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Bioinvasive Seaweed Genus, *Turbinaria* in Coral Reefs of Gulf of Mannar

CH. Ramesh[1] ✉
S. Koushik[2]
T. Shunmugaraj[3]
M.V. Ramana Murthy[4]

[1,2,3]*National Center for Coastal Research (NCCR) NCCR Field Office, Ministry of Earth Sciences (MoES) Mandapam-623519, Tamil Nadu, India.*
[1]*Email: chrameshpu@gmail.com Tel: +919474227148*
[2]*Email: sadhukhan.1985@gmail.com Tel: +919903266800*
[3]*Email: raj@nccr.gov.in Tel: +918056081193*
[4]*National Center for Coastal Research (NCCR) Ministry of Earth Sciences (MoES), Pallikaranai, Chennai-600100, Tamil Nadu, India.*
[4]*Email: mvr@nccr.gov.in Tel: +914466783599*


(✉ Corresponding Author)

Abstract

Coral reefs are the important marine biodiversity hotspots, providing livelihood for coastal population around the world. In recent times, coral reef ecosystems are facing natural and anthropogenic threats. Coral reefs in the Gulf of Mannar Marine Biosphere Reserve, southeast coast of Tamil Nadu, India are one of the peculiar ecosystems less studied. Thus, to unveil the potential threats in the coral reefs of Gulf of Mannar region, the present study has made several coral reef monitoring by Line Intercept Transect method in the Gulf of Mannar group of Islands. Surveys revealed the canopy-forming indigenous and invasive macroalgal species, *Turbinaria ornata*, *T. decurrens* and *T. conoides* overgrowing dead reef areas. Although these macroalgae are not an alien species in these islands, but have become increasingly abundant and competing against coral colonies for space. Underwater visual censuses have indicated *Turbinaria* species as opportunistic invaders. These species are taking the advantage of dead corals for substrata and thereby restricting the settlement of coral polyps. Dense growths of these species have formed patches with several 100s of thalli per m^{-2} and as continuous canopies in some dead reef areas. Further studies on spatial and temporal distribution of these invasive species are yet to be undertaken for developing better management strategies.

Keywords: *Turbinaria ornata*, *T. decurrens*, *T. conoides*, Coral reefs, *Porites* sp, Gulf of Mannar, Invasive.

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1. Introduction

Coral reef ecosystems are in general called as the tropical rain forests of the sea, harboring enormous number of marine flora and fauna. In fact, corals are made up of several thousands of small tiny polyps which build a hard outer reef skeleton by secreting calcium carbonate. Usually, healthy and adult corals have the ability to prevent settlement of different algae on their live tissues [1]. However, newly growing polyps are very susceptible to algal assemblage [2]. The role of marine plants in coral reefs including seagrasses [3] and seaweeds [4, 5] have been well understood. Seagrasses are biological filters which traps sediment particles from surrounding reef area [3]. Among macroalgae, crustose coralline algae are known to play an important role in the settlement of coral polyps [6].

Conversely, reports also indicated the impact of indigenous and nonindigenous invasive macroalgae, including *Acanthophora spicifera* and *Hypnea musciformis* [7] *Hypnea musciformis* [8] *Sargassum muticum* [9] *S. mangarevense* [10] *S. horneri* [11] *Fucus serratus* [9] *T. ornata* [10] *Caulerpa taxifolia* [12, 13] *A. spicifera*, *Avrainvillea amadelpha*, *Gracilaria salicornia*, *H. musciformis*, *Kappaphycus* sp. and *Dictyosphaeria cavernosa* [14] *Codium fragile*, *Membranipora membranacea* [15] and *Codium isthmocladum* [16] from geographically different coral reefs environments.

According to the IUCN maintained "Global invasive species database" [17] two marine macroalgae species *Caulerpa taxifolia* [13] and the kelp *Undaria pinnatifida* [18] are listed among top 100 invasive species. Significantly, the brown macro alga belong to class Phaeophyceae, *Turbinaria ornata* has also been identified as an evolving invasive species from different reef environments [4, 19]. Previously, commercially important exotic red alga, *Kappaphycus alvarezii* was reported as an exotic invasive species that associated with *Acropora* sp. and *Montipora* sp. corals from Krusadai and Mulli Islands of Gulf of Mannar [20].

In general, *Turbinaria* species are distributed widely in tropical and subtropical areas of Indian and Pacific oceans. These macroalgae are usually found on dead corals, rubbles and rocks in intertidal region, and has ability to form blooms. These macroalgae can propagate abundantly by fragmentation and sexual reproduction via mature fronds [21]. In the present study we report the native invasive macroalgal species belonging to genus *Turbinaria* distribution in coral reefs and their impact on corals.

2. Materials and Methods

The present study was conducted on the fringing reef of Gulf of Mannar. Underwater surveys were carried out in Hare Island, Manoli Island and Manoli Putti Island. Macroalgae were photographed while diving at a depth of 0.7m to 2m using underwater camera. Line Intercept Transect method and Quadrates were carried out during the survey, following the standard methodology described earlier [22]. Specimens were identified based on morphological characters available in AlgaeBase [23].

3. Results and Discussion

Over the past decade, coral reefs in Gulf of Mannar have experienced severe bleaching. Now the dead reef areas are playing an important role in restoring the reef environment. Our underwater census revealed that there is a high competition for substrata between recruiting corals and algae. This observation is in agreement with the previous reports as detailed in a review [2]. Apparently, *Turbinaria* species are highly predominate in reef areas unlike *Sargassum* species which have grew away from coral reefs Figure 1.

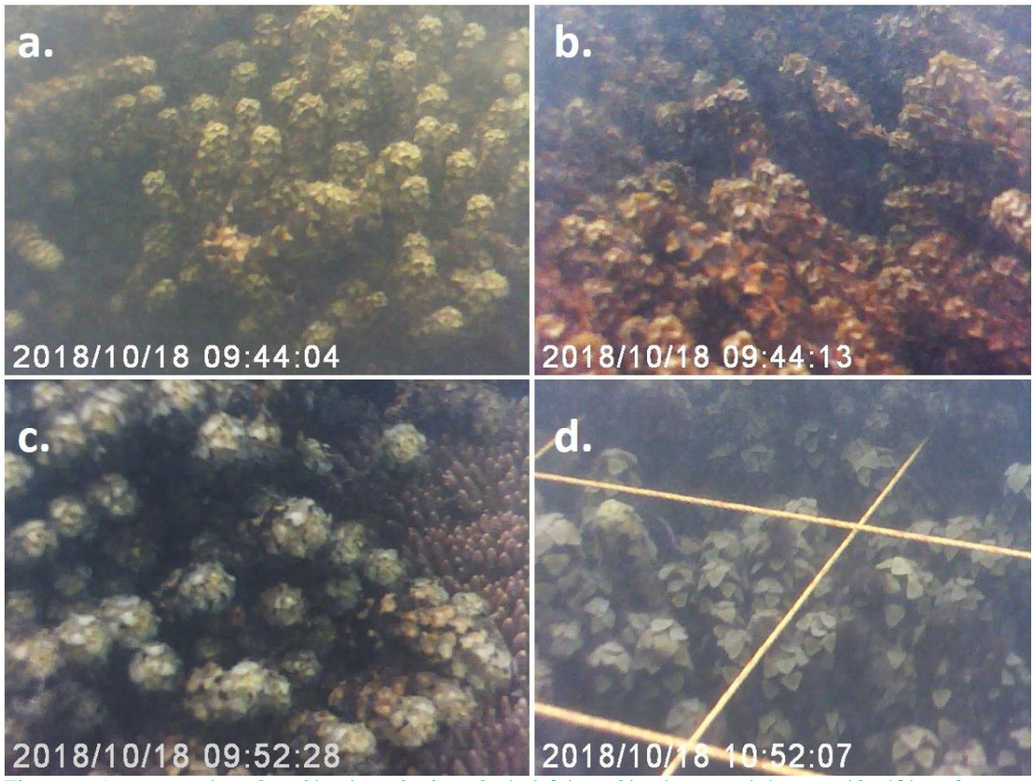

Figure-1. An aggregation of *Turbinaria* on dead corals. **(a & b.)** *Turbinaria ornata*; **(c.)** *T. conoides*; **(d.)** *T. decurrens*.
Source: Present study.

Significantly, *Turbinaria* species are abundant on dead corals and also forms patchy and continuous beds in the reef area. Apparently, over 60 to 70% of the dead coral reef area is occupied by *Turbinaria* species. Only 30 to 40%

of the dead coral area is found with unidentified filamentous brown and red algae. Sedimentation on the upper surfaces of several massive *Porites* sp. has given opportunity to flourish *Turbinaria* species up to 56.25%. We also observed that shoots of *Turbinaria* species are involved in spreading pink line disease faster on the upper body surface of *Porites* sp. than on the other body areas Figure 2. The artificial surfaces such as tires and fishing ropes in the reef area were also appear to be suitable substrata for *Turbinaria* species covering up to 80% to 100%.

Although, *Sargassum* species are being considered as putative invasive algae, turf *Turbinaria ornata* and *T. conoides* have succeeded as the major invader in the dead coral areas for the settlement Figure 2. If these species continue to prevail the dead coral reefs, then we may not be able to expect the recruitment of corals to replace the dead reef region to become healthy as they were before. Although *T. ornata* has been reported to increase the local macroalgal richness by acting as an herbivory refuge [24] we have not found such incidence in this study.

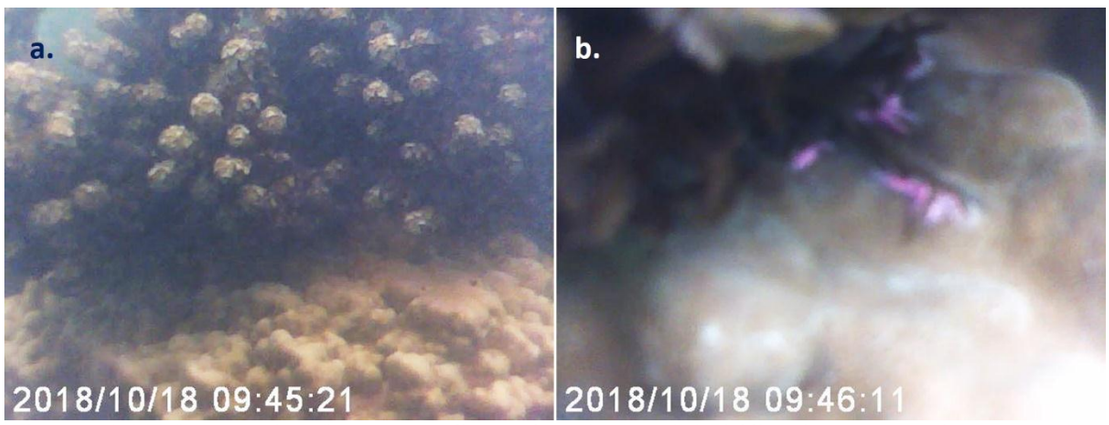

Figure-2. (a.) Tuft aggregation of *T. ornata* on live coral, *Porites lutea*; **(b.)** Pinkline disease propagation on upper body surface of *Porites lutea* due to *T. ornata* shoots.
Source: Present study.

Indeed, grazing and herbivore animals (for instance, parrotfishes) in the reef crest are known to play a significant role in controlling the growth of algae, thereby contributing to ecological balance of reef ecosystem [25]. Evidently, we have found very few parrotfish in Hare Island and not seen abundant fish diversity like that of healthy reef. This is an indication of reef that experiencing multifactorial stress conditions which are yet to be unveiled. The present study observations are challenging and make sense that restoring coral reefs is a very essential step to raise local densities of herbivore fishes to graze the algae. Previous studies demonstrated that *T. ornata* can produce anti-herbivore phenolic compounds to avoid grazers [26].

Field investigations suggest that *Turbinaria* species could be a potential competitors which promote their settlement on reef habitats, thus inhibits the settlement of coral polyps for regeneration. Recently, a study from Fiji found that coral species are tended to display positive association with non-allelopathic macroalgae *Turbinaria conoides* and *Sargassum polycystum* [5]. However, the allelopathic effect of *T. ornata* on corals has not been studied so far. Also, we noticed that *T. ornata* has not caused any visible damage such as mortality or bleaching to *Acropora* and *Porites* species they contacted. However, it was apparent in our underwater visual census that reef crest was fully occupied by well flourished *T. ornata*. We believe that *T. ornata* manifestation is one of the reason that preventing recovery of corals as well as reef resilience. A recent study indicated that dominance of *T. ornata* can reduce the growth of corals as observed in *Acropora pulchra* and *Porites rus* irrespective of predation intensity [4]. Based on our census, we infer that *T. ornata* posing threats and being one of the potential inhibitor in coral recruitment. Further, *Turbinaria* species are being monitored to understand their competitive strategies as well as negative impact on corals as well as on other algal diversity in Gulf of Mannar.

Reportedly, *T. ornata* has potential therapeutic applications such as anticancer [27] anti-inflammatory [28] antiulcer [29] antibacterial [30] antidiabetic and antioxidant [31] antiangiogenic [32] and for cosmetics including oils, soaps, shower gels, shampoo, body oil, skin moisturizing creams and protective lotions in French Polynesia (www.pacifiquesud.com). The local people in Gulf of Mannar are already exploring the abundant resource of *Sargassum* species for industrial applications. Thus we suggest that *Turbinaria* species may also be harvested and utilized for further lucrative industrial applications. This approach would help to reduce the risks prone to coral settlement and to substantially control the proliferation of *T. ornata* and *T. decurrens*. Also, multidisciplinary approaches are needed to address these issues related to mitigation and eradication of invasive species in Gulf of Mannar. Apparently, a study showed the exclusion of *T. ornata* from coral reefs resulted in increase in the fish species richness (McCarthy). Such practice may be easy to implement in Gulf of Mannar, however we are not sure about the later consequences, hence further studies are yet to demonstrated. Different methods to control various invasive seaweeds have also been suggested for implementation [33].

References

[1] G. Diaz-Pulido and L. J. McCook, "Effects of live coral, epilithic algal communities and substrate type on algal recruitment," *Coral Reefs*, vol. 23, pp. 225-233, 2004. Available at: https://doi.org/10.1007/s00338-004-0370-5.

[2] L. J. McCook, J. Jompa, and G. Diaz-Pulido, "Competition between corals and algae on coral reefs: A review of evidence and mechanisms," *Coral Reefs*, vol. 19, pp. 400-417, 2001.

[3] J. Mellors, H. Marsh, T. J. Carruthers, and M. Waycott, "Testing the sediment-trapping paradigm of seagrass: Do seagrasses influence nutrient status and sediment structure in tropical intertidal environments?," *Bulletin of Marine Science*, vol. 71, pp. 1215-1226, 2002.

[4] F. Bulleri, M. Couraudon-Réale, T. L. de Loma, and J. Claudet, "Variability in the effects of macroalgae on the survival and growth of corals: the consumer connection," *PloS One*, vol. 8, p. e79712, 2013. Available at: https://doi.org/10.1371/journal.pone.0079712.

[5] R. M. Bonaldo and M. E. Hay, "Seaweed-coral interactions: variance in seaweed allelopathy, coral susceptibility, and potential effects on coral resilience," *PloS One*, vol. 9, p. e85786, 2014. Available at: https://doi.org/10.1371/journal.pone.0085786.

[6] M. Vermeij, M. Dailer, and C. Smith, "Crustose coralline algae can suppress macroalgal growth and recruitment on Hawaiian coral reefs," *Marine Ecology Progress Series*, vol. 422, pp. 1-7, 2011. Available at: https://doi.org/10.3354/meps08964.

[7] D. J. Russell, "The ecological invasion of Hawaiian reefs by two marine red algae, Acanthophora spicifera (Vahl) Boerg. and Hypnea musciformis (Wulfen) J. Ag., and their association with two native species, Laurencia nidifica J. Ag. and Hypnea Cervicornis," *J. Ag. CES Mar. Sei. Symp.*, vol. 194, pp. 110-125, 1992.

[8] D. J. Russell and G. H. Balazs, "Colonization by the alien marine alga Hypnea musciformis (Wulfen) J. Ag.(Rhodophyta: Gigartinales) in the Hawaiian Islands and its utilization by the green turtle, Chelonia mydas L," *Aquatic Botany*, vol. 47, pp. 53-60, 1994. Available at: https://doi.org/10.1016/0304-3770(94)90048-5.

[9] A. Critchley, W. Farnham, and C. Thorp, "On the co-occurrence of two exotic, invasive marine organisms: The brown seaweed Sargassum muticum (Yendo) Fensholt and the Spirorbid tube worm Janua (Neodexiospira) brasiliensis (Grube), in association with the indigenous eelgrass, Zostera marina L. and Wrack, Fucus serratus L. in the south-west Netherlands and the Channel Islands, Europe," *South African Journal of Botany*, vol. 63, pp. 474–479, 1997. Available at: https://doi.org/10.1002/jid.1083.

[10] V. Stiger and C. Payri, "Spatial and seasonal variations in the biological characteristics of two invasive brown algae, Turbinaria ornata (Turner) J. Agardh and Sargassum mangarevense (Grunow) Setchell (Sargassaceae, Fucales) spreading on the reefs of Tahiti (French Polynesia)," *Botanica Marina*, vol. 42, pp. 295-306, 1999. Available at: https://doi.org/10.1515/bot.1999.033.

[11] L. M. Marks, P. Salinas-Ruiz, D. C. Reed, S. J. Holbrook, C. S. Culver, J. M. Engle, D. J. Kushner, J. E. Caselle, J. Freiwald, and J. P. Williams, "Range expansion of a non-native, invasive macroalga Sargassum horneri (Turner) C. Agardh, 1820 in the eastern Pacific," *BioInvasions Rec*, vol. 4, pp. 243-248, 2015. Available at: https://doi.org/10.3391/bir.2015.4.4.02.

[12] X. De Villèle and M. Verlaque, "Changes and degradation in a Posidonia oceanica bed invaded by the introduced tropical alga Caulerpa taxifolia in the north western Mediterranean," *Botanica Marina*, vol. 38, pp. 79-88, 1995. Available at: https://doi.org/10.1515/botm.1995.38.1-6.79.

[13] G. Ceccherelli and F. Cinelli, "The role of vegetative fragmentation in dispersal of the invasive alga Caulerpa taxifolia in the Mediterranean," *Marine Ecology Progress Series*, vol. 182, pp. 299-303, 1999. Available at: https://doi.org/10.3354/meps182299.

[14] J. E. Smith, C. L. Hunter, and C. M. Smith, "Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands," *Pacific Science*, vol. 56, pp. 299-315, 2002. Available at: https://doi.org/10.1353/psc.2002.0030.

[15] P. S. Levin, J. A. Coyer, R. Petrik, and T. P. Good, "Community-wide effects of nonindigenous species on temperate rocky reefs," *Ecology*, vol. 83, pp. 3182-3193, 2002. Available at: https://doi.org/10.2307/3071852.

[16] B. E. Lapointe, P. J. Barile, M. M. Littler, D. S. Littler, B. J. Bedford, and C. Gasque, "Macroalgal blooms on southeast Florida coral reefs: I. Nutrient stoichiometry of the invasive green alga Codium isthmocladum in the wider Caribbean indicates nutrient enrichment," *Harmful Algae*, vol. 4, pp. 1092-1105, 2005. Available at: https://doi.org/10.1016/j.hal.2005.06.004.

[17] Global Invasive Species Database, "Available from http://www.iucngisd.org/gisd/search.php. [Accessed 11-10-2018]," 2018.

[18] G. Casas, R. Scrosati, and M. L. Piriz, "The invasive kelp Undaria pinnatifida (Phaeophyceae, Laminariales) reduces native seaweed diversity in Nuevo Gulf (Patagonia, Argentina)," *Biological Invasions*, vol. 6, pp. 411-416, 2004. Available at: https://doi.org/10.1023/b:binv.0000041555.29305.41.

[19] E. Martinez, K. Maamaatuaiahutapu, C. Payri, and A. Ganachaud, "Turbinaria ornata invasion in the tuamotu archipelago, French Polynesia: ocean drift connectivity," *Coral Reefs*, vol. 26, pp. 79-86, 2007. Available at: https://doi.org/10.1007/s00338-006-0160-3.

[20] J. K. P. Edward, G. Mathews, D. K. Raj, S. Rajesh, A. Arasamuthu, and R. L. Laju, "Invasion of the exotic seaweed, Kappaphycus alvarezii, on coral areas in two islands (Krusadai & Mulli) in the Gulf of Mannar, Southeastern India - status and control measures," *The News Journal of the International Society for Reef Studies*, vol. 30, pp. 50-53, 2015.

[21] H. L. Stewart, "Ontogenetic changes in buoyancy, breaking strength, extensibility, and reproductive investment in a drifting macroalga Turbinaria ornata (Phaeophyta)," *Journal of Phycology*, vol. 42, pp. 43-50, 2006. Available at: https://doi.org/10.1111/j.1529-8817.2006.00184.x.

[22] S. English, C. Wilkinson, and V. Baker, *Survey manual for tropical marine resource*. Townsville, Australia: Australian Institute of Marine Sciences, 1997.

[23] M. D. Guiry and G. M. Guiry, *"AlgaeBase" world-wide electronic publication*. Galway: National University of Ireland, 2018.

[24] S. J. Bittick, N. D. Bilotti, H. A. Peterson, and H. L. Stewart, "Turbinaria ornata as an herbivory refuge for associate algae," *Marine Biology*, vol. 157, pp. 317-323, 2010. Available at: https://doi.org/10.1007/s00227-009-1319-6.

[25] C. Doropoulos, G. A. Hyndes, D. Abecasis, and A. Vergés, "Herbivores strongly influence algal recruitment in both coral-and algal-dominated coral reef habitats," *Marine Ecology Progress Series*, vol. 486, pp. 153-164, 2013. Available at: https://doi.org/10.3354/meps10325.

[26] V. Stiger, E. Deslandes, and C. E. Payri, "Phenolic contents of two brown algae, Turbinaria ornata and Sargassum mangarevense on Tahiti (French Polynesia): Interspecific, ontogenic and spatio-temporal variations," *Botanica Marina*, vol. 47, pp. 402-409, 2004. Available at: https://doi.org/10.1515/bot.2004.058.

[27] F. Asari, T. Kusumi, and H. Kakisawa, "Turbinaric acid, a cytotoxic secosqualene carboxylic acid from the brown alga Turbinaria ornata," *Journal of Natural Products*, vol. 52, pp. 1167-1169, 1989. Available at: https://doi.org/10.1021/np50065a045.

[28] S. Ananthi, H. R. B. Raghavendran, A. G. Sunil, V. Gayathri, G. Ramakrishnan, and H. R. Vasanthi, "In vitro antioxidant and in vivo anti-inflammatory potential of crude polysaccharide from Turbinaria ornata (Marine Brown Alga)," *Food and Chemical Toxicology*, vol. 48, pp. 187-192, 2010. Available at: https://doi.org/10.1016/j.fct.2009.09.036.

[29] K. A. Senthil and A. Murugan, "Antiulcer, wound healing and hepatoprotective activities of the seaweeds Gracilaria crassa, Turbinaria ornata and Laurencia papillosa from the southeast coast of India," *Brazilian Journal of Pharmaceutical Sciences*, vol. 49, pp. 669-678, 2013. Available at: https://doi.org/10.1590/s1984-82502013000400006.

[30] P. Vijayabaskar and V. Shiyamala, "Antibacterial activities of brown marine algae (Sargassum wightii and Turbinaria ornata) from the Gulf of Mannar Biosphere Reserve," *Advances in Biological Research*, vol. 5, pp. 99-102, 2011.

[31] P. S. Unnikrishnan, K. Suthindhiran, and M. A. Jayasri, "Inhibitory potential of Turbinaria ornata against key metabolic enzymes linked to diabetes," *BioMed Research International*, vol. 2014, p. 783895, 2014.

[32] J. L. Canoy and J. G. Bitacura, "Cytotoxicity and antiangiogenic activity of Turbinaria ornata agardh and Padina australis Hauck ethanolic extracts," *Analytical Cellular Pathology*, vol. 2018, pp. 1-8, 2018. Available at: https://doi.org/10.1155/2018/3709491.

[33] L. W. Anderson, "Control of invasive seaweeds," *Botanica Marina*, vol. 50, pp. 418-437, 2007. Available at: https://doi.org/10.1515/bot.2007.045.