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Full Length Research Paper

Circulation, multiplicity and classification of marine angelfishes (Pomacanthidae) of Tamilnadu, Southeast coast of India

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In the present investigation, a total of 5 species belonging to three genera such as *Pomacanthus*, *Centropyge* and *Apolemichthys* were reported from the 10 selected stations of Tamilnadu, south east coast of India. The diversity studies revealed that the species diversity, richness and evenness were comparatively higher at Rameshwaram and Kanniyakumari due to the rocky shore and coral reef ecosystem. Species composition study revealed that the smoke angel (*Apolemichthys xanthurus*) was found to be dominant group which constituting 57% of total fishes. The results of the present study evidenced that the occurrence and distribution of marine angel fishes were higher in Gulf of Mannar than other region of Tamilnadu. The present findings clearly explained about distribution pattern of marine angel fishes which could be useful for better understanding of the status of its diversity along southeast coast of India and also highlights the need for effective conservation measures of these commercially important marine ornamental fish group.

Key words: South east coast of India, distribution, diversity, taxonomy, marine angelfishes, pomacanthidae.

INTRODUCTION

The marine ornamental fishes are one of the most popular attractions in worldwide due to their adaptability to live in confinement. The trade of marine ornamentals has been expanding in recent years and has grown into a multimillion dollar enterprise. The worldwide market of marine ornamental fishes has shown a steady increase over the past few years and the annual trade varies between 2 and 7 billion US$ (Jayalal and Ramachandran, 2012). A total of 1471 species of ornamental fish are traded globally (Wabnitz et al., 2003). Of which, angelfishes (Pomocanthidae) are the next most important group than damsel and anemone fish (33%), consisting of about 25% of the total trade (Sadovy, 1992). Pomacanthus angel fishes are one among the most highly prized of the coral reef fishes which contains 8 genera and 82 species worldwide (Debelius et al., 2003; Nelson, 2006). Marine angelfishes (Pomacanthidae) are among the most spectacularly coloured and widely recognized groups of coral reef-associated fishes. They are found on tropical reef bottoms, widespread in the Atlantic, Indian and pacific oceans (Murugan and Durgekar, 2008). Marine angelfishes have deep compressed bodies, ctenoid scales, a single un-notched dorsal fin and a small mouth with brush-like teeth. The best way to identify them is to look for the spine in front of the gill plates (Alwany, 2009). Marine angel fishes contain an elongate extension on the hind margin of the soft dorsal and anal fins and rounded or crescent-shaped caudal fin. Most angelfishes

are pygoplites which feed mainly on sponges as adults, but *Genicanthus* sp. feed mainly on zooplankton and *Centropyge* sp. are grazers on algae and detritus (Khalaf and Kochzius, 2002). As pelagic spawners, marine angelfish releases 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).

Tamil Nadu is one among the important maritime states on the east coast of India, with a coastline of 1,076 km, 13 coastal districts and 591 fishing villages. The Coromandel coast extends 357 km, from Pulicat to Point Calimere, and Palk Bay extends 294 km from Point Calimere to Dhanushkodi. The Gulf of Mannar, rich in biodiversity and hosting a variety of marine species, is a marine biosphere reserve, and extends 335 km from Dhanushkodi to Kanniyakumari (Murugan and Durgekar, 2008). So far, Venkataramani and Jawahar (2004) reported about 113 marine ornamental fish and their biodiversity and standing stock biomass from Gulf of Mannar region. Although marine angelfish plays a very significant role in ornamental fish trade, there is no attempt made to study its occurrence, distribution and diversity along Tamil Nadu coast, Southeast coast of India. 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 Southeast coast of India. In view of that, present investigation was aimed to be the first detailed investigation to understand the distribution pattern and diversity of marine angel fishes along Tamil Nadu coast, Southeast coast of India.

MATERIALS AND METHODS

Collection of data

To understand the occurrence, distribution and diversity of marine angel fish, survey was made between January 2008 and December 2009 in the 10 selective stations along southeast coast of India. Collection of marine ornamental fish has been done in two ways such as incidental fishing and target fishing. The incidental fishing includes use of traps, shore seine operations and country trawl nets, and target fishing includes skin diving with scoop nets and gill nets. Target fishing has been carried out for the collection of fishes during low turbidity and calm periods. Gill netting with skin diving was practiced when the conditions are calm in the reef regions. In addition, data were also collected by regular enquiry from the local fish traders and fish collectors in the respective landing centres.

Description of the study area

The survey was conducted from 10 stations along Tamil Nadu, Southeast coast of India (Figure 1). Station 1 is located in Chennai, (Lat: 12°51'58.58"N, Lon: 80°14'40.70"E) which is one among the major landing centre in Southeast or Coramental coast of India. Station 2 is located in Puducherry (11°55'40.21"N, 79°47'26.13"E) is rocky shore area, rich in algae and echinoderms. Station 3 is located in Cuddalore (11°45'15.95"N, 79°47'27.63"E) which is polluted due to the chemical, petrochemical, pharmaceutical biocide, fertilizer and metal processing industrial discharges. Station 4 situated in Nagapattinam (10°45'40.19"N, 79°50'56.80"E) is also one of the major fish landing centres in Tamil Nadu. Station 5 is located in Thondi (09°44'1.32"N, 79° 0'59.06"E) in the Palk Strait which is being influenced mainly by the northeast monsoon and has strong potential of both living and non-living resources. The coastal area has a very minimal wave action and turbidity of the seawater is moderately low and also they are rich in nutrients hence, it is a potential zone for ornamental fishes and many fish collectors were involved in ornamental fish collection and trade. Station 6 is situated in Kilakkarai (09°13'43.43"N, 78°47'33.02"E) is rich in seaweeds, seagrass and coral reefs which is also a potential zone for ornamental fishery resources. Station 7, Rameshwaram (9°16'50.96"N, 79°19'3.66"E) is an island connected to the main land by the Pamban Bridge which is rich in seaweed *Sargassum* sp. and the fish collectors and traders were extensively involving in ornamental fish trading. Station 8, Tuticorin (8°47'38.94"N, 78°9'36.58"E) is one of the well-known and age old fishery ports of India especially by virtue of production of valuable and good quality pearls and chanks in addition to marine ornamental fish production. Station 9 is located in Thiruchendur (8°29'19.16"N, 78° 7' 26.57"E) contains rocky bottom with shallow waters which is also famous for its live ornamental fish trade. Station 10, Kanniyakumari (8°5'7.28"N, 77°33'11.75"E) is situated at the southernmost end of the India where the meeting place of Arabian Sea, Bay of Bengal and Indian Ocean. The fish collectors and traders were also extensively involving in ornamental fish trading in this area.

Data analysis

The data were analysed with approached to various statistical methods such as univariate, graphical/distributional and multivariate methods. The computer programme PRIMER (Ver.6.1) was used for univariate and multivariate data analysis. 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.

RESULTS

Distribution, diversity and taxonomy of marine angel fishes

The survey was made on the quantitative assessment of marine angel fish distribution and diversity in southeast coast of India. In the present survey, a total of 5 species belong to three genera were recorded viz., Pomacanthus (3 species), Centropyge (1 species) and Apolemichthys (1 species). The taxonomical position and distinctive characters of the marine angel fishes reported were presented below.

Taxonomical position of marine angel fishes (Pomacanthidae)

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii

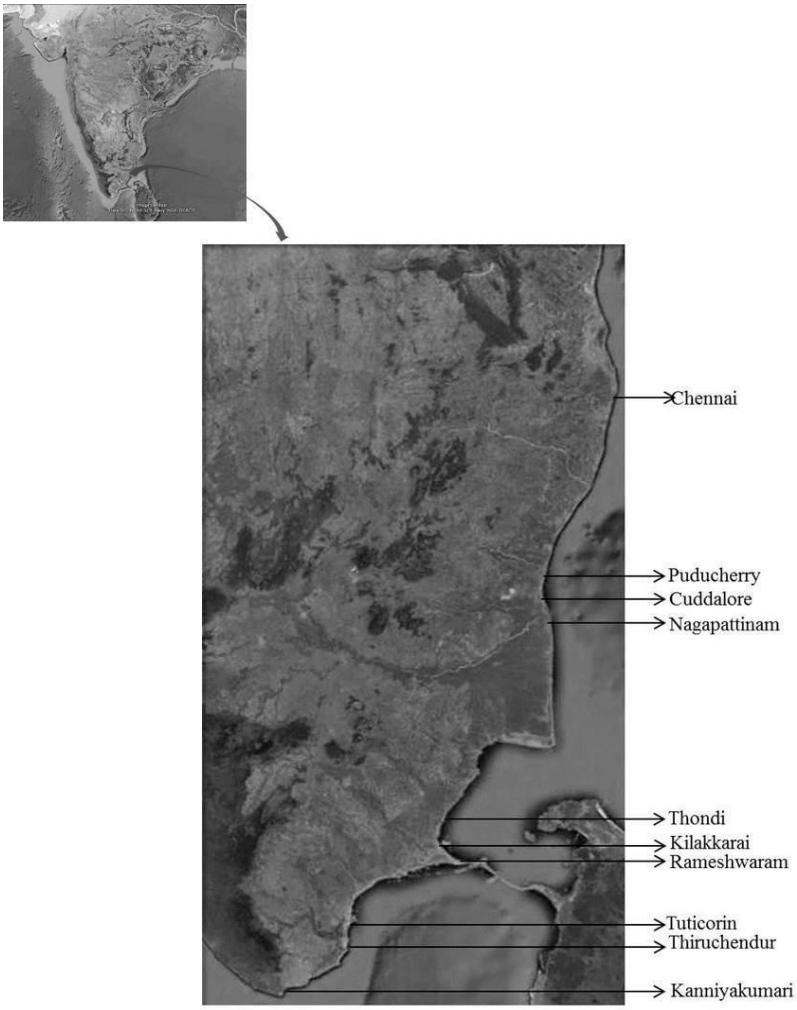


Figure 1. Study area.

Order: Perciformes
Family: Pomacanthidae.

***Apolemichthys xanthurus* (Bennett, 1832) (Smoke angel)**

Distinctive characters

Dorsal spines: 14 - 15; dorsal soft rays: 16 - 18; anal spines: 3; anal soft rays: 17 - 19. Body oval to square and latterly compressed; eyes are distinct and small mouth. Pre-opercle bears strong spine. Lateral line is crossing from the upper part of the body.

Colour

Head is dark brown or black in colour. Snout lighter; a yellow spot present very close to eye. Caudal fin is yellow in colour; dorsal and anal fins are dark brown to black with white margin; adjacent caudal peduncle region also black. Body pale grey or light brown; black spots on scales larger dorsally, resulting in dark colour on upper sides grading to pearly white ventrally.

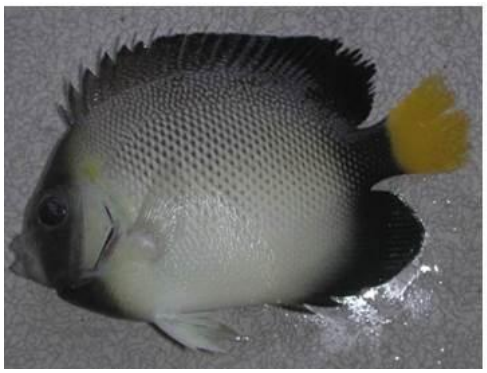
Habitat and biology

Inhabits in coral-rich areas, singly or in pairs. Frequently observed outer reef edge and reef slopes at depths of 15 m. Feeds mainly on sponges and sea squits. Maximum size is about 25 cm (Diagram 1).

***Centropyge nox* (Bleeker, 1853) (Midnight angel)**

Distinctive characters

Dorsal spines (total): 14 - 15; dorsal soft rays (total): 16 - 17; anal spines: 3; anal soft rays: 16 - 17. Body is oval and latterly compressed; distinct eye and small mouth. Pre-opercle bears strong spine. Lateral line is crossing from the



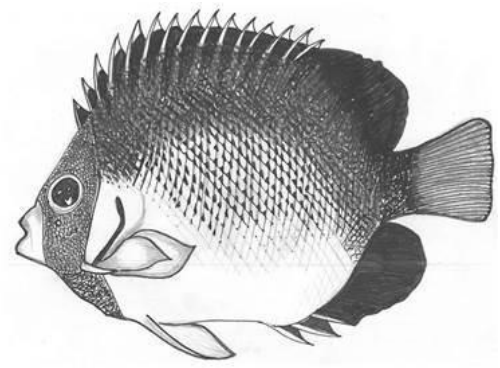


Diagram 1. *Apolemichthys xanthurus* (Bennett, 1832) (Smoke angel). Local Name: Yellow tail Angel, Smoke angel.

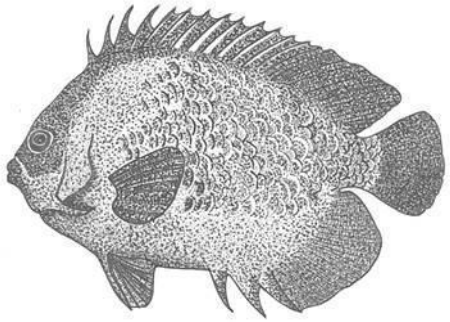


Diagram 2. *Centropyge nox* (Bleeker, 1853) (Midnight angel). Local Name: Midnight Angel.

upper part of the body.

Colour

Dark brown to black in colour; caudal fin with a narrow white margin. Uniformly black at all stages, sometimes a yellowish on the pectoral fin base but has a rare xanthic form in which most of the body is dark yellow.

Habitat and biology

Common in coral rich areas of outer reef slopes, occasionally sighted in lagoons and passages. Prefers habitats with richly mixed invertebrate growth. Usually occur singly or in pairs. Feeds on algae, forms harems of 3 to 7 individuals, maximum length is about 10.0 cm.

Characters

Body oval to square and laterally compressed; distinct eye and small mouth. Pre-opercle bears strong spine. Creamy white colour with anterior and posterior thick black black vertical patch; lateral line crossing from the upper part of the body (Diagram 2).

***Pomacanthus semicirculatus* (Cuvier, 1831) (Koran Angel)**

Distinctive characters

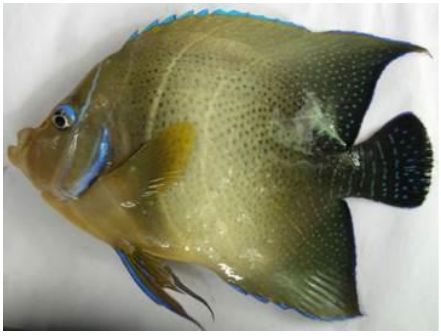
Dorsal fin with 13 spines and 20 to 23 rays. Anal fin with 3 spines and 18 to 21 rays. Pectoral *fin* rays 19 to 21. A filament posteriorly on dorsal and anal fins.

Colour

Greenish body with dark flecks. Bright blue streaks on cheek, and posterior part of the body with a blue outline and lips are yellow. Juveniles are looks dark blue with white and pale blue crescents on their sides.

Habitat and biology

Adults occur in coastal reefs with heavy coral growth to



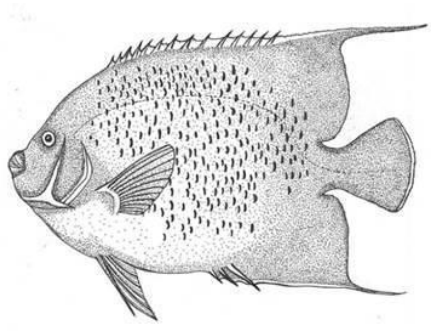


Diagram 3. *Pomacanthus semicirculatus* (Cuvier, 1831) (Koran Angel). Local Name: Alla Fish.

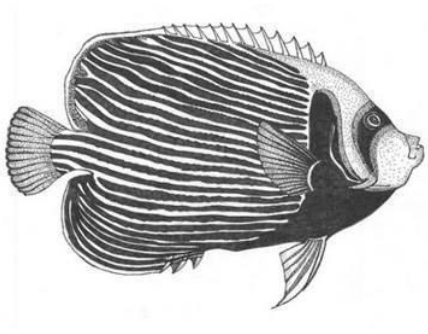


Diagram 4. *Pomacanthus* **imperator** (Bloch, **1787)** (Emperor Angel). Local Name: Emperor angel fish.

depths of 30 m. Solitary, but sometimes in pairs. Maximum size is about 38 cm.

Characters

Dorsal profile straight to slope towards front, body compressed. Mouth is small and prominent upwards; distinct eye, body with excellent seven blue lines bending towards down to tip of the soft dorsal fin (Diagram 3).

***Pomacanthus imperator* (Bloch, *1787)* (Emperor Angel)**

Distinctive characters

Dorsal fin with 13 to 14 spines and 18 to 21 rays. Anal fin with 3 spines and 18 to 21 rays. Pectoral fin rays are 19 to 20. Body depth 1.6 to 1 .8 in standard length. Soft dorsal fin develops a point with growth. Posterior margin of preopercle finely serrate. Caudal fin rounded.

Colour

Sides with alternate blue and yellow stripes. Dorsal and caudal fin are mainly yellow and anal blue or black. Black face mask with blue edge. Juveniles are deep blue with curved circular white bands.

Habitat and biology

Solitary, usually seen on exposed outer reef areas near edges and caves in rich coral areas up to 25 m. Feeds primarily on sponges. Maximum size is about 40 cm.

Characters

Laterally compressed and rhomboid. Pre-opercle spine longer and prominent with serration on margin. Dorsal fin acute and soft at the end, body purplish blue with yellow stripes. Snout and chick bluish in colour. Anal fin semicircled or blended at the end (Diagram 4).

***Pomacanthus annularis* (Bloch, 1787) (Bluering Angel)**

Distinctive characters

Dorsal spines (total): 13; dorsal soft rays (total): 20 to 21;

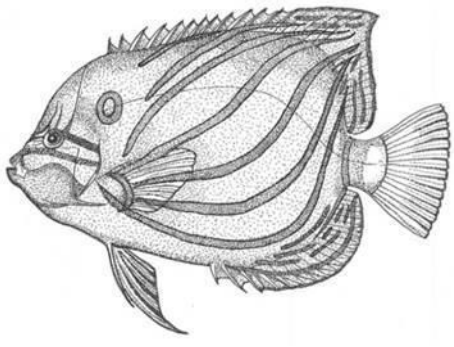


Diagram 5. *Pomacanthus* **annularis** (Bloch, 1787) (Bluering Angel). Local Name: Ring angel, Vannathi meen.

anal spines: 3; anal soft rays: 20. Juveniles black with alternating white and blue curved well-spaced stripes on the sides. Adults golden brown or orange with well-spaced curved horizontal stripes radiating from the pectoral-fin base area, running along the sides towards the posterior portion of the dorsal fin.

Colour

Two similar blue stripes run horizontally across the face, one running through the eye, from above the snout to the edge of the operculum. A blue ring is behind and slightly above the edge of the operculum. Caudal fin is white with bright yellow margin.

Habitat and biology

Inhabits coastal reefs to at least 30 m. Adults often found in pairs inside caves, Juveniles settle in very shallow inshore habitats with short filamentous algae growth on rock or dead coral substrates. Feeds on sponges and tunicates. Undergoes a complete colour transformation from the juvenile to adult stage. Maximum size is about 45.0 cm.

Characters

Dorsal profile straight to slope towards front, body compressed. Mouth is small and prominent upwards; body with excellent seven blue lines bending towards down to tip of the soft dorsal fin (Diagram 5).

Diversity of marine angel fishes

In the present study, abundance of marine angel fishes between January 2008 and December 2009 in 10 stations along Tamilnadu coast, Southeast coast of India was investigated. During the study period, a total of 5 species belong to three genera namely *Apolemichthys xanthurus (*Smoke angel*)*, *Centropyge nox* (Midnight angel), *Pomacanthus semicirculatus* (Koran angel)*, Pomacanthus annularis* (Bluering angel) and *Pomacanthus imperator* (Emperor angel) were recorded. Of these, smoke angel was found to be the dominant followed by midnight angel, koran angel, bluering angel and emperor angel was found to be lower in the order with 5 species in all seasons at 10 stations. The population density of marine angel fishes ranged between 1638 and 10,656 number of fishes with maximum during summer'08 and minimum during postmonsoon'08 (Figure 2).

The studies on station wise abundance of marine angel fishes revealed that maximum was recorded at Tuticorin and minimum at Puducherry during the study period (Figure 3). The higher abundance of marine angel fishes reported in Tuticorin, Kilakkarai, Rameshwaram and Thiruchendur was due to the occurrence of shallow water, coral reefs and rocky bottom. The koran angel, bluering angel and emperor angel were recorded in higher numbers only in Gulf of Mannar region especially in Rameshwaram, Kilakkarai and Tuticorin whereas emperor angel was only in Thiruchendur due to the rocky shore. The species wise abundance studies revealed that the smoke angel was found to be reported at all the 10 stations throughout the year followed midnight angel was predominant and almost recorded in all the 10 stations in throughout the year. Compared to other marine angel fishes, smoke angel (*Apolemichthys xanthurus*) possessing high market demand, easy to acclimatize to any environmental condition and ready to accept any kind of feed.

The percentage compositions of marine angel fish in all the 10 stations were presented in Figure 4. The results revealed that the smoke angel was found to be the dominant group by constituting 57% of the total fishes recorded followed by midnight angel (14%), koran angel (14%), bluering angel (10%) and emperor angel (9%). To study the diversity of marine angel fishes in south east coast of India, three biodiversity indices, namely, Simpson diversity, Shannon diversity and Brillouin divers-

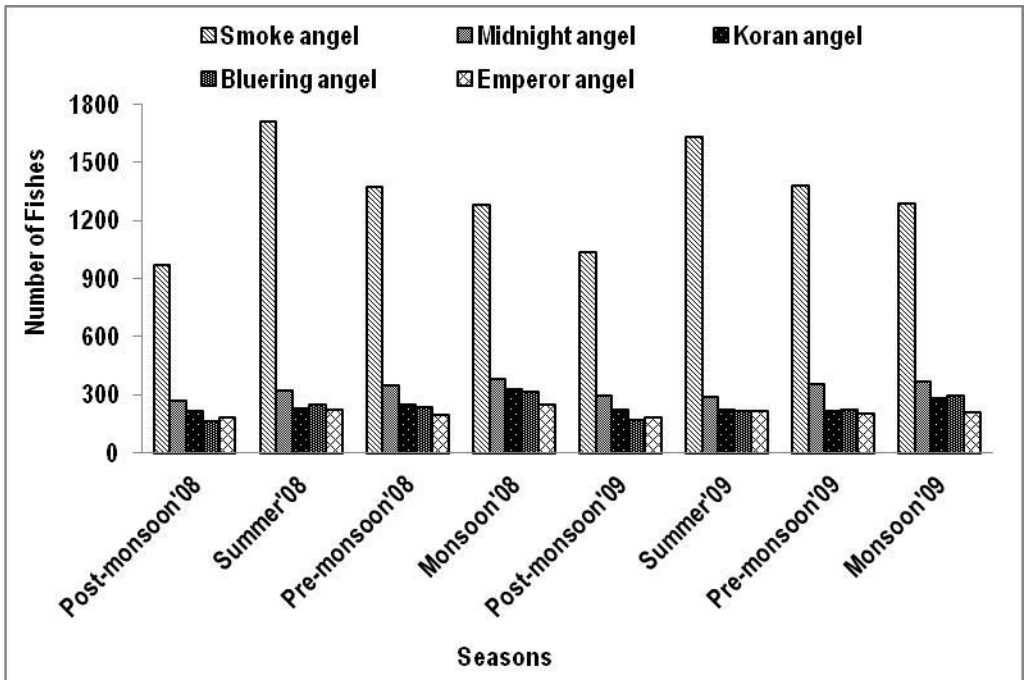


Figure 2. Abundance of marine angelfishes on various seasons between January 2008 and December 2009 along Tamilnadu, southeast coast of India.

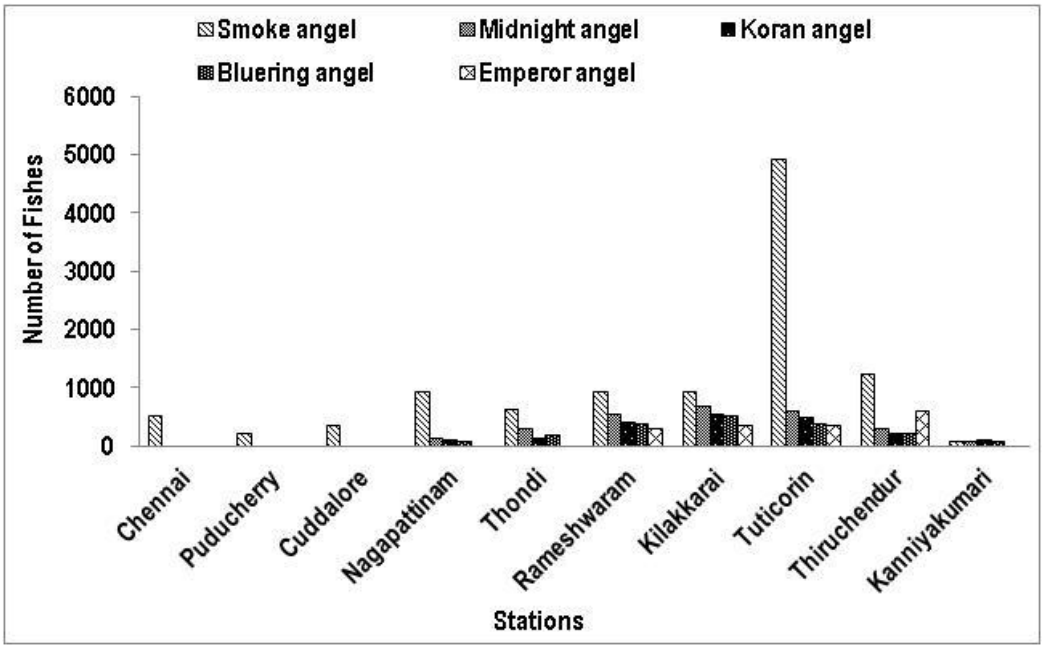


Figure 3. Abundance of marine angelfishes at various stations between January 2008 and December 2009 along Tamilnadu, southeast coast of India.

ity, Simpson evenness, Evenness and Brillouin evenness were employed. The marine angel fish diversity (H) was ranged between 0.187 and 2.298 with maximum at Rameshwaram and minimum at Chennai. The richness (d) ranged between 0.281 and 1.169 with maximum at Kanniyakumari and minimum at Chennai and the evenness ranged between 0.170 and 1 with maximum at Kanniyakumari and minimum at Nagapattinam (Table 1).

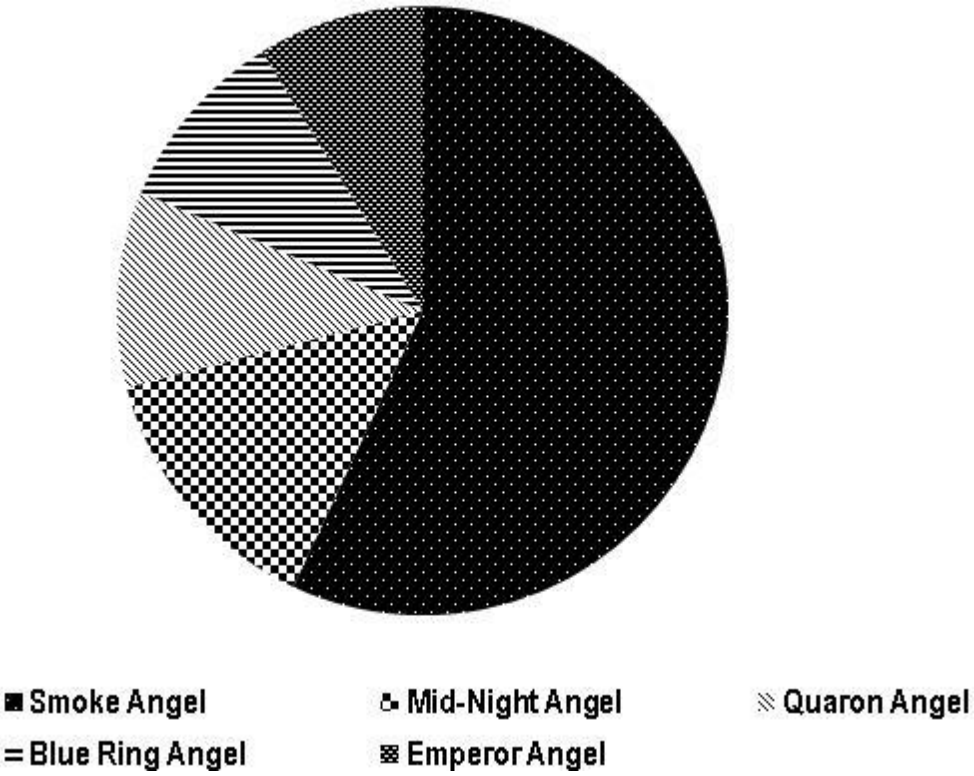


Figure 4. Percentage composition of marine angel fish species recorded during study period along Tamilnadu, southeast coast of India.

Table 1. Diversity indices of marine angel fish along Tamilnadu, Southeast coast of India.

Stations	Diversity		Richness		Evenness	
	Max	Min	Max	Min	Max	Min
Chennai	1.378783	0.187176	1.027797	0.281266	0.970951	0.187176
Pondy	1.378783	0.266765	1.027797	0.314658	0.970951	0.266765
Cuddalore	1.459148	0.242292	1.116221	0.303413	0.970951	0.242292
Nagapattinam	1.408311	0.270512	0.834065	0.253085	0.823812	0.170674
Thondi	2.119451	0.803072	1.027797	0.522379	0.991964	0.506682
Kilakkarai	2.297499	2.11075	1.022489	0.729842	0.989479	0.90181
Rameshwaram	2.298543	2.032264	1.022489	0.746089	0.989929	0.875248
Tuticorin	1.683164	1.026483	0.805989	0.648559	0.724899	0.442082
Thiruchenthur	2.105318	1.468818	1.038921	0.785276	0.906711	0.632585
Kanyakumari	2.092625	0.591673	1.169614	0.434294	1	0.591673

In order to ascertain the diversity pattern graphically, K-dominance plot drawn combine for all the 10 stations did not show any pronounced variation between the stations (Figure 5). The trend observed in diversity index was quite evident here as well. The plots drawn for 10 stations rose slowly due the presence of more number of species. As the percentage contribution of each species was added, the curve extended horizontally giving 'S' shape, before reaching the cumulative 100%.

The MDS plot drawn clearly revealed that the postmonsoon'08 and postmonsoon'09 were grouped at the highest level of similarity (98%) and followed by monsoon'08 (Figure 6). Among the 5 species of recorded marine angel fishes, smoke angel was grouped separately with higher level of similarity followed by midnight angel (Figure 7). Similarly, Tuticorin was grouped separately with highest level followed by Rameshwaram and Kilakkarai (Figure 8). The above

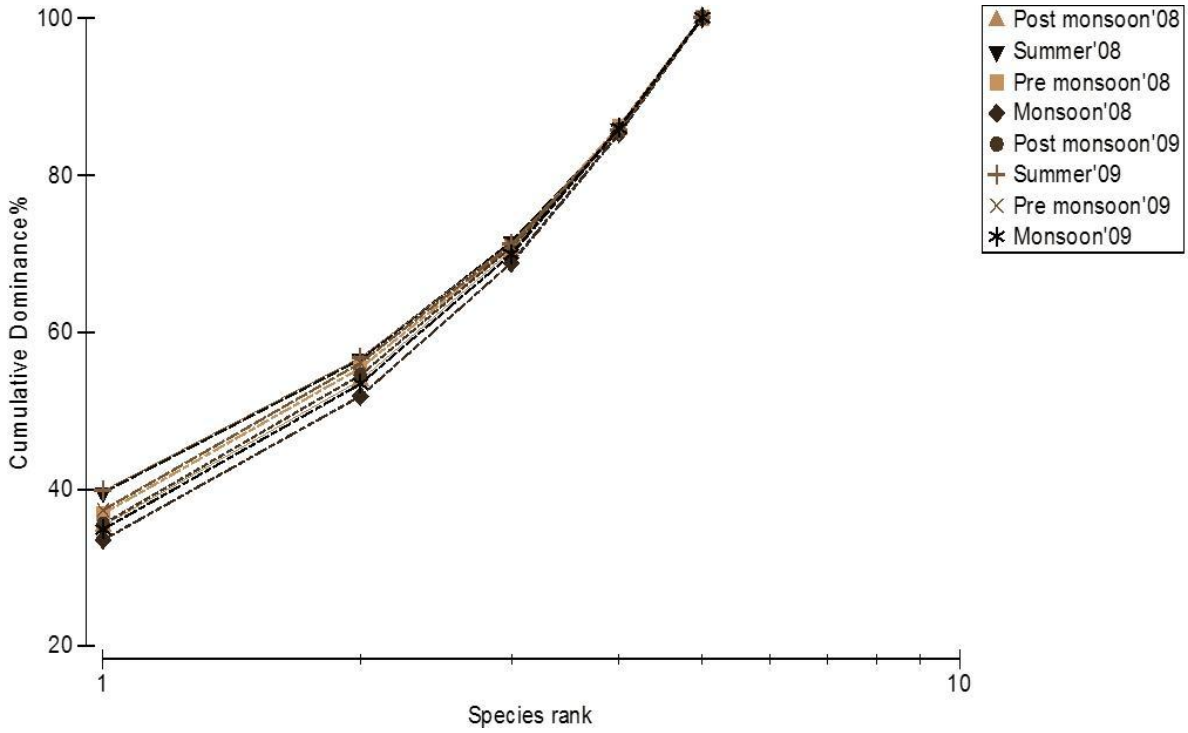


Figure 5. K - Dominance curve drawn for abundance of marine angel fishes at various seasons between January 2008 and December 2009.

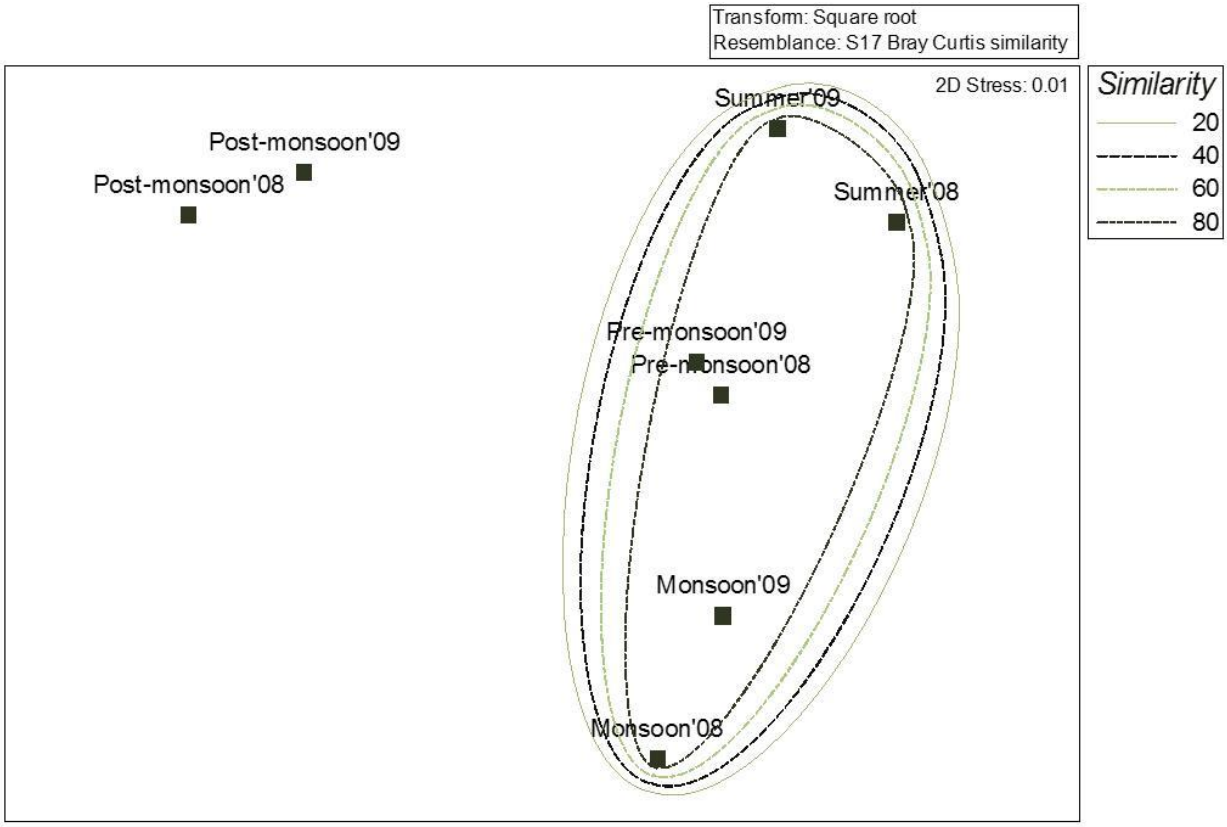


Figure 6. MDS ordination plot for abundance of marine angel fishes at various seasons.

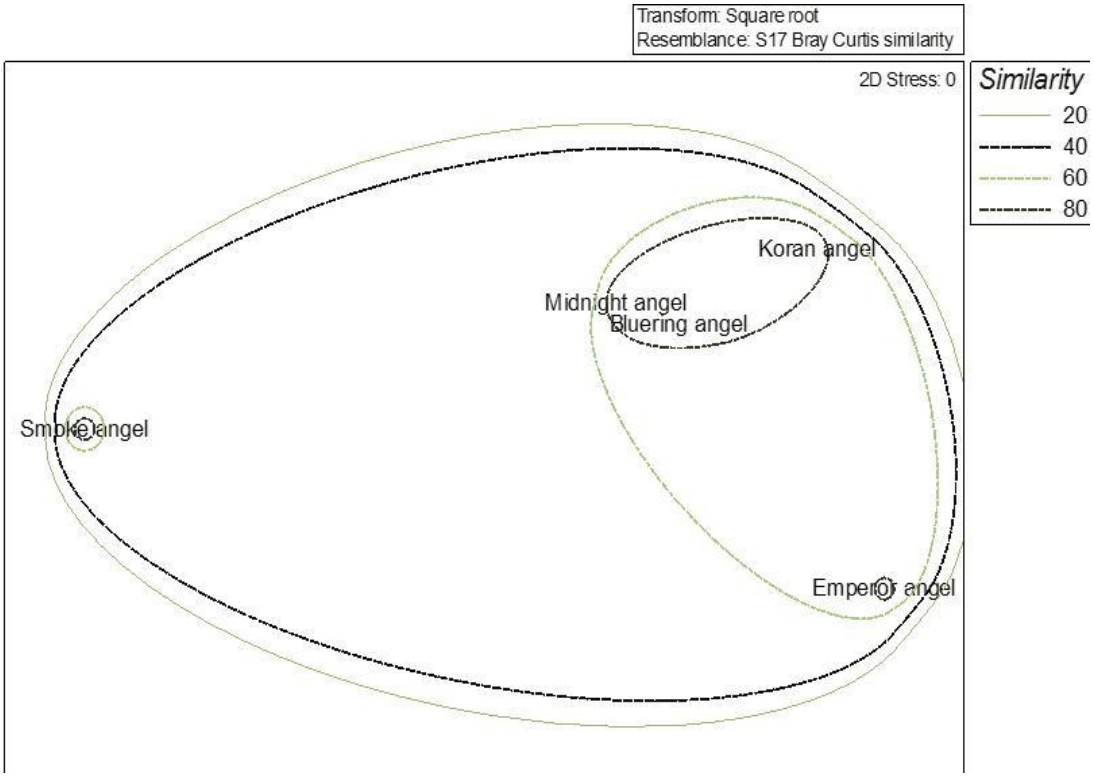


Figure 7. MDS ordination plot for species wise abundance of marine angel fishes recorded along Tamilnadu, southeast coast of India.

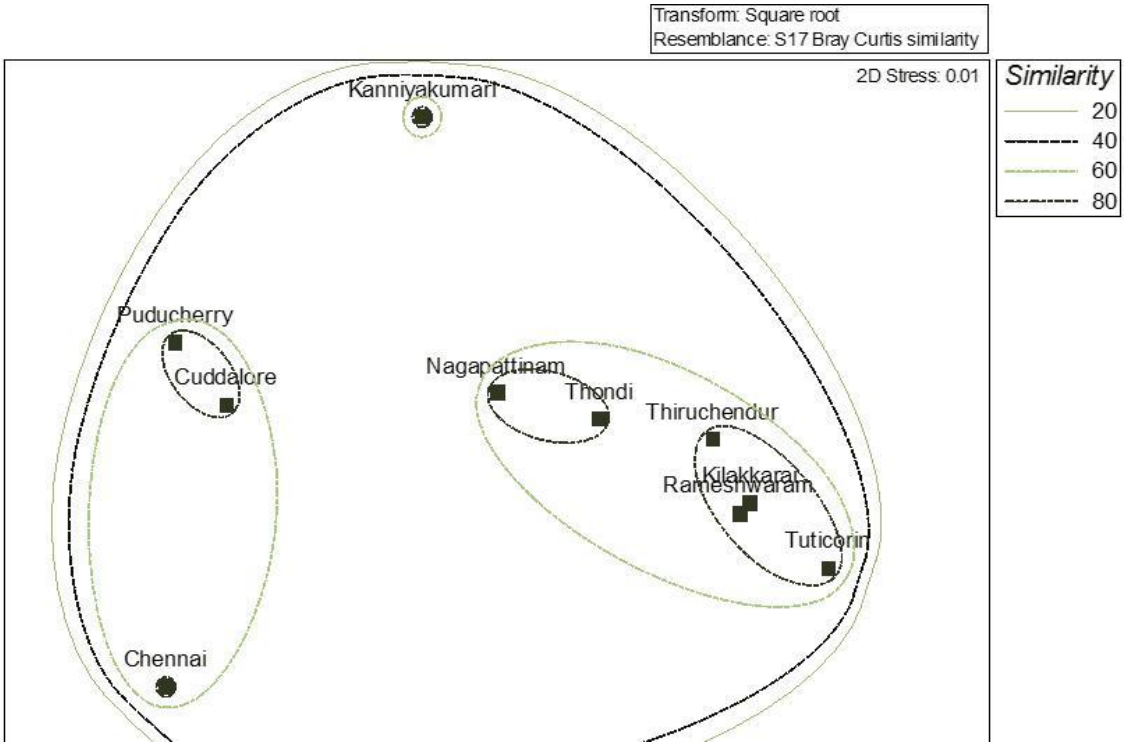


Figure 8. MDS ordination plot for station wise abundance of marine angel fishes recorded along Tamilnadu, southeast coast of India**.**

patterns of grouping of stations were quite evident in MDS due to the fact that the Rameshwaram and Kilakkarai were more lying on the one side of the map and other stations on the other side. The stress value which was overlying on the MDS was also vary (0.01) indicating the excellent ordination pattern of the stations

DISCUSSION

Marine angelfishes of the family Pomacanthidae are typical coral reef inhabitants and are economically important as high priced ornamental fishes (Moenich, 1991). The family Pomacanthidae has circumtropical distribution with 88 species in eight genera (Chung and Woo, 1998; Debelius et al., 2003). In the present study, a total of 5 species of marine angelfishes belongs to 3 genera such as Pomacanthus (3), Centropyge (1) and Apolemichthys (1) were recorded between 1 and 20 m depth along Tamilnadu coast, South east coast of India. Bellwood et al. (2004) reported about 24 Pomacanthid species with two individuals of each species and at least two species from each of the eight genera in Australian waters. However, Alwany (2009) recorded about 6 species of angelfishes which occurred at the depth ranged between reef flat (0.5 to 1 m) in Shalateen region in the northern Red Sea. Khalaf and 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. It seems that the healthy coral communities of the northern Red Sea, a low diversity of species of angelfishes and number of individual was higher than other areas, such as the French Polynesia and the Great Barrier Reef. The closed - system of Red Sea may be the important factor, which leads to scarcity of fish species indicates that the number of individuals was high because of the healthy coral communities of the northern Red Sea (Alwany, 2009).

The results of the present study indicated that, there are five species of marine angelfishes were reported to occur at the depth ranged between 0.5 to 1 and 20 m. Similarly, Alwany et al. (2007) also stated that the abundance and number of species of the angelfishes were increased with increasing depth in Shalateen region in the northern Red Sea. The occurrence of marine angel fish studies concealed that the smoke angel was distributed uniformly in all the 10 stations throughout year whereas midnight, blue ring, Koran and emperor angel were distributed at some specific locations. The diversity of marine angel fishes were analysed using various diversity indices such as Simpson diversity, Shannon diversity, Brillouin diversity and evenness test revealed that the diversity and evenness was comparatively higher in Rameshwaram and Kanyakumari respectively. Venkataramani and Jawahar (2004) recorded about 113 marine ornamental finfish species in Gulf of Mannar and also claimed that this region could be exploited more for ornamental fish trade in India.

The abundance of marine angel fishes in this study was comparatively higher especially in coral reef rich regions such as Gulf of Mannar comprising of Thondi, Rameshwaram, Kilakkarai, Tuticorin and Thiruchendur compared to other regions. In addition to this, MDS ordination plots were also revealed that the diversity was higher in the postmonsoon season and Rameswaram and Kilakarai were grouped separately with highest level of similarity (98%). 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). Roberts and Ormond (1987) stated that most of the coral reef fishes tend to increase in both abundance and number of species with increasing depth on fringing reefs. In contrast, Olivotto et al. (2006) stated that the vertical distribution of angelfishes was increasing with depths, where the highest average abundance of angelfishes was recorded on 20 m (93.0 ± 6.1 fish/600 m^3). However, due to unavailability of the comparable published literature, it is safe to say this is the first as well as pioneer attempt on this commercially important ornamental fish group which could be useful for better understanding of the status of diversity and distribution pattern of marine angelfishes along Tamil Nadu coast, southeast coast of India.

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