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Species Diversity and Habitat Distribution of Fishes in Sharm El-Maiya Bay, Sharm El-Sheikh, Red Sea

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ABSTRACT

The fish assemblages of different habitats in Sharm El-Maiya Bay, Sharm El-Sheikh, Red Sea, were examined by visual census technique. Fish communities were estimated for each different habitat (coral patches, seagrasses, muddy substrate and coral reefs). A total of 155 fish species representing 98 genera were counted. Coral reef habitat had the highest number of species (146 species), while the muddy habitat had the lowest number (6 species). The highest average abundance was recorded at coral patch habitat (1014 fish/1000 m^3), with the lowest value at muddy habitat (64 fish/1000 m^3). Most individuals belonged to the Mullidae, followed by the Pomacentridae, Chaetodontidae, Labridae, Serranidae and Acanthuridae. The highest diversity of fishes was recorded on the coral reef areas. This habitat has nearly all fish families (36 families). Sparidae and Mullidae were more abundant at seagrass habitats inside the Sharm El-Maiya Bay more than other habitats. Corallivores were less abundant at the seagrass and muddy habitats than on fringing coral reefs and coral patches. In general, both the herbivores and invertebrate-feeder fishes are the most abundant in the Sharm El-Maiya Bay. They represent 42.2 % of total fish population in the study area.

Key words: fish abundance, habitats, diversity, Red Sea, Egypt.

INTRODUCTION

The distribution and abundance of coral reefs are mainly determined by the quality, diversity and availability of suitable habitat (Bouchon-Navarro, 1986; Williams, 1991) and the habitat preferences of incoming larvae (Booth and Wellington, 1998). Therefore, fish community parameters are usually correlated with specific features. For example, fish richness, abundance (Bell and Galzin, 1984; Ormond *et al.,* 1996; Lewis, 1998) and diversity (Ormond *et al.,* 1996) are generally correlated with live coral cover.

Certain fish species or assemblages are characteristic for certain habitats (e.g. Bell and Galzin, 1984; Harmelin-Vivien, 1989; Alwany, 1997; McClanahan and Arthur, 2001; Garpe and Öhman, 2003). They may be selective or non-selective, obligate, facultative or opportunistic in relation to their habitat (Bergman *et al*., 2000). Many reef fishes associate with particular microhabitats within the main habitats (Sale, 1991), although the importance of such associations in determining larger-scale patterns of distribution and abundance appears to vary widely among species (Munday, 2000).

The Red Sea has lower reef fish species diversity than the greater part of the Western Indo-Pacific, probably as a consequence of its relatively recent origin. Sharm El-Maiya Bay is a semi-closed bay with a limited water circulation and acting as sediment trap for sediment and organic particles of various origins. The bay is dominated by a number of recently built hotels and recreational facilities. Sharm El-Maiya Bay suffered for a long time from being use as a mooring area for all the diving vessels in Sharm El-Sheikh. While the Red Sea fish fauna is taxonomically quite well known compared with other parts of the tropical Indo-Pacific Ocean, the structure of coastal fish communities has been less well investigated (Khalaf and Kochzius, 2002). The present study investigates the fish communities of four different shallow-water habitats in Sharm El-Maiya Bay to obtain ecological information to facilitate a proper management of the Northern Red Sea.

MATERIALS AND METHODS

Study area

The coastal area of Sharm El-Sheikh has many sharms and bays, which interrupt the fringing reefs along the coastal-line and Sharm El-Maiya Bay is one of Sharm El-Sheikh bays. Sharm El-Maiya Bay is located in Southern Sinai area approximately 34º 17′ 30″ E and 27º 51′ 36″ N. The perimeter of the bay is about 2150 m with 800 by 500 m main dimensions and surface area of approximately 0.4 km^2 and a maximum depth of 6 m. The Bay has sandy, muddy and rocky shores with different marine habitats (Gab-Alla, 2001). The research was conducted at four different habitats (coral patches, seagrasses, muddy substrate and coral reefs) of Sharm El-Maiya Bay (Fig. 1 and Table 1). These habitats represented the Northern Red Sea Bays, were chosen to observe the fish composition of each habitat and show the differences between them. Data were collected between March and April 1999.

Fish abundance

The fish communities in shallow water habitats inside the Sharm El-Maiya Bay was examined by using visual censuse, which is the most non-destructive method to quantify fish abundance (Sale, 1980). The species were counted visually along 100 m long, 10 m wide and 1 m high transects (100 x 10 x 1 = 1000 m^3) laid parallel to the shoreline (three transects in each habitat with three replicates for each transect). Fish communities were

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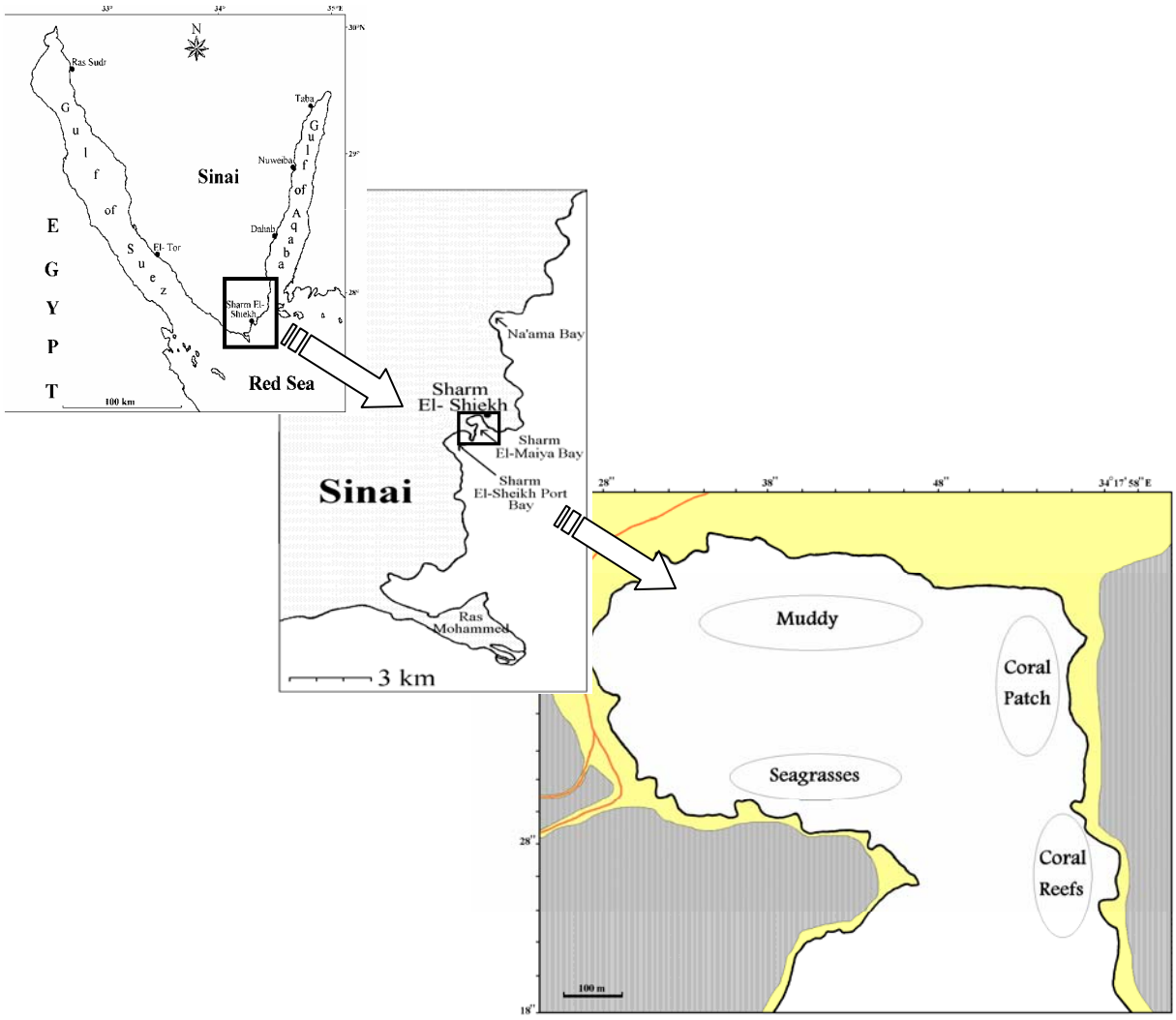

Figure (1): Map of Sharm El-Sheikh area showing the location of Sharm El-Maiya Bay and the positions of the different habitats.

estimated for each different bottom habitat, i.e. coral patches, seagrasses, muddy substrate and coral reefs, in the whole bay area.

Data analysis

The data were analyzed statistically using PRIMER (V.5; Clarke and Gorley, 2001). To compare fish diversity among different habitats, three diversity indices were calculated based on the abundance of fishes: species richness D (Margalef, 1968); Shannon H′ [$\log_e$] (Shannon and Weaver, 1949); and Pielou's evenness J (Pielou, 1969). We used analyses of variance (ANOVA) SPSS software (SPSS, 2000).

RESULTS

Species diversity and fish abundance

The species recorded in each habitat inside the Sharm El-Maiya Bay are listed in Table 2. A total of 155 fish species representing 98 genera were counted. Coral reef habitat had the highest number of species (146 species), while the muddy habitats had the lowest number (6 species). The highest average abundance was recorded at coral patch habitat (1014 fish/1000 m^3), with the lowest value at muddy habitat (64 fish/1000 m^3). The most individuals belonged to the Mullidae (27.91 %, 4 species), follow by the Pomacentridae (24.63 %, 22 species), Chaetodontidae (6.32 %, 8 species), Labridae (6.04 %, 18 species), Serranidae (4.56 %, 6 species) and Acanthuridae (4.09 %, 8 species). The number of species varied highly significantly between the four habitats ($P < 0.001$), and the number of individuals also differed significantly between habitats ($P = 0.007$). Average species richness ranged from 1.20 at muddy habitats to 21.49 at coral reef habitat. The highest evenness index (J′) was recorded at coral reef habitat (0.89), while the muddy habitat yielded the lowest value (0.31). Average Shannon-Wiener diversity (H′) varied between 0.56 at muddy habitat and 4.48 at coral reef habitat (Table 3 and Fig. 2).

Habitat distribution

The highest diversity of fishes was recorded on the coral reef areas. This habitat had all fish families (36 families), except one family, Anthennariidae, which is

Table (1): Description of the four habitats chosen for the present study.

Habitat	Position	Depth (m)	Structural complexity	Structural components
Coral patches	27º 51′ 42″ N 34º 17′ 49″ E	1-2	High	- rich in corals and algae - rich in echinoderms - many holes - few rocks and stones
Seagrasses	27º 51′ 30″ N 34º 17′ 40″ E	0.5-2	Medium	- rich in algal communities - hotel rubbish is low - low rocks and stones
Muddy	27º 51′ 43″ N 34º 17′ 33″ E	1-2	Low	- no corals and few algae - very turbid water - rich in hotel rubbish - rich in rock and stones
Coral Reefs	27º 51′ 26″ N 34º 17′ 59″ E	0.5-2	High	- well developed corals - high tourism activities - strong wave actions

Table (2): The recorded abundance (no. of individuals / 1000 m^3) of the different fish species found at each habitat in Sharm El-Maiya Bay with trophic categories based on field observations (C: corallivore; D: detritivore; H: herbivore; I: invertebrate-feeder; IF: invertebrate and fish-feeder; O: omnivore; PI: piscivore; PL: planktivore).

Fish species	Coral patches	Seagrass	Muddy	Coral reefs	trophic categories
Dasyatididae					
Taeniura lymma	0	0	0	1	I
Synodontidae					
Synodus variegates	4	0	0	5	PI
Saurida gracilis	2	0	0	2	PI
Muraenidae					
Gymnothorax	0	0	0	1	IF
Siderea grisea	2	0	0	2	PI
Belonidae					
Tylosurus choram	2	0	1	3	PI
Hemiramphidae					
Hemiramphus far	0	4	0	1	O
Hyporhamphus gambarur	0	2	0	0	O
Fistulariidae					
Fistularia commersonii	0	0	0	2	IF
Syngnathidae					
Hippocampus histrix	0	0	0	1	I
Trachyhamphus	2	3	0	0	PL
Corythoichthys schultzi	2	1	0	2	I
Anthennariidae					
Antennarius coccineus	0	1	0	0	PI
Holocentridae					
Myripristis murdjan	0	0	0	3	PL
Adioryx ruber	2	0	0	5	IF
Flammeo sammara	1	0	0	2	IF
Scorpaenidae					
Scorpaenopsis diabolus	0	0	0	2	IF
Synanceia verrucosa	1	0	1	1	PL
Pterois volitans	2	0	0	5	IF
P. radiate	0	0	0	2	I
Serranidae					
Cephalopholis argus	1	0	0	3	IF
C. hemistiktos	0	0	0	2	IF
C. miniata	0	0	0	1	IF
Epinephelus fasciatus	2	0	0	3	IF
Anthias squamipinnis	24	0	0	45	PL
A. taeniatus	4	0	0	11	PL
Grammistidae					
Grammistes sexlineatus	1	0	0	4	PI
Priacanthidae					
Priacanthus hamrur	2	0	0	3	IF
Cirrhitidae					
Cirrhitus pinnulatus	0	0	0	3	IF
Paracirrhites forsteri	0	0	0	2	IF
Pseudochromidae					
Pseudochromis flavivertex	2	0	0	8	I
P. fridmani	4	0	0	12	I
Pseudoplesiops auratus	1	0	0	4	I
Carangidae					
Carangoides bajad	4	2	0	4	IF
C. fulvogutatus	2	0	0	4	IF
Caranx melampygus	1	0	0	2	IF
Lutjanidae					
Lutjanus ehrenhergi	2	0	0	6	IF
L. fulviflamma	1	2	0	3	IF
L. kasmira	0	0	0	1	IF
L. coeruleolineatus	0	1	0	0	IF
L. argentimaculatus	0	1	0	2	IF
Caesionidae					
Caesio lunaris	2	0	0	3	PL
C. suevicus	11	3	0	25	PL
Pterocaesio chrysozona	5	0	0	12	PL
Lethrinidae					
Lethrinus harak	1	0	0	4	I
L. mahsenoides	0	0	0	2	I
L. mahsena	3	2	0	2	I
L. nebulosus	1	1	0	1	I
L. lethrinus	2	0	0	0	I
Monotaxis grandoculis	0	0	0	2	I
Sparidae					
Rhabdosargus haffara	0	12	0	0	I
R. sarba	15	2	0	12	I
Acanthopagrus bifasciatus	0	1	0	2	I
Diplodus noct	2	2	0	1	H, I
Soleidae					
Pardachirus marmoratus	2	0	0	1	I
Mullidae					
Parupeneus forsskali	390	45	0	36	IF
P. cyclostomus	5	0	0	12	IF
Mulloides flavolineatus	6	12	0	24	IF
M. vanicolensis	25	22	0	10	IF
Echeneididae					
Echeneis naucrates	1	2	0	1	O
Mugilidae					
Crenimugil crenilabis	4	3	56	0	D
Oedalechilus labiosus	0	4	0	0	D
Sphyraenidae					
Sphyraena jello	0	0	0	2	PI
Atherinidae					
Atherinomorus lacunosus	3	0	0	2	PL
Apogonidae					
Apogon aureus	0	0	0	4	PL
A. kallopterus	0	0	0	1	PL
A. annularis	0	0	0	1	PL
A. bifasciatus	0	0	0	4	PL
Cheilodipterus	0	0	0	2	PL
Pomacentridae					
Abudefduf saxatilis	82	0	0	19	PL
A. sexfasciatus	47	0	0	22	PL
A. sordidus	4	0	0	6	H, I
Amblyglyphidodon	4	0	0	4	PL
	3	0	0	6	PL
	6	0	0	2	H, PL
Chromis caerulea	0	0	0	3	C
C. dimidiata	32	0	0	25	PL
Chrysiptera annulata	0	0	0	2	H, PL

C. unimaculata	0	0	0	4	H
Dascyllus aruanus	22	0	0	17	PL, I, H
D. marginatus	8	0	0	5	H, PL
D. trimaculatus	13	0	0	11	PL
Neoglyphidodon melas	4	0	0	6	C
Plectroglyphidodon	11	0	0	11	H
P. leucozona	2	0	0	12	H
Pomacentrus albicaudatus	18	0	0	13	H
P. aquilus	12	0	0	23	H, PL
P. sulfureus	3	0	0	13	PL
P. trichourus	13	0	0	12	H, PL
P. trilineatus	7	0	0	4	H, PL
Stegastes nigricans	3	0	0	4	H
Labridae					
Anampses lineatus	0	0	0	2	I
A. meleagrides	0	0	0	1	I
Bodianus anthioides	1	0	0	3	I
Cheilinus fasciatus	0	0	0	7	O
C. lunulatus	1	0	0	3	O
C. undulatus	0	0	0	2	O
Coris aygula	0	0	0	5	I
Epibulus insidiator	0	0	0	2	IF
Gomphosus coeruleus	4	0	0	11	I
Halichoeres hortulanus	0	0	0	4	I
H. scapularis	0	0	0	2	I
Hemigymnus fasciatus	2	0	0	6	I
Labroides dimidiatus	0	0	0	5	I
Larabicus quadrilineatus	0	0	0	2	C
Novaculichthys taeniourus	2	0	0	4	I
Pseudocheilinus hexataenia	0	0	0	3	PL
Pseudodax moluccanus	0	0	0	2	H, I
Thalassoma rueppellii	18	0	0	35	IF
Scaridae					
Cetoscarus bicolor	1	0	0	3	C
Chlorurus gibbus	0	0	0	1	C
C. sordidus	0	0	0	2	H
Hipposcarus harid	4	0	0	5	H
Scarus collana	3	0	0	2	H
S. ferrugineus	0	0	0	2	H
S. frenatus	0	0	0	1	H
S. fuscopurpureus	1	0	0	3	H
S. ghobban	2	0	0	1	H
S. niger	3	0	0	6	H
S. psittacus	0	0	0	2	H
Ostistidae					
Ostracion cyanurus	5	2	0	1	O
O. cubicus	0	0	0	0	O
Tetrosomus gibbosus	0	0	0	0	O
Chaetodontidae					
Chaetodon auriga	5	2	0	6	O
C. austriacus	9	0	0	14	C
C. fasciatus	8	1	0	11	O
C. melannotus	3	0	0	6	C
C. paucifasciatus	5	2	0	11	O
C. semilarvatus	3	0	0	6	O
C. trifascialis	0	0	0	4	C
Heniochus intermedius	19	4	0	14	PL
Pomacanthidae					
Centropyge multispinis	6	0	0	6	H
Pomacanthus imperator	1	0	0	2	O
Pygoplites diacanthus	2	0	0	3	O
Acanthuridae					
Acanthurus gahhm	0	0	0	2	H
A. nigrofuscus	6	0	0	11	H
A. sohal	1	0	0	6	H
Ctenochaetus striatus	12	0	0	15	D
Naso lituratus	1	0	0	2	H
N. unicornis	0	0	0	1	H
Zebrasoma desjardinii	4	2	0	13	H
Z. xanthurum	2	0	0	8	H
Siganidae					
Siganus rivulatus	2	2	0	4	H
S. argenteus	0	1	0	0	H
S. luridus	0	0	0	1	H
S. stellatus	0	2	0	3	H
Balistidae					
Balistapus undulates	3	0	0	2	O
Sufflamen albicaudatus	2	0	0	1	I
Rhinecanthus assasi	3	2	0	3	I
Balistoides viridescens	0	0	0	2	C, IF
Odonus niger	1	0	0	1	PL
Tetraodontidae					
Arothron diadematus	3	3	2	3	O
A. hispidus	12	6	1	1	O
A. stellatus	9	14	3	2	O
Diodontidae					
Diodon hystrix	0	0	0	1	I
Haemulidae					
Plectorhynchus gaterinus	2	2	0	3	IF
P. pictus	0	1	0	2	IF

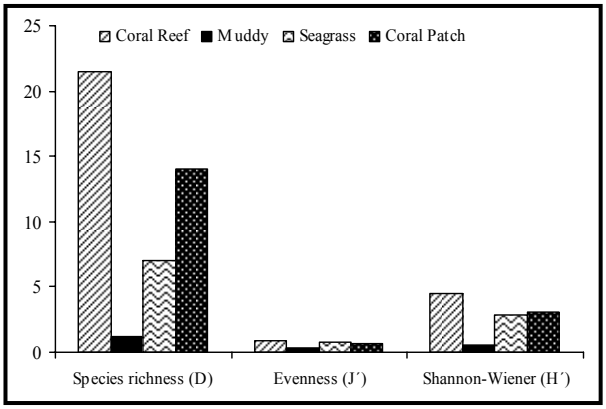

Figure (2): Fish community parameters (species richness, diversity and evenness) of different habitats at Sharm El-Maiya Bay.

represented only in seagrass habitat by one species (*Antennarius coccineus*). Two groups, Sparidae and Mullidae, were more abundant at seagrass habitats inside the Sharm El-Maiya Bay comparing with other habitats. Two species of Hemiramphidae (*Hemiramphus far* and *Hyporhamphus gambarur*) are abundant in the seagrass habitats, where they feed on floating seagrass leaves, crustaceans and small fishes. Coral patches habitat had highest number of fishes. This was due to large numbers of one Mullidae species (*Parupeneus forsskali*, being 390 fish/1000 m^3). The poorest area in fish abundance and diversity was the muddy habitat. This habitat had only 6 species (Table 3), belonging to four families (Belonidae, Scorpaenidae, Mugilidae and Tetraodontidae).

Abundance of trophic groups

The total abundance of the various trophic groups at different habitats revealed patterns connected with the benthic substrate and physical parameters of these habitats. Corallivores were less abundant at the seagrass and muddy habitats than on fringing coral reefs and coral patches. In general, both the herbivores and invertebrate-feeder fishes are most abundant in Sharm El-Maiya Bay. They represent 42.2 % of total fish population in the study area (herbivores 21.4 % and invertebrate-feeders 20.8 % of the total fish population). The piscivores and detritivores fishes were the lowest abundant fish trophic group (piscivores 4.2 % and detritivores 1.8 % of the total fish population). The fish feeds on planktons (PL) and invertebrates and small fishes (IF) were represented by 18.5 and 17.9 %

Table (3): Summary of diversity indices and characteristics at each habitat in Sharm El-Maiya Bay.

	Coral patches	Seagrass	Muddy	Coral reefs
Number of species	98	37	6	146
Number of individuals	1014	174	64	851
Species richness (D)	14.01	6.98	1.20	21.49
Evenness (J´)	0.67	0.79	0.31	0.89
Shannon-Wiener (H´)	3.06	2.88	0.56	4.48

respectively. Ominivores were relatively less abundant (10.1 %). Corallivores tended to be less abundant inside the Bay, where represented 5.4 % of the total fish population.

DISCUSSION

In Sharm El-Maiya Bay, species diversity and habitat distribution of different trophic group of fishes were examined in relation to the different habitats and benthic communities. Sharm El-Maiya Bay is ecological valuable due to its role as the nursery ground for some commercially valuable fishes, and presence of some ecologically sensitive ecosystem, i.e. segrass and coral patches ecosystems. Overall, our results indicate that the type of habitats have the most dramatic effect on near-shore fish distributions and abundances in Sharm El-Maiya Bay.

Larval and juvenile recruitment in reef fish communities have an important role in determining the structure and stability of these communities. Settlement is influenced by habitat selection for substrate types (Williams and Sale, 1981), and many reef fish species prefer to settle on live corals (Booth and Beretta, 2002). Hanafy and Kotb (1999) reported that the larvae of Pomacentridae were the highest abundant group of fishes in the coral reef in Sharm El-Maiya Bay. Our results confirm the previous finding, where the Pomacentridae represented 24.63 % of the total fish population, belonging to 22 species. In addition, Jones (1997) found that juvenile growth and survival may be substantially affected by the structure of the habitat. Comparing with the available data reported by Ahmed (1992) taken during the same month of 1990, the relative abundance of fish juveniles increased sharply. However it is very difficult to give a certain reason for this result and it is questionable if it is related to a recovery in the bay environment. If so, it could be concluded that the value of the bay as a nursery ground for fish juveniles is increasing.

Gab-Alla (2001) reported that the seagrass meadow in the Sharm El-Maiya Bay has 3 species of seagrasses (*Halodule uninervis, H. ovalis* and *Halophila stipulacea*). Also he mentioned that the leaves of these species were nearly free from epiphytes, which many fishes feed on it. Herbivores represented by 21.4 % of the total fish population in the present study. But it is surprising that most fishes recorded in the seagrass habitat were omnivore fishes, and the herbivore fishes mainly recorded at the coral and coral patches habitats (where the most herbivores feeds on turf algae on the hard substrate of this habitats).

Planktivore fishes dominate the fish community on coral reefs in the Gulf of Aqaba (Khalaf and Kochzius, 2002). This finding corresponds with studies in Sri Lanka, the Great Barrier Reef, New Caledonia and the Gulf of Mexico (Williams and Hatcher 1983; Öhman *et al*., 1997; Pattengill *et al*., 1997). In the Sharm El-Maiya Bay, the planktivores (18.5 %) represented the third trophic categories, where it comes after herbivores (21.4 %) and invertebrate-feeders (20.8 %) of the total fish population. The proportion of species belonging to particular feeding guilds is different between the four habitats in Sharm El-Maiya Bay, also differs somewhat from habitats in the Indian and Pacific Oceans. The contribution of planktivores species to fish assemblages in the Red Sea seems to be high in comparison to other coral reefs in the world, whereas piscivores play only a minor role (Khalaf and Kochzius, 2002). Aamer *et al*. (2006) reported that the abundance of total zooplankton was higher inside (6710 individuals/m^3) than outside (4567 individuals/m^3) the Bay. This finding give the reason; why many Planktivore species were found inside the Sharm El-Maiya Bay.

The reduced abundance of corallivores in seagrass and muddy habitats than on fringing coral reefs and coral patches is not surprising, since these fishes and their larae and juveniles are strongly associated with live corals (Bouchon-Navaro *et al*., 1985; Jennings *et al*., 1996; Öhman and Rajasuriya, 1998; Khalaf and Kochzius, 2002; Alwany, 2003; Alwany and Stachowitsch, 2007). In Sharm El-Maiya Bay, the percentage of corallivore fishes is only about one third of the normal fringing reefs outside the Bay. This might be due to low diversity of the scleractinian corals inside the Sharm El-Maiya Bay.

In conclusion, the fish communities at the Sharm El-Maiya Bay were different between the investigated habitats. Our field results, however, demonstrated that the Sharm El-Maiya Bay is ecological valuable as nursery ground for some commercially valuable fishes and the diversity of habitats inside the Bay. Management for the protection the marine resources inside the Bay is therefore needed urgently. Ras Mohammed National Park provides important baseline data for intensive research and conservation of the Sharm El-Sheikh areas, especially Sharm El-Maiya Bay.

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تعدد الأنواع وتوزيع البيئات للأسماك فى خليج شرم الميه، شرم الشيخ، البحر الأحمر

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الملخص العربـــى

تمت هذه الدراسة للتعرف على التعددية النوعية للأسماك فى أربعة بيئات مختلفة فى خليج شرم الميه والذى يقع فى المدخل الرئيسى لمدينة شرم الشيخ. خليج شرم الميه يعتبر خليج مغلق وتطل عليه العديد من المنتجعات السياحية، حيث أستخدم ولفترة طويلة كمرسى لمعظم المراكب السياحية فى منطقة شرم الشيخ.

تم عمل هذه الدراسة فى بيئات مختلفة، وهى بيئة الشعاب المبعثرة وبيئة الحشائش والبيئة الطينية وبيئة الشعاب المتلاصقة. من خلال هذه الدراسة تم التعرف على 155 نوع سمكى والتى تمثل 98 جنس سمكى. حيث وجد أن بيئة الشعاب المتلاصقة كانت تحوى أكثر عدد من الأنواع (146 نوع سمكى)، بينما البيئة الطينية كانت أقلها (6 أنواع سمكية). وكذلك وجد أن أكثر متوسط لأعداد الأسماك تم تسجيله فى بيئة الشعاب المبعثرة (1014 سمكة لكل 1000 متر مكعب)، وأن أقل متوسط تم تسجيله فى البيئة الطينية (64 سمكة لكل 1000 متر مكعب). ووجد كذلك أن أغلب الأسماك تنتمى لعائلة أسماك الميوليدى (البربونى) ثم تليها أسماك عائلة البوماسنتيريدى (العذراء) ثم أسماك الكيتودونتيدى (الفراشة) ثم أسماك اللبريدى (العروسة) ثم أسماك السرلنيدى (القشر) وآخيرا أسماك عائلة الآكانسيدى (الجراح). أعلى تنوع للأسماك وجد فى بيئة الشعاب المرجانية المتلاصقة، حيث تضم هذه البيئة تقريبا جميع عائلات الأسماك السباريدى (الدنيس) والميوليدى (البربونى) وهى أكثر العائلات وفرة داخل خليج شرم الميه أكثر منها فى البيئات الآخرى. الأسماك آكلات الشعاب يكون عددها أقل فى بيئة الحشائش والبيئة الطينية عنها فى البيئات الآخرى. آكلات الحشائش واللافقاريات تكون أكثر عددا حيث تمثل 42.2 % ، بينما تعد آكلات الأسماك والطين أقلها فى خليج شرم الميه.