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Short Communication

Crustose coralline algae (Corallinales, Rhodophyta) diversity in the Gulf of Mannar marine national park, Southern India

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Rhodoliths are the prominent global reef builders, providing a hard calcium carbonate substrate to develop coral polyps and several marine algae. Studies on rhodoliths in the Gulf of Mannar Biosphere Reserve are very scarce. The present study investigated the various forms of crustose coralline algae inhabiting coral reefs in three islands of the Gulf of Mannar Biosphere Reserve. Eleven coralline algal genera with various morphological forms such as encrusting, fruticose, layered, lumpy, and warty were recorded. Further, the study infers that molecular assessment of the biodiversity of these rhodoliths is required to discriminate morphological similarities and confirm the species identity.

[**Keywords**: Calcified red algae, Coral reef habitats, Corals, Distribution, Mandapam region]

Introduction

Crustose coralline algae (CCA), also called rhodoliths, are an important and ubiquitous biological base components and primary producers involved in the construction of coral reef-building in reef environments[1,2]. These red algae are commonly found on coral rubbles, rocks[2] and as epiphytes on seaweeds such as *Sargassum* spp. as observed in this study. Species of CCA play a vital role in framing and maintaining the entire reef ecosystem by depositing calcium carbonate ($CaCO_3$) and by supporting other algae[3]. CCA is known to induce larval metamorphosis of many coral species pertaining to planula larvae to polyps[3]. However, studies have evidenced the dissolution of CCA due to ocean acidification[4,5]. Similarly like corals, these dead CCA also forms cemented hard calcareous skeletons on dead corals, rocks, and rubbles, which are subsequently sought by the coral planulae larvae for settlement. Therefore, there is a need to study and understand the influence of climatic changes on this vital component (CCA) development and dissolution. Although CCA is considered and proved to support coral polyps recruitment in tropical, subtropical, and temperate regions, aspects of CCA taxonomy, diversity, and distribution are scarce.

Gulf of Mannar (GoM) marine national park is the first international marine biosphere reserve in India and Southeast Asia. It is well known for its rich marine biodiversity. However, studies on CCA in India are very limited and scarce[5]. Particularly, the Corallinaceae present in GoM has not been documented except in a preliminary study from the Tuticorin group of islands of the GoM[6]. Also, CCA's importance has not been emphasized much in India except few studies from Andaman[7,8]. Although partially calcareous green algae *Halimeda* species have been studied widely worldwide, CCA species are not well explored. Conversely, though numerous authors have well explored GoM, still GoM represents several unexplored marine resources like CCA. Therefore, a comprehensive assessment of the abundance, distribution, and genetic diversity of CCA species needs to be investigated in the GoM and Indian scenario. To understand their diversity, distribution, and ecological role in coral reefs of the Gulf of Mannar marine national park, the present study is focused to monitor reef associated CCA. Further, this study will serve as a baseline reference for future studies on CCA.

Materials and Methods

Field surveys on CCA were carried out in the coral reefs in Mandapam group of islands of Hare Island (09°11.779’ N, 079°04.420’ E), Manoli and Manoliputti Islands (09°12.377’ N, 079°08.406’ E) (Fig. 1), from September to November 2018. Various forms of CCA on dead corals were investigated by several underwater field surveys performed in these three islands. CCA samples were photographically documented underwater. Genus level identification was made following Harvey *et al.*[9], Farr *et al.*[10], Littler *et al.*[11], Kundal[12], Peña *et al.*[13], and Amado-Filho *et al.*[14]. Relative frequency occurrence of CCA in a 10 meter line transect was calculated in Microsoft

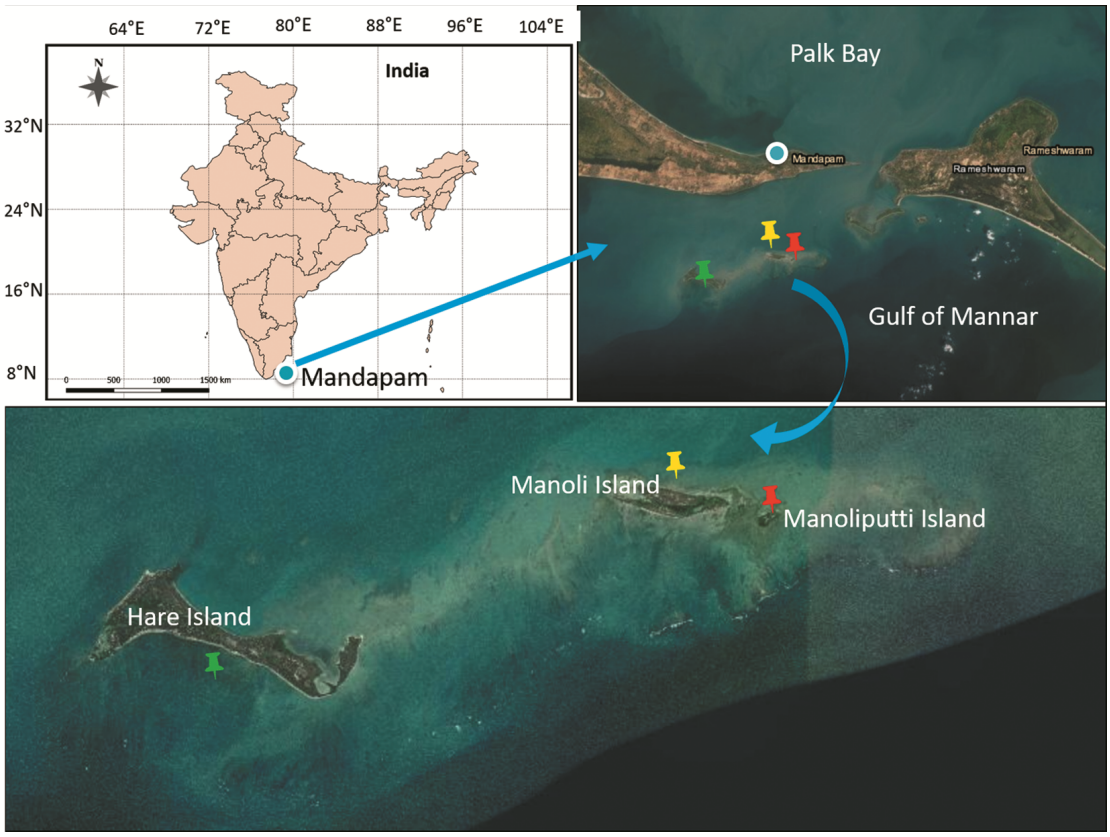

Fig. 1 — Study areas in the Gulf of Mannar Marine National Park, southeast coast of Tamil Nadu, India

excel by dividing each CCA genus by the total number of CCA.

Results and Discussion

Surveys revealed various forms of CCA in these islands, and a total of eleven genera were recorded on diseased and dead corals, and on rubbles (Fig. 2). The depth gradient distribution of CCA has not been studied in this study, as this study is currently focused only on shallow reefs in the Gulf of Mannar marine national park. Aggregation of fruticose form of *Mesophyllum* rodolith bed was found abundantly on dead Acroporidae coral reef in the eastern part of Manoliputti Island. Other genera like *Hydrolithon*, *Lithothamnion* and *Peyssonnelia* are commonly available in all the three islands namely, Hare Island, Manoli Island, and Manoliputti Island. *Peyssonnelia* is relatively less abundant to the former two genera, which were found commonly on dead coral rubbles and on some gastropods. *Hydrolithon* and *Lithothamnion* species were observed to overgrow on oyster *Malleus malleus*. More frequently, dead reefs are occupied by *Hydrolithon* and *Lithothamnion* species (Fig. 3).

Hare Island and Manoliputti Island have represented the more abundant distribution of CCA. In all three study areas, *Hydrolithon*, *Lithothamnion*, *Lobophora*, *Sporolithon*, and *Neogoniolithon* species are common. A previous study reported the dominance of *Lithophyllum kotschyanum* in the Palk Bay region[15]. This species is not seen abundantly in the present study Islands. In little Andaman, 13 CCA species under 9 genera[16], 11 CCA species under 11 genera from Neil Island[17], and three *Hydrolithon* species from South Andaman were recorded[18]. From the terrestrial region, six species belonging to six genera were recorded from Jaintia hills, Meghalaya[19]. Coralline algal distribution in the ocean[16,17] and terrestrial environment[19] has importance in many ecological and evolutionary studies. Thus molecular analyses are imperative to resolve their genomic identity and interlink their evolutionary relationships.

Post-deployment survey on transplanted corals in Hare Island revealed overgrown encrusting CCA on plastic tags used for labelling coral fragments. They indicated their role as a primary basement by cementing calcium carbonate[3]. These CCA species are essential for rebuilding the reef environment.

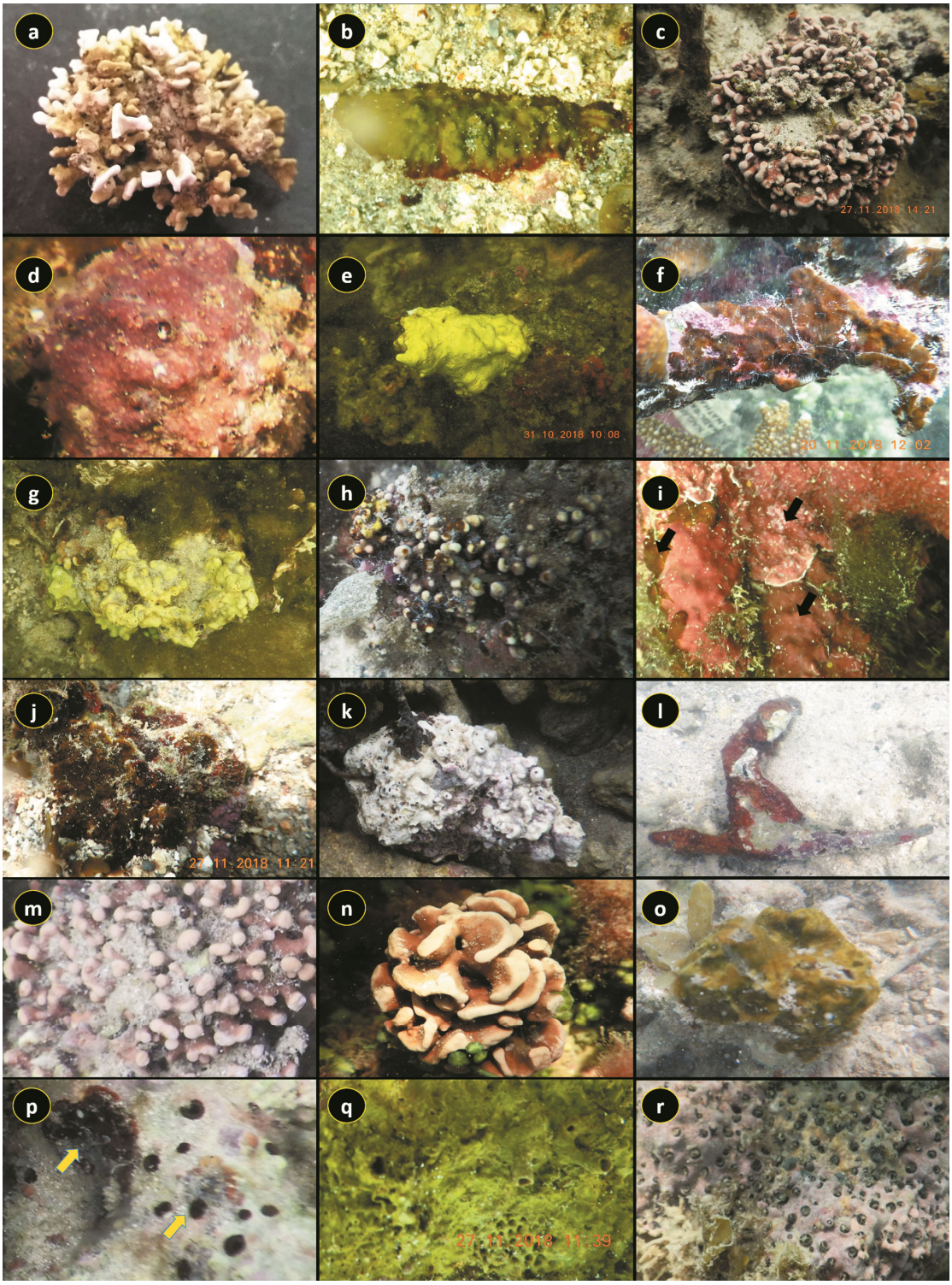

Fig. 2 — Different types of CCA: (a) *Lithophyllum* sp.; (b) anepilithic form of *Lobophora* sp.; (c) afruticose form of *Mesophyllum* sp.; (d) *Hydrolithon* sp.; (e) unidentified yellowish lumpy CCA (likely *Hydrolithon* sp.); (f) layered CCA; (g) yellow-colored nodular *Lithothamnion* sp. likely; (h) a lumpy nodular form of *Sporolithon* sp.; (i) interaction of irregular surfaced *Lithothamnion* sp. bright red, dark red and metallic green sheen red; (j) unidentified form; (k) warty whitish growth of *Hydrolithon* sp.; (l) a rodolith species overgrowing on *Malleus malleus*; (m) *Porolithon* sp.; (n) *Hydrolithon* overgrowing on coral-killing snail *Drupella*; (o) *Palmophyllum* sp.; (p) new colonies of *Peyssonnelia obscura* growing on dead *Acropora*; (q) yellowish calcified deposition on *Porites* by likely *Porolithon* sp.; and (r) shell openings of *Dendropoma* sp. (black spots) are cemented by *Neogoniolithon* sp.

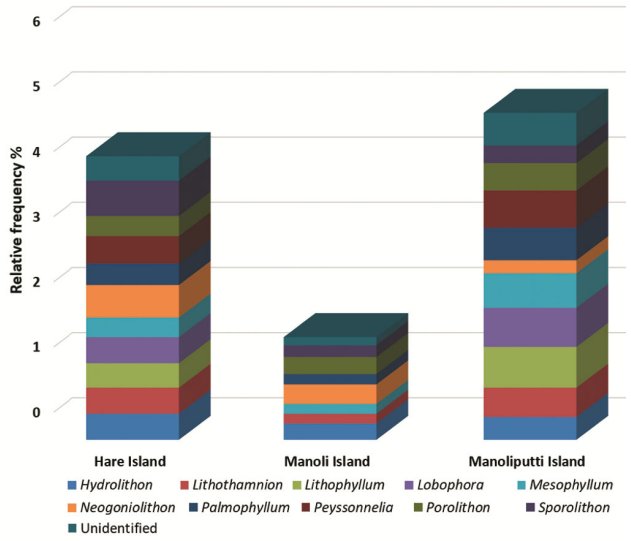

Fig. 3 — Relative frequency occurrence of coralline algae in reef habitats of three study islands

Therefore further monitoring is being carried out to study their dynamics with environmental factors correlation. Particularly, a full-depth profile of their distribution in warm waters (surface water) and cold waters (deep water) in each study area will be analyzed. Future studies are focused on comparative genomic analyses of CCA in reef ecosystems of Indian waters.

An earlier study has only reported some forms of CCA available in the Tuticorin group of islands[6]. In this study, genus-level identification of various forms of CCA inhabiting the coral reefs of the Mandapam group of Islands was demonstrated. Further, all the 21 islands in GoM are under investigation for CCA. Further, morphological similarities persisting in these species will be delineated by genetic studies, and a rapid biodiversity assessment would be performed using the latest genome sequencing techniques. Also, the biochemistry and interactions of several CCA species have to be unveiled. In particular, spatial and temporal dynamics and a systematic integrative approach on CCA species assemblage and abundance are yet to be studied.

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Conflict of Interest

Authors do not have any conflict of interest to declare.

Author Contributions

CHR, SK & TS did field surveys and underwater diving's and wrote the manuscript. TS & MVRM guided the project, edited and approved the manuscript.

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