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STATUS OF CORALS AND FISHES IN A DEEPER REEF PATCH OF GULF OF MANNAR, SOUTHEAST INDIA

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Abstract: Coral reefs around the world are undergoing severe decline because of various natural and human induced factors. But in many parts of the world, various reef systems still remain unexplored. Gulf of Mannar off the southeast coast of India has been known for its coral islands where most of the research work is done. There has been hardly any study pertaining to the coral status and diversity in the deeper waters of Gulf of Mannar. There are reef patches in deeper waters outside the jurisdiction of Gulf of Mannar Marine National Park (GoMMNP). These reef patches are called 'pars' and they have not been explored yet. The present underwater study was taken up during April 2017 to investigate one such par called 'Madapar' in Tuticorin region of Gulf of Mannar. In Madapar, live corals constitute a reasonable 15.25% while the abiotic part and rocks are dominant in abundance with 40.69 and 37.17% respectively. The mean fish abundance in Madapar was 418.44±5.75 50 m^{-2} dominated by *Lutjanus* sp. with 86.22 50 m^{-2} followed by *Siganus* sp. with 69.11 50 m^{-2}. More underwater works in deeper reef patches are warranted to arrive at values and figures based on which measures may be taken to manage the reef systems of Gulf of Mannar in a better manner, and ultimately to help the dependant fishermen.

Keywords: Gulf of Mannar, Par, Madapar, Corals, Reef, Par

INTRODUCTION

Most of what we have learned about coral reefs has been gathered by scientists during the past 150 years (Darwin, 1842: Dana, 1872; Maragos *et al.*, 1996). Coral reefs are made of reef-building organisms which serve as the basis for one of the most diverse ecosystems in the world (Talbot, 1994). Coral reef ecosystems generally have high species diversity and they are considered as the rain forests of the marine realm (Norse, 1993; Odum *et al.*, 1959; Helfrich and Townsley, 1965). Reef fishes, molluscs, echinoderms, crustaceans, algae, and many other species of plants and animals contribute to the health of a reef ecosystem and they play a significant role in maintaining its resilience and stability. In developing countries, coral reefs contribute about ¼ of the total fish catch, providing critical food resources for tens of millions of people (http://www.reefresilience.org/). Coral reef systems around the world are currently in severe decline; Caribbean reefs have already lost 60% of coral cover since 1970s (Gardner *et al.*, 2003; Jackson *et al.*,2014). In the Indo-Pacific, an approximate reduction of 50% has been reported (Bruno and Selig 2007; De'ath *et al.*,2012). Local threats from overfishing, land-based pollution, coastal development and human activities combined with the global threats of warming sea temperatures, mass coral bleaching and changing weather patterns are putting an unprecedented pressure on the world's coral reef ecosystems (Burke *et al.*, 2011, Jackson *et al.*, 2014; Hoegh-Guldberg *et al.*, 2016; Wake, 2016). India has four major reef regions (Gulf of Mannar and Palk Bay, Gulf of Kachchh, Lakshadweep and Andaman and Nicobar Islands) with an approximate area cover of 2,375 sq. km (Pillai, 1994). All major coral reef areas in India, including Gulf of Mannar, Lakshadweep, Andaman and Nicobar Islands, and Gulf of Kachchh, are under threat from human activities (Arthur, 2000; Rajasuriya *et al.*, 2004).

Gulf of Mannar located off the southeast coast of India extends from Rameswaram Island in the north to Kanyakumari in the south. It has a chain of 21 uninhabited islands stretching from Mandapam to Tuticorin for a distance of 140 km along the coast. The islands occur at an average distance of 8-10 km from the mainland (Edward *et al.*, 2007). Gulf of

Mannar has the legal status of Marine Biosphere Reserve and Marine National Park. The reefs in Gulf of Mannar (GoM) occur around the 21 uninhabited islands between Tuticorin and Rameswaram of Tamil Nadu, southeast coast of India. Patch reefs occur from depths of 2 to 9 m and extend to 1 to 2 km in length with width as much as 50 meters (Edward *et al.*, 2008). There are numerous studies on the coral reefs and on the reef-associated resources in GoM (Pillai, 1971, 1972, 1977, 1986, 1994 and 1996). Pillai (1986) provided a comprehensive account of coral fauna of Gulf of Mannar; according to this study the diversity included 94 species of 37 genera. Edward *et al.* (2004) updated the checklist of corals of GoM to 104 species adding 10 new records. Edward *et al.* (2007) further updated the species list to 117 species of 40 genera. Degradation suffered by GoM has been heavy for the past few decades; over 32 km^2 of coral reef has already been degraded around the 21 islands of Gulf of Mannar (Edward *et al.*, 2008). The large areas of reefs along GoM are generally in poor condition due to a number of destructive activities pursued by the coastal people who depend on fishery resources of reef areas for their livelihood (Edward *et al.*, 2007).

The reef patches found in the deeper waters outside the jurisdiction of Gulf of Mannar Marine National Park (GoMMNP) are called 'pars', and they remain still unexplored. The present study taken up during April 2017 examines one such par called 'Madapar' in Tuticorin region of Gulf of Mannar.

MATERIALS METHODS

Study area

Madapar (N 08^0 37.889 E 78^0 14.805) is located 24 km away from Vaan Island and 12 km away from Punnakayal shore. The area of the reef patch was delineated using the GPS to estimate the total area cover.

Assessment

The assessment protocol involved scuba diving, and LIT (Line intercept transect) method was used to assess the benthic community structure (English *et al.*, 1997). A total of 9 transects were laid perpendicular to the shore, and the collected data were entered on underwater slates. The percentage cover of benthic communities such as live corals, sand, dead corals, soft corals etc. was estimated following English *et al.* (1997). Coral growth forms were identified as per the description of English *et al.* (1997): CB (coral branching), CM (coral massive), CF (coral foliose), CE (coral encrusting) etc. Coral diversity and total number of colonies were recorded underwater.

Fish Diversity

The belt transect method (English *et al.*, 1997) was used for visual survey of fishes involving scuba diving. A total of 9 belt transects were laid and 2.5 m area on both sides of the transect was assessed. The aim of this method was to quantify the abundance and community composition of fish in the study area. Diversity and density of fishes encountered were noted on underwater slates. Underwater photographs

Fig. 1. Map showing the study site

were taken using Nikon AW100 underwater digital camera. Fish identification was carried out using Fish base identification keys (Froese and Pauly, 2005) and Reef fish Identification Tropical Pacific Manual (Gerald *et al.*, 2003).

Fish diversity was statistically assessed using Shannon diversity index (H) in natural log; Species richness (S) and Evenness (J) were calculated using Primer 6 software.

RESULTS AND DISCUSSION

Research works on coral reefs in Gulf of Mannar have mainly been undertaken inside the GoMMNP, and the deeper reef patches are often neglected. This is because of the tedious survey protocol involved and the accompanying element of risk. The present work was carried out to explore the reef patches in the deeper waters of Gulf of Mannar. Severe coral mortality caused by coral bleaching was recorded in Gulf of Mannar during the summer of 2016 (Edward *et al.*, 2018). But the status of deeper reef patches during the bleaching periods is still unknown. Hence, the present study on the status of Madapar reef patch is significant for the better management of Gulf of Mannar. The total area of Madapar was about 0.5 km^2. The bottom was mostly made of hard sand with elevated rocks about 4 m. Depth of the area was around 19 m in the hard sand and around 15 m over the rocks. In Madapar, live corals were found with a reasonable cover of 15.25%. Abiotic factors and rocks were more abundant with 40.69 and 37.17% respectively. Soft corals were also found sporadically with 1.91% and algae had a cover of 0.48% while others were 4.50% (Fig. 2). Of the coral life form categories, CM was the dominant life form category with 8.63, followed by CE with 5.41%, and the other life form categories found were CF and CB with 1.07 and 0.15% respectively (Fig. 3).

Madapar is reasonably diverse in terms of coral species; a total of 8 coral genera were identified during the study; these genera mainly comprised massive and encrusting forms. The massive and encrusting coral forms found in Madapar include *Porites*, *Favia*, *Favites*, *Goniastrea*, *Platygyra* and occasionally *Symphyllia*. *Porites* was the dominant genus in Madapar making 5.96% of the coral population, followed by *Turbinaria* spp. with 3.46%. The other coral genera were *Goniastrea* spp., *Favia* spp., *Acanrhastrea* spp., *Favites* spp., *Cyphastrea* spp. and *Symphyllia* spp. with 1.86%, 1.33%, 0.91%, 0.84%, 0.47% and 0.42% respectively (Fig: 4). Edward *et al*. (2012) recorded the live coral cover during 2003-2005 as 36.98% in Gulf of Mannar, which increased gradually to 42.85% in 2009. This increase in live coral cover was due to the halting of coral mining which was prevalent before 2004. However, coral cover was disturbed significantly in 2010 because of the bleaching driven mortality during that year (Edward *et al.*, 2012) and 2016 (Edward *et al.*, 2018). Several other factors such as bio-invasion of exotic seaweed; harmful practices like trap fishing, bottom trawling; coral diseases, and competition among the species for space, etc. have also been serious threats which damage the corals of Gulf of Mannar.

Edward *et al.* (2018) updated the coral cover and species diversity upto the year 2016 which took into consideration the bleaching driven coral mortality during 2010 and 2016. However, these accounts did not include the status of corals in the reef patches in the deeper waters. Edward *et al*. (2007) reported the following as some of the dominant corals species in Gulf of Mannar: *Pocillopora damicornis, Acropora formosa, A. intermedia, A. nobilis, A. cytherea, Montipora digitata, M. foliosa, Favia pallida, Favites abdita, Goniastrea retiformis, Porites solida* and *P. lutea*. But the reef patch in Madapar did not include fast growing species from the genera *Acropora, Montipora* and *Pocillopora* and this could be attributed to the higher depth range in Madapar. Occurrence of deep water organisms has been linked to the scale of productivity, heterogeneity of sediment, availability of oxygen, hydrodynamics, slope and disturbance to the habitat (Davies and Guinotte, 2011; Yesson *et al.*, 2012). The coral community structure in Madapar is dominated by boulders and encrusting corals which, might be because of the hydrodynamics and sediment heterogeneity.

It has been reported that among the coastal and marine biodiversity, only fish has been well catalogued across the countries of the Indian Ocean vis-à-vis other fauna (Wafar *et al.*, 2011). Fishes have the highest species diversity among all the vertebrate taxa (Sarkar *et al.*, 2012). Coral reef fish community has been reported to be distinctive, and it includes

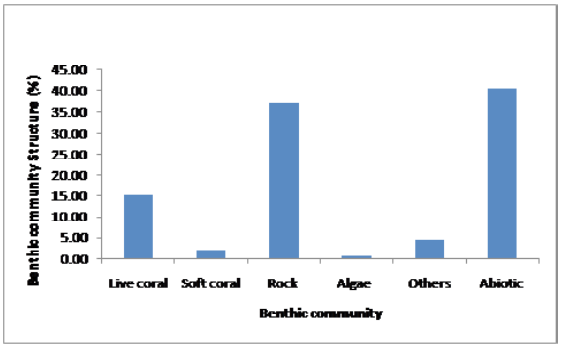


Fig. 2. Benthic community structure in Madapar

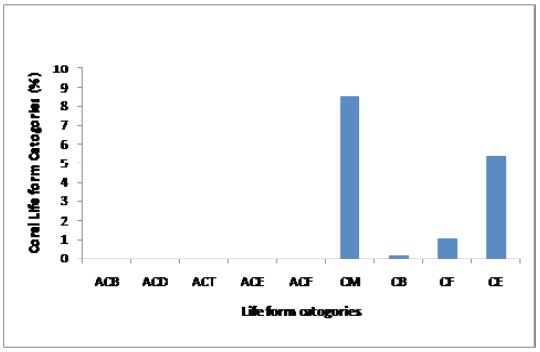


Fig. 3. Coral life form categories in Madapar

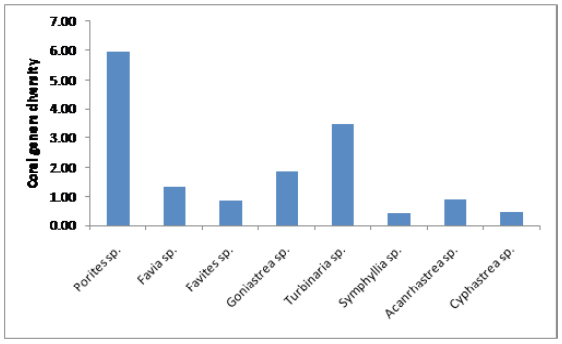


Fig. 4. Coral generic diversity in Madapar

many endemic species; further the fish community is different from its counterpart in the shallow reef areas (Brokovich *et al.*, 2008). It has also been reported that the mid-depth range of around 30 m has more species whereas there is a sharp decline in the deep reefs (Brokovich *et al.*, 2008). A unique fish community structure was observed in Madapar. A relatively good number of individual fishes were witnessed during the study, which amounts to a total of 3,766. A total of 31 genera from 22 families were observed during the survey.

The mean fish abundance was 418.44±5.75 50 m^{-2} in Madapar during the study. Of the different fish species, the highest abundance was recorded for *Lutjanus* sp. with 86.22 50 m^{-2} followed by *Siganus* sp. with 69.11 50 m^{-2}. The values of abundance for the other fishes in Madapar were: *Lethrinus* sp. (65.44 50 m^{-2}), *Odonus* sp. (36.44 50 m^{-2}), *Pempheris* sp. (23.22 50 m^{-2}), *Acanthurus* sp. (15.78 50 m^{-2}), *Chaetodon* sp. (13.67 50 m^{-2}), *Parupeneus* sp. (12.67 50 m^{-2}), and *Diagramma* sp. (6.56 50 m^{-2}) (Table 1). Poor representation was observed for *Pterosis* sp. and

Table 1. Mean abundance of fish genera in Madapar

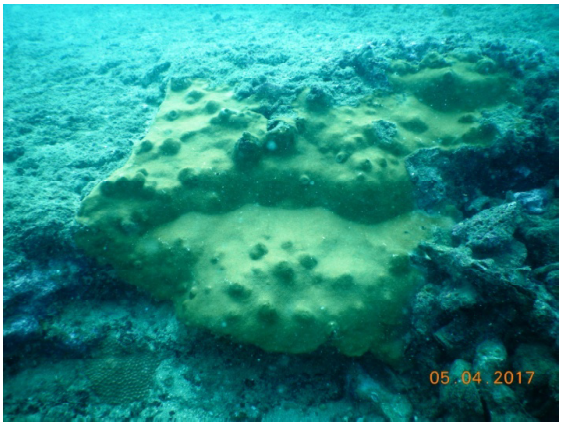
Fish genera	Family	Mean abundance
Lutjanus sp.	Lutjanidae	86.22±15.57
Lethrinus sp.	Lethrinidae	65.44±12.36
Acanthurus sp.	Acanthuridae	15.78±2.38
Plectorhinchus sp.	Haemulidae	2.22±0.76
Parupeneus sp.	Mullidae	12.67±1.72
Pempheris sp.	Pempheridae	23.22±3.02
Pomacanthus sp.	Pomacanthidae	2.44±0.94
Abalistes sp.	Balistidae	12±2.55
Balistoides sp.	Balistidae	2.44±0.93
Odonus sp.	Balistidae	36.44±5.02
Pomacentrus sp.	Pomacentridae	7.67±2.31
Pristotis sp.	Pomacentridae	6.11±2.11
Amphiprion sp.	Pomacentridae	2.78±0.97
Chaetodon sp.	Chaetodontidae	13.67±4.21
Heniochus sp.	Chaetodontidae	1.22±0.49
Apolemichthys sp.	Pomacanthidae	1.89±0.96
Siganus sp.	Siganidae	69.11±11.65
Diagramma sp.	Haemulidae	6.56±1.69
Cephalopholis sp.	Serranidae	1.33±0.60
Epinephelus sp.	Serranidae	5.44±1.83
Carangoides sp.	Carangoidae	16±3.82
Caranx sp.	Carangoidae	8±2.35
Scarus sp.	Scaridae	6.44±2.95
Gymnothorax sp.	Muraenidae	2.67±0.76
Sepia sp.	Sepiidae	1.22±0.60
Narcine sp.	Narcinidae	0.78±0.32
Arius sp.	Ariidae	0.89±0.48
Himantura sp.	Dasyatidae	0.89±0.45
Pterosis sp.	Scorpaenidae	0.44±0.24
Sargocentron sp.	Holocentridae	5.89±1.87
Lagocephalus sp.	Tetraodontidae	0.56±0.24

Turbinaria sp.

Favia sp.

Symphyllia sp.

Favites sp.



Porites sp.

Favia sp.

Underwater photos of corals in Madapar

Lutjanus sp.

Heniochus sp.

Diagramma sp.

Cephalopholis sp.

Scarus sp.

Pempheris sp.

Underwater photos of fishes in Madapar

Lagocephallus sp. with 0.44 50 m^{-2} and 0.56 50 m^{-2} respectively. Ray *et al*., (2013) recorded fish diversity, species richness and evenness in Andaman Island which were 1.57, 18.98 and 0.31 respectively. In Madapar during the present survey the Shannon diversity index (H) showed diversity, richness and evenness as 2.42, 23.48 and 0.79 respectively.

A total of 78 species of reef fishes belonging to 45 genera from 24 families were recorded in Tuticorin region of Gulf of Mannar by Mathews *et al.*, (2015). The comparatively lower fish diversity in Madapar could be attributed to the lack of branching coral forms which provide higher rugosity and shelter to the small reef fishes (Ohman *et al.*, 1997). The decline in the amount of branching corals with depth, together with a more flattened coral morphology hinders the use of the corals as shelter (Mass *et al.*, 2007). Besides depth, many other biotic and abiotic factors such as habitat structure, light intensity levels, competition, predation, larval supply and behavior also influence the fish abundance.

The present underwater exploration in Madapar provides an insight into the unveiled wealth of Gulf of Mannar. The response of the deep dwelling corals during the bleaching period might hold the key to the protection of the reef areas inside the GoMMNP. Further exploration is needed to understand the status and diversity of corals in deeper reef patches of Gulf of Mannar. Fish abundance and diversity in Madapar is different from those of the shallower regions of Gulf of Mannar. Hence, further studies become all the more important to the understanding of the ecology of fishes and spawning aggregation. The livelihood of thousands of fishermen along the coast of Gulf of Mannar depends on reef-related fishery. Hence a better understanding of deeper reef patches would help in the proper management of them, which in turn would help the dependant fisher folk.

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