Mass mortality of *Montipora digitata* (Scleractinia) in Vaan Island, Gulf of Mannar, southeast India

Coral reefs around the world have undergone a dramatic degradation in the past 20–50 years because of anthropogenic factors such as coral mining, destructive fishing, coastal development and pollution, along with natural factors such as coral bleaching and diseases[1]. Coral diseases are lethal, and could further deteriorate reefs across the tropics[2]. The Gulf of Mannar (GoM), southeast India, falls within the Indo-Pacific realm which is considered as the world's richest marine biodiversity region. For the past few decades, reefs of the GoM have been experiencing various threats[3–5]. Although these reefs have received considerable attention[6], the role of disease as a significant driver of these systems has only recently received serious attention[7–10]. Vaan Island (lat. 8°50′N, long. 78°13′E) is one of the 21 uninhabited islands of the GoM, and it has 3 sq. km of reef area[3]. The reefs of Vaan Island are dominated by *Montipora digitata*, which is restricted to very shallow waters between 0.5 and 1.5 m depth, where this species is almost mono-specific (Figure 1).

In September 2014, we noticed an unprecedented mortality of *M. digitata* (Figure 2), apparently due to black band disease (BBD). Morphological sign of BBD is a bacterial mat forming a thick black or dark reddish-brown band of approximately 1 mm at the interface between live and dead portions of the tissue which spreads outward causing mortality[9,11]. BBD lesions were observed on infected coral colonies in Vaan Island and morphological observations were done underwater. An initial manta tow survey on the reefs of Vaan Island was done[12]. Approximately 300 sq. m of the reef area was found to be packed with dead coral rubbles of *M. digitata*. Subsequently during Setember 2014, we used the line intercept transect (LIT) method to assess the intensity of mortality[13]. In this method, a 20 m transect is laid on the ocean bottom and change of life-form categories along the tape measures is recorded on underwater data sheets. A total of 12 LITs were laid in the infected area, and the percentage cover of each life-form category was calculated[13]. The results showed severe mortality of *M. digitata* with 94.51% (SD = 1.91; $n = 12$ transects for this and subsequent estimates) dead colonies; infected colonies (still alive) were 3.56% (SD = 1.26); healthy colonies were 1.02% (SD = 0.6); macro algae were 0.91% (SD = 0.81).

Tissue samples were peeled-off from the infected and healthy portions of a coral colony with sterilized forceps and brought to laboratory in sterile screw cap tubes. Samples were serially diluted and pour-plated on Zobell marine agar medium and incubated at room temperature (37°C) for 48 h. Water samples were also collected from the infected site. Sample size in all the cases was three. Total heterotrophic bacteria (THB) was estimated to be $11.73–12.35 \times 10^4$ CFU/ml in the infected tissue samples, while it was $3.89–4.59 \times 10^4$ CFU/ml in the healthy tissue samples and $3.56–4.25 \times 10^4$ CFU/ml in the water samples. High amount of THB can be correlated with the infection of BBD, as this has been described as a poly-microbial disease presumably caused by a consortium of microorganisms rather than a single

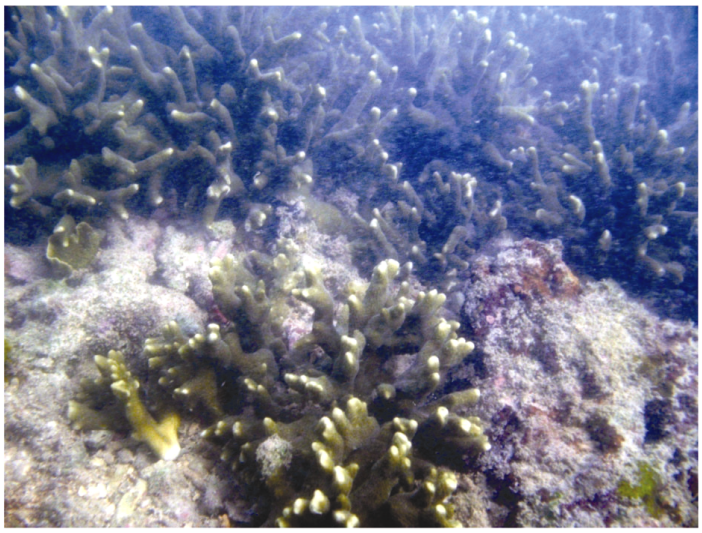

Figure 1. Healthy *Montipora digitata* bed during 2008 in Vaan Island.

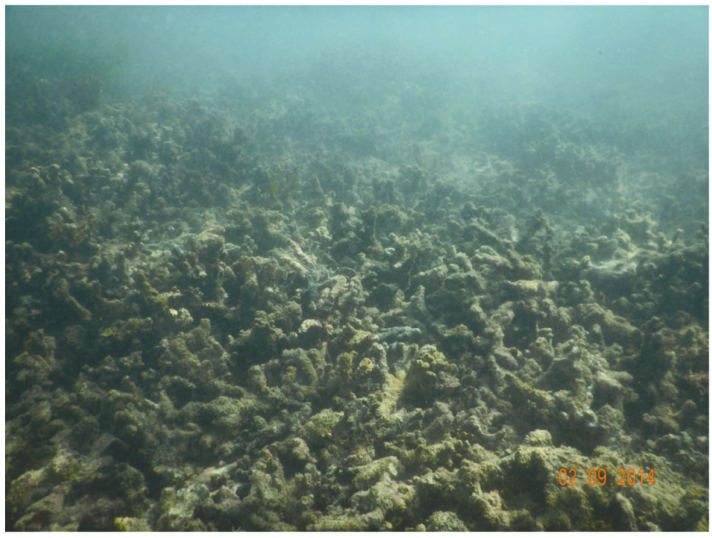

Figure 2. Mass mortality of *M. digitata* during 2014 in Vaan Island.

pathogen[14]. The consortium is comprised of cyanobacterium (*Phormidium corallyticum*) and other bacteria[15–18].

M. digitata has been reported to be the dominant species and has high recruitment rate in the GoM[3,4]. This species has been associated with fast growth and propagation[19]. Hence in a reef like the GoM, where recovery is in process[3,5], *M. digitata* can increase the live coral cover due to its fast-growing nature. Unfortunately, mass mortality of this species would affect the overall live coral cover. Temperature elevation and nutrient enrichment have earlier been suggested as a trigger for sudden disease outbreaks[20,21]. We found no obvious proliferation of algae or eutrophication in the study area, which rules out hazardous nutrient enrichment. In 2010, mass mortality of *Pocillopora damicornis* colonies was recorded in Shingle Island of the GoM due to temperature-triggered BBD. Water temperature in the GoM may reach up to 33°C during summer, and it has been reported that *M. digitata* is prone to temperature elevation[4]. Hence, persistent high temperature could have triggered the outbreak of BBD among *M. digitata* colonies as they occur in very shallow waters where the temperature is relatively high. Although other factors such as pollution, sedimentation and nutrient enrichment may not be the immediate cause of the disease, they might worsen the situation in future. It is difficult to prevent coral diseases and cure them; however, the managers could intervene to reduce the driving factors. While temperature cannot be controlled, steps could be taken to address the other potential issues such as pollution. Further studies are also needed to ascertain the exact causative agent or combinations of agents that lead to sudden outbreaks of coral diseases.

1. Pandolfi, J. M. *et al.*, *Science*, 2003, **301**, 955–958.
2. Green, E. and Bruckner, A. W., *Biol. Conserv*., 2000, **96**, 347–361.
3. Edward, J. K. P., Mathews, G., Patterson, J., Wilhelmsson, D., Tamelander, J. and Linden, O., *Coral Reefs of the Gulf of Mannar, Southeastern India – Distribution, Diversity and Status*, SDMRI Special Publication No. 12, Tuticorin, 2007, p. 113.
4. Edward, J. K. P., Mathews, G., Raj, K. D. and Tamelander, J., In Proceedings of the 11th Coral Reef Symposium, Fort Lauderdale, Florida, 2008, pp. 1292–1294.
5. Raj, K. D. and Edward, J. K. P., *Indian J. Mar. Sci*., 2010, **39**, 219–226.
6. Kumaraguru, A. K., Joseph, V. E., Marimuthu, N. and Wilson, J. J., *Scientific Information on Gulf of Mannar – A Bibliography*, Centre for Marine and Coastal Studies, Madurai Kamaraj University, Madurai, 2006, p. 656.
7. Thinesh, T., Mathews, G. and Edward, J. K. P., *Indian J. Mar. Sci*., 2009, **38**, 444–450.
8. Thinesh, T., Mathews, G. and Edward, J. K. P., *Indian J. Geo. Mar. Sci*., 2011, **40(6)**, 813–820.
9. Thinesh, T., Raj, K. D., Mathews, G. and Edward, J. K. P., *Dis. Aquat. Org*., 2013, **106**, 69–77.
10. Thinesh, T., Mathews, G., Raj, K. D. and Edward, J. K. P., *Dis. Aquat. Org*., 2014, **110**, 227–234.
11. Richardson, L. L., In *Coral Health and Disease* (eds Rosenberg, E. and Loya, Y.), Springer, Heidelberg, Germany, 2004, pp. 325–336.
12. Done, T. J., Kenchingron and Zell, L. D., In Proceedings of the 4th International Coral Reef Symposium, Manila, Philippines, 1982, pp. 597–600.
13. English, S., Wilkinson, C. and Baker, V., *Survey Manual for Tropical Marine Resources*, ASEAN Australian Marine Science Project: Living Coastal Resources, Townsville, 1997, p. 368.
14. Richardson, L. L., Kuta, K., Schnell, S. and Carlton, R., In Proceedings of the 8th Coral Reef Symposium, Panama, 1997, vol. 1, pp. 597–600.
15. Rutzler, K. and Santavy, D. L., *PSZNI Mar. Ecol.*, 1983, **4**, 301–319.
16. Carlton, R. G. and Richardson, L. L., *FEMS Microbiol. Ecol*., 1995, **18**, 155–162.
17. Richardson, L. L., *Microbial Ecol*., 1996, **32**, 323–335.
18. Viehman, S., Mills, D. K., Meichel, G. W. and Richardson, L. L., *Dis. Aquat. Org*., 2006, **69**, 119–127.
19. Heward, A. J. and Collins, J. D., *Coral Reefs*, 1985, **4**, 35–40.
20. Bruno, J. F., Petes, L., Harvellm, C. D. and Hettinger, A., *Ecol. Lett*., 2003, **6**(1), 1056–1061.
21. Bruno, J. F., Selig, E. R., Casey, K. S., Page, C. A., Willis, B. L. and Harvell, C. D., *PLoS Biol*., 2007, **5**(6), 1220–1227.

ACKNOWLEDGEMENTS. We thank the Ministry of Environment, Forests and Climate Change, Government of India for providing funds. We also thank the Principle Chief Conservator of Forests and Chief Wildlife Warden and Wildlife Warden, Gulf of Mannar Marine National Park for research permission; Suganthi Devadason Marine Research Institute, Tuticorin for providing the necessary facilities.

Received 16 September 2015; revised accepted 26 November 2015

K. DIRAVIYA RAJ*
G. MATHEWS
M. SELVA BHARATH
J. K. PATTERSON EDWARD

Suganthi Devadason Marine Research Institute,
44-Beach Road,
Tuticorin 628 001, India
**For correspondence.*
e-mail: diraviyam_raj@yahoo.co.in

Electric ray *Narcine timlei* (Torpediniformes: Narcinidae) from Chilika lagoon, Odisha, India

The Chilika, situated along India's eastern coast (in Odisha), is the largest brackish water lagoon in Asia with water spread varying from 906 km^2 during summer to 1165 km^2 during monsoon. It is among the most internationally focused Ramsar site in India owing to its rich biodiversity[1], including species that have been categorized as threatened by IUCN. The spatial and seasonal variability in salinity gradient delineates the lagoon into four ecological zones[2], i.e. Northern Sector (2.8–14.4 ppt), Central Sector (6.9–16.3 ppt), Southern Sector (9.4–13.1 ppt) and Outer Channel (12.6–32.2 ppt) (Figure 1). The lagoon had turned into a completely freshwater system due to closure of sea mouth. It