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INCREASING MACROALGAE POSE A THREAT TO CORALS IN KOSWARI ISLAND OF GULF OF MANNAR, SOUTHEAST INDIA

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Abstract: Coral reefs are important ecosystems from which humans derive several benefits. However, coral reefs are increasingly subject to various pressures and threats, and they are declining rapidly. Gulf of Mannar is one of the major coral reef systems in India endowed with a reasonable extent of coral cover. The present study was carried out in Koswari Island (8°52'11.94"N 78°13'31.70"E) of Gulf of Mannar during January 2017. Competition for space between the corals and algae was assessed using standard protocols for underwater survey. Algal cover in the study site was as high as 50.31% and coral cover was 18.01%. Live coral colonies of six coral genera were found invaded by macroalgae. Of the fish communities, the herbivorous fishes which feed on macroalgae were far less in density (10.48%). The increasing algal cover on the one hand, and the decreasing population size of the herbivorous fishes on the other pose a serious threat to the corals of Gulf of Mannar. Immediate steps should be taken to conserve the corals, and further focused research on the coral-algal dynamics is also required for better management.

Keywords: Coral reefs, macroalgae, herbivore, Gulf of Mannar.

INTRODUCTION

Coral reefs are highly prolific and much diverse ecosystems on earth (Tomascik *et al*., 1997; Thomas, 2001). They provide shelter to one third of all marine organisms (Reaka-Kudla, 2001). Coral reefs not only offer sanctuary but also help in fishery production, besides protecting the coastline from erosion and natural disasters like cyclones, storms and tsunamis. Of late coral reefs are fast declining because of various natural and human-induced factors (Epstein *et al*., 2001; Pandolfi *et al*., 2003; Bellwood *et al*., 2004; Wilkinson, 2002). Competition of algae with live corals for space is an important factor in the reef areas. This may happen due to the overgrowth of macroalgae caused by overfishing of herbivorous fishes (Hughes *et al*., 2003).

Competition for space is very common among the benthic communities (Karlson, 1999). Particularly well-known is the competition between the benthic macroalgae and hard corals. It is a vital ecological input that decidedly affects the structure, arrangement and abundance of both coral and algal communities (Diaz-Pulido and McCook, 2002). Positive conditions for algal overgrowth are brought about by the diminishing population size of the herbivorous fish and also by the phenomenon known as eutrophication (Pandolfi *et al*., 2005). When the algae grow in the primary available space in the vicinity of the corals, the coral-algal competition is indirect; and if the algae invade the coral colonies and live on them, then the competition in direct. In the last few decades it has been reported by many studies that when coral cover declines, algal abundance increases (Birkeland, 1997).

The nature of the competition between corals and algae depends to a large extent on the coral species also (Jompa and McCook, 2003). Generally algae cannot attach themselves to live corals because of the defence mechanism of corals. All corals are capable of defending themselves against pathogens and predators by developing physical and chemical mechanisms. If the defensive protection is not robust

enough it gives way to the competitors and predators (Zust *et al*., 2011; McCook, 2001). If a part of a coral colony dies, the resultant space is immediately occupied by the alga, and it eventually overgrows the coral colony and kills it. Likewise in the last few decades marine sponges have also been reported to compete with live corals, and arrest the coral growth and suppress their defence mechanism (Endara and Coley, 2011). It has been reported that direct abrasion of macroalgae on live corals can cause chronic injury (Lirman, 2001). Algae are generally present only in shallow waters for they require sunlight for their survival, and hence they affect more the branching corals in shallow waters than the corals living in deeper waters (Barnes and Chalker, 1990). Interestingly, algae actually help the corals during bleaching by shading the corals from direct sunlight (Jompa and McCook, 1998).

The coral reefs in Gulf of Mannar occur mainly around the 21 uninhabited islands, located between Rameswaram and Tuticorin, along the southeast coast of India. Degradation of reefs in Gulf of Mannar has been on the rise in the past few decades; more than 32 km^2 of coral reef has already been degraded (Edward *et al*., 2008). Reefs degradation in Gulf of Mannar have been caused by various anthropogenic threats such as coral mining, destructive fishing practices, pollution, etc. apart from natural and other factors such as coral bleaching, diseases, bio-invasion, sedimentation, etc. The issue of algal competition in Gulf of Mannar has been reported earlier too (Raj *et al*., 2006). Understanding the dynamics of coral-algal interaction is very important for the effective management of the reef ecosystems. The purpose of the present study is to assess the coral-algal interaction in Koswari Island of Gulf of Mannar.

MATERIALS AND METHODS

Survey area

The present study was carried out in Koswari Island of Gulf of Mannar during January 2017. Koswari Island (8°52'11.94"N 78°13'31.70"E) is one of the seven islands of the Tuticorin group (Fig. 1), which occur within Gulf of Mannar Marine National Park (GoMMNP). Fringing and patch reef types occur in this island with a coral cover of 15.27% (Edward *et al.,* 2007).

Underwater assessments

All the assessment protocols involved scuba diving or snorkelling depending on the depth. Preliminary assessment was done using manta tow technique to understand the broad changes in benthic communities (Done *et al.,* 1982). After confirming the detailed location of the coral reef area, line intercept transects of 20 m and belt transects (English *et al.,* 1997) were

Fig. 1. Geographical location of Koswari Island

laid randomly parallel to the island. Coral cover was assessed through line intersects and the overgrowth of macroalgae was assessed through belt transect method in the same transect. A total of 15 transects were laid and each transect covered an area measuring 20 X 2 m (1 m on each side of the transect line) and a distance of 20 m was left between each transect. Prevalence was calculated by the following formula,

$$\text{Macroalgae competition prevalence} = \frac{\text{Number of colonies with macroalgae competition per site}}{\text{Number of colonies examined per site}} \times 100$$

Visual census method applying belt transects was used to estimate the abundance and diversity of fish (English *et al.*, 1997). The transect area for fish assessment covered 25 X 10 m (5 m on each side). In order to establish spatial variation, fishes were categorised into four trophic levels using data from the previous studies described in literature (Hamelin-Vivien 1979). Live coral cover Vs prevalence of macroalgae overgrowth Vs abundance of herbivorous fishes were correlated with one another and significant differences were determined using correlation regression test in SPSS 16.0 software.

RESULT AND DISCUSSION

India has four major reef areas viz. Gulf of Mannar and Palk Bay in Tamil Nadu, Gulf of Kutch in Gujarat, Andaman and Nicobar Islands, and Lakshadweep islands. Corals in Gulf of Mannar currently face various human induced threats such as destructive fishing practices and pollution coupled with natural and other factors such as coral bleaching, coral diseases and bio-invasion. Apart from these obvious threats, there are other biotic factors such as predation by fish and snail, infestation by worm, macroalgae overgrowth, competition from coralline algae, mucus sheathing, sponge overgrowth etc. Competition between corals and macroalgae is common in a reef area; but, when the algae triumph over the corals and snatch the space previously occupied by corals, the reef is considered declining (Hughes *et al.*, 2003); and such phenomenon is called coral-algal phase shift. Nutrients play an important role in determining the abundance of macroalgae in the reef areas (Steneck and Dethier, 1994; Szmant, 2002). Macroalgae are directly in competition with hard corals for space and light.

Overall, the mean live coral cover was 18.01±1.48% (SE) in the studied area, ranging from 7.01% to 25.87% within transects. *Porites* was the dominant coral genus with the value at 7.4±1.51%, followed by *Favia* (3.49±0.76%), *Favities* (2.66±0.51%), *Goniastrea* (1.39±0.37%), *Turbinaria* (0.96±0.20%), *Acropora* (0.71±0.18%), *Symphyllia* (0.54±0.24%), *Pocillopora* (0.50±0.2%) and *Montipora* (0.38±0.17%) (Fig.3). The macroalgae had an area cover of as high as 50.31± 2.34%, followed by crustose coralline algae with the value at 8.85±1.59% while sand, rubbles and others had 4.53±0.58%, 6.72± 0.63% and 5.88±0.59% respectively (Fig. 2). Of the total 656 coral colonies counted in the belt transect method, 20-40 cm size class category was dominant with 29.68% followed by 10-20 cm category with 24.54% (Fig. 4).

Macroalgae directly affect the coral tissue by overgrowth, chemical effects, abrasion and shading (McCook *et al.*, 2001). If the algae get in contact with corals, the coral polyps are damaged by abrasion and in turn the coral growth is disturbed (Coyer *et al.*, 1993). By shading, algae inhibit the sunlight penetration to the corals and thus upset coral growth and survival (Jamaluddin *et al.*, 2003). Once corals are overgrown by algae it is very difficult for them to recover from the suffocating effects. Hughes (1989) reported that macroalgae had the capacity to overgrow the massive coral *Montastraea faveolata* and they destroyed 10% of the live tissue per month. In the present study, a massive 50.31% of algal cover has been observed in the entire reef areas, including the live and dead, of Koswari Island, which value very high. It has also been reported that a few coral species are able to defend themselves from the algae (Knowlton *et al.*, 1992). Likewise, in the Koswari Island, it was observed that a few coral species (Fig. 7) were susceptible and a few were resistant to the overgrowth of macroalgae. The affected coral genera

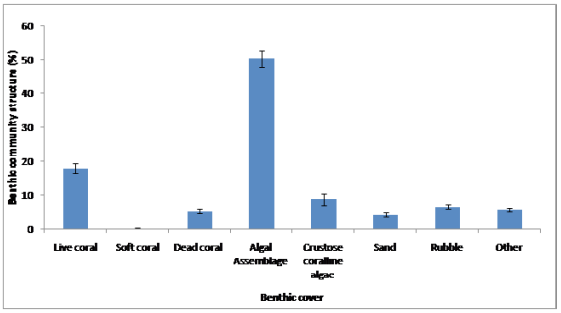

Fig. 2. Benthic community structure in the study site

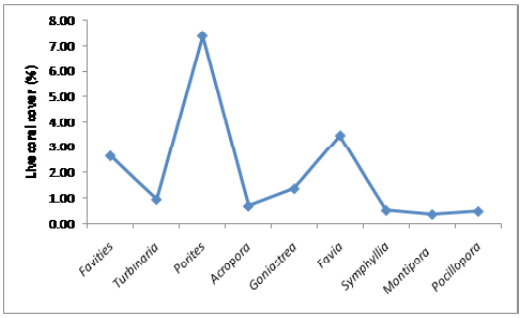

Fig. 3. Live coral cover in the study site

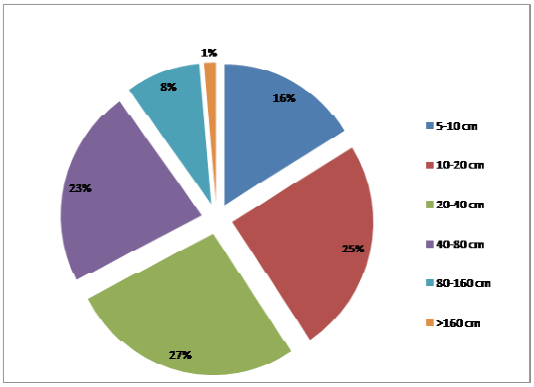

Fig. 4. Proportion of coral size classes in the study site

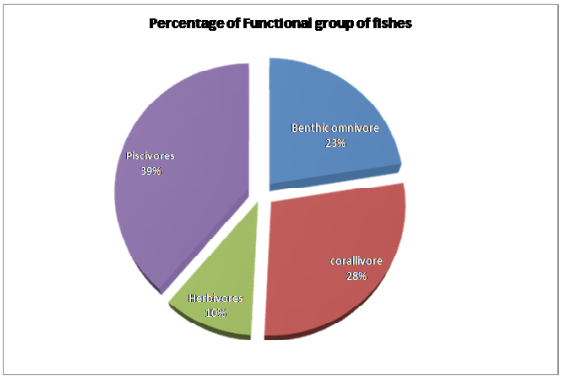

Fig. 5. Proportion of fish categories in the study site

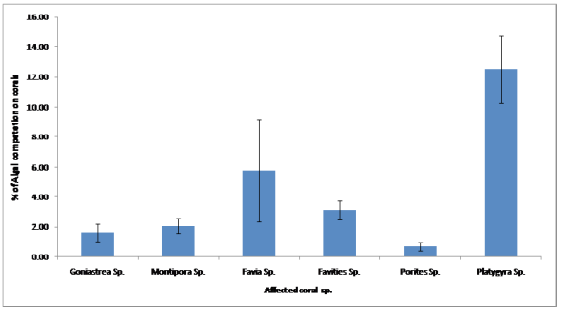

Fig. 6. Macroalgae competition prevalence with standard error bars

comprise *Symphyllia* (12.5±2.22%), *Favia* (5.77±3.41%), *Favities* (3.13±0.64%), *Montipora* (2.06±0.54%), *Goniastrea* (1.61±0.58%) and *Porites* (0.69±0.28%). The following coral genera were not overgrown by macroalgae in the study area: *Acropora*, *Turbinaria* and *Pocillopora*. Total prevalence of algal overgrowth on live corals in Koswari Island was 25.76% (Fig. 6).

Totally 124 fishes were counted which include 19 species belonging to 10 families (Table. 1). *Chaetodon auriga* and *Diagramma pictum* were the dominant fish species with 1.13 and 0.87 no/50 m^2. The observed fishes were classified according to their feeding behaviours (Fig. 5). Benthic omnivores were the dominant category with 22.58% (n=28) followed by corallivores with 28.23% (n=35) while herbivores were 10.48% (n=13) and piscivores were 38.71% (n=48). Correlation analysis between the live coral cover and the overgrowth of macroalgae showed a positive non-significance (r^2=0.30) and it showed a positive non-significance also with the density of herbivorous fishes (r^2=0.1). Mathews *et al* (2015) reported that Koswari Island had more omnivores (56%) than herbivores (10%). The herbivorous fishes play a vital role in controlling the algal growth and defending the corals (Borowitzka, 1981). Reduction in the herbivore population and the consequent proliferation of macroalgae have been reported in reefs of the other parts of the world (Hughes *et al*., 1987; McClanahan and Muthiga, 1998, Hughes *et al*., 2007). The herbivores also control the asexual reproduction of the algal communities (Walters *et*

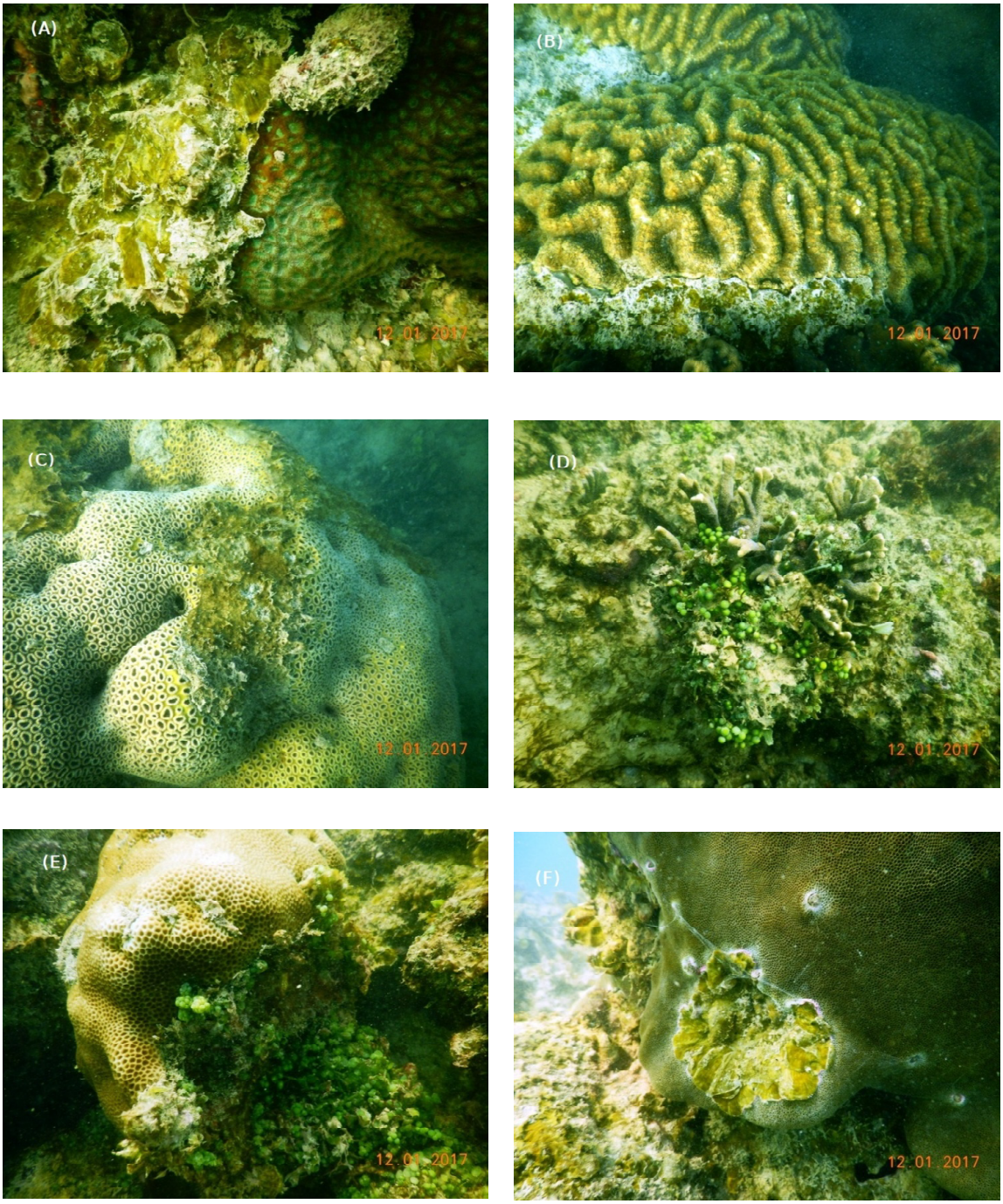

Fig. 7. Competitive interactions between macroalgae and coral; a. *Favities*; b. *Symphyllia*; c. *Favia*; d. *Montipora*; e. *Goniastrea*; f. *Porites*

al., 2002). The relationship between the abundance of algae and that of the herbivorous fishes is much complicated (Ferreira *et al*., 1998). Herbivorous fishes feed on the reef algae and reduce the overgrowth on coral colonies (Choat 1991); and if these herbivores are excluded, macroalgae would naturally increase in abundance (Hay, 1991). Targeted fishing on herbivorous fishes has been reported to result in decreased grazing of macroalgae and eventually in algal proliferation (McManus *et* al., 2001). Likewise, high herbivore abundance has been linked with low macroalgae cover (Kramer *et al*., 2015). The present study evidently brings out the fact that the density of herbivorous fishes is very low in Koswari Island. This could be attributed to the prevailing trap fishing activity around the islands of Gulf Mannar. Trap fishing mainly targets the herbivorous fishes and thus paves the way for macroalgae proliferation.

The present study further discloses the alarming trend of macroalgae proliferation in the reef areas of Kowari Island. Targeted fishing of herbivores seems to be the main cause of this proliferation. The bleaching events, and coral mortalities are more likely and hence proper management actions should be in place to control the macroalgae proliferation. Domestic pollution, the main source of nutrients, should also be checked to avoid eutrophication. Since coral reefs in Gulf of Mannar provide direct and indirect livelihood to thousands of people, they have to be conserved from coral-algal phase shift. Further focused research on the coral-algal dynamics is also highly warranted for better management.

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