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Distribution and Abundance of Butterflyfishes Along the Gulf of Aqaba, Egypt

^{1,2}Magdy A. Alwany, ¹Salah G. El-Etreby and ¹Mahmoud H. Hanafy

¹Department of Marine Science, Faculty of Sciences,
Suez Canal University, Ismailia, Egypt

²Department of Marine Biology, Faculty of Life Sciences, University of Vienna,
Althanstrasse 14, A-1090, Vienna, Austria

Abstract: The distribution and abundance of butterflyfishes were examined along the Egyptian coast of the Gulf of Aqaba, Red Sea. The total number of butterflyfish species recorded at different sites was 9 species belonging to 2 genera (in addition to 2 species recorded outside the transect on non-reef area). Site 6 (in the south) has the highest number of species at different depths, while site 1 (in the north) has the lowest number. In general, the northern sites (1 and 2) had the lowest number of individuals and species compared with the southern ones. There are two obvious patterns of butterflyfishes distribution relative to depth along the Gulf of Aqaba. The first pattern shows the total number of individual fish's increases slightly at the Reef Edge (RE) and then decreases with depth. The second pattern, the number of species of butterflyfish showed an increase until reached a highest abundance under 15 m depths. The dominance of the butterflyfish species at different sites along the Gulf of Aqaba was alternated between two species, *Chaetodon paucifasciatus* and *C. austriacus*. Generally, *C. paucifasciatus* was the most abundant butterflyfish species along the Gulf of Aqaba (37.0% of total butterflyfish populations), followed by *C. austriacus* (29.6%). *C. paucifasciatus* the only species of butterflyfishes recorded on all depths at all sites.

Key words: Butterflyfishes, distribution, coral reef fishes, Gulf of Aqaba, Red Sea

INTRODUCTION

Fish assemblages are helpful in illuminating many important ecological processes, which help to study the contexts of the environments. Butterflyfishes (Chaetodontidae) are a diverse family of small and colourful tropical fishes. Butterflyfishes are almost exclusively associated with coral reefs, although a few species are found in estuarine areas and over soft bottom habitats (Burgess, 1978; Allen, 1979). The coral serves both as a hiding place for small invertebrates that consider part of the diet of butterflyfishes and as a food source itself (Hobson, 1972). The coral reef is so constructed as to provide a good protection for extremely compressed fishes such as butterflyfishes.

Coral reef habitats are highly heterogeneous and may be subject to strong environmental gradients. Consequently reef fishes are seldom uniformly distributed. Differences in the composition of coral reef fish assemblages have been recognized at a number of scales. This difference over long distances between zoogeographic regions has been well documented and also differences at small scales. Even within reefs, assemblages inhabiting different zones differ markedly (Robertson and Lassig, 1980; Roberts *et al.*, 1992).

Corresponding Author: Magdy A. Alwany, Department of Marine Science, Faculty of Sciences, Suez Canal University, Ismailia, Egypt Tel: +2 0104499116

Previous studies of chaetodontids on the Gulf of Aqaba includes their spatial distribution on the reefs (Bouchon-Navaro, 1979; Khalaf and Kochzius, 2002a; Khalaf and Crosby, 2005; Khalaf and Abdallah, 2005; Brokovich and Baranes, 2005; Alwany and Stachowitsch, 2007), feeding habits (Fishelson, 1977; Harmelin-Vivien and Bouchon-Navaro, 1981; Fricke, 1986; Bouchon-Navaro, 1986; Khalaf and Kochzius, 2002b; Alwany *et al.*, 2003, 2007) and reproduction (Randall and Fridman, 1981; Gharaibeh and Hulings, 1990). Despite the large quantity of literature describing the distribution of butterflyfishes, but most of these previous studies were conducted on the Jordanian coast of the Gulf of Aqaba. The northern part of Egyptian coast is the first Red Sea areas to be heavily influenced by human activities. The information about reef fish communities on the Egyptian coast of the Gulf is relatively limited. Therefore, it could be concluded that establishing a data base on this subject is urgently needed. This study is aimed to survey the distribution and abundance of butterflyfishes along the coast of the Gulf of Aqaba at different depths.

MATERIALS AND METHODS

Study Area

This study was done at seven different sites along the Egyptian coast of the Gulf of Aqaba (about 280 km) in the northern Red Sea (Fig. 1). The Gulf of Aqaba is very steep-sided and deep, reaching maximum depths of over 1800 m near the east coast, although the Gulf is only some 30 km wide. The Gulf of Aqaba is in these respects a model, on a very small scale, of the Red Sea itself (Head, 1987). The reefs of the Gulf, along the Sinai Peninsula are the most diverse and complex, when compared with other localities (Loya, 1972). Field observations were made by snorkeling on reef flat and reef edge and by diving to about 30 m depth. Underwater observations were recorded by using water proof papers, pencils and water resistant watch. The observations were made through the day time from 11:00 to 15:00 during the period from October 1994 to March 1995.

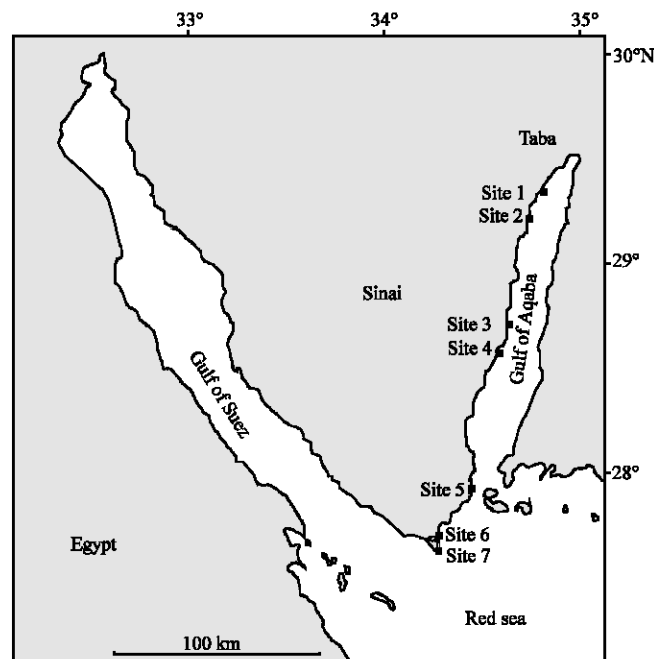


Fig. 1: Egypt and the northern parts of the Red Sea coast show the studying sites

Fish Counting

Visual censuses are the most common, non-destructive methods to quantify fish abundances (Sale, 1980). Species of the butterflyfishes were counted visually along 100 m, 5 m wide and 1 m height transects laid along the reefs at 7 sites on the Egyptian side of the Gulf of Aqaba coast. The transects were laid parallel to the reef edge at depths of 0.5 to 1 m (reef flat RF and reef edge RE), 5, 10, 15, 20 and 25 m.

Data Analysis

The data were analyzed statistically using PRIMER (V. 5.0) and SPSS (V. 11.5). To compare diversity among different sites, two diversity indices were calculated based on the abundance of fishes: Species richness D (Margelf, 1968), Pielou's evenness J' (Pielou, 1969). ANOVAs were performed on raw data to compare fish abundance among sites and depths.

RESULTS

The list and number of butterflyfish species at different depths; at seven sites; along the Gulf of Aqaba are given in Table 1. In general, the total number of butterflyfish species recorded, at different sites, was 9 species (*Chaetodon auriga*, *C. fasciatus*, *C. lineolatus*, *C. melannotus*, *C. austriacus*, *C. paucifasciatus*, *C. semilarvatus*, *C. trifascialis* and *Heniochus intermedius*) belonging to 2 genera. All 9 species of butterflyfishes were recorded only in one site (site 7, in the south of the Gulf of Aqaba, Fig. 2). There are two obvious patterns of distribution of butterflyfishes with depth along the Gulf of Aqaba. The first pattern shows the total number of individual fishes increases slightly at the RE, then decreases with depth (Fig. 3). The second pattern, the number of species of butterflyfish showed an increase until reached a highest abundance under 5 m depths.

Distribution According to Sites

In general, the northern sites (1 and 2) had the lowest number of individuals comparing with southern ones (Fig. 2). The southern part of the Gulf of Aqaba, especially Sharm El-Sheikh (site 5) has the highest abundance of butterflyfishes. Also at the middle part of the Gulf, the abundance of fishes was relatively high comparing with the north. The number of species of butterflyfishes shows the clear trend along the Gulf of Aqaba. Where the lowest number of species was recorded at the north, increase at the middle, then reaches its maximum at the south (site 7).

The dominance of the butterflyfish species at different sites along the Gulf of Aqaba was alternated between two species, *Chaetodon paucifasciatus* and *C. austriacus*. The *C. paucifasciatus* is the most abundant (dominant) butterflyfish on the reef at four sites (1, 2, 4 and 6). In contrast, the

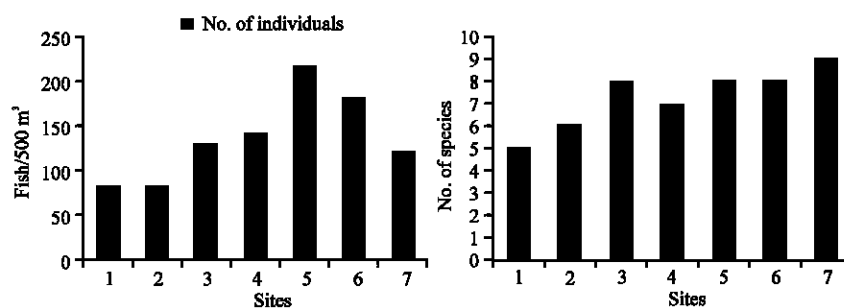


Fig. 2: Total abundance and No. of species of butterflyfishes at different seven sites along Gulf of Aqaba

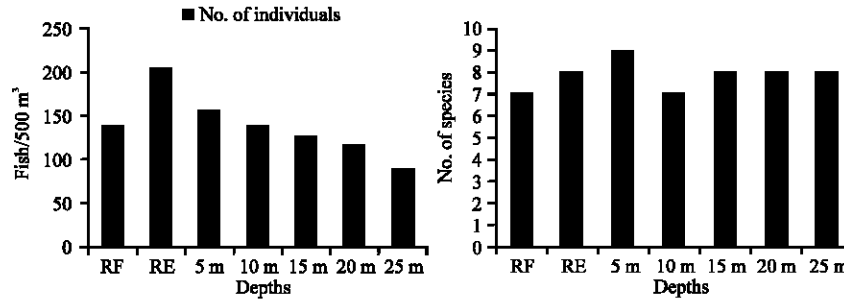


Fig. 3: Total abundance and No. of species of butterflyfishes at different seven depths along Gulf of Aqaba

Table 1: The mean abundance (mean±SD) of occurrence of each species to the butterflyfishes at different sites and depths along Gulf of Aqaba

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
<i>Chaetodon auriga</i>	0.6±0.6	1.50±1.6	0.90±0.8	0.80±0.6	1.91±1.7	1.71±1.4	1.00±1.2
<i>C. fasciatus</i>	2.2±2.7	1.60±2.9	1.00±0.7	2.70±3.0	3.41±2.4	0.61±0.7	1.00±0.8
<i>C. lineolatus</i>	0	0	0.04±0.1	0	0	0	0.04±0.1
<i>C. melannotus</i>	0	0	0.20±0.3	0.04±0.1	2.71±0.8	1.91±1.5	0.40±0.5
<i>C. austriacus</i>	1.6±3.8	2.20±1.9	7.40±4.5	5.40±4.3	11.0±4.3	7.41±2.5	6.70±1.7
<i>C. paucifasciatus</i>	7.1±4.0	6.10±2.4	6.30±3.9	8.80±2.8	8.70±3.4	11.0±2.9	4.20±1.1
<i>C. semilarvatus</i>	0	0	0	0	0.20±0.6	0.31±0.5	0.30±0.5
<i>C. trifascialis</i>	0.2±0.3	0.04±0.1	0.40±0.8	0.80±1.4	0.50±0.6	0.81±0.9	1.30±1.7
<i>Heniochus intermedius</i>	0	0.20±0.3	1.50±1.3	1.70±1.1	2.50±2.9	2.20±1.9	2.50±1.3

	RF	RE	5 m	10 m	15 m	20 m	25 m
<i>Chaetodon auriga</i>	2.3±1.9	2.10±1.6	1.40±0.7	1.0±0.5	0.60±0.6	0.80±0.6	0.30±0.5
<i>C. fasciatus</i>	4.2±3.3	2.80±2.4	2.30±2.4	1.3±0.7	0.80±1.6	0.60±0.7	0.70±0.5
<i>C. lineolatus</i>	0	0	0.04±0.1	0	0	0	0.04±0.1
<i>C. melannotus</i>	0.3±0.6	0.50±0.9	0.70±1.0	1.1±1.4	1.10±1.7	0.70±1.4	0.90±1.3
<i>C. austriacus</i>	4.2±3.3	11.0±4.9	6.90±4.5	6.1±4.1	4.40±4.2	4.30±3.9	4.80±3.4
<i>C. paucifasciatus</i>	6.4±4.0	8.60±4.4	8.60±2.3	7.0±3.4	8.30±3.6	7.60±4.0	5.70±3.3
<i>C. semilarvatus</i>	0	0.60±0.8	0.10±0.3	0	0.04±0.1	0.04±0.1	0.04±0.1
<i>C. trifascialis</i>	0.7±1.1	2.10±1.5	0.60±0.6	0.3±0.4	0.20±0.3	0.20±0.5	0.04±0.1
<i>Heniochus intermedius</i>	0.3±0.9	1.40±1.9	2.50±2.7	1.9±1.7	1.70±1.5	0.90±0.9	1.90±1.8

RF = Reef Flat, RE = Reef Edge

C. austriacus is the most dominant species at the other three sites (3, 5 and 7). The *C. paucifasciatus* is the most abundant butterflyfish species along the Gulf (37.0% of total butterflyfish population), followed by *C. austriacus* (29.6% of total butterflyfish population). At the site 1, *C. paucifasciatus* forms 60.8% of the total population. While at site 2, this species form 52.3% the total population of butterflyfishes. This species was dominant, also at sites 4 and 6, where it forms 44.1 and 42.1%, respectively. *C. austriacus* is the most common butterflyfish species seen at sites 3 (41.5%), 5 (35.6%) and 7 (38.3%). The dominance of the other butterfly species was varied greatly at different sites. The average abundance of *C. melannotus* species was high at the southern sites of the Gulf of Aqaba. It was not recorded at the two northern sites (1 and 2, Table 1). Along the Gulf of Aqaba, the *C. semilarvatus* was recorded at three southern sites (5, 6 and 7). Similar to the most butterflyfish species, *C. trifascialis* is more common at southern sites (6 and 7). According to Table 2, the highest richness of fishes was recorded at site 7 (1.7), while the lowest recorded at site 1 (0.9). The evenness at different sites shows that site 1 was the lowest (0.6), while site 5 was the highest (0.8).

Distribution According to Depths

Generally, the distribution of butterflyfishes shows increasing in shallower depths and then decreasing with more depths after 15 m (at least for the number of butterflyfish individuals, Fig. 3).

Table 2: The diversity indices (richness and evenness) recorded at different sites and depths along the Gulf of Aqaba

Sites	Butterflyfishes		Depths	Butterflyfishes	
	Richness	Evenness		Richness	Evenness
Site 1	0.913	0.688	RF	1.241	0.958
Site 2	1.144	0.725	RE	1.134	0.959
Site 3	1.457	0.689	5 m	1.184	0.987
Site 4	1.221	0.741	10 m	1.239	0.979
Site 5	1.306	0.802	15 m	1.260	0.947
Site 6	1.351	0.755	20 m	1.295	0.954
Site 7	1.674	0.776	25 m	1.309	0.923

RF = Reef Flat, RE = Reef Edge

Table 3: One-way ANOVA performed on abundance of butterflyfishes

Factor	Source of variation	df	MS	F-value	p-value
Sites	Between groups	6	39.149	3.620	0.0016**
	Within groups	434	10.816		
	Total	440			
Depths	Between groups	6	20.375	1.840	0.0899
	Within groups	434	11.075		
	Total	440			
Species	Between groups	8	350.300	71.164	0.0001**
	Within groups	432	4.922		
	Total	440			

* = Significant at 5% significance level, ** = At 1% significance level

The average abundance of *Chaetodon auriga* shows mainly higher abundance at the shallow depths rather than the deeper ones. There was no clear pattern of distribution of this species with depth, except at some sites (which shows decreasing with depth). The highest abundance of this species was recorded at the Reef Flat (RF) at most sites (5.0 fish/500 m³). The distribution of *C. fasciatus* along Gulf of Aqaba shows preference to shallow water habitats (RF, RE, 5 and 10 m) rather than deep waters (more than 20 m). However, the highest average abundance was recorded on the reef flat of site 4 (8.7 fish/500 m³). *C. lineolatus* was a very rare species of butterflyfishes along the Gulf (0.3 fish/500 m³), where it was recorded at two sites only (3 and 7) and also at two depths (5 and 25 m depth). The highest abundance of *C. melannotus* was recorded at 15 m depth at site 6 (4.0 fish/500 m³). *C. austriacus* was the most abundant butterflyfish species on the reef edge (0.5-1.0 m) at most sites. However, the highest average abundance was recorded on the reef edge of site 5 (19.7 fish/500 m³).

Chaetodon paucifasciatus was the most abundant butterflyfish species along the Gulf of Aqaba. It was recorded on all depths at all sites. The highest abundance of this species was recorded at the site 5 on the reef edge (15.0 fish/500 m³). Distribution of the *C. paucifasciatus* was not affected with depths. The highest abundance of the *C. semilarvatus* was recorded at shallow waters (especially at reef edge) in the southern sites. The zonation of this species was very clear, where it is restricted to the reef edge. However, the highest average abundance of *C. semilarvatus* was recorded on the reef edge of site 5 (1.7 fish/500 m³). *C. trifascialis* preferred the shallow water at the most sites (between RF and 10 m depth). The highest average abundance of this species was recorded at site 7 on the RE (4.0 fish/500 m³). *Heniochus intermedius* found at all depths from the RE to 25 m at the most southern sites. It was not seen at site 1 at all depths, while it was recorded at the deep water at the site 2. The highest average abundance of this species was recorded at site 5 at 5 m depth (7.3 fish/500 m³).

The highest richness of the butterflyfishes was recorded at 25 m (1.31), while the lowest richness was recorded at the reef edge (1.13). The evenness at different depths shows that the 5 m depth has the highest value of evenness (0.99) (Table 2) while the 25 m depth has the lowest one (0.92). Results of one-way ANOVA (Table 3) shows the abundance of butterflyfishes differed significantly among sites and species, while the depths not effect significantly (p = 0.0899). The two-way ANOVA (Table 4)

Table 4: Two-way ANOVA performed on abundance of butterflyfishes

Source of variation	df	MS	F-value	p-value
Sites	6	39.149	3.474	0.0023**
Depths	6	20.375	1.808	0.0963
Sites × Depths	36	4.280	0.380	0.9996
Sites	6	39.149	11.214	0.0001**
Species	8	350.300	100.345	0.0001**
Species × Sites	48	11.917	3.414	0.0001**
Species	8	350.300	79.067	0.0001**
Depths	6	20.375	4.599	0.0002**
Species × Depths	48	6.866	1.550	0.0142*

* = Significant at 5% significance level and ** = At 1% significance level

shows that the differences in the abundance of butterflyfish species at different sites are significant. Also, the differences at different depths are significant. But it did not differ significantly between different sites at different depths ($p = 0.9996$).

DISCUSSION

The importance of butterflyfishes stems from the fact that they are one of the reef resident species which use the reef for sheltering, feeding and breeding grounds. This extensive use of the coral reef habitat develops the idea of using this group as coral reef health indicator (Reese, 1977). About 114 species arranged in 10 genera were recognized in the most recent systematic revision of butterflyfishes (Burgess, 1978). In the Red Sea, the butterflyfishes are represented by 18 species (Bouchon-Navaro, 1979; Dor, 1984; Klausewitz and Fricke, 1985), while Goren and Dor (1994) identified 21 species of this family. The chaetodontidae are represented in the Gulf of Aqaba by 10 species (Bouchon-Navaro, 1979; Dor, 1984; Klausewitz and Fricke, 1985; Khalaf and Disi, 1997), although 11 species were recognized by Goren and Dor (1994). The present study recorded 9 species of butterflyfishes along the Gulf of Aqaba from reef flat to 25 m depth in addition to 2 species just recorded outside the transect in non-reefs area.

Reviewing the updated check-list of the fishes of the Red Sea, provided by Goren and Dor (1994), two species of butterflyfishes were recorded in this study as a new record in Sharm El-Sheikh area. The first, *Chaetodon larvatus*, was not recorded in the Gulf of Aqaba before (Bouchon-Navaro, 1979; Randall, 1983; Klausewitz and Fricke, 1985). Sheppard *et al.* (1992) reported that the *C. larvatus* is characteristic of the southern Red Sea but very rare in the north and absent from the Gulf of Aqaba. This species have been recorded at 17 m depth (only one fish, its length about 12.0 cm) off the Marine Station of Suez Canal University on wreck. The second, *Heniochus diphreutes*, was not recorded in the northern part of the Gulf of Aqaba (Fricke, 1973). While in this study, it was recorded in the southern part of the Gulf. Bouchon-Navaro (1979) also reported that he never saw this species on reef. During the present study, *H. diphreutes* was recorded at one location only around tires on a seagrass bed with scattered coral patches at 10 m depth in Sharm El-Sheikh area and this species was not seen on the reefs.

There are differences between the western and eastern coast of the Gulf of Aqaba. For example, the abundance of certain fishes *Chaetodon paucifasciatus* has been reported to be more abundant than *C. austriacus* on the eastern coast of the Gulf (on the Jordanian reefs by Bouchon-Navaro, 1979; Khalaf and Crosby, 2005). In the present study, the dominance of the butterflyfish species was alternated between these two species. The *C. paucifasciatus* is the most abundant butterflyfish on the reef at four sites (1, 2, 4 and 6), while, the *C. austriacus* is the most abundant species at the other three sites (3, 5 and 7).

Many coral reef fishes tend to increase in both abundance and number of species with increasing depth on fringing reefs (Roberts and Ormond, 1987). The present study shows two obvious patterns

of distribution of butterflyfishes with depth along the Gulf of Aqaba, but this increasing only until certain depth (15 m) and then decreased slightly. The first pattern shows the total number of individual fishes increases slightly at the RE, then decreases with depth. The second pattern, the number of species of butterflyfish showed an increase until reached a highest richness under 15 m depths. The distribution of reef fishes differs according to food habits of fishes. Herbivores are much more abundant in the shallow reef flat region than on the outer slope of the reef (Bouchon-Navaro and Harmelin-Vivien, 1981; Russ, 1984). This is likely to be related to the more abundance of algae on the shallow region of the reef. In contrast, carnivorous fishes are usually more abundant on the outer reef slope. Bouchon-Navaro (1979) reported that *C. trifascialis* is occurred abundantly on the reef front and less abundantly on the outer slope to 30 m depth. In corresponding, *C. trifascialis* in the study area, showed a similar trend and mainly populated abundantly in the zone between RF (0.5-1.0 m) and 10 m depth.

Concerning the butterflyfish *C. austriacus*, there was no relation between the abundance of this species and the occurrence of the branched colonies of *Acropora* as reported by Bouchon (1979). He linked between *C. austriacus* and branched *Acropora* in the northern part of the Gulf of Aqaba and referred this link to the feeding preference of this species to this coral. Thus although *Acropora* composed a major food item in the stomach (about 40% in Alwany, 1997) and feeding rates (about 31% in Alwany *et al.*, 2003). Therefore, it could conclude that the abundance of *Acropora* may not be the only factor for the distribution of *C. austriacus*.

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