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Report on an outbreak of coral-killing sponge *Clathria (Microciona) aceratoobtusa* in an unprotected reef of the Gulf of Mannar, India

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Short Communication

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Abstract

Global climate change has aggravated the severity of space competition put up by marine sponges in the tropical coral reef ecosystems. We report here an outbreak of coral-killing sponge *Clathria* (Microciona) *aceratoobtusa* (Carter, 1887) over live coral colonies of the genus *Turbinaria* in an unprotected reef (mainland patch reef) in the Gulf of Mannar in India. An outbreak of this orange-reddish sponge was observed during an explorative dive in April 2020. Live coral cover in the reef was 62.06% (SD±3.36), which was dominated by the genus *Turbinaria* with 82.31%. Among the total of 549 *Turbinaria* colonies counted in five transects, 21.86% (n = 120) of colonies were found infested by the sponge. As the mainland patch reef lies outside the boundary of marine protected area, it is exposed to human-induced threats, apart from climate change implications. This report would serve as an evidence to indicate the intensity of the space competition waged by sponges in a disturbed reef ecosystem.

Introduction

Coral reefs are dynamic marine ecosystems that offer a wide range of ecological and economic benefits to human beings, especially in tropical countries. In the past few decades, coral reefs have suffered a significant decline. Natural factors such as coral bleaching, ocean acidification, disease outbreaks, and ocean deoxygenation coupled with human activities such as coral harvesting, destructive fishing practices, tourism, and pollution have considerably damaged global coral reef ecosystems (Hoegh-Guldberg *et al.* 2017). Global coral bleaching events driven by climate change have been reported to be the major cause of reef decline during the past two decades (Hughes *et al.* 2018). Mass bleaching events and the consequent coral mortalities have paved the way for the emergence and expansion of opportunistic space competitors such as macroalgae, octocorals, and sponges (Chadwick & Morrow 2011). These benthic space competitors can grow faster and snatch space from corals causing phase shifts. Particularly, when the environmental conditions are ideal for them, marine sponges act as strong space competitors causing damage to corals (e.g. Schönberg & Ortiz 2008, Bell *et al.* 2013). Climate change has worsened this competition as the heat-stressed corals are often overpowered by sponges (Ashok *et al.* 2018, Schönberg *et al.* 2008).

India enjoys a tropical climate and is thus bestowed with coral reefs in different parts of the country. The Gulf of Mannar (GoM) in India is one of the biodiversity hotspots in the country, with significant extents of coral reefs and associated biodiversity. There are 21 uninhabited islands in GoM, around which major reef areas occur. Coral cover in GoM has declined significantly during the past couple of decades due to various climatic and non-climatic factors (Edward *et al.* 2008, Raj *et al.* 2021). The bleaching event of 2016 was massive, which killed a significantly great population of corals in GoM (Raj *et al.* 2021), facilitating the rise of space competitors such as algae and sponges (Ashok *et al.* 2018, Raj 2021, Raj *et al.* 2021). Recent reports from GoM highlight the intensity of sponge–coral interaction, which negatively affects corals (Raj *et al.* 2018a, 2019, Ashok *et al.* 2018, 2020, Raj 2021). For the purpose of conservation, all 21 islands and the surrounding shallow waters of GoM were declared as a marine protected area (MPA) called Gulf of Mannar Marine National Park (GOMMNP) in 1986. This MPA is a 'no go' and 'no take' zone, where human activities are restricted. However, there are certain other patch reefs in GoM falling outside the jurisdiction of this MPA even though they have a good coral cover (e.g., Raj *et al.* 2019). In spite of the abundance, diversity, and significance of the coral reefs outside the boundary of the MPA, not many studies have happened on these patch reefs. In this study, we report the outbreak of the coral-killing sponge *Clathria* (Microciona) *aceratoobtusa* (Carter, 1887) in one such unprotected reef called the mainland patch reef in the Tuticorin region of GoM.

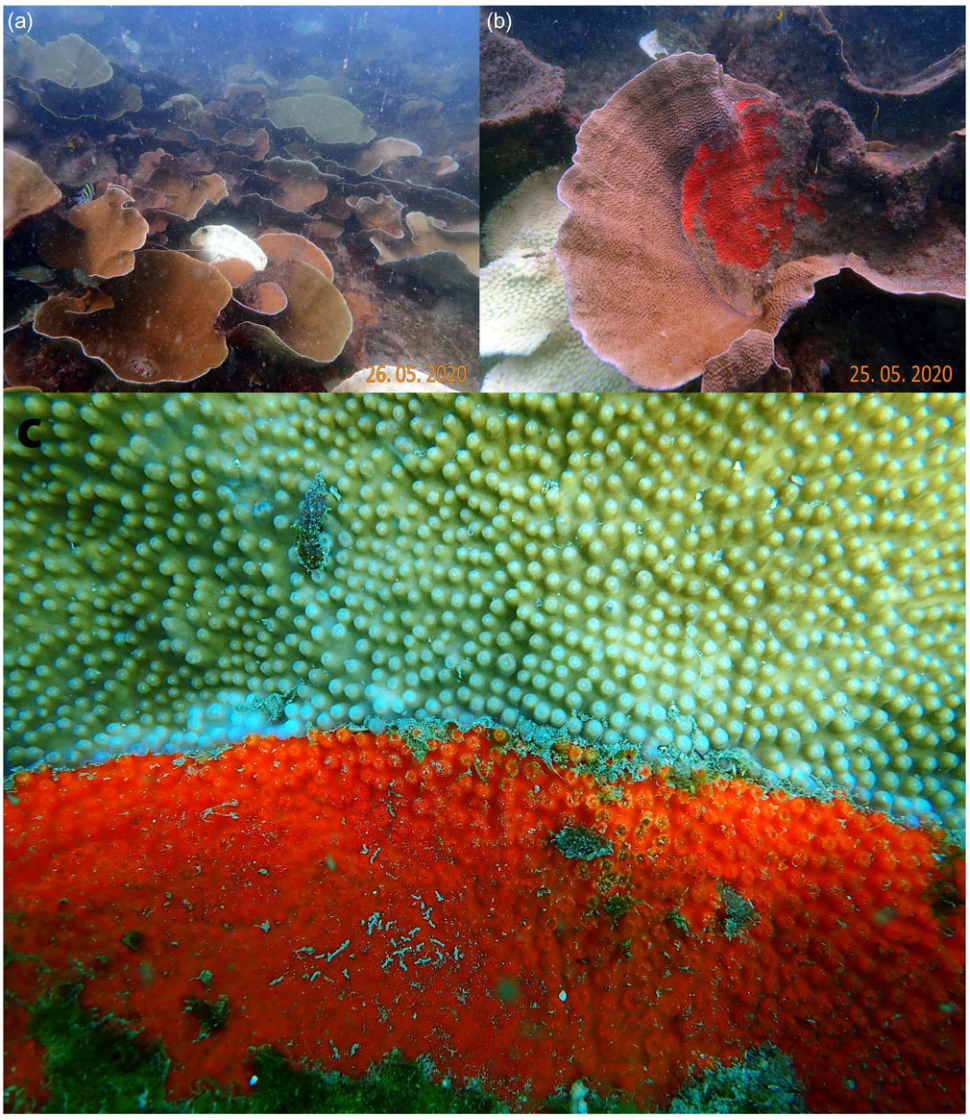

Figure 1. a. View of mainland patch reef dominated by *Turbinaria*; b. A *Turbinaria* colony infested by *Clathria (Microciona) aceratoobtusa*; c. A closer look at the progression front.

Materials and methods

GoM, one of the four major reef regions of India, occurs on the southeast coast of the country. Mainland patch reef occurs outside the jurisdiction of GOMMNP (Suppl. Fig. 1), where fishing and other human activities are allowed. The present underwater assessment was carried out in April 2020, when an outbreak of orange-reddish sponge was sighted during an explorative dive. The depth of the reef ranges between 1 and 6 m, but live corals are abundant at depths between 5 and 6 m where the outbreak was observed. For the assessment of the prevalence of sponge outbreak at the affected site, five 20-m line intercept transects (English *et al.* 1997) were laid on the reef to estimate the benthic cover. These transects, laid parallel to the mainland shore, were separated from each other by a minimum distance of 20 m. The benthic cover was categorized as live corals, octocorals, sponges, sand, dead corals, algae, crustose coralline algae, and others (sea stars, sea anemones, ascidians, zoanthids). Along these transects, the prevalence of coral colonies infested with the sponge was assessed by applying the belt transect method (English *et al.* 1997). Live coral colonies within 1 m on each side were identified up to genus level and counted. Coral colonies affected by the red sponge were counted separately along each transect. For taxonomical identification, small volumes of sponge samples were collected from sponge-infested corals and preserved in 80% ethanol for further analysis in the laboratory. The sponge species was identified following the protocols explained by Ashok *et al.* (2020).

Results and discussion

All the major coral reef ecosystems in India are affected by bleaching events triggered by climate change (e.g. Arthur *et al.* 2012, Raj *et al.* 2018b, 2021). Space competition posed by sponges has been reported to be severe on reefs that are affected by bleaching events (Carballo *et al.* 2013). Incidences of sponges overpowering corals have increased considerably in the Indian reefs during the last decade (e.g. Ashok *et al.* 2018, 2020, Raj *et al.* 2018a, 2019, Thinesh *et al.* 2015; Raj 2021; Emmett *et al.* 2021; Emmett and Raj 2022) and many of those incidences are from GoM. Reported species of coral-overgrowing sponges in GoM include *Cliona* spp., *Terpios hoshinota* Rützler & Muzik, 1993, C. *(Microciona) aceratoobtusa,* and *Rhabdastrella globostellata* Carter, 1883 (Ashok *et al.* 2018, 2020, Raj *et al.* 2018a, 2019).

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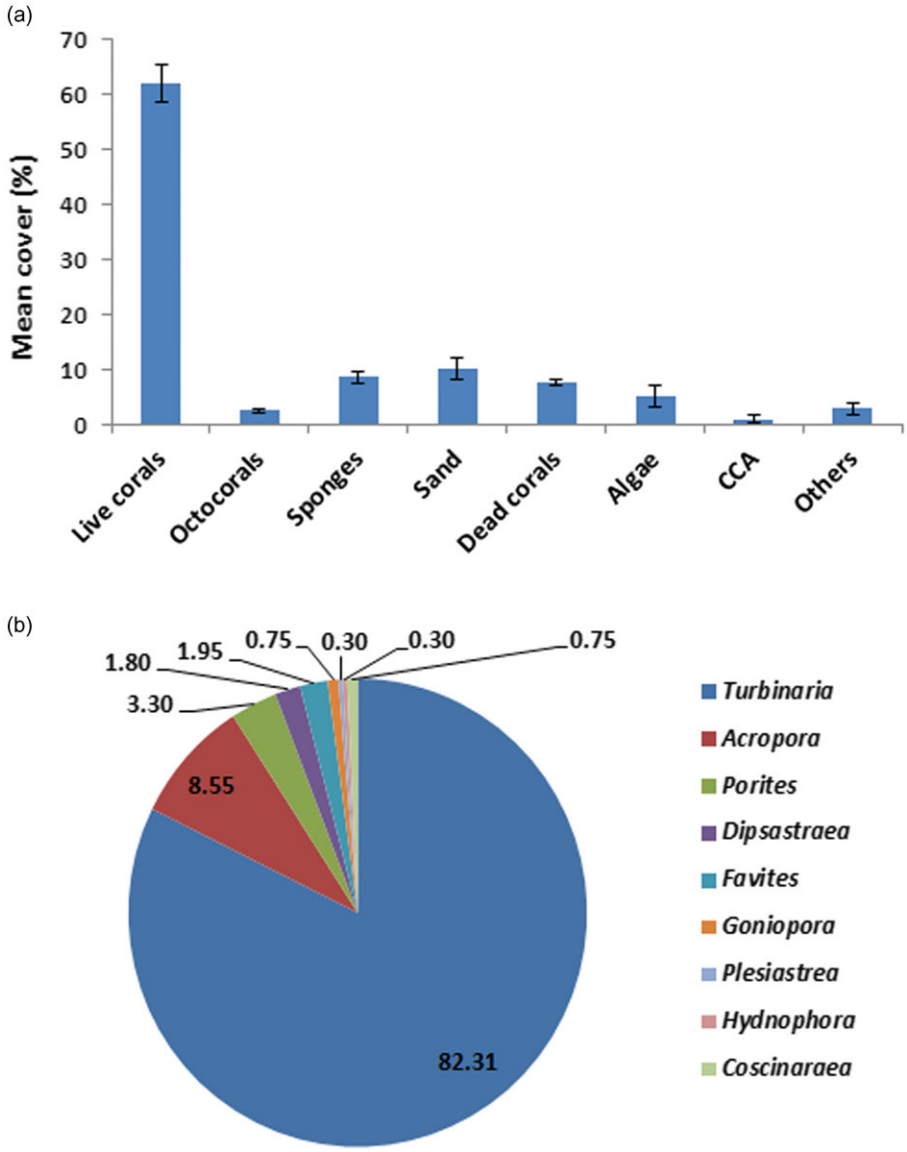

Figure 2. a. Benthic community structure at mainland patch reef (bars represent standard deviation); b. The proportion of coral genera at mainland patch reef.

The sponge observed in this study was identified as the coral-killing species *C. (Microciona) aceratoobtusa* as per the descriptions given by Ashok *et al.* (2020). Underwater morphology, colour, pattern (Figure 1), and spicule combinations (Suppl. Fig. 2) confirmed the species. The sponge is found to be progressing towards the live portion of corals as a thin red sheet making the infested portion look orange-reddish (Figure 1, Suppl. Fig. 3). A thin exposed coral skeleton is also observed at the contact front. In some cases, the sponge had almost killed the entire coral colony (Suppl. Fig. 3). Benthic community structure at the study site is dominated by live corals with 62.06% (SD±3.36), distantly followed by sand and sponges with 10.22% (SD±2.03) and 8.64% (SD±0.98), respectively (Figure 2). The live coral cover at the study site is comparatively higher than that of GOMMNP where the average live coral cover was only 23.78% in 2017 which decreased from 42.85% in 2009 (Raj *et al.* 2021). Sharp declines in the coral cover have been witnessed in the GOMMNP due to bleaching-driven mass coral mortalities in 2010 and 2016 (Edward *et al.* 2018; Raj *et al.* 2021). The temporal trend of live coral cover in the mainland patch reef is not available as this reef has not been monitored regularly.

The genus *Turbinaria* is the most abundant at the study site, with 82.31% (n = 549), distantly followed by *Acropora* with 8.55% (n = 57) (Figure 2). Other coral genera observed in the reef include *Porites, Dipsastraea, Favites, Goniopora, Plesiastrea, Hydnophora,* and *Coscinaraea*. *Turbinaria* is the only genus affected by *C. (Microciona) aceratoobtusa* with 21.86% (n = 120) of the total colonies found infested. Earlier studies have reported that this sponge overgrows coral genera such as *Porites, Acropora, Montipora, Favia,* and *Turbinaria* in GoM (Ashok *et al.* 2020). The sponge has been reported to affect the species *Porites lutea* with a prevalence of 50% in South Yemen (Benzoni *et al.* 2008). The dominance of *Turbinaria* in the study site is presumably the reason for the high impact on the genus. Other available genera at the study site were scattered while *Turbinaria* corals occur close to each other having direct contact.

Turbinaria has been reported as the preferred substrate of *C. (Microciona) aceratoobtusa* in GoM (Ashok *et al.* 2020). Another sponge from *Cliona viridis* complex was also found to affect *Turbinaria* in GoM (Ashok *et al.* 2018). Corals and sponges display a differential response to temperature anomalies depending on the symbiont species and clades associated with them

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(e.g. Schönberg & Ortiz 2008, Fang *et al.* 2018). Focused studies on symbionts associated with *Turbinaria* and the infesting sponges are warranted to understand the susceptibility of this genus to the infection of bio-eroding sponges. After the 2016 bleaching event, the cover of the coral morphotype 'coral foliose' (CF) has decreased significantly in GoM (Raj *et al.* 2021) and CF is represented only by *Turbinaria* spp. here. Thus *Turbinaria* is decreasing in abundance in GoM due to bleaching events and consequent space competition by sponges. A total of 120 infested colonies are significantly high considering the slow growth rate of this genus in GoM (Mathews 2009). The presence of *Turbinaria* is of critical importance for reef-associated organisms including fishes (Raj *et al.* 2021), and hence the genus warrants conservation initiatives. Ashok *et al.* (2020) reported the sponge infestation at depths between 2 and 4.5 m within the GOMMNP whereas the present observation was at depths 5 to 6 m in the mainland patch reef. In spite of the depth differences, the sponge was able to infest corals at both sites.

Future climate projections are not good for global coral reefs (Hooidonk *et al.* 2016) including GoM (Raj *et al.* 2021). Sponges are comparatively tolerant to temperature anomalies and can proliferate during such temperature scenarios (Kelmo *et al.* 2013). Hence, sponges have been reported to fare better in projected climatic conditions in the future (Bell *et al.* 2013, Fang *et al.* 2013). Corals of GoM undergo annual bleaching (Edward *et al.* 2008) and have suffered severe mortalities (Raj *et al.* 2021). The prevalence of coral colonies overgrown by sponges in Vaan Island was reported to increase from 9.69% in 2018 to 13.38% in 2021 and post-bleaching stress has been attributed to this increase (Raj 2021). Vaan Island falls within the boundary of the GOMMNP and occurs at about 15 km from the mainland patch reef. Hence, it is likely that the same trend is happening in the mainland patch reef. It has been predicted that for the high emissions scenario RCP8.5 the reefs of GoM will experience severe annual bleaching before 2045 (Raj *et al.* 2021). Hence, it is likely that space competition from sponges will be more aggressive in the reefs of GoM in the future. Reefs dominated by *Turbinaria* such as the mainland patch reef are likely to be affected by sponges severely in the future.

Apart from climate change implications, human-induced factors such as coastal development, destructive fishing methods, pollution, and tourism can affect reef ecosystems. Fishing activities such as trap fishing, spearfishing, trawling, and the use of bottom settling nets can be seen on the mainland patch reef regularly. Further, the mainland patch reef is surrounded by various industries including a major port. The cultivation of the dangerous invasive macroalga *Kappaphycus alvarezii* is also happening near the mainland patch reef (Suppl. Fig. 4). Thus, it is comparatively more disturbed by human activities than the reefs within the MPA. Disturbed reefs have been reported to be prone to sponge infestation (Thinesh *et al.* 2015). Sponges have been projected to withstand the effects of human-induced factors such as pollution, harmful fishing techniques, and sedimentation (Powell *et al.* 2014, Shi *et al.* 2012, Thinesh *et al.* 2015) while corals would not. Many global initiatives are being taken to tackle climate change implications and conserve coral reefs. However, local conservation initiatives to reduce human-induced threats are also equally or more important. The establishment of MPAs is one of the key initiatives to reduce human-induced threats such as fishing, tourism, and pollution (Lester *et al.* 2009, McCook *et al.* 2010). As the mainland patch reef occurs outside the MPA (GOMMNP), it suffers both climatic and human-induced threats. In spite of the threats, the live coral cover in the mainland patch reef is higher than that of the GOMMNP, showing its resilience. It is imperative that the status, diversity, associated organisms, and threats of the mainland patch reef are studied regularly to understand and conserve them better. This study recommends that the mainland patch reef should be accorded some sort of legal protection in order to have regular monitoring and conservation system. The results of this report provide evidence that the combination of climate change and human impacts would cause much bigger damage to coral reef ecosystems.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/S0266467422000487

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Competing Interests. The author(s) declare none.

Ethical Statement. None

References

Arthur R, Karkarey R, Lobo AS, Alcoverro T and Kelkar N (2012) Coral reef resilience: Recovery and resistance across the Lakshadweep Archipelago. Nature Conservation Foundation. Report submitted to Rufford Small Grants Programme.

Ashok AM, Calcinai B and Edward JKP (2020) The coral-killing red sponge *Clathria (Microciona) aceratoobtusa* (Porifera: Demosponigiae) invades various coral communities of Gulf of Mannar Marine National Park, south-east India. *The European Zoological Journal* **87**, 1–11. https://doi.org/10.1080/24750263.2019.1708486

Ashok AM, Schönberg CHL, Raj KD, Bhoopathi M, Bharath MS and Patterson EJ (2018) A sponge of the *Cliona viridis* complex invades and excavates corals of the Gulf of Mannar, south-eastern India. *Marine and Freshwater Research* **69**, 874–882. https://doi.org/10.1071/MF17247

Bell JJ, Davy SK, Jones T, Taylor MW and Webster NS (2013) Could some coral reefs become sponge reefs as our climate changes? *Global Change Biology* **19**, 2613–2624. https://doi.org/10.1111/gcb.12212

Benzoni F, Calcinai B, Eisinger M and Klaus R (2008) Coral disease mimic: sponge attacks *Porites lutea* in Yemen. *Coral Reefs* **27**, 695. https://doi.org/10.1007/s00338-008-0371-x

Carballo JL, Bautista E, Nava H, Cruz-Barraza JA, Chávez JA (2013) Boring sponges, an increasing threat for coral reefs affected by bleaching events. *Ecology and Evolution* **3**, 872–886. https://doi.org/10.1002/ece3.452

Chadwick NE and Morrow KM (2011) *Competition among sessile organisms on coral reefs*. In Dubinsky Z, Stambler, N. (eds.), *Coral reefs: an ecosystem in transition*. Dordrecht: Springer, pp. 347–371.

Edward JKP, Mathews G, Raj KD, Laju RL, Bharath MS, Arasamuthu A, Kumar PD, Bilgi DS and Malleshappa H (2018) Coral mortality in the Gulf of Mannar, southeastern India, due to bleaching caused by elevated sea temperature in 2016. *Current Science* **114**, 1967–1972.

Edward JKP, Mathews G, Raj KD and Tamelander J (2008) Coral reefs of the Gulf of Mannar, Southeastern India–observations on the effect of elevated SST during 2005–2008. *Proceedings of the 11th International Coral Reef Symposium*. Florida, 1286–1288.

Emmett JS and Raj KD (2022) Status and importance of research on marine sponges in India with special reference to sponges on coral reefs. *Indian Journal of Geo-Marine Sciences* **51**, 589–596. https://doi.org/10.56042/ijms.v51i07.43639

Emmett JS, Raj KD, Mathews G and Laju RL (2021) Opportunistic spongivore fishes in a reef of Gulf of Mannar, India. *Environmental Biology of Fishes* **104**, 1251–1262. https://doi.org/10.1007/s10641-021-01185-6

English S, Wilkinson C and Baker V (1997) *Survey manual for tropical Marine resources*. Townsville, Australia: Australian Institute of Marine Science.

Fang JK, Mello-Athayde MA, Schönberg CHL, Kline DI, Hoegh-Guldberg O and Dove S (2013) Sponge biomass and bioerosion rates increase under ocean warming and acidification. *Global Change Biology* **19**, 3581–3591. https://doi.org/10.1111/gcb.12334

Fang JK, Schönberg CHL, Mello-Athayde MA, Achlatis M, Hoegh-Guldberg O and Dove S (2018). Bleaching and mortality of a photosymbiotic bioeroding sponge under future carbon dioxide emission scenarios. *Oecologia* **187**, 25–35. https://doi.org/10.1007/s00442-018-4105-7

Hoegh-Guldberg O, Poloczanska ES, Skirving W and Dove S (2017) Coral reef ecosystems under climate change and ocean acidification. *Frontiers in Marine Science* **4**, 158. https://doi.org/10.3389/fmars.2017.00158

Hughes TP, Anderson KD, Connolly SR, Heron SF, Kerry JT, Lough JM, Baird AH, Baum JK, Berumen ML, Bridge TC, Claar DC, Eakin, CM, Gilmour JP, Graham, NAJ, Harrison H, Hobbs JA, Hoey AS, Hoogenboom M, Lowe RJ, McCulloch MT, Pandolfi JM, Pratchett M, Schoepf V, Torda G and Wilson SK (2018) Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. *Science* **359**, 80–83. https://doi.org/10.1126/science.aan8048

Kelmo F, Bell JJ and Attrill MJ (2013) Tolerance of sponge assemblages to temperature anomalies: resilience and proliferation of sponges following the 1997–8 El-Nino southern oscillation. *PLoS One* **8**, e76441. https://doi.org/10.1371/journal.pone.0076441

Lester SE, Halpern BS, Grorud-Colvert K, Lubchenco J, Ruttenberg BI, Gaines SD and Warner RR (2009) Biological effects within no-take marine reserves: a global synthesis. *Marine Ecology Progress Series* **384**, 33–46. https://doi.org/10.3354/meps08029

Mathews G (2009) Studies on the coral reef restoration in Tuticorin region of the Gulf of Mannar Southeast Coast of India. *Ph.D thesis*. Manonmaniam Sundaranar University, Tirunelveli.

McCook LJ, Ayling T, Cappo M, Choat JH, Evans RD, De Freitas DM and Williamson DH (2010) Adaptive management of the Great Barrier Reef: a globally significant demonstration of the benefits of networks of marine reserves. *Proceedings of the National Academy of Sciences* **107**, 18278–18285. https://doi.org/10.1073/pnas.0909335107

Powell A, Smith DJ, Hepburn LJ, Jones T, Berman J, Jompa J and Bell JJ (2014) Reduced diversity and high sponge abundance on a sedimented Indo-Pacific reef system: implications for future changes in environmental quality. *PloS one* **9**, e85253. https://doi.org/10.1371/journal.pone.0085253

Raj KD (2021) Studies on the status of Post-bleaching Stressors that affect the Recovery of Corals in Tuticorin group of islands, Gulf of Mannar. Project report submitted to the Gulf of Mannar Biosphere Reserve Trust, Ramanathapuram. Pp 49.

Raj KD, Aeby GS, Mathews G, Williams GJ, Caldwell JM, Laju RL, Selva B, Dinesh Kumar PA, Arasamuthu A, Gladwin A, Lisa W, Andrew D, Monica M and Edward JKP (2021) Coral reef resilience differs among islands within the Gulf of Mannar, southeast India, following successive coral bleaching events. *Coral Reefs* **40**, 1–16. https://doi.org/10.1007/s00338-021-02102-0

Raj KD, Bharath MS, Mathews G, Aeby GS and Edward JKP (2018a) Coral-killing sponge *Terpios hoshinota* invades the corals of Gulf of Mannar, Southeast India. *Current Science* **114**, 1117–1119.

Raj KD, Mathews G, Bharath MS, Sawant RD, Bhave V, Apte D and Edward JKP (2018b) Climate change-induced coral bleaching in Malvan Marine Sanctuary, Maharashtra, India. *Current Science* **114**, 384–387.

Raj KD, Mathews G and Kumar PD (2019) Tiger cowrie *Cypraea tigris* feeds on coral-competing sponge *Rhabdastrella globostellata* in an *Acropora* dominated reef of Gulf of Mannar, India. *Marine and Freshwater Behaviour and Physiology* **52**, 101–105. https://doi.org/10.1080/10236244.2019.1637701

Schönberg CHL and Ortiz JC (2008) Is sponge bioerosion increasing? *Proceedings of the 11th International Coral Reef Symposium*. Florida. pp. 520–523.

Schönberg CHL, Suwa R, Hidaka M and Loh WKW (2008) Sponge and coral zooxanthellae in heat and light: preliminary results of photochemical efficiency monitored with pulse amplitude modulated fluorometry. *Marine Ecology* **29**, 247–258. https://doi.org/10.1111/j.1439-0485.2007.00216.x

Shi Q, Liu GH, Yan HQ and Zhang HL (2012) Black disease (*Terpios hoshinota*): a probable cause for the rapid coral mortality at the northern reef of Yongxing Island in the South China Sea. *Ambio* **41**, 446–455. https://doi.org/10.1007/s13280-011-0245-2

Thinesh T, Jose PA, Hassan S, Selvan, KM and Selvin J (2015) Intrusion of coral-killing sponge (*Terpios hoshinota*) on the reef of Palk Bay. *Current Science* **109**, 1030–1032.

Van Hooidonk R, Maynard J, Tamelander J, Gove J, Ahmadia G, Raymundo L and Planes S (2016) Local-scale projections of coral reef futures and implications of the Paris Agreement. *Scientific Reports* **6**, 1–8. https://doi.org/10.1038/srep39666

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