Distribution and feeding ecology of the angelfishes (Pomacanthidae) in Shalateen region, Red Sea, Egypt

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ABSTRACT

This study aimed to estimate the distribution and feeding ecology of the angelfishes (Family Pomacanthidae) in Shalateen region, Red Sea, Egypt. The total number of recovered species was six species, where *Centropyge multispinis* and *Pygoplites diacanthus* were the most abundant at most sites, while *Pomacanthus imperator* and *P. maculosus* were the lowest. The royal angelfish, *Pygoplites diacanthus,* was represented in all sites and all reef zones in Shalateen region. Most angelfish species were not found on the reef flat (except *Pygoplites diacanthus*), since they prefer the reef slope and increase with depth. Based on the number of individuals, the reef flat comprised only 2.7 % of the total Pomacanthids population, while the slope comprised 97.3 % of population (34.1 % at 1-10 m depth and 63.2 % at 10-20 m depth). The highest feeding rate was recorded for *C. multispinis*, with 84.3 ± 26.4 bites·(5min)$^{-1}$, while the lowest was recorded for *P. maculosus*, with 58.9 ± 21.6 bites·(5min)$^{-1}$. Most species of angelfishes use biting mode for feeding and diurnal feeders, except *Genicanthus caudovittatus* that use ram mode for feeding on zooplankton and nocturnal feeder. Feeding guilds are divided into three categories: a) invertebrate-feeders, represented by three species, namely *P. asfur, P. imperator* and *P. maculosus*, b) omnivores, represented by two species, *C. multispinis* and *Pygoplites diacanthus*, c) zooplankton feeder, represented by only *G. caudovittatus*.

Key words: distribution, abundance, diversity, angelfishes, Red Sea, Egypt

INTRODUCTION

The Red Sea is not just a unique environment, but also of high diversity with great scientific and ecological importance. There are many changes in the Red Sea communities along 18º of latitude. Such specific habitat connecting the distribution of reef fishes to a certain type of specific utilization of the coral reef. Coral reef fish communities are heterogeneous at many scales and one of the most complex marine ecosystems in which fish communities reach their highest degree of diversity (Harmelin-Vivien, 1989). Many biotic and abiotic factors are controlling the distribution and abundance of reef fishes. In the same time, fish assemblages are helpful in illuminating many important ecological processes, which help to study the contexts of the environments. Angelfishes

(Pomacanthidae) are among the most spectacularly coloured and widely recognized groups of coral reef-associated fishes.

The angelfishes were once grouped with the butterflyfishes in the same family. They share a number of characteristics, such as deep compressed bodies, ctenoid scales, a single un-notched dorsal fin and a small mouth with brush-like teeth. Pomacanthidae has relatively low species (88 species, belonging to 8 genera), yet it represents one of the most conspicuous components in extant coral reef fish assemblages, with representatives in all tropical seas (Allen *et al.*, 1998; Delbelius *et al.,* 2003). The genus *Centropyge* has the richest species, where it includes 32 species (Pyle, 2003). Within the family, there is a diverse range of ecological traits, including striking variation in body size, colour patterns, reproductive systems and diets, which range from planktivory to omnivory (Alwany, 1997; Bellwood *et al.,* 2004). Most of angelfishes are diurnal, the species of *Pomacanthus* and *Pygoplites* feed mainly on sponges as adults, where *Genicanthus* species feed on zooplankton and those of *Centropyge* are grazers on algae and detritus (Khalaf and Kochzius, 2002a and b). Angelfishes generally occur as solitary individuals or in pairs. As pelagic spawners, marine angelfishes release many tiny buoyant eggs into water, which then become part of the plankton. The eggs float freely with currents until hatching, a high number falling victim to planktonic feeders (Thresher, 1982).

Despite its prominent status among the coral reef fishes, the biology and ecology of the Pomacanthidae has not been yet studied in details, especially in the Red Sea. This study was performed to establish a data base on this subject which is urgently needed. This study aimed also to describe the distribution of angelfishes in Shalateen region. In addition, it aimed to be the first detailed investigation on distribution of angelfishes in this region from the Red Sea. Moreover, this study provides important data on the feeding rate, mode, guild, time and prey items of the family Pomacanthidae on fringing reefs in the northern Red Sea.

MATERIALS AND METHODS

The field observations were carried out by snorkeling on reef flat and reef edge, and by SCUBA diving to about 20 m depth. Underwater observations were recorded by using water proof papers, pencils and water resistant watch. Species identification was based on Randall (1983).

Study area

The research was conducted at six different reefs in Shalateen region, Red Sea , Egypt (Figure 1). The study area is located on a shallow reef flat and reef slope down to depths of about 20 m. Site1 is located south Ras Banas (Mirear: 23° 11′ N, 35° 38′ E) and it is a barrier reef. The reef flat (30-40 m wide) and slope (relatively steep) comprise well-developed coral communities. Site 2 (Shalateen Coast: 23° 09′ N, 35° 36′ E) is located at the coast of Shalateen City. The reef flat (50-70 m wide) is rich in algae and echinoderms, while reef

slope (gentle) is rich in corals and algae. Site 3 (Marsa Shab: 22° 30′ N, 36° 11′ E) is coastal reef and has turbid water. The reef flat (40-70 m wide) is rich in corals and algae and reef slope (relatively steep) having well-developed corals and algal communities. Site 4 (Sial Island: 22° 47′ N, 36° 12′ E) is small island has fringing reef. The reef flat (20-30 m wide) is rich in coral and algae. Its reef slope (gently sloping) is characterized by diverse coral communities. Site 5 (Dibia Patch: 22° 23′ N, 36° 29′ E) holds large patched reefs. The reef flat (20-30 m wide) is rich in algae, while the reef slope (gently sloping) is rich in corals and algal communities. Site 6 (Abu Ramad: 22° 23′ N, 36° 25′ E) is located at the coast of Abu Ramad City. The reef flat (50-70 m wide) is rich in coral and algae. Its reef slope (relatively steep) is characterized by well-developed coral communities.
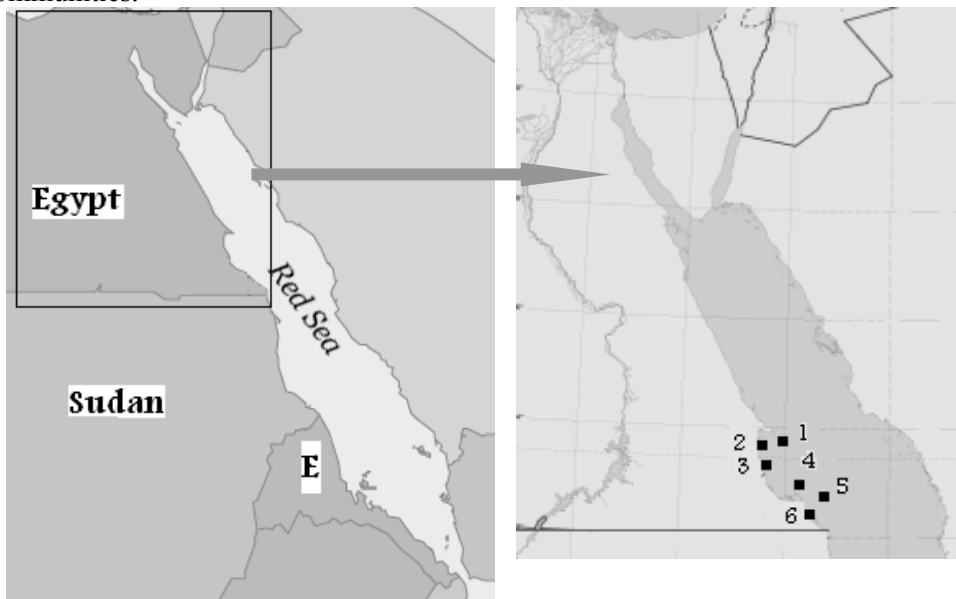

Figure 1: Map of Red Sea showing the positions of different sites in the study area of Egyptian coast.

Visual census

Underwater visual census techniques have been used to record fish densities and abundances on reefs since more than fifty years ago (e.g. Brock, 1954) and form the basis for population ecology studies and management decisions (Harmelin-Vivien *et al.,* 1985). Furthermore, they provide rapid estimates of the relative abundance and distribution of reef fishes (Samoilys and Carlos, 2000). Here, members of the angelfishes were counted using this approach along transects (100 m X 6 m X 1 m = 600 m^3) on the reef flat (RF,

depth: 0.5-1 m) and reef slope (RS, depth: 1-10 & 10-20 m). Transect width was estimated visually, and time used to estimate the length of transect, was as long as to avoid the disturbance to fishes that occur when a line is laid. Fishes were observed using snorkeling and SCUBA diving during day-time from 1100 to 1400 h.

Feeding activities

The feeding rates of 98 angelfishes were measured as the biting action of fish per unit time (feeding rate = number of bites per minute). Randomly selected, mature fishes of the same size and condition were observed by snorkeling and SCUBA diving at a distance of 1-3 m. The observer swam slowly to minimize disturbance. Bites per food item were counted for six consecutive periods of 5 minutes for each individual (after Reese, 1975, 1977). The trophic categories or guilds based on visual field observations were recorded; (IV: invertebrate-feeder; OM: omnivore; PL: planktivore). Also, the feeding mode of angelfish species were recorded; (B: biting; R: ram). Also, the time of feeding was recorded (diurnal or nocturnal).

Data analysis

The data were analysed statistically using the software packages PRIMER (V 5.0) and SPSS (V 15). Species richness was expressed by considering the number of species (D), and species diversity and homogeneity were determined using the Shannon-Wiener diversity index (H') and the evenness index (J') (Pielou, 1966). One-way ANOVA was carried out with SPSS program. When necessary, the data were square root transformed to produce normality and homogeneity of variance.

RESULTS

General distribution and abundance

The list and number of surgeonfish species at reef flat and reef slope (1-10 & 10-20 m) in Shalateen region are shown in Table (1). In general, there were six species (*Centropyge multispinis, Genicanthus caudovittatus, Pomacanthus asfur, P. imperator, P. maculosus* and *Pygoplites diacanthus*). *C. multispinis* and *Pygoplites diacanthus* were the most abundant at most sites (2.4±0.6 fish/600 m^3 and 2.0±0.4 fish/600 m^3, respectively). In contrast, *P. imperator* and *P. maculosus* were the lowest at most sites (0.2±0.3 fish/600 m^3 and 0.9±0.7 fish/600 m^3, respectively). The royal angelfish, *Pygoplites diacanthus,* was represented in all sites and all reef zones in Shalateen region (Figrs. 3 and 4). Sites 1 and 6 (Mirear and Abu Ramad, respectively) have the highest number of species (6 species), while site 5 (Dibia Patch) has the lowest number of species (3 species). One-way ANOVA showed that the influence of species is significant (p = 0.045, Table 2), the influence of zones highly significant (p < 0.001), but the influence of sites was not significant (p = 0.976).

Table (1). The mean abundance (mean±SD) of species of the angelfishes on the reef flat and reef slope (1-10 & 10-20 m), and diversity indices at different sites in Shalatenn region in the northern Red Sea.

Species	site 1	site 2	site 3	site 4	site 5	site 6
Reef flat (0.5-1.0 m)						
Centropyge multispinis	0	0	0	0	0	0
Genicanthus caudovittatus	0	0	0	0	0	0
Pomacanthus asfur	0	0	0	0	0	0
Pomacanthus imperator	0	0	0	0	0	0
Pomacanthus maculosus	0	0	0	0	0	0
Pygoplites diacanthus	0.7±0.6	0.3±0.6	0.3±0.6	0.7±0.6	1.3±0.6	0.7±0.6
Reef slope (1-10 m)	site 1	site 2	site 3	site 4	site 5	site 6
Centropyge multispinis	1.7±0.6	0	1.0±1.0	2.3±1.5	2.7±1.2	2.7±1.2
Genicanthus caudovittatus	0	0	0	0	0	0
Pomacanthus asfur	3.3±1.2	3.0±1.0	4.0±1.0	3.3±0.6	6.0±2.0	0.7±1.2
Pomacanthus imperator	0	0	0	0	0	1.7±0.6
Pomacanthus maculosus	3.3±0.3	3.7±1.5	3.7±0.6	1.0±1.0	0	0.7±1.2
Pygoplites diacanthus	1.3±0.6	1.3±0.3	0.7±0.6	1.0±1.0	0.7±0.6	0.7±0.6
Species richness (D)	1.326	0.962	1.339	1.479	0.893	2.137
Evenness (J′)	0.946	0.928	0.839	0.907	0.763	0.892
Shannon-Wiener (H′)	1.311	1.02	1.162	1.258	0.838	1.436
Reef slope (10-20 m)	site 1	site 2	site 3	site 4	site 5	site 6
Centropyge multispinis	6.3±1.5	5.0±1.7	4.3±1.5	7.3±0.6	5.7±0.6	5.0±1.7
Genicanthus caudovittatus	8.7±2.5	3.7±1.5	0	6.7±2.1	0	4.3±1.2
Pomacanthus asfur	0.3±0.6	0.7±0.6	1.7±0.6	0	0.7±0.6	1.3±0.6
Pomacanthus imperator	0.3±0.6	0.3±0.6	0	1.0±0	0	0.7±0.6
Pomacanthus maculosus	0.7±0.6	0	1.7±1.2	0.7±0.6	0	0.3±0.6
Pygoplites diacanthus	4.3±0.6	3.7±1.2	3.3±0.6	4.3±1.5	3.7±0.6	6.3±1.2
Species richness (D)	1.653	1.541	1.251	1.335	0.865	1.733
Evenness (J′)	0.721	0.819	0.942	0.828	0.797	0.810
Shannon-Wiener (H′)	1.291	1.318	1.306	1.332	0.876	1.452

Table (2). One-way ANOVA performed on abundance of angelfishes.

Factor	Source of variation	df	MS	F value	P value
Sites	between groups	5	0.681	0.161	0.976
	within groups	102	4.225		
	total				
zones	between groups	2	60.120	20.093	< 0.001**
	within groups	105	2.992		
	total				
Species	between groups	5	9.015	2.362	0.045*
	within groups	102	3.817		
	total				

* Significant at $p < 0.045$
** Highly significant at $p < 0.0001$

Habitat distribution and diversity

Some fish species were more widespread than others, which may be explained by associated preferences for certain habitats. Based on the number of species, the pattern of habitat preferences is clear in the distribution of

Pomacanthidae in Shalateen region (Figrs. 2). All angelfish species were not found on the reef flat (except *Pygoplites diacanthus*), but they preferred the reef slope and increase with depths (Fig. 3). Based on the number of individuals, the reef flat comprised only 2.7 % of the total Pomacanthids population, while the reef slope comprised 97.3 % of population (34.1 % at 1-10 m depth and 63.2 % at 10-20 m depth). On reef flat, only one species was recorded, so no diversity indices can be calculated. On reef slope (1-10 m), the average species richness ranged from 0.893 at site 5 (Dibia Patch) to 2.137 at site 6 (Abu Ramad). The highest evenness index (J´) was recorded at site 1 (0.946), while site 5 yielded the lowest value (0.763). Average Shannon-Wiener diversity (H´) varied between 0.838 at site 5 and 1.436 at site 6 (Table 1). On reef slope (10-20 m), the average species richness ranged from 0.865 at site 5 to 1.733 at site 6. The highest evenness index (J´) was recorded at site 3 (0.942), while site 1 yielded the lowest value (0.721). Average Shannon-Wiener diversity (H´) varied between 0.876 at site 5 and 1.452 at site 6 (Table 1).
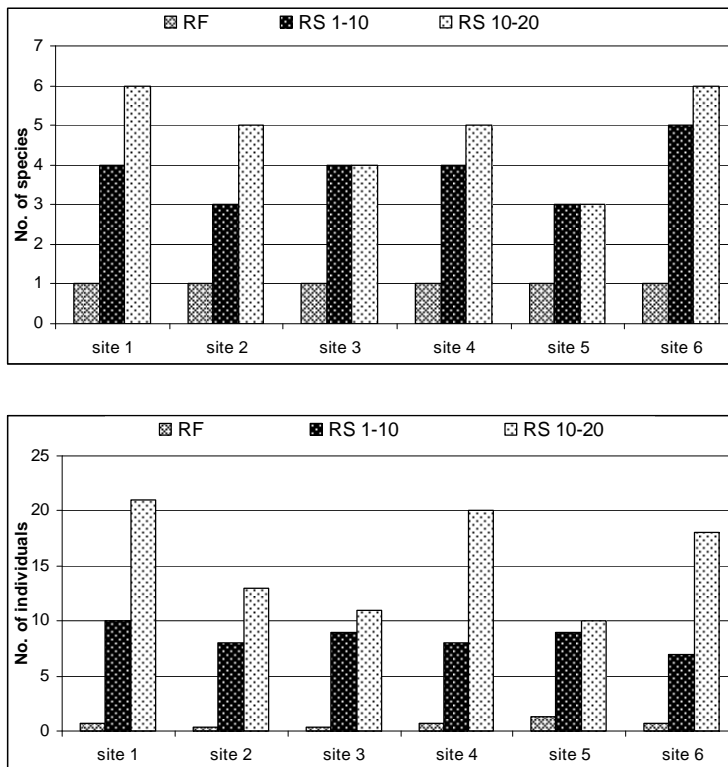

Figure (2). Average number of species and individuals for angelfishes at the reef flat (RF) and reef slope (1-10 m & 10-20 m) at six different sites in Shalateen region.
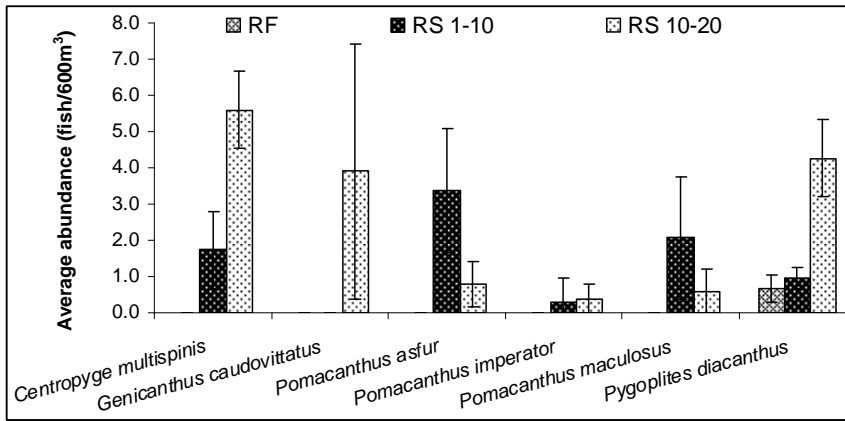
Figure (3). Average abundance of angelfish species at the reef flat (RF) and slope (RS 1-10 & 10-20 m) in Shalateen region.

Figure 4. The royal angelfish, *Pygoplites diacanthus*, was recorded in all sites and all reef zones at Shalateen region.

Feeding activities

Table (3) shows the average feeding rate, mode, guild, time and prey items for each species of the angelfishes on the reefs in Shalatenn region. The highest feeding rate was recorded for *Centropyge multispinis* , with 84.3±26.4 bites·(5min)[-1], while the lowest value was recorded for *Pomacanthus maculosus*,

with 58.9 ± 21.6 bites·$(5min)^{-1}$. The feeding rates of all angelfish species did not differ significantly between different sites (One-way ANOVA). Based on data pooled for the entire study, most species are selective feeders in the sense that they prefer algae and sponges than other food items. Most species of angelfishes use biting mode for feeding and described as diurnal feeders, except *Genicanthus caudovittatus* which use ram mode for feeding on zooplanktons and described as nocturnal feeder. Invertebrate-feeders (IV) were represented by three species of angelfishes, namely: *Pomacanthus asfur, P. imperator* and *P. maculosus* (Table 3). Omnivores (OM) were represented by two species: *Centropyge multispinis* and *Pygoplites diacanthus*, which feed on algae, cnidarians and sponges. The last species, *Genicanthus caudovittatus,* feeds on zooplanktons (mainly copopods) in depth of more than 15 m.

Table (3). The feeding activities of angelfishes species in Shalatenn region in the northern Red Sea. (feeding mode; B: biting, R: ram), (feeding guild; IV: invertebrate-feeder, OM: omnivore, PL: planktivore), (feeding time; D: diurnal, N: nocturnal). All feeding activities were based on visual field observations.

angelfish species	feeding rate	feeding mode	feeding guild	feeding time	prey items
Centropyge multispinis	84.3 ± 26.4	B	OM	D	algae, cnidarians, sponges
Genicanthus caudovittatus	-	R	PL	N	Zooplanktons, mainly copopoda
Pomacanthus asfur	74.1 ± 14.1	B	IV	D	sponges, tunicates
Pomacanthus imperator	69.2 ± 18.3	B	IV	D	sponges, tunicates
Pomacanthus maculosus	58.9 ± 21.6	B	IV	D	sponges, tunicates
Pygoplites diacanthus	65.4 ± 13.5	B	OM	D	algae, cnidarians, sponges

DISCUSSION

Marine angelfishes of the family Pomacanthidae are typical coral reef inhabitants and are economically important as high priced ornamental fishes (Steene, 1977; Allen, 1979; Moenich, 1991). Angelfishes have been considered as one of the most famous and beautiful fishes among the coral reef fish community. The family Pomacanthidae has circumtropical distribution with 88 species in eight genera (Fraser-Brunner, 1933; Chung and Woo, 1998; Debelius *et al.,* 2003). In the Red Sea, angelfishes were represented by 9 species (Goren and Dor, 1994). During the present study, six species of angelfishes were recognized in Shalateen region from reef flat (0.5-1 m) to reef slope until 20 m depth. Angelfish community in the study area was represented by 66.7 % of the total number of angelfish species in Red Sea, and 6.8 % of the total number of angelfish species all over the world. Alwany (1997) and Khalaf & Disi (1997) reported 5 species of angelfishes in the Gulf of Aqaba. This gives evidence that the angelfish community is relatively the same inside the fringing reefs of Egyptian coast of the Red Sea.

Distribution

The present study shows that, there are six species of angelfishes which occur at depth range between reef flat (0.5-1 m) and 20 m in different locations in Shalateen region in the northern Red Sea. The comparative data were not available in the literature. So it is safe to say that, this is the first attempt to study the distribution of angelfishes in this area (reefs in Shalateen region) of Red Sea. In spite the healthy coral communities of the northern Red Sea, a low diversity of species of angelfishes was observed. In contrast, the number of individuals (abundance) was higher than other areas, such as the French Polynesia and the Great Barrier Reef. The closed-system of the Red Sea may be the important factor, which leads to scarcity of fish species. So, the number of individuals is high because of the healthy coral communities of the northern Red Sea.

The abundance and distribution of fishes is dependent on several distinct factors such as recruitment, habitat structure, food availability, and environmental factors (Jones, 1991; Williams, 1991). Most of the investigations about the factors explaining the abundance of fishes have studied some fishes, and little attention has been paid to angelfish populations. Many coral reef fishes tend to increase in both abundance and number of species with increasing depth on fringing reefs (Roberts and Ormond, 1987). In the present study (Shalateen region), the abundance and number of species of the angelfishes were increased with increasing depth according to Roberts and Ormond (1987) and Alwany *et al.* (2007).

Olivotto *et al.* (2006) indicated that the high water temperature is better for larval survival of several coral reef fish groups and the angelfishes are not exception for this base. The temperature in Shalateen region may reach a peak in summer. So the temperature may play essential role in the angelfish horizontal distributions in the Gulf. On the other hand, the vertical distribution of angelfishes shows increasing in deeper depths, where the highest average abundance of angelfishes was recorded on the 20 m (93.0 ± 6.1 fish/600 m^3). Angelfish species are greatly affected with depth, except the royal angelfish, *Pygoplites diacanthus,* which was represented in all sites and all reef zones in Shalateen region (Figs. 3 and 4). In the present study, food availability may play an essential role in the vertical distributions of angelfishes in Shalateen region.

Feeding activities

In general, feeding mode in pomacanthids varied from biting, suction to ram mode. In fact, intramandibular articulation may be the most significant morphological specialization in the feeding apparatus of pomacanthids (Konow and Bellwood, 2005). In addition, the mandible protrusion of 30 % of head length of most genera of angelfishes (Konow and Bellwood, 2005), may be considered as extreme and rare in teleosts. This is also considered as another adaptation in pomacanthids for their food items (especially sponges). In the present study, most species of angelfishes use biting mode for feeding and

described as diurnal feeders, except *Genicanthus caudovittatus* which use ram mode for feeding on zooplanktons and nocturnal feeder (Table 3).

The feeding habits of the reef fishes affects the distribution of those fishes. Herbivores and omnivores are much more abundant in the shallow reef flat region than on the outer slope of the reef (Bouchon-Navaro and Harmelin-Vivien, 1981). This is likely to be related to the abundance of algae and different food items on the shallow region of the reef. In contrast, carnivorous or invertebrate-feeder fishes are usually more abundant on the outer reef slope. The two omnivore species, *Centropyge multispinis* and *Pygoplites diacanthus* which feed on algae, cnidarians and sponges, are distributed in wide range of habitats. On the other hand, *Genicanthus caudovittatus* which feeds on zooplankton preferred deeper habitats of more than 15 m depth.

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