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FULL LENGTH ARTICLE

Role of mangroves as a nursery ground for juvenile reef fishes in the southern Egyptian Red Sea

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Abstract This work aims to study the importance of mangrove area as nursery grounds for the juvenile of reef fishes in the Red Sea. Juvenile fishes were collected during three seasons in 2010 from three mangrove swamps by a beach seine net. The net was dragged on the bottom for 100 m three times. A total of 269 juvenile fishes were collected, representing 21 species in 19 families. The most abundant species formed about 86% of all collected fishes. Nine species were collected for the first time from mangrove areas in the Egyptian Red Sea. Most of the collected fishes are economically important fishes. Moreover, eleven families were belonging to coral reef fishes. The highest species richness value was recorded in Hamata mangroves. This finding showed that how mangroves could support the life history of many coral reef fishes.

Introduction

About one thousand of fish species included in 100 families live on coral reefs. The vast majority of coral-reef fishes have pelagic larva that spent in the water column away from adult habitat on the reef (Leis et al, 1996). This pelagic phase is potentially much more dispersive than the relatively sedentary adult stage (Sale, 1991). Many marine organisms have complex life histories that include distinct stages that depend on different marine habitats (Leis et al., 1996). Most marine fishes spawn 10,000 eggs to 1,000,000 small eggs (less than 1 mm) which hatch into larvae that drift in ocean currents for 1 week to several months before transforming into juveniles and entering nursery habitats. For some species these nursery habitats are the same habitats as their adults, but for most species nursery habitats are distinct (Jones, 1991; Leis et al., 1996; Rosenberg, 1982).

Juveniles are sexually immature pre-adult stages that resemble the adult morphologically, although in some cases they may exhibit different patterns of coloration. Nursery grounds are usually found near the shore (shallow water) and may be estuaries (Munro et al., 1973), insular shelves of the reef habitats, sheltered inshore areas including mud flats, sandy shores, seagrass and mangrove habitats (Ahmed, 1992). They must have certain characteristic features including abundant food supply and protection from predation.

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It has been proved that high number of fishes and marine invertebrates depends to a large extent on mangrove habitats during the juvenile phase of their life cycles, where the mangrove prop-roots create a special underwater habitat, especially during the breeding and juvenile stages (Bennett, 1989). The availability of mangrove nursery habitat had a striking impact on the community structure and biomass of reef fish in their adult, coral reef habitat. The biomass of several species was more than doubled when the reefs were connected to rich mangrove resources (Mumby, 2005).

Despite the importance of mangroves as nursery area for life history of fishes, researches on the early stages of fishes and their biology and ecology in the Red Sea are very rare. Moreover, information on the distribution of juvenile fishes of the coral reef in the Red Sea is almost lacking. However, Ahmed (1992) studied the distribution, growth, feeding, species composition and abundance of the juvenile in the Gulf of Aqaba. Therefore, this study aims to determine the composition of juvenile fish communities inhabiting mangrove swamps in the Egyptian Red Sea, to evaluate the importance of these swamps as nursery areas for the economically important fishes and how mangroves could support the life history of reef fishes.

Materials and methods

Description of study area

This study was carried out in three coastal mangrove swamps along the Egyptian Red Sea (Fig. 1). Sharm Al-Bahary is located at 35 km south of Al-Qussier. Most of the coast of Sharm Al-Bahary is formed of medium to coarse sand while the northern part is characterized by grit stone. The tidal flat is wide, nearly horizontal and extends smoothly with very gentle slope seaward. Its bottom floor is rocky mainly from the dead coralline limestone covered with thin layer of fine sand and mud inhabited with mangrove trees. This area is very shallow and the mangrove trees were situated along the beach zone, also the area has narrow rocky tidal flat.

Qula'an is shallow with a narrow coastal area that is inhabited by mangrove trees located at 24° 21′ 33 N 35° 17′ 46°E. The tidal flat is narrow in the middle and southern parts while the northern part is sandy and inhabited with dense seagrasses cover. It extends smoothly with very gentle slope seaward.

Hamata (24°37′N and 35°28′E) in the Southern Egyptian Red Sea coast is about 70 km south of Marsa Alam (Fig. 1). It contains the best-developed stands of mangrove on the entire coast. This stand has a crescent shape, with two sandy protected shallow lagoons with muddy bottom. The lagoons are sheltered and nearly isolated from the sea.

Field work

Physico-chemical parameters of temperature and salinity, were measured by the Hydro-lab. Juvenile fishes were collected from the mangroves of Sharm Al-Bahary, Qula'an and Hamata in winter, spring and autumn. Fishes were collected by a small beach seine that was towed horizontally creeping on the

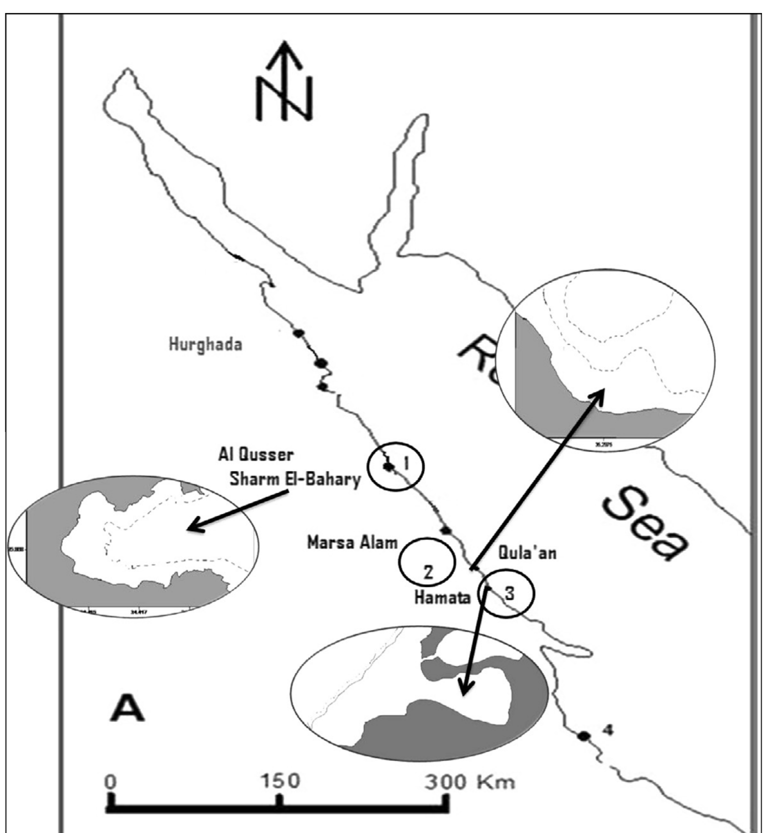

Figure 1 Location map of the Red Sea showing the sampling mangrove sites, (1) Sharm El-Bahary, (2) Qula'an and (3) Hamata.

bottom for a distance of approximately 100 m (Ahmed, 1992). Fishes were removed and then frozen for further investigation. Sizes of the juvenile fishes were measured to the nearest 0.1 cm.

Data analysis

The univariate statistics was done in SPSS v.17.0, using ANOVA to determine differences in the number of individuals and number of species between months and sites. Shannon–Wiener-Diversity (H′), Pielou's evenness index (J) and Margalef's index-species richness (d) were calculated at each site using PRIMER 5 after standardization and square root transformation (Zar, 1999).

Results

Environmental conditions

Mangroves in Sharm Al-Bahary and Qula'an were highly exposed during the low tide with a water depth of less than 10 cm. On contrary, the mangrove prop-roots at Hamata were not exposed at low tide with an average depth of about 30–100 cm. The average water temperature, measured during the entire study period was 23 °C. The salinity of the studied sites ranged from 41.2 to 44 (Table 1).

Diversity of juvenile fishes

A total of 269 juvenile fishes, representing 21 species and 19 families were collected throughout the period of study (Table 2). The most abundant 10 species, formed about 86% of all collected fishes. The most abundant species was *Gerres oyena* with 62 fishes forming 23% of all collected juveniles. The second most abundant species was *Sardinella maderensis* with 37 fishes forming 15% of the collected fishes (Fig. 2).

With the exception of families Mullidae and Tetraodontidae that were represented by two species, all fish families were represented in the collection by one species.

The analysis of the diversity indices showed that Hamata mangroves had the highest diversity index (2.24) whereas, Qula'an mangroves has the lowest value of diversity index. The number of species was also much higher in Hamata than both Qula'an and Sharm Al-Bahary as indicated by the richness values (Fig. 3). Evenness values were almost the same for Hamata and Sharm Al-Bahary (0.79 and 0.8 respectively) (Fig. 3).

The analysis of variance (ANOVA) showed that there was a significant difference between the three mangrove areas ($F = 4.27$, $P < 0.05$). Regarding the spatial distribution of juveniles (Table 2), Hamata mangroves harbored the highest number of fishes where 193 fishes representing 17 species (71.7% of all fishes and 81% of species) were collected. Mangroves of Qula'an and Sharm Al-Bahary have almost the same number of fishes with 37 fishes (3 species) and 39 fishes (5 species), respectively (Figs. 4 and 5). Almost all species occurred in Hamata mangroves. *Terapon jarba, Aphanius dispar*, *Arothron stellatus and Platax orbicularis* were absent from mangroves of Hamata.

The highest number of juveniles was collected in winter (118) whereas the lowest was collected in fall (63) (Table 3 and Fig. 6).

The highest number of species was found in winter where 15 species were collected. Whereas, the lowest number (9) was recorded in fall (Fig. 7).

Size frequency distribution

The size frequency distribution of the four abundant species was analyzed. Size of the collected fishes throughout the present study ranged from 3 cm (*A. dispar* and *S. maderensis)* to 21.5 cm (Mugilidae). Fishes of Mugilidae (6.5–21.5 cm) and *Chanos chanos* (8–18.5 cm) seem to have the full size range (Table 4). Juveniles of *G. oyena* varied in size from 5.5 cm to 9.5 cm. Most fishes lie in the intervals from 6 to 8 cm where 36 fishes forming 85% of all collected fishes were recorded.

The seasonal variation in the size indicated that the largest fishes (9.5 cm) occurred in autumn. *Terapon jurba* had the largest fishes in winter and the smallest in fall and spring (Fig. 8).

Discussion

Many studies in various parts of the world have recognized the importance of mangroves as habitats for fishes. Mangroves provide habitat for early life stages of invertebrates and fish (Dorenbosch et al., 2004). It has been known to contain a high diversity and abundance of coral reef fishes in the Caribbean (Weinstein and Heck, 1979), in the Indian Ocean (Pinto and Punchihewa, 1996). The present study showed the importance of mangroves as nursery for commercial reef fish species along the Red Sea coast. Several hypotheses have been proposed to explain the high abundance of juvenile fishes in mangroves. These hypotheses are based on avoidance of predators and the abundance of food (Ahmed, 1992; Robertson and Blaber, 1992).

When fishes become too large to be protected by mangrove prop-roots they often migrate to the coral reef. This migration pattern has largely been described qualitatively for a few species (Rooker and Dennis, 1991). In the present study, most juveniles leave the mangroves as they grow. These species may be dependent on mangroves for longer periods than other species. Most of the studied species use the shallow water (mangroves) as nurseries during their juvenile stage, but migrate permanently to the deeper (coral reef) when reaching a specific size class. However, *Lutjanus monostigma*, *C. chanos* and Mugilidae reach large size in mangrove of Hamata.

Of the species recorded in the present study, two are found in other habitats than mangrove (Juvenile of *Siganus rivulatus* was encountered by the author in seagrass beds, and *Mulloides flavolineatus* was recorded in sandy areas of the reef lagoons.

Table 1 Environmental characteristics and physic-chemical parameters of sites supporting juvenile fishes inhabiting mangrove swamps.

Environmental variables	Sharm El-Bahary	Qula'an	Hamata
Substrate	Rocky	Rocky	Muddy
Water depth	35	20	100
Temperature	24	23	23
pH	8.3	8.3	8.1
Salinity	40.7	41.2	44

Table 2 Density of juvenile fishes inhabiting mangrove swamps in different sites.

Family	Species	SH.BHRY	Qula'an	Hamata	Total
Gerreidae	*Gerres oyena*	0	0	62	62
Teraponidae	*Terapon jurba*	17	24	0	41
Clupeidae	*Sardinella maderensis*	0	0	37	37
Mugilidae	Mugilidae sp.1	11	12	8	31
Chanidae	*Chanos chanos*	0	0	19	19
Atherinidae	*Atherinomorous lacunosus*	0	0	11	11
Sphyraenidae	*Sphyraena barracuda*	0	0	8	8
Mullidae	*Parupeneus forsskali*	0	0	8	8
	Mulloides flavolineatus	0	0	7	7
Gobiidae	Gobiidae sp. 1	5	0	2	7
Sparidae	*Acanthopagrus bifasciatus*	0	0	6	6
Bothidae	*Bothus pantherinus*	0	0	6	6
Lutjanidae	*Lutjanus monostigma*	0	0	5	5
Cyprinodontidae	*Aphanius dispar*	5	0	0	5
Monodactylidae	*Monodactylus argenteus*	0	0	5	5
Siganidae	*Siganus rivulatus*	0	0	3	3
Synodontidae	*Synodus variegatus*	0	0	3	3
Hemirhamphidae	*Hyporhamphus gamberur*	0	0	2	2
Tetraodontidae	*Arthron stellatus*	1	0	0	1
	Arthron hispidus	0	0	1	1
Ephippidae	*Palatax arabicularis*	0	1	0	1
Total		39	37	193	269

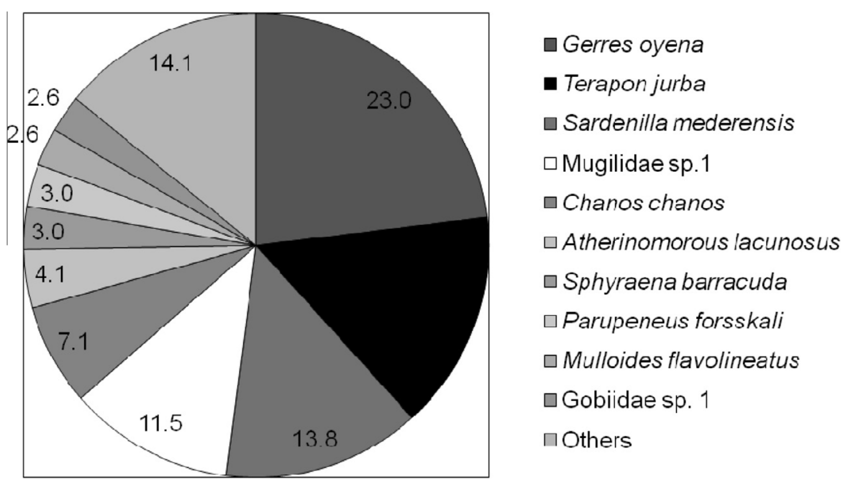

Figure 2 The percentage contribution of the most abundant species.

Very limited work has been carried out on the juvenile stages of reef fishes in the Red Sea (Ahmed, 1992). Nine species were collected during the present study where they were absent from the previous surveys. These were *S. rivulatus*, *Arothron hispidus*, *Arothron stellatus*, *Sphyraena barracuda*, *L. monostigma*, *Hyporhamphus gamberur*, *Synodus variegates*, *Bothus pantherinus*, *M. flavolineatus*, *A. dispar*, and *P. arabiculus* (Table 5). Five of these species were collected from Hamata. Two species (*A. stellatus and A. dispar)* were collected from Sharm Al-Bahary and one species (*P. arabiculus)* was collected from Qula'an. Whereas, *T. jurba* was collected from both Sharm Al-Bahary and Qula'an (Table 2). The substrate of both Sharm Al-Bahary and Qula'an is rocky with a lot of prob-roots that may suit the existence of this species which avoids the muddy substrate in Hamata. It was recorded that two juvenile fish species; *P. arabiculus* and *T. jurba* were collected from Qula'an. This may due to that the area in Qula'an is frequently exposed.

Mangroves of the Red Sea are now protected by law because of their environmental and economical importance. However, data on the utilization of these areas by early stages of reef fishes as feeding and nursery areas is very scarce. This is the first comprehensive study in the Red Sea proper that focuses on the importance of mangrove areas to juvenile of the coral reef fishes as a nursery ground.

However, Ahmed (1992) studied the species composition, abundance and some biological aspects of juvenile fish in the Sharm El-Moya Bay and Mangrove of Wadi Kid (South Sinai – Gulf of Aqaba). He collected and studied 14 species belonging to 10 families. Only 12 species were collected from man-

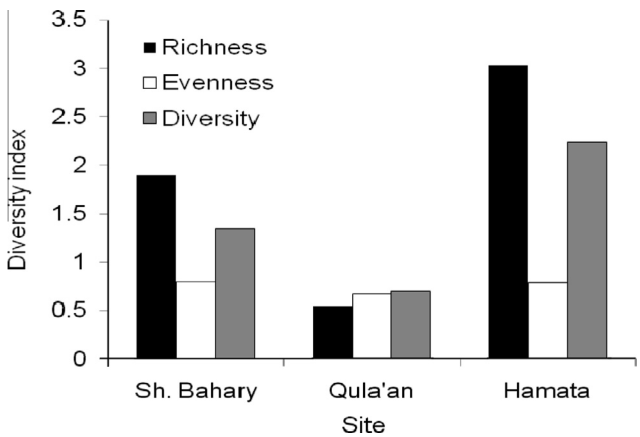

Figure 3 The diversity indices in the different sites.

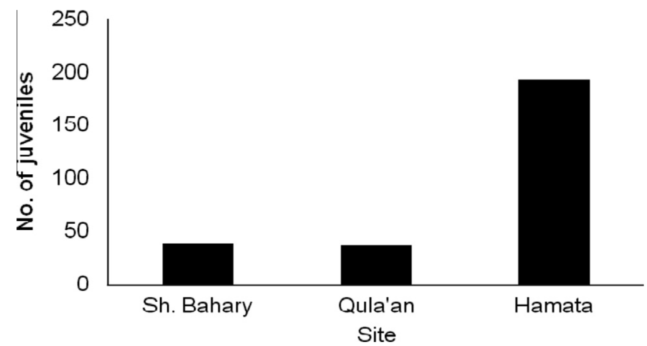

Figure 4 Number of juvenile fishes at different mangrove swamps.

grove Wadi Kid. The most abundant species were *Liza carinata, Valimugil seheli* (Mugilidae*), G. oyena* (Gerridae), *S. maderensis* (Clupeidae*) and Rhabdosargus haffara* (Sparidae) that formed about 82% of all recorded juvenile fishes. In the present study *L. carinata, V. seheli and R. haffara* along with *Diplodus noct* (Sparidae), are not collected at all (Table 5). On the other hand, juveniles of 9 fish species that were not recorded by Ahmed (1992) from Wadi Kid mangroves occurred in mangroves in the present study.

A recent study from the Caribbean found that the availability of mangrove nursery habitat had a striking impact on the community structure and biomass of reef fish in their adult, coral reef habitat (Mumby, 2005). Coral reefs adjacent to mangrove nursery areas might be expected to harbor higher densities of adults of nursery species than reefs located at greater distance to these nursery areas. It has been shown on

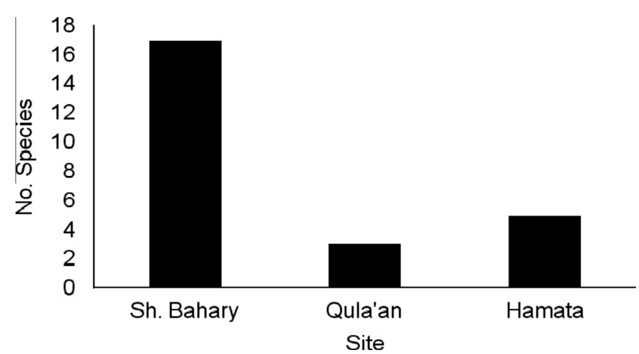

Figure 5 Number of species at different mangrove swamps.

Table 3 Seasonal variation of abundance of juvenile fishes.

Family	Species	Winter	Spring	Fall	Total
Gerreidae	*Gerres oyena*	35	17	10	62
Teraponidae	*Terapon jurba*	15	5	21	41
Clupeidae	*Sardinella maderensis*	15	21	1	37
Mugilidae	Mugilidae sp.1	6	12	13	31
Chanidae	*Chanos chanos*	12	7	0	19
Atherinidae	*Atherinomorous lacunosus*	5	5	1	11
Sphyraenidae	*Sphyraena barracuda*	0	0	8	8
Mullidae	*Parupeneus forsskali*	2	6	0	8
	Mulloides flavolineatus	0	0	7	
Gobiidae	Gobiidae sp. 1	7	0	0	7
Sparidae	*Acanthopagrus bifasciatus*	5	1	0	7
Bothidae	*Bothus pantherinus*	0	5	1	6
Lutjanidae	*Lutjanus monostigma*	4	1	0	6
Cyprinodontidae	*Aphanius dispar*	5	0	0	5
Monodactylidae	*Monodactylus argenteus*	2	3	0	5
Siganidae	*Siganus rivulatus*	0	3	0	5
Synodontidae	*Synodus variegatus*	3	0	0	3
Hemirhamphidae	*Hyporhamphus gamberur*	0	2	0	3
Tetraodontidae	*Arthron stellatus*	1	0	0	2
	Arthron hispidus	1	0	0	1
Ephippidae	*Palatax arabicularis*	0	0	1	1
Total		118	88	63	269

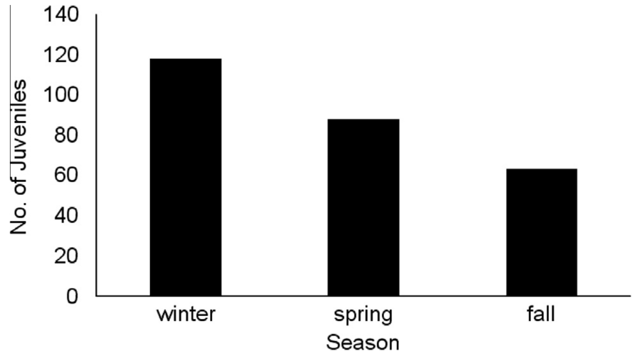

Figure 6 Seasonal variation of the juvenile fish abundance.

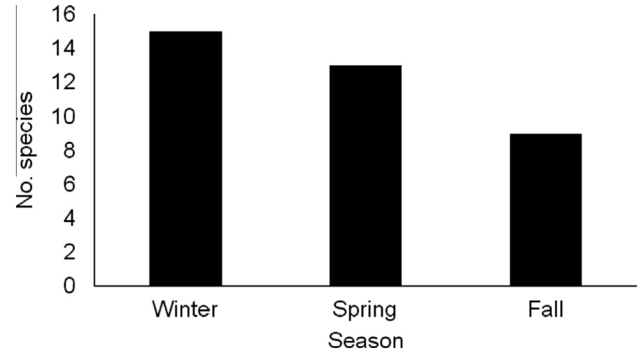

Figure 7 Seasonal variation of the number of species of juvenile fish.

various islands that a reduced density of several of coral reef fish species is related to the absence of seagrass beds and mangroves (Nagelkerken et al., 2002).

Why juvenile fishes utilize mangroves was deeply discussed by Laegdsgaard and Johnson (2001) and they concluded that juvenile fishes are utilizing mangroves for shelter and food. As the complexity and structures such as prop-roots increase the number of juveniles increases.

Most fish species do not spawn in mangrove swamps as evidenced by low densities of fish eggs and larvae in mangrove plankton samples (El-Sherbiny, 1997; Little et al., 1988). Juvenile fishes enter the nursery habitats after metamorphosis, having been spawned in the open sea, and spend some time, not more than a year, in the nursery area before returning to their natal reef habitat and entering the adult population, thus adding to the recruitment. This pattern of habitat utilization ensures protection and food supply for the young fish (Boesch and Turner, 1984).

Abu El-Regal (2013) found that mangroves were the second most frequently used ecosystem by juveniles as a nursery area after the coral reefs, where 10 species forming 32% of the species used mangroves for settlement.

Differences in size class of juvenile fishes among different seasons may be used to determine the growth rate of some species and indicate the recruitment of the population. For *C. chanos*, it is obvious that the fish increases in length from winter (average: 13.2 cm) to spring (18.3 cm).

About 72% of juveniles collected are of coral reef fishes indicating the very complex dispersal of the coral reef fishes. About 85% of the collected fishes are of economic importance. Snappers, lizardfish, milkfish, goatfish, barracudas and rabbit fish are of high commercial value. Others like silversides and halfbeaks have minor importance as food but are considered the main diet of most predator fishes such as snappers, barracudas and jacks and can also be used as bait (Randall, 1986).

Table 4 Minimum, maximum and mean size of the collected juveniles.

Species	Winter				Spring				Fall			
	No.	Min	Max	Mean	No.	Min	Max	Mean	No.	Min	Max	Mean
Gerres oyena	35.0	5.0	8.5	6.8	17.0	5.5	9.5	7.5	10.0	5.0	8.5	6.8
Terapon jurba	15.0	6.0	8.0	7.0	5.0	5.6	8.0	6.8	21.0	5.0	8.0	6.5
Sardinella maderensis	15.0	3.0	8.0	5.5	21.0	4.0	7.5	5.8	1.0	2.5	7.0	4.8
Mugilidae sp.1	6.0	6.5	8.5	7.5	12.0	7.5	21.5	14.5	13.0			
Chanos chanos	12.0	8.0	16.0	12.0	7.0	18.0	18.5	18.3	0.0			
Atherinomorous lacunosus	5.0				5.0	4.0	5.0	4.5	1.0			
Sphyraena barracuda	0.0				0.0				8.0	11.0	16.0	13.5
Parupeneus forsskali	2.0				6.0	4.0	6.0	5.1	0.0			
Mulloides flavolineatus	0.0				0.0				7.0	7.0	8.0	7.5
Gobiidae sp. 1	7.0		7.0	7.0	0.0				0.0			
Acanthopagrus bifasciatus	5.0	6.0	6.4	6.2	1.0	4.0	4.3	4.2	0.0			
Bothus pantherinus	0.0				5.0	7.0	14.0	10.5	1.0	9.1	10.0	9.6
Lutjanus monostigma	4.0	13.0	13.0	13.0	1.0	4.7	6.0	5.4	0.0			
Aphanius dispar	5.0	3.0	3.5	3.5	0.0				0.0			
Monodactylus argenteus	2.0	6.0	6.2	6.1	3.0	6.0	6.5	6.3	0.0			
Siganus rivulatus	0.0				3.0	6.0	9.0	7.5	0.0			
Synodus variegatus	3.0				0.0		11.0	11.0	0.0			
Hyporhamphus gamberur	0.0				2.0	6.1	6.3	6.2	0.0			
Arthron stellatus	1.0		5.0		0.0				0.0			
Arthron hispidus	1.0		5.1	5.1	0.0				0.0			
Palatax arabicularis	0.0		8.0		0.0				1.0			

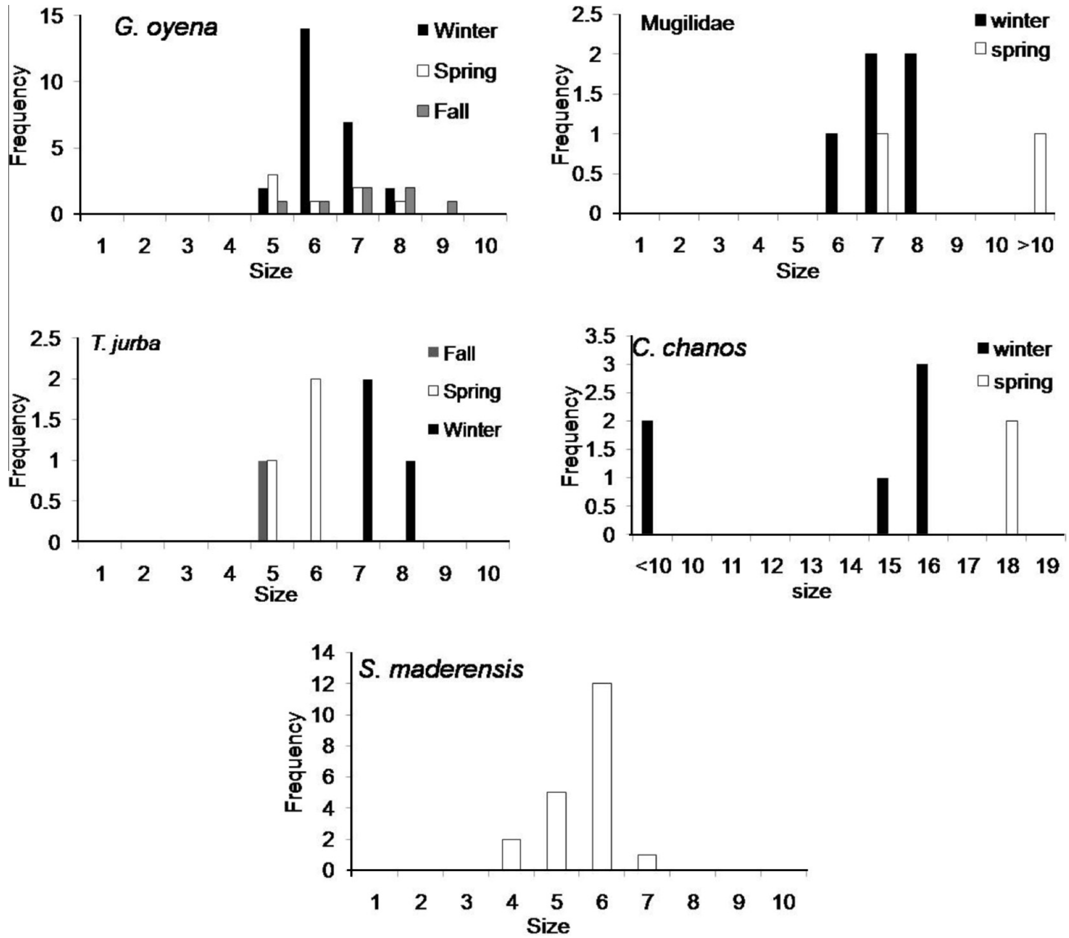

Figure 8 Size frequency distribution of juvenile fishes collected during the present study.

Table 5 Comparison of juvenile fishes collected during the current and previous studies.

Family	Species	Ahmed, 1992 (Sharm El-Sheikh)	Present work
Sparidae	*Acanthopagrus bifasciatus*	+	+
	Diplodus noct	+	–
Atherinidae	*Atherinomorous lacunosus*	+	+
Tetraodontidae	*Arthron hispidus*	–	+
Bothidae	*Bothus pantherinus*	–	+
Chanidae	*Chanos chanos*	+	+
Gerridae	*Gerres oyena*	+	+
Gobiidae	Gobiidae sp.1	–	+
Hemirhamphidae	*Hyporhamphus gambarur*	–	+
Mugilidae	*Liza carinata*	+	–
	Valimugil seheli	+	–
Lutjanidae	*Lutjanus ehrenbergi*	–	+
Monodactylidae	*Monodactylus argenteus*	+	+
Mullidae	*Mulloides flavolineatus*	–	+
	Parupeneus forsskali	+	+
Clupeidae	*Sardinella maderensis*	+	+
Siganidae	*Siganus rivulatus*	–	+
Sphyraenidae	*Sphyraena barracuda*	–	+
Synodontidae	*Synodus variegatus*	–	+
Teraponidae	*Terapon jurba*	+	+

This indicates the importance of mangrove ecosystem as nursery areas for the economically important fishes.

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