The multi-species tropical sea cucumber fishery throughout the Red Sea has existed for many of years. However, unsustainable harvesting rates, recently, can contribute to local species depletion and/or extinction. Since sea cucumbers are slow-growing, populations in shallow water they are easily over-exploited. The average size animals caught has become much smaller as the larger animals are taken first especially since the trade is not regulated.

The holothurians or sea cucumbers are echinoderms with orally-aborally elongated cylindrical bodies having the mouth at or near one end and the anus at or near the other. They are distributed widely in all tropical seas and depths, and adapted to live in a wide variety of habitats, including rock, mud, and the fronds of sea weed (Hyman, 1955). There are wide variety of the forms present. Around eighty species belonging to twenty-two genera have been recorded from the Red Sea (Vine, 1986). The most conspicuous species are members of the families Holothuridae and Stichopodidae.

These animals are often gregarious live above/or partially covered with sand and shallow vegetation close to coral reefs (James, 1994), and some other species burrow through mud and the five sediments as *Molpadia oolitca* (Young and Rhoads, 1971).

Variability in the supply of food is a major controlling factor in the population dynamics of benthic animals, in particular holothurians. Deposit feeders are amongst the most important consumers of detrital to the ocean floor, playing an important role in the removal, recycling and repackaging of nutrients, especially organic carbon (Jumars and Self, 1986).

Some species are capable of living in a diversity of habitats, while others are restricted to certain areas. Also, the abundance of certain species of holothurians in some areas is probably bounded by the type of food supply (Pawson, 1963).

In the deep waters, holothurians comprise a high percentage of the total biomass, where at 4000 meters depth they constitute about 50%, and at 8500 meters they are up to 90% of the total biomass (Zenkevitch, 1963). However, holothurians are not a traditional food and fishery in Egypt, and their harvest is mainly commercial.

Most of the research so far carried out on sea cucumber in Egypt has been part of wider programmes of work with general data, often lacking in specific details.

This study aims to investigate the effect of habitat conditions on abundance and distribution of most important holothurian species in Red Sea area to preserve these areas and help the population to thrive.

2. MATERIALS AND METHODS

2.1. Description of the study area

Three different sites in the shallow tidal Flat of Hurghada characterized by high species abundance were chosen for holothurians sampling Figure (1).

Site I: Lies 4 km northern National Institute of Oceanography and Fisheries (NIOF-Hurghada) in an open area has relatively heterogeneous thin sand bed mainly from the biogenic origin of coral debris and shell remains. This site shows healthy and widespread coral reef batches with water depth variation between 0.5 m at the low tide time and 1.50 m in the high tide time. It contains some sparsely distributed young coral batches and very small seagrass and algae spots. The holothurian species in this site do not suffer from any stresses in their life style only the water warming during the summer season.

Site II: is located in protected area from the intense wave action. Here the water column, relatively deeper than site I directly facing the NIOF. The area surrounding this site is considered a natural sedimentation basin due to its morphologic feature where as, it is bounded by a rocky wide tidal zone from the lime-stone terrace that extends for more than three kilometers between the coast and El-Famadir stony Islands and a restricted a shallow lagoon with only one inlet in the northeast direction. This site shows thin loose sediment layer, with high representation for the macro-algal flora and many spots of the seagrasses. There is a relatively low coral batch occurrence. The water depth in this site reaches to less than 60 cm at low tide time.

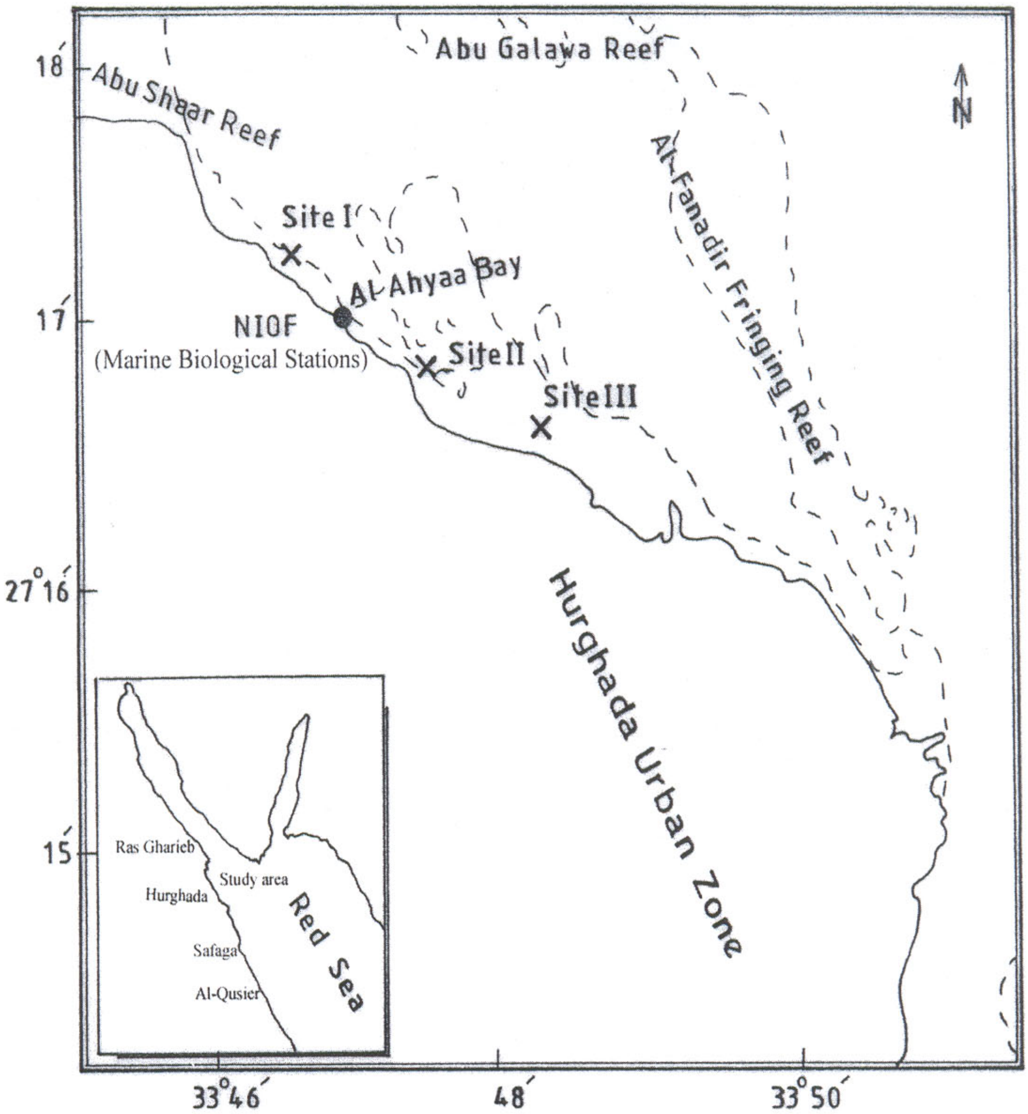

Fig. (1) Map of the study area.

Site III: Is located 4 km to the south of NIOF, the holothurian species were spread over a homogeneas thick sediment layer. This layer is composed from a mixture of biogenic and terrestrial sands. This site is shows high turbidity rates especially during the windy days relative to the other sites with very low coral patch occurrences whereas many of these patches show partial mortality and mostly were attached by the seasonally flourishing algal communities. In this site, the holothurian species suffer from both the high turbidity and the tidal exposing with high temperature rates in the low tide time especially in summer season. The three selected species; *Holothuria atra, Holothuria hawaiiensis* and *Bohadschia vitiensis* were predominantly occurred in the three sites.

2.2. Collection of samples

Throughout the period from January, 2003 to December 2003; samples of about 10-15 individuals of each holothurian species; *Holothuria atra, Holothuria hawaiiensis* and *Bohadschia vitiensis* were collected monthly and randomly using quadrate transect (10 x 10 m) from the selected sites. Specimens were collected monthly by hand through snorkeling in the intertidal areas.

The distribution and abundance of studied species were calculated by counting the number of each species per 100 m^2, various sizes were included in the sample so as nearly all population age groups were represented.

Environmental parameters such as salinity (‰), Hydrogen concentration (pH), Dissolved oxygen (O_2) and temperature (^oC) were measured using Hydrolab instrument (Surveyor 4; U.S.A.). The recorded average parameters as in Table (1).

Observations on the type of habitat from which the studied species were sampled were recorded, as well as the other Holothurian species found in the same area.

Samples of the bottom sediments were collected from each site in order to determine the variation in the total organic matter contents and sediment fractions between the holothurian gut contents and the bottom sediments.

2.3. Laboratory analysis

A total number of 483 individuals of *Holothuria atra,* 471 *Holothuria hawaiiensis* and 447 *Bohadschia vitiensis* were sampled. Measurements were done after relaxation of sea cucumber in 2.5% $MgCl_2$ (w/v) in plastic container. This was found to overcome the error resulting from contraction and relaxation by the animal body, as reported by Swell (1994). The specimens were dissected to obtain the gut contents, weighed and dried for the analysis.

Sediment samples from the bottom sediments of the different sites were dried and sieved in order to study the degree of divergence or coincidence between bottom sediments and the gut content of the animals. The total organic matter (TOM) content in the animals gut sediments and the bottom sediments were determined as the ignition weight loss at 550^{o}C (Yingst, 1976; Flannery *et al.,* 1982; Brenner and Binford, 1988), it was expressed as (mg/g).

Table (1): Seasonal variations in water parameters in the study area during the period of study (January 2003- December 2003)

Parameter / Season	Temperature ^oC	Salinity ‰	Oxygen ppm	pH
Winter	19.86 ± 1.29	40.09±1.07	7.23±1.61	8.27±0.26
Spring	28.20±1.53	41.34±0.40	5.57±0.16	8.74±0.12
Summer	29.94±1.09	40.60±0.84	6.42±0.83	8.48±0.25
Autumn	22.49±3.83	39.79±0.56	6.51±0.27	8.40±0.34

3. RESULTS

The observed holothurian species recorded in the studied sites were found mainly as *Holothuria scabra, Holothuria leucospilota, Bohadschia marmoratea, Synapta maculatea, Actinophyga echinites, Stichopus variegates, Stichopus chloronotus, Holothuria fuscogilva, Holothuria edulis* and *Thelenota ananas.* These species were observed frequently with small numbers during the period of investigation. While *Holothuria atra, Holothuria hawaiiensis* and *Bohadschia vitiensis* were found in considerable numbers and selected for the following analysis.

3.1. Abundance and distribution

The relative abundance of the three studied holothuria species in the different sites as shown in Fig. (2). *H. atra* was largely abundant in site II, while *H. hawaiiensis* represented the highest percentage occurrence in site III in comparison with the other two species. On the other hand, the three studied species were nearly of equal abundance in site I.

3.2. Length distribution of the three species under study

Length frequency distribution for 160 specimens of *H. atra*, 150 specimens of *H. hawaiiensis* and 149 specimens of *Bohadshia vitensis* measured between January and December are illustrated in Fig. (3), from the three sites.

The length frequency distribution of *H, atra* was bimodal. For most individuals it ranged from 9.5 to 28.5 cm. The frequent length category was 21.5 cm. The total catch consisted of individuals measuring between 9.0 and 29.0 cm.

The length frequency distribution of *H. hawaiiensis* was for most individuals ranging from 15.5 to 43.5 cm. The most frequent length categories were 25.5, 29.5, 33.5, 35.5, 37.5 and 41.5 cm. The total catch consisted of individuals measuring between 14.0 and 42.0 cm.

The length frequency distribution of *Bohadshia vitiensis* ranged between 14.5 and 41.5 cm. The most frequent length categories were 21.5, 25.5, 30.5 and 35.5 cm.

The total catch consisted of individuals measuring between 14.0 and 42.0 cm.

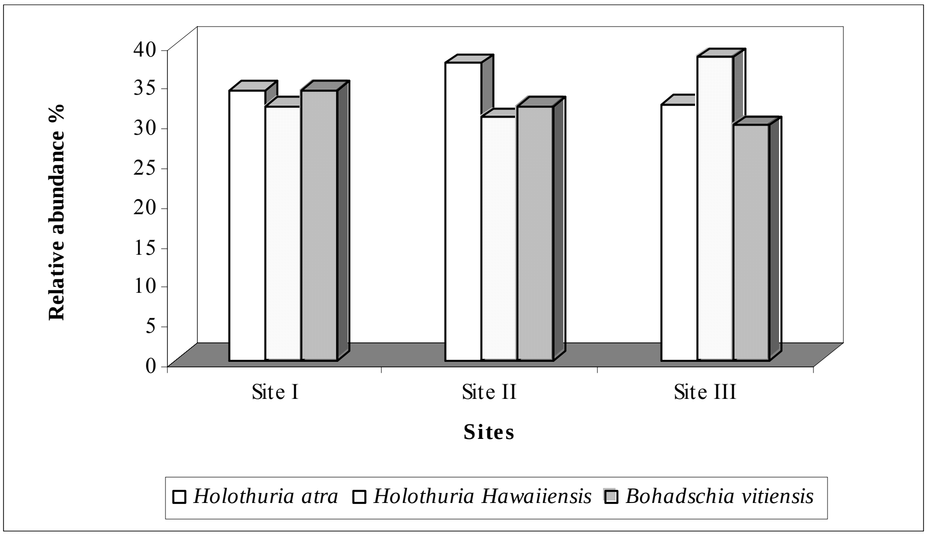

Fig. (2): Relative abundance of the three studied species in the three sites during the period of investigation (Jan. 2003 – Dec. 2003).

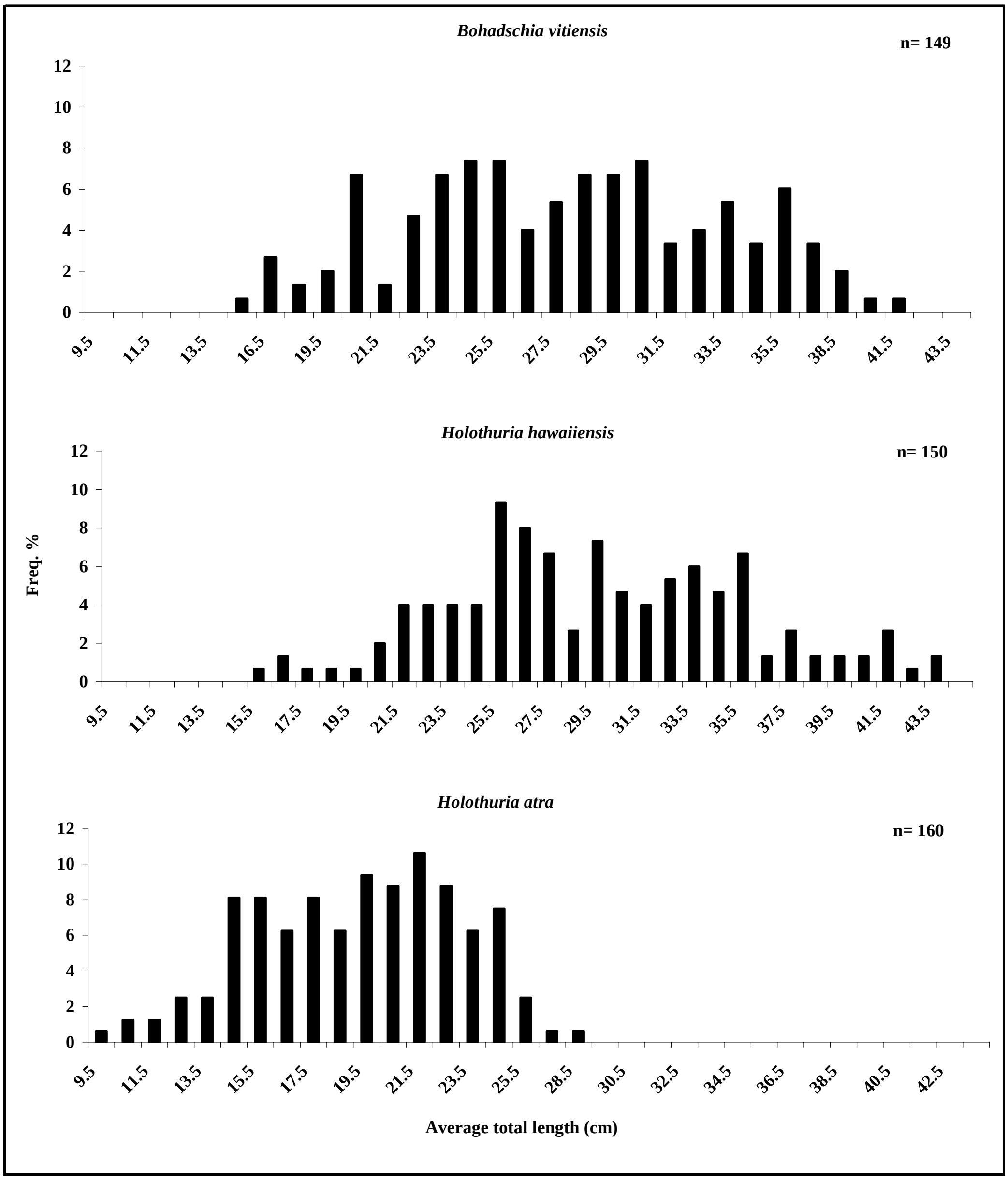

Fig. (3): Length frequency distribution of the three holothurian populations during the period of study (Jan- Dec. 2003)

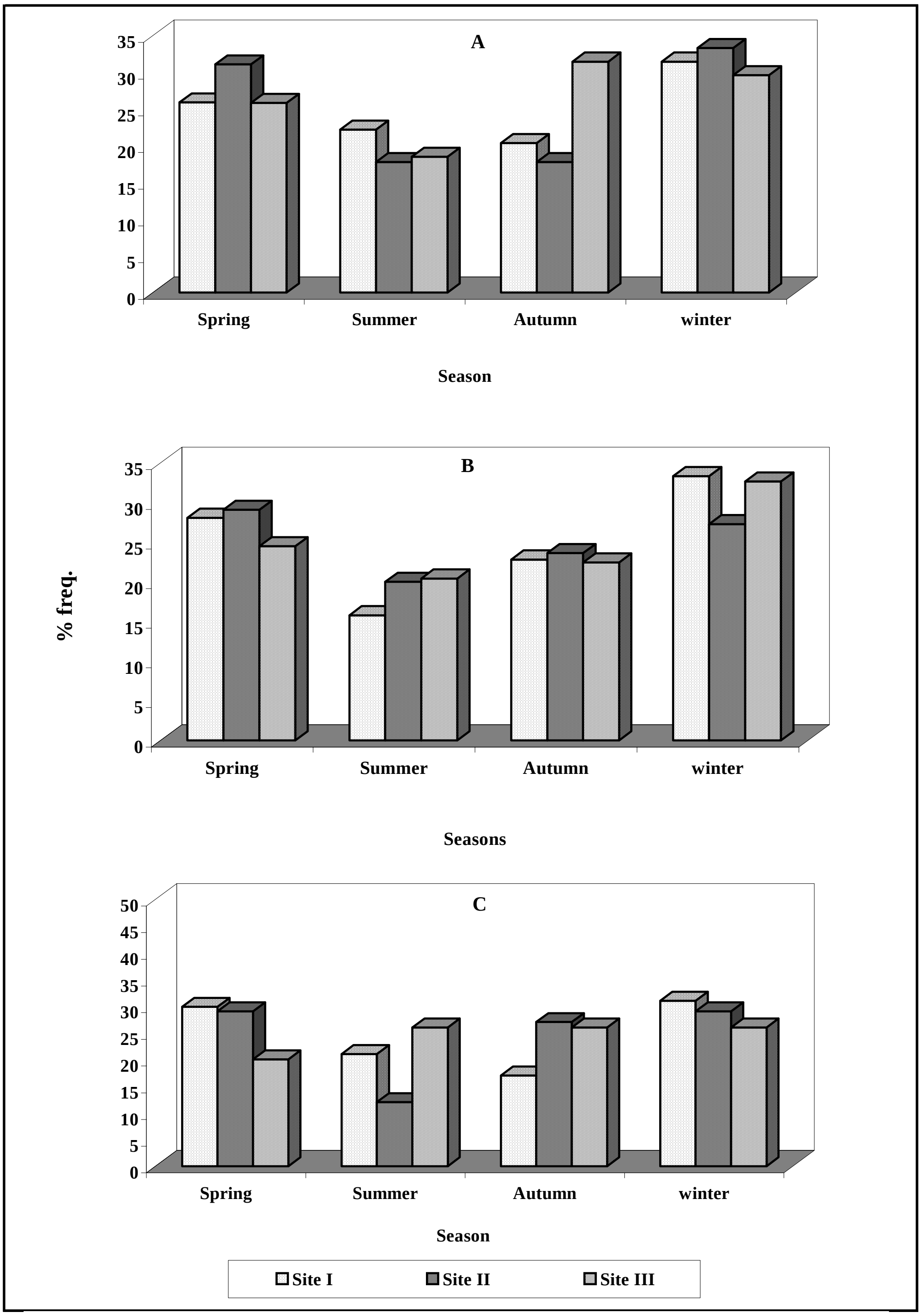

Fig. (4): Seasonal Abundanc of Holothurian species in three sites during the period of study A (*Holothuria hawaiiensis*), B (*Holothuria atra*) and C (*Bohadschia vitiensis*) (Jan 2003 – Dec. 2003)

3.3. Seasonal abundance in relation to type of habitat

Fig. (4) A, B and C describe the seasonal abundance of each of the studied holothrian species in the three sites, while Fig. (5) A, B and C represents this distribution according to the different types of habitat for the three sites.

Holothuria hawaiiensis showed higher abundance during winter and spring in the studied sites Fig. (4) A, where the habitat is mainly of sand, algae, living and dead coral Fig. (5). In autumn this species was highly abundant in site III as in Fig. (4) A, which characterized by the abundance of dead coral, algae, sea grass and sandy habitats in site III as in Fig. (5).

Holothuria atra, as in Fig. (4) B, it was abundant during winter and spring in all sites with a type of habitat mainly composed of algae and sand for the three sites as shown in Fig. (6). During summer and autumn it was less abundant in all sites with a decreasing in the abundance of algae and sea grass habitat and prevailing of dead coral and sand in all of the studied sites as in Fig. (6).

Bohadschia vitiensis as shown in Fig. (4) C, there was little seasonal fluctuations in the three sites we notice here that the habitat comprised only sand, algae and sea grass as in Fig. (7).

3.4. The inter relation between the species gut sediment contents and the bottom sediments of the studied sites.

Holothurians are considered as the most famous deposit feeders in the marine environment and are almost detritivores. They eat the tiny scrap particles that are usually abundant in the environments that they inhabit. Most holothurians are feeding on the sandy substrate, while some others are feedings on hard rocky surfaces.

The present studied sites represent four different types of the tidal flat environment, exposed tidal zones, together with small coral communities, algal and sea grass beds. Small coral batches either dead or live corals are present in addition to sand and macro algae.

Table (2) show the average percentage composition of the dry contents of the bottom sediments of the three studied sites. All sites characterized by large abundance of sand followed by gravel than mud. Site II was relatively the highest in sand and mud sediment fractions and the lowest in gravel. The total organic matters (T.O.M) was estimated as 47.0, 41.6 and 45.0 mg/g in site I, II and III respectively.

While Table (3) illustrates the seasonal variations of the average percentage gut sediment fractions of the three studied holothurian species during the period of study. The gut sediment contents of *H. arta* and *H. hawaiiensis* were found with average high gut percentage composition of sand, gravel and mud during the four seasons of study.

On the other hand, in *B. vitiensis* the gut sediment contents was represented by lower values of gravel contents during summer, autumn and winter seasons. This observation can be attributed to the habitat preference behaviour of *B. vitiensis* which illustrated by its great abundance in algae and sea grass habitat with sand during these periods of the year as shown in Fig. (7).

Total organic matter values were generally large for all species with a limited seasonal variation as in Table (2).

As a general observation, the values of sediment contents and T.O.M as described in Tables (2) and (3) illustrate a great correlation between the type of sediment contents ingested by the animals and that found in the bottom in different studied sites.

Table (2): Average percentage abundance of gravel, sand, mud and total organic matter in the bottom sediments of the studied sites

Study area	No. of analyzed samples	Av.% Composition of sediment			Av. T.O.M mg/g
		Gravel	Sand	Mud	
Site I	5	23.83±3.74	75.34±4.00	0.82±0.99	47.0±5.83
Site II	5	18.53±5.74	80.05±6.29	1.44±1.03	41.6±10.53
Site III	5	23.03±5.17	76.12±4.7	0.85±0.57	45.0±13.32

T.O.M.: Total organic matter mg/g.

Table (3): Average seasonal variations of percentage dry gut sediment fractions and total organic matter of the studied holothrian species

Species	Season	Average % composition of gut sediment content			Total organic matter mg/g	No. of individuals
		Gravel	Sand	Mud		
B. vitiensis	Spring	15.36+9.13	82.95+7.83	1.69+1.32	67.98+8.52	30
	Summer	8.43+5.22	84.50+1.73	7.07+4.51	56.26+12.51	27
	Autumn	2.92+1.85	84.70+3.13	12.38+1.91	59.95+8.01	28
	Winter	7.48+3.46	74.98+6.24	17.54+7.42	54.04+4.6	29
H. atra	Spring	21.55+5.04	76.85+5.77	1.61+0.73	65.3+2.41	24
	Summer	16.95+14.2	80.7+14.5	2.3+0.76	60.1+9.51	27
	Autumn	20.95+15.7	75.37+13.6	3.68+2.07	59.8+7.28	30
	Winter	27.58+9.24	69.71+7.71	2.70+1.62	62.4+2.4	27
H. hawaiiensis	Spring	14.87+6.75	72.3+13.15	8.39+0.30	77.59+23.12	29
	Summer	18.49+10.89	80.43+9.85	1.08+1.04	49.03+5.31	30
	Autumn	25.05+18.88	71.83+15.75	3.14+3.14	72.33+17.22	30
	Winter	19.52+6.41	75.34+3.17	5.14+3.59	55.4+6.66	30

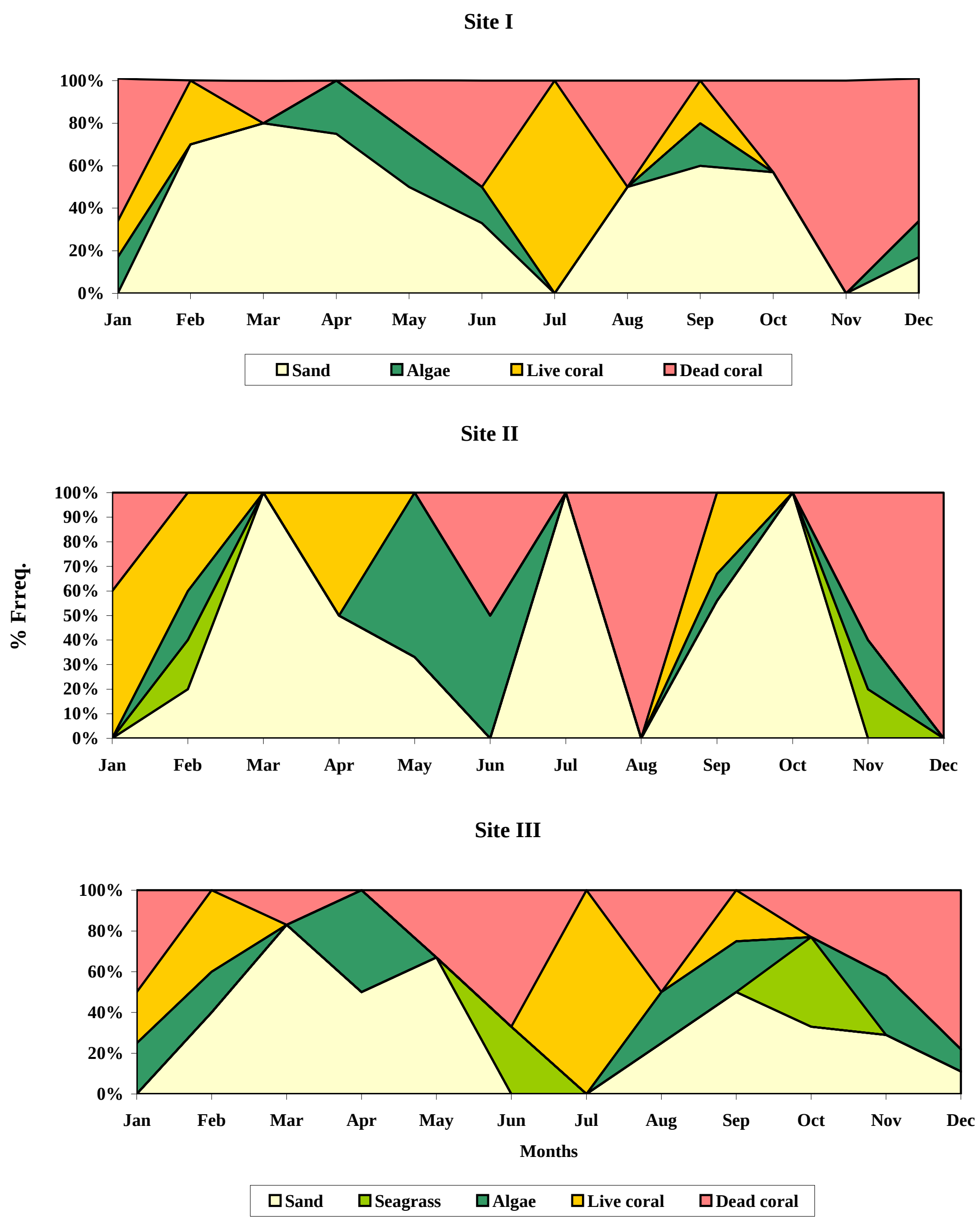

Fig. (5): Distribution of *Holothuria hawaiiensis* in three different sites according to the different habitat

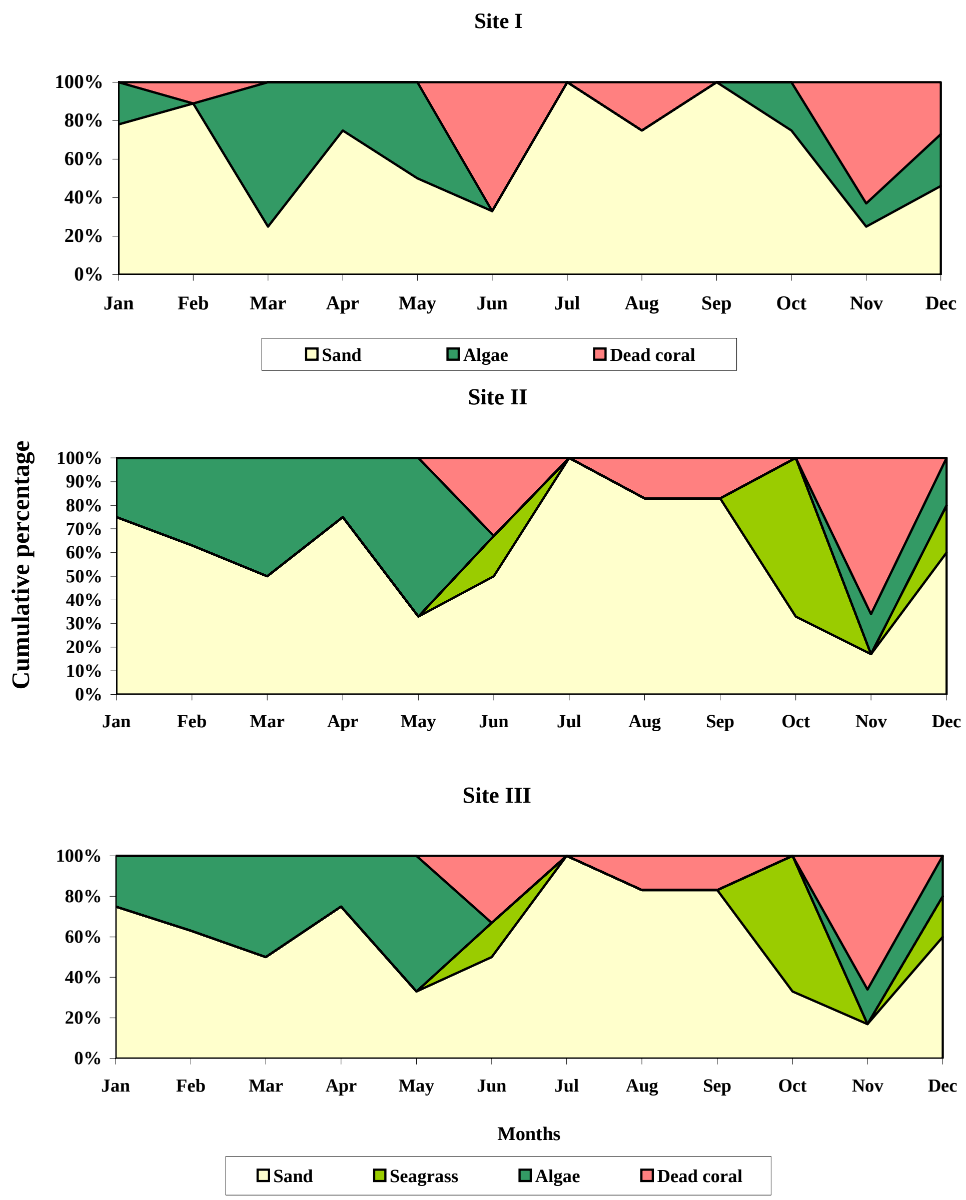

Fig. (6): Monthly distribution of *Holothuria atra* in three different sites according to the different habitat

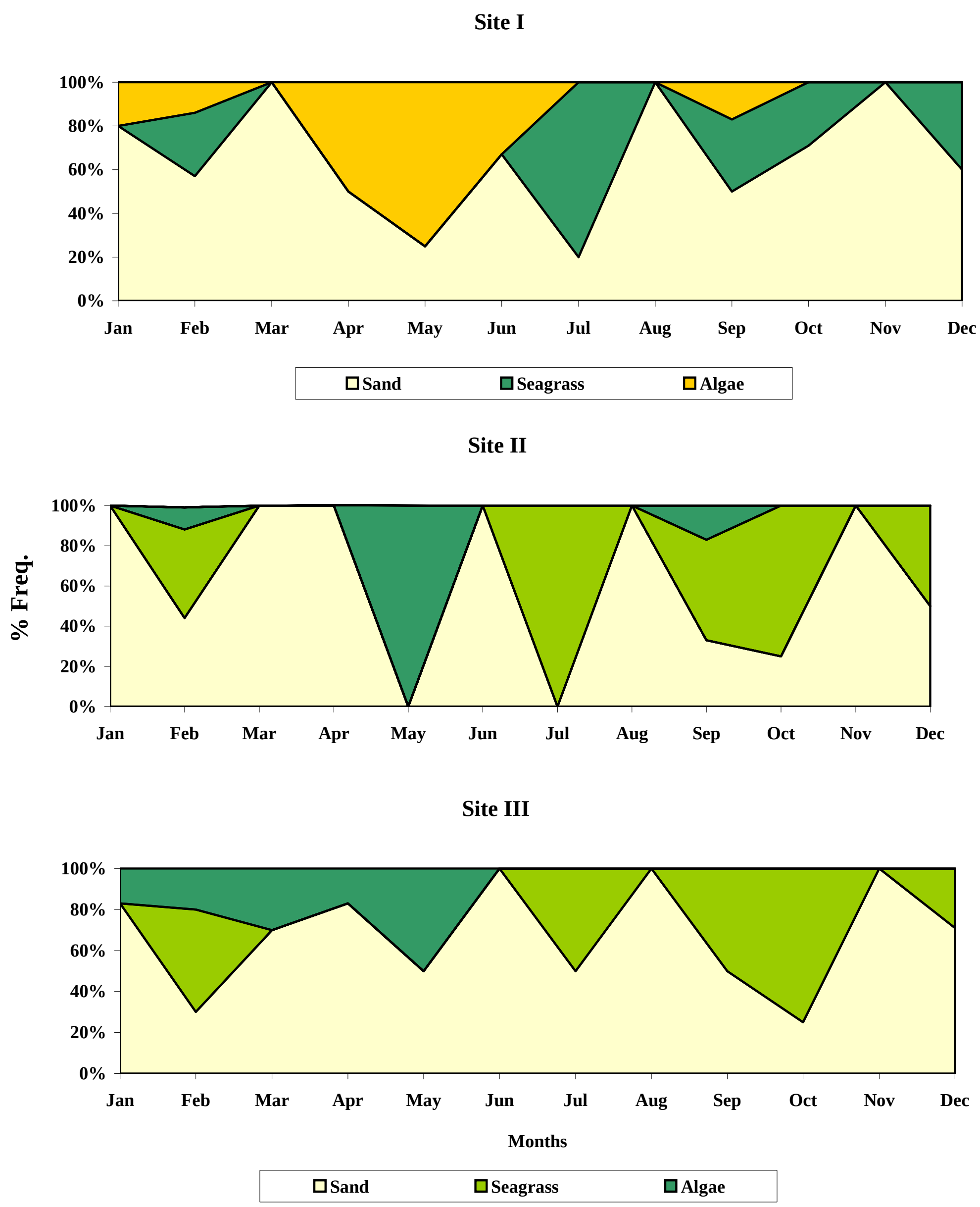

Fig. (7) : Distribution of *Bohadschia vitiensis* in three different sites according to the different habitat

4. DISCUSSION

Increasing attention is being given to the effects of international trade on the environment, especially in situations where biodiversity conservation is opposed to export-led industries such as fisheries.

Even many small-scale fisheries are not an exception when a natural resource represents high revenues to artisanal fishermen, fishing effort rapidly increases and fish stocks become over exploited. Sea cucumber fisheries around the globe have gone through this cycle.

The Red sea holothurians fauna had suffered a lot of negligence, but recently the concern about this group starts to increase with the increase of knowledge about their economic and pharmaceutical importance Abou Zaid *et al.*, (2002).

Holothurian distribution in the marine environment is controlled by many factors as salinity, temperature, light intensity and food availability (Smith, 1962; Hyman, 1955 and Pawson, 1963 & 1964). Seven (2000) reported that the micro-habitat and grain size selection appear to be important means of niche separation between the different species. *H. atra* was significantly more abundant in shallow water with higher cover of soft sediment and low coral.

The present study illustrates that the local conditions are controlling the species distribution of the holothurians. The dominance of certain species relative to the others is completely combined with the surrounding conditions as; the nature of the bottom sediments, degree of tolerance the exposure at the low tide time, benthic communities distribution (coral reefs and algal cover) food availability and may be the degree of pollution. The last item is a scribed to the dominance of *H. atra, B. marmorata* and *H. leucospilota* in highly polluted areas as reported by (Dar, 2002).

There was a significant correlation between the holothurian abundance and the characteristics of the habitats such as substratum type and sea grass cover percentage. In the present study *H. atra* & *B. vitinesis* are more abundant in a habitat rich in algae, sea grass sand, while live and dead coral with algae were considered the most optimum habitat for abundance of *H. howensis* James (1994) considered the mud flats as the best habitats suitable for the sea cucumbers as they are detritus feeders & live on the organic matter present in the mud. The abundance of *H. scbra* increased significantly with the sea grass cover percentage (Lang and Skewes, 1997).

Many species of holothurians have fed selectively, particularly with respect to particle size, whereas, the others have no selection based on particle size. On the other hand, if any particle size selection occur, it is a result of non-uniform distribution of organic matter in the sediments (Moriarty, 1982).

The holothurians do feed selectively on organically rich components of sediments, where *H. tubulosa* selectively ingested sand with an organic coating and rejected cleaned sand, while *H. atra* fed selectively on organic matter (Moriarty, 1982).

The bottom sediments of the present studied sites were mostly of the fractions of gravel and coarse sand and are mainly of biogenic origin as coral debris, foraminifera, shell fragments, coralline algae debris and unidentified fractions as reported by Dar (2004).

The deposit feeders produce changing in the micro-relief of the sea floor and sediment properties by their feeding activities. These biogenic modifications influence the ecology of the soft bottom mud community.

Dar (2004) suggested that the holothurians have consumed large amounts of the surface sediments throughout each feeding period. The repeating of such processes every period is responsible for most sediment reworking operations in the tidal flat zones and generally controlled by individual numbers, food availability, local conditions and individual sizes.

Young and Rhoads (1971) stated that the bottom sediments (mainly in the fine sediments as mud) are extensively reworked by *Molpadia oolitica,* which produces an unstable substratum frequently re-suspended by the tidal cuurent scour.

Also, they reported that the deposit feeders produce unstable sedimentary conditions, which present or restrict the feeding and establishment of suspension feeders and sessile epifauna.

The reworking processes, especially in the eutrophicated localities as the high land fill zones (e.g. Hurghada) changes the bottom sediment characteristically.

Research on the population structures (weighing and measuring animals) and regular monitoring and the continuation of this study on all the other areas of Red Sea would make it possible to introduce sustainable management measures for this important resource.

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