



Open Access





Publisher

Wildlife Information Liaison Development Societywww.wild.zooreach.org

Host

Zoo Outreach Organizationwww.zooreach.org43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India

Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India

Ph: +91 9385339863 | www.threatenedtaxa.orgEmail: sanjay@threatenedtaxa.org**EDITORS****Founder & Chief Editor****Dr. Sanjay Molur**Wildlife Information Liaison Development (WILD) Society & Zoo Outreach Organization (ZOO),
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore, Tamil Nadu 641006, India**Deputy Chief Editor****Dr. Neelesh Dahanukar**

Noida, Uttar Pradesh, India

Managing Editor**Mr. B. Ravichandran**, WILD/ZOO, Coimbatore, India**Associate Editors****Dr. Mandar Paingankar**, Government Science College Gadchiroli, Maharashtra 442605, India**Dr. Ulrike Streicher**, Wildlife Veterinarian, Eugene, Oregon, USA**Ms. Priyanka Iyer**, ZOO/WILD, Coimbatore, Tamil Nadu 641006, India**Dr. B.A. Daniel**, ZOO/WILD, Coimbatore, Tamil Nadu 641006, India**Editorial Board****Dr. Russel Mittermeier**

Executive Vice Chair, Conservation International, Arlington, Virginia 22202, USA

Prof. Mewa Singh Ph.D., FASc, FNA, FNASc, FNAPsy

Ramanna Fellow and Life-Long Distinguished Professor, Biopsychology Laboratory, and Institute of Excellence, University of Mysore, Mysuru, Karnataka 570006, India; Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; and Adjunct Professor, National Institute of Advanced Studies, Bangalore

Stephen D. Nash

Scientific Illustrator, Conservation International, Dept. of Anatomical Sciences, Health Sciences Center, T-8, Room 045, Stony Brook University, Stony Brook, NY 11794-8081, USA

Dr. Fred Pluthero

Toronto, Canada

Dr. Priya Davidar

Sigur Nature Trust, Chadapatti, Mavinahalli PO, Nilgiris, Tamil Nadu 643223, India

Dr. Martin Fisher

Senior Associate Professor, Battcock Centre for Experimental Astrophysics, Cavendish Laboratory, JJ Thomson Avenue, Cambridge CB3 0HE, UK

Dr. John Fellowes

Honorary Assistant Professor, The Kadoorie Institute, 8/F, T.T. Tsui Building, The University of Hong Kong, Pokfulam Road, Hong Kong

Prof. Dr. Mirco Solé

Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Vice-coordenador do Programa de Pós-Graduação em Zoologia, Rodovia Ilhéus/Itabuna, Km 16 (45662-000) Salobrinho, Ilhéus - Bahia - Brasil

Dr. Rajeev Raghavan

Professor of Taxonomy, Kerala University of Fisheries & Ocean Studies, Kochi, Kerala, India

English Editors**Mrs. Mira Bhojwani**, Pune, India**Dr. Fred Pluthero**, Toronto, Canada**Mr. P. Ilangovan**, Chennai, India**Ms. Sindhura Stothra Bhashyam**, Hyderabad, India**Web Development****Mrs. Latha G. Ravikumar**, ZOO/WILD, Coimbatore, India**Typesetting****Mrs. Radhika**, ZOO, Coimbatore, India**Mrs. Geetha**, ZOO, Coimbatore India**Fundraising/Communications****Mrs. Payal B. Molur**, Coimbatore, India**Subject Editors 2019–2021****Fungi****Dr. B. Shivaraju**, Bengaluru, Karnataka, India**Dr. R.K. Verma**, Tropical Forest Research Institute, Jabalpur, India**Dr. Vatsavaya S. Raju**, Kakatiya University, Warangal, Andhra Pradesh, India**Dr. M. Krishnappa**, Jnana Sahyadri, Kuvenpu University, Shimoga, Karnataka, India**Dr. K.R. Sridhar**, Mangalore University, Mangalagangotri, Mangalore, Karnataka, India**Dr. Gunjan Biswas**, Vidyasagar University, Midnapore, West Bengal, India**Plants****Dr. G.P. Sinha**, Botanical Survey of India, Allahabad, India**Dr. N.P. Balakrishnan**, Ret. Joint Director, BSI, Coimbatore, India**Dr. Shonil Bhagwat**, Open University and University of Oxford, UK**Prof. D.J. Bhat**, Retd. Professor, Goa University, Goa, India**Dr. Ferdinando Boero**, Università del Salento, Lecce, Italy**Dr. Dale R. Calder**, Royal Ontario Museum, Toronto, Ontario, Canada**Dr. Cleofas Cervancia**, Univ. of Philippines Los Baños College Laguna, Philippines**Dr. F.B. Vincent Florens**, University of Mauritius, Mauritius**Dr. Merlin Franco**, Curtin University, Malaysia**Dr. V. Irudayaraj**, St. Xavier's College, Palayamkottai, Tamil Nadu, India**Dr. B.S. Kholia**, Botanical Survey of India, Gangtok, Sikkim, India**Dr. Pankaj Kumar**, Department of Plant and Soil Science, Texas Tech University, Lubbock, Texas, USA**Dr. V. Sampath Kumar**, Botanical Survey of India, Howrah, West Bengal, India**Dr. A.J. Solomon Raju**, Andhra University, Visakhapatnam, India**Dr. Vijayasankar Raman**, University of Mississippi, USA**Dr. B. Ravi Prasad Rao**, Sri Krishnadevaraya University, Anantapur, India**Dr. K. Ravikumar**, FRLHT, Bengaluru, Karnataka, India**Dr. Aparna Watve**, Pune, Maharashtra, India**Dr. Qiang Liu**, Xishuangbanna Tropical Botanical Garden, Yunnan, China**Dr. Noor Azhar Mohamed Shazili**, Universiti Malaysia Terengganu, Kuala Terengganu, Malaysia**Dr. M.K. Vasudeva Rao**, Shiv Ranjani Housing Society, Pune, Maharashtra, India**Prof. A.J. Solomon Raju**, Andhra University, Visakhapatnam, India**Dr. Manda Datar**, Agharkar Research Institute, Pune, Maharashtra, India**Dr. M.K. Janarthanam**, Goa University, Goa, India**Dr. K. Karthigeyan**, Botanical Survey of India, India**Dr. Errol Vela**, University of Montpellier, Montpellier, France**Dr. P. Lakshminarasimhan**, Botanical Survey of India, Howrah, India**Dr. Larry R. Nobile**, Montgomery Botanical Center, Miami, USA**Dr. K. Haridasan**, Pallavur, Palakkad District, Kerala, India**Dr. Analinda Manila-Fajard**, University of the Philippines Los Baños, Laguna, Philippines**Dr. P.A. Sinu**, Central University of Kerala, Kasaragod, Kerala, India**Dr. Afroz Alam**, Banasthali Vidyapith (accredited A grade by NAAC), Rajasthan, India**Dr. K.P. Rajesh**, Zamorin's Guruvayurappan College, GA College PO, Kozhikode, Kerala, India**Dr. David E. Boufford**, Harvard University Herbaria, Cambridge, MA 02138-2020, USA**Dr. Ritesh Kumar Choudhary**, Agharkar Research Institute, Pune, Maharashtra, India**Dr. Navendu Page**, Wildlife Institute of India, Chandrabani, Dehradun, Uttarakhand, India**Dr. Kannan C.S. Warrier**, Institute of Forest Genetics and Tree Breeding, Tamil Nadu, India**Invertebrates****Dr. R.K. Avasthi**, Rohtak University, Haryana, India**Dr. D.B. Bastawde**, Maharashtra, India**Dr. Partha Pratim Bhattacharjee**, Tripura University, Suryamaninagar, India**Dr. Kailash Chandra**, Zoological Survey of India, Jabalpur, Madhya Pradesh, India**Dr. Ansie Dippenaar-Schoeman**, University of Pretoria, Queenswood, South Africa**Dr. Rory Dow**, National Museum of natural History Naturalis, The Netherlands**Dr. Brian Fisher**, California Academy of Sciences, USA**Dr. Richard Gallon**, Ilandudno, North Wales, LL30 1UP**Dr. Hemant V. Ghate**, Modern College, Pune, India**Dr. M. Monwar Hossain**, Jahangirnagar University, Dhaka, Bangladesh**Mr. Jatishwar Singh Irungbam**, Biology Centre CAS, Branišovská, Czech Republic.**Dr. Ian J. Kitching**, Natural History Museum, Cromwell Road, UKFor Focus, Scope, Aims, and Policies, visit https://threatenedtaxa.org/index.php/JoTT/aims_scopeFor Article Submission Guidelines, visit <https://threatenedtaxa.org/index.php/JoTT/about/submissions>For Policies against Scientific Misconduct, visit https://threatenedtaxa.org/index.php/JoTT/policies_various

continued on the back inside cover

Cover: Green Bee-eater with colour pencils and watercolor wash by Elakshi Mahika Molur.



Occurrence of opportunistic invasive macroalgal genus *Caulerpa* and *Halimeda opuntia* in coral reefs of Gulf of Mannar

Chatragadda Ramesh¹ , Koushik Sadhukhan² , T. Shunmugaraj³  & M.V. Ramana Murthy⁴ 

¹⁻³ National Centre for Coastal Research (NCCR), Ministry of Earth Sciences (MoES), Mandapam Field Research Centre, Mandapam Camp, Ramnathapuram, Tamil Nadu 623519, India.

⁴ National Centre for Coastal Research (NCCR), Ministry of Earth Sciences (MoES), Pallikaranai, Chennai, Tamil Nadu 600100, India.

¹ chrameshp@gmail.com (corresponding author), ² sadhukhan.1985@gmail.com, ³ raj@nccr.gov.in, ⁴ mvr@nccr.gov.in

Abstract: Investigations on indigenous and non-indigenous invasive flora and fauna of a certain geographical area are always important to assess their impact on native biodiversity and control their spread by making conservation strategies to protect biodiversity. In this study, we have encountered overwhelming growth of six seaweed species, *Caulerpa racemosa*, *C. serrulata*, *C. sertularioides*, *C. taxifolia*, *C. peltata*, and *Halimeda opuntia* on the reef flat. These algal covers on reef area appear to compete with coral polyps and restrict their settlement and resilience. Our concern on invasive species distribution in Gulf of Mannar revealed these overgrowing invasive species, which can become potential threats to coral reefs, benthic diversity, and reef assemblage. These observations will help us to develop multidisciplinary management approaches related to the expansion, mitigation, and control of these opportunistic invasive species. Further seasonal monitoring on these algal species is under process to investigate their spatial shift patterns on various coral forms.

Keywords: algal blooms, algal cover, coral-algal interactions, reef conservation, reef flat, reef resilience, reef restoration, reef threats, seaweed, seaweed utilization.

Editor: R. Ravinesh, Centre for Marine Living Resources and Ecology, Ministry of Earth Sciences, Kochi, India. **Date of publication:** 26 March 2023 (online & print)

Citation: Ramesh, C., K. Sadhukhan, T. Shunmugaraj & M.V.R. Murthy (2023). Occurrence of opportunistic invasive macroalgal genus *Caulerpa* and *Halimeda opuntia* in coral reefs of Gulf of Mannar. *Journal of Threatened Taxa* 15(3): 22883-22888. <https://doi.org/10.11609/jott.4744.15.3.22883-22888>

Copyright: © Ramesh et al. 2023. Creative Commons Attribution 4.0 International License. JoTT allows unrestricted use, reproduction, and distribution of this article in any medium by providing adequate credit to the author(s) and the source of publication.

Funding: The project is funded by Ministry of Earth Sciences, Government of India under "Coastal Research scheme" implemented by National Centre for Coastal Research (NCCR), Chennai.

Competing interests: The authors declare no competing interests.

Author details: DR. RAMESH CHATRAGADDA has been working on different aspects of coral reefs, such as coral diseases, coral restoration, coral reef monitoring, and reef diversity. His research is aimed at molecular taxonomy of reef communities and microbial ecology of coral communities for drug discovery and reef conservation. DR KOUSHIK SADHUKHAN has been working in NCCR since 2018. He has experienced with eight years of R & D work on coral reef monitoring and coral restoration programme in India. His research interest lies in the area of marine biology, taxonomy and ecology. DR T. SHUNMUGARAJ is the senior scientist of NCCR (scientist-G) and he has excellent research experience of 27 years in the field of marine biology and mariculture. His research is focused on marine biodiversity assessment in Indian Ocean. He has also worked on stock enhancement and sea ranching programme of cultivable marine species in India. DR M.V. RAMANA MURTHY serves as scientist-G and director of NCCR who has been engaged in R & D work for 30 years in the field of offshore and coastal hydrodynamics, coastal conservation and Information service programme in India.

Author contributions: RC conceived the study, conducted the fieldwork, and prepared the manuscript. KS helped in field work, wrote and edited the manuscript. TS designed the study, assisted in the field study, corrected the draft manuscript, and supervised the project. MVRM coordinated the study and gave technical advice.

Acknowledgements: The authors are thankful to the Ministry of Earth Sciences, New Delhi, for financial support.



NCCR

राष्ट्रीय नदीय अनुसंधान केन्द्र

पृथ्वी विज्ञान मंत्रालय, भारत सरकार

NATIONAL CENTRE FOR COASTAL RESEARCH

MINISTRY OF EARTH SCIENCES, GOVERNMENT OF INDIA

INTRODUCTION

Invasive species belonging to flora and fauna can lead to adverse effects such as altering the biodiversity and community structure (Antolić et al. 2008), and can even invade or cause mortality to flora (de Villèle & Verlaque 1995) and fauna (Žuljević et al. 2011). A study on the impact of invasive *Caulerpa taxifolia* on seagrass beds of *Posidonia oceanica* has revealed degradation of seagrass beds in the west of Menton, France (de Villèle & Verlaque 1995). Various authors have also reported the distribution of indigenous invasive species, including *Ulva fasciata*, *Cladophora sericea*, and *Dictyosphaeria cavernosa* in the Hawaiian Islands (Smith et al. 2002), and non-indigenous invasive algae, including *Caulerpa verticillata* in the Gulf of California (Perez-Estrada et al. 2013), *Lophocladia lallemandii* (Kersting et al. 2014), *Caulerpa racemosa* var. *cylindrica* and *C. taxifolia* in Mediterranean region (Žuljević et al. 2011), and *C. racemosa* in the Gulf of Arzew, Algerian coast (Bouiadra et al. 2010). Currently, the genus *Caulerpa* has been indicated as an invasive species by the International Union for Conservation of Nature (IUCN) Centre for Mediterranean Cooperation (Otero et al. 2013).

The invasive *Caulerpa* species spread rapidly all along the Mediterranean countries (Klein & Verlaque 2008). Since then, the issue of invasive algae in other parts of the world was also undertaken in different countries, as mentioned above. Recently, studies on invasive flora from the Gulf of Mannar region are gaining more importance due to their reef damaging nature. A few studies showed the invasion of *Kappaphycus alvarezii* on coral reefs in Krusadai and Mulli Islands (Edward et al. 2015), *Caulerpa* sp. and *Halimeda* sp. in the Gulf of Mannar and Palk Bay coral reefs (Manikandan & Ravindran 2016), and *Turbinaria* in the Gulf of Mannar corals (Ramesh et al. 2019). However, there is very little information on the current distribution patterns of invasive seaweeds around the Gulf of Mannar Islands. Therefore, during coral reef monitoring, we investigated invasive species distribution in the Gulf of Mannar group of Islands.

MATERIAL AND METHODS

Reef monitoring surveys were carried out during August to November 2018, from Manoli Putti and Hare Islands under the Gulf of Mannar region, southeastern coast of Tamil Nadu, India. Several underwater dives on fringing reefs of these two islands revealed moderate

bloom forming and overwhelming growth of four green seaweeds *Caulerpa serrulata*, *C. racemosa*, *C. sertularioides*, and *C. peltata* on live and dead corals. Underwater photographs of these bloom-forming species were documented using Nikon Coolpix underwater camera. Species identification was made using standard identification keys and AlgaeBase (Guiry & Guiry 2018).

RESULTS AND DISCUSSION

Caulerpa racemosa, *C. serrulata*, *C. sertularioides*, *C. taxifolia*, *C. peltata*, and *Halimeda opuntia* are usually seen in smaller size on corals and rubbles. Their usual occurrence on reefs or rubbles used to be within the size range $<5\text{--}30\text{ cm}$. However, their bloom forming nature identified by recording their overwhelming spread on corals ranged $>30\text{ cm}\text{--}1\text{ m}$. Blooms of these species overwhelming on the coral reefs of Mandapam group of Islands were recorded during our study (Image 1a–h; Image 2a–f). The favourable physicochemical conditions that promote their spread in the reef area are poorly understood. These algal species have displayed a distinct distribution in the reef environment, where *C. sertularioides* and *C. racemosa* grew on rubbles, rocky substratum, and *Porites* sp.; *C. serrulata* on dead *Acropora* corals and live *Porites* species; and *C. peltata* on live *Acropora* corals. *C. taxifolia* has formed small patches on rubbles and near reef slopes, and is also found to grow mostly on *Montipora digitata* and *Porites solida* rather than on *Acropora*. Interestingly, *C. racemosa* was observed to grow on multiple species of corals such as *Porites*, *Acropora*, and *Montipora*. *C. racemosa*, *H. opuntia*, and *C. taxifolia* grew together with no inhibition activity against each other. *H. opuntia* was found to cover a few massive *Porites* coral colonies in Manoliputti Island. While its spread in seagrass beds was also observed (Image 2a–f), its actual impact on seagrass beds is yet to be studied.

We did not observe any grazers that preferred to feed on these *Caulerpa* species. Although *C. taxifolia* was found in the reef flats but were not seen to occur profusely. These algal blooms appear to be unsuitable for the development of corals due to their proliferation, smothering the corals. Also, overwhelming algal growth inhibits light penetration required for zooxanthellae to generate energy for polyps. These reasons appear to inhibit the growth of coral polyps and restrict juvenile corals' settlement on the dead reefs or rubble in the Gulf of Mannar reefs.

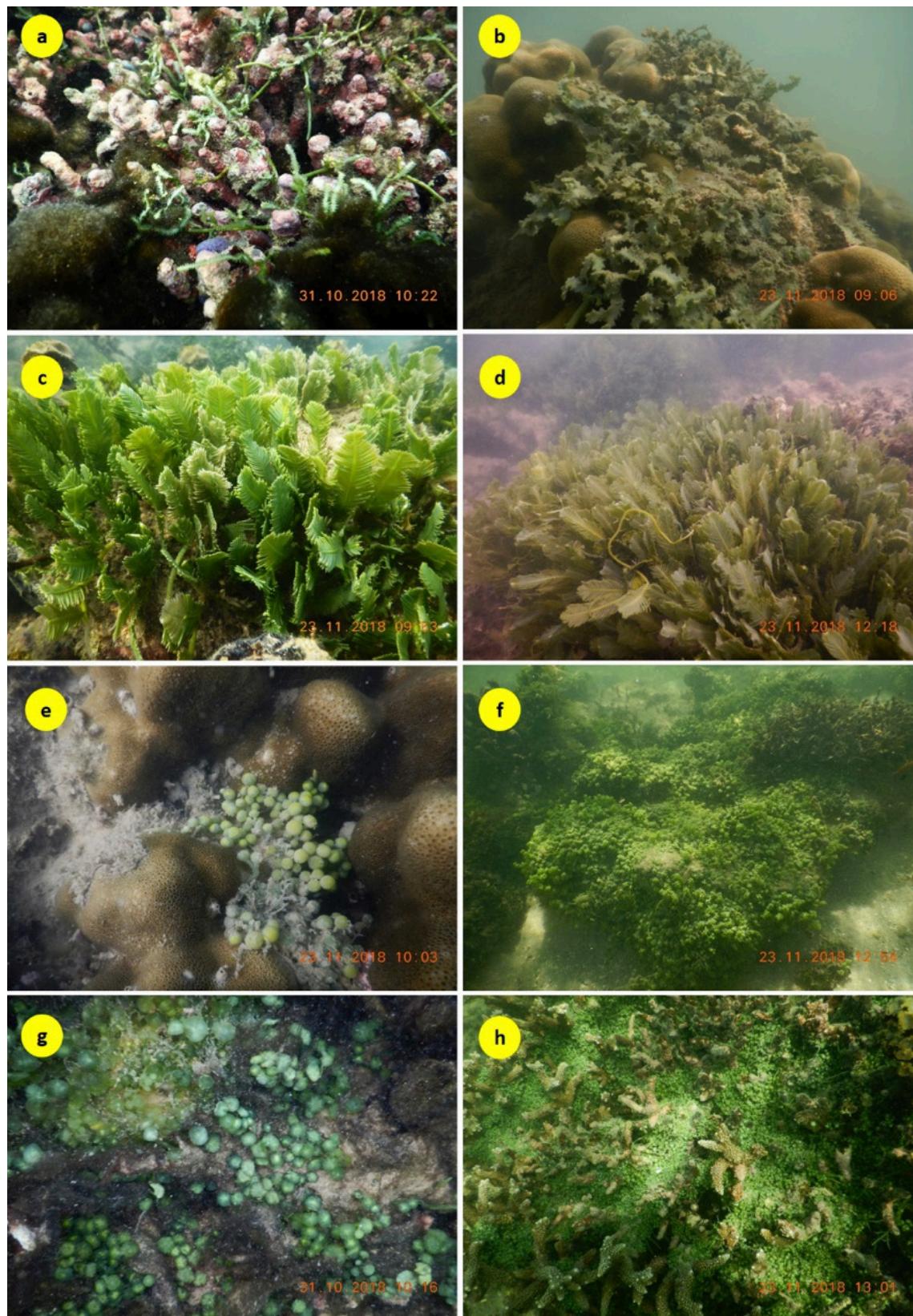


Image 1. a—Invasive and bloom-forming *Caulerpa serrulata* on dead *Acropora* reef | b—its overwhelming growth on *Porites* | c—*Caulerpa sertularioides* usual occurrence | d—canopy formation on the upper surface of *Porites* sp., dead corals and coral rubbles | e—*C. racemosa* in normal condition | f—its algal mat formation on *Porites* sp., dead corals and rubbles | g—*C. peltata* on dead *Acropora* coral | h—its algal mat formation on *Acropora* coral. © Ramesh Ch.

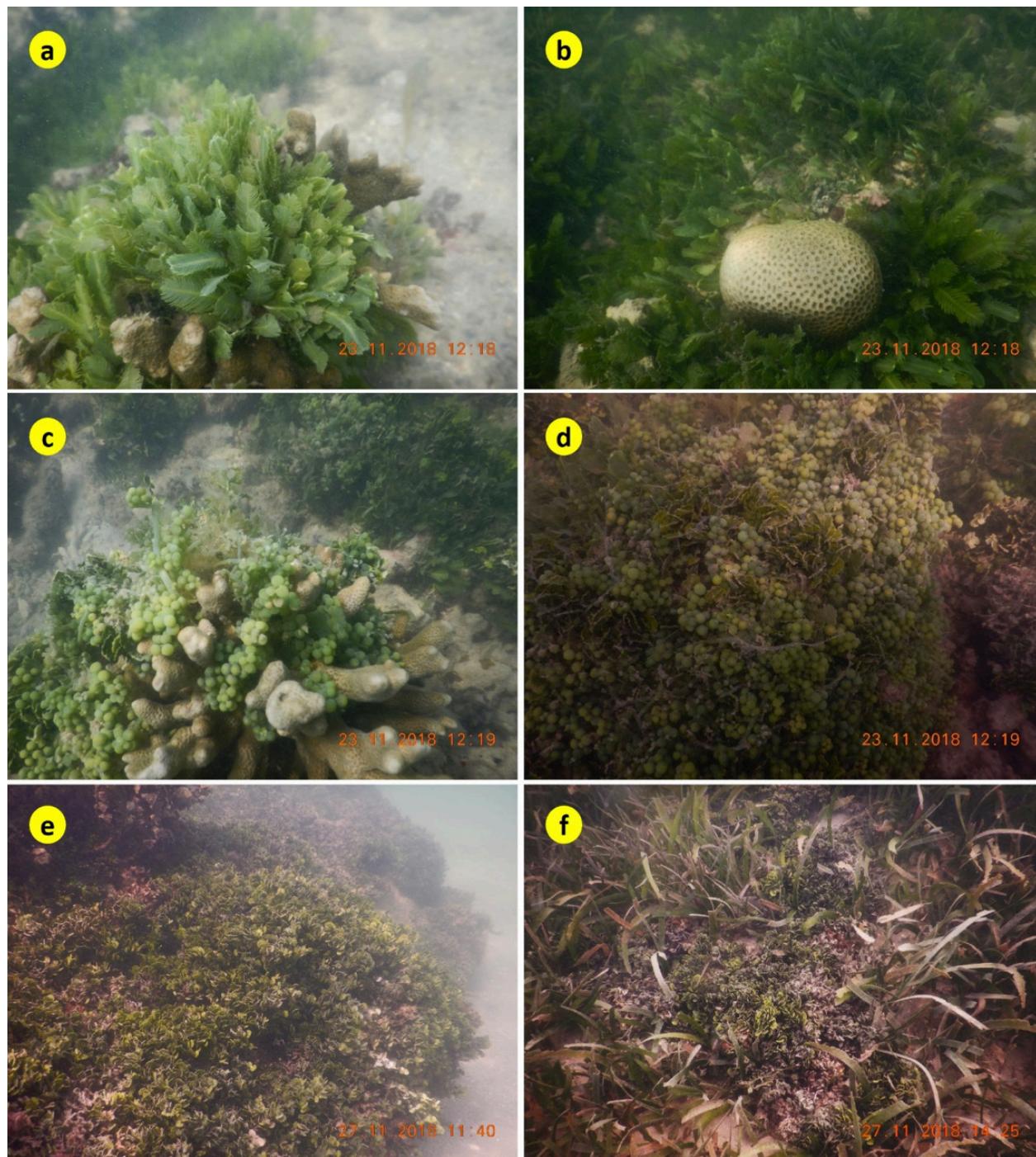


Image 2. a—*Caulerpa taxifolia* invasion on *M. digitata* | b—around a newly recruited *P. solida* | c—*C. racemosa* invading on *M. digitata* | d—its interaction with *Halimeda opuntia* and *C. sertularioides* (top left) | e—profuse growth of *H. opuntia* on *P. luteus* | f—its propagation in seagrass bed. © Ramesh Ch.

Previous reports indicated that *C. racemosa* and *C. taxifolia* could inhabit the entire reef area, which would ultimately undermine the resilience of corals (Hoey et al. 2011). The impact of these *Caulerpa* species on Gulf of Mannar's reef environment is yet to be studied in detail. However, the present study observations are

challenging the issues related to the algal destruction and conservation of corals and coral reef biodiversity from invasive algae.

A recent study revealed that a feeding deterrent activity assay on green algae *C. peltata*, *C. sertularioides*, and *C. taxifolia* species display highest deterrent

activity of >80% (Rajan & Padmakumar 2017). While *C. cupressoides* and *C. fergusonii* showed moderate deterrent activity, *C. scalpelliformis* and *C. microphysa* exhibited negligible deterrent activity (Rajan & Padmakumar 2017). Experimental studies also show that grazing on *C. taxifolia* resulted in the loss of spines and less gonosomatic ratios in sea urchin *Paracentrotus lividus* (Boudouresque et al. 1996). Later it was observed that high production of toxic and repellent chemical metabolite 'caulerpenyne' in summer causes sea urchins to avoid *C. taxifolia* (Lemeé et al. 1996). The deterrent activity exhibited by *C. taxifolia* might be the reason that restricts grazers not to feed on it.

Whereas the same compound produced by *C. racemosa* had not displayed any deterrent activity towards herbivorous surgeon fish *Zebrasoma flavescens* (Wylie & Paul 1988), and it was highly preferred by both juvenile and adult rabbitfish *Siganus argenteus* (Paul et al. 1990). In this study, we have not found any grazers feeding on these *Caulerpa* species during our underwater observations. A recent study also indicated that *C. racemosa* distribution could drastically change over time by spreading from deep water to the shallow waters, as observed in the Columbretes Islands, Mediterranean Sea (Kersting et al. 2014). A study also suggested that overgrowth of *C. racemosa* via chemotropism results in smothering or even death of sponge *Sarcotragus spinosulus* (Žuljević et al. 2011).

Caulerpa species are well known as edible seaweeds in eastern Asian countries such as China, Japan, Korea, Philippines; southeastern Asian countries like Indonesia, Vietnam; and Indo-Pacific regions (Kaliaperumal & Chennubhotla 2017). In India, *C. lentillifera* is cultured on the Gulf of Mannar coast (Mary et al. 2009). But utilization of these six species in India has not been implemented so far. Hence, they remain an untapped and unutilized food resource from the Indian Coast. Thus, *Caulerpa* species can be considered a potential natural edible seafood to the increasing population in India.

Crustose coralline algae are well known as they support the settlement of coral polyps (Tebben et al. 2015). Although we have found very few coralline algae in our surveys at Hare Island and Manoli Island, the coral recruitment was appreciable on the dead corals free from these algae. However, there is high competition for substrata between algae and corals, similar to previous reports (McCook et al. 2001). Therefore, monitoring the bloom-forming invasive seaweeds in terms of their reproductive strategies and favourable conditions that promote their propagation is essential for developing

remedies. Reports evidenced that ease dispersion and spread of *Caulerpa* species is mostly due to fishing nets, anchors, boats, and aquaria (Otero et al. 2013). Studies from the Mediterranean Sea have shown the rapid spread of invasive *C. taxifolia* by fragment mechanism (Ceccherelli & Cinelli 1999; Smith & Walters 1999). Therefore, further investigations are important to understand the temporal and spatial expansion of *C. racemosa*, *C. serrulata*, *C. sertularioides*, *C. taxifolia*, and *C. peltata* in these Islands. Also, multidisciplinary approaches are essential to address issues related to invasive species distribution dynamics, impacts, management, and utilization in the Gulf of Mannar. Also, the impact of environmental factors such as light, temperature, and water quality in different seasons should be analysed in future studies to understand bloom dynamics.

REFERENCES

Antolić, B., A. Žuljević, M. Despalatović, I. Grubelić & I. Cvitković (2008). Impact of the invasive green alga *Caulerpa racemosa* var. *cylindracea* on the epiphytic macroalgal assemblage of *Posidonia oceanica* seagrass rhizomes in the Adriatic Sea. *Nova Hedwigia* 86(1–2): 155–167.

Boudouresque, C.F., R. Lemeé, X. Mari & A. Meinesz (1996). The invasive alga *Caulerpa taxifolia* is not a suitable diet for the sea urchin *Paracentrotus lividus*. *Aquatic Botany* 53(3–4): 245–250.

Bouiaidjra, B.B., M.Z. Taleb, A. Marouf, Y.M. Benkada & H. Riadi (2010). First record of the invasive alga *Caulerpa racemosa* (Caulerpales, Chlorophyta) in the Gulf of Arzew (western Algeria). *Aquatic Invasions* 5(1): S97–S101.

Ceccherelli, G. & F. Cinelli (1999). The role of vegetative fragmentation in dispersal of the invasive alga *Caulerpa taxifolia* in the Mediterranean. *Marine Ecology Progress Series* 182: 299–303.

de Villèle, X. & M. Verlaque (1995). Changes and degradation in a *Posidonia oceanica* bed invaded by the introduced tropical alga *Caulerpa taxifolia* in the north western Mediterranean. *Botanica Marina* 38(1–6): 79–88.

Edward, J.K.P., G. Mathews, D.K. Raj, S. Rajesh, A. Arasamuthu & R.L. Laju (2015). 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* 30: 50–53.

Guiry, M.D. & G.M. Guiry (2018). AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. Searched on 29 October 2018.

Hoey, A.S., M. S. Prachett & C. Cvitanovic (2011). High macroalgal cover and low coral recruitment undermines the potential resilience of the world's southernmost coral reef assemblages. *PLoS One* 6(10): e25824. <https://doi.org/10.1371/journal.pone.0025824>

Kaliaperumal, N. & V.S.K. Chennubhotla (2017). Studies on value added products from Indian marine algae- A review. *Seaweed Research and Utilization* 39(1): 1–9.

Klein, J. & M. Verlaque (2008). The *Caulerpa racemosa* invasion: A critical review. *Marine Pollution Bulletin* 56(2): 205–225.

Kersting, D.K., E. Ballesteros, S. De Caralt & C. Linares (2014). Invasive macrophytes in a marine reserve (Columbretes islands, NW Mediterranean): Spread dynamics and interactions with the endemic scleractinian coral *Cladocora caespitosa*. *Biological Invasions* 16: 1599–1610.

Lemee, R., C.F. Boudouresque, J. Gobert, P. Malestroit, X. Mari, A. Meinesz, V. Menager & S. Ruitton (1996). Feeding behavior of *Paracentrotus lividus* in the presence of *Caulerpa taxifolia* introduced in the Mediterranean Sea. *Oceanologica Acta* 19(3–4): 245–253.

Manikandan, B. & J. Ravindran (2016). Differential response of coral communities to *Caulerpa* spp. bloom in the reefs of Indian Ocean. *Environmental Science and Pollution Research* 24(4): 3912–3922. <https://doi.org/10.1007/s11356-016-8136-5>

Mary, A., V. Mary, A. Lorella & J.R.M. Matias (2009). Rediscovery of naturally occurring seagrass *Caulerpa lentillifera* from the Gulf of Mannar and its mariculture. *Current Science* 97(10): 1418–1420.

McCook, L.J., J. Jompa & G. Diaz-Pulido (2001). Competition between corals and algae on coral reefs: a review of evidence and mechanisms. *Coral Reefs* 19: 400–417.

Otero, M., E. Cebrian, P. Francour, B. Galil & D. Savini (2013). Monitoring marine invasive species in Mediterranean marine protected areas (MPAs)—strategy and practical guide for managers. IUCN centre for Mediterranean cooperation, Gland, Switzerland.

Paul, V.J., S.G. Nelson & H.R. Sanger (1990). Feeding preferences of adult and juvenile rabbit fish *Siganus argenteus* in relation to chemical defenses of tropical seaweeds. *Marine Ecology Progress Series* 60: 23–34.

Perez-Estrada, C.J., R. Rodriguez-Estrella, D.S. Palacios-Salgado & D.A. Paz-Garcia (2013). Initial spread of the invasive green alga *Caulerpa verticillata* over coral communities in the Gulf of California. *Coral Reefs* 32: 865.

Rajan, D.S. & K. Padmakumar (2017). Feeding deterrent activity of marine algae from southern coast of India. *Seaweed Research and Utilization* 39(1): 39–43.

Ramesh, C.H., S. Koushik, T. Shunmugaraj & M.V.R. Murthy (2019). Bioinvasive seaweed genus, *Turbinaria* in coral reefs of Gulf of Mannar. *Journal of Life Sciences* 6: 1–4.

Smith, C.M. & L.J. Walters (1999). Fragmentation as a strategy for *Caulerpa* species: fates of fragments and implications for management of an invasive weed. *Marine Ecology* 20(3–4): 307–319.

Smith, J.E., C.L. Hunter & C.M. Smith (2002). Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands. *Pacific Science* 56(3): 299–315.

Tebben, J., C.A. Motti, N. Siboni, D.M. Tapiolas, A.P. Negri, P.J. Schupp, M. Kitamura, M. Hatta, P.D. Steinberg & T. Harder (2015). Chemical mediation of coral larval settlement by crustose coralline algae. *Scientific Reports* 5: 10803.

Wylie, C.R. & V.J. Paul (1988). Feeding preferences of the surgeonfish *Zebrasoma flavescens* in relation to chemical defenses of tropical algae. *Marine Ecology Progress Series* 45: 23–32.

Žuljević, A., T. Thibaut, M. Despalatovic, J.M. Cottalorda, V. Nikolic, I. Cvitkovic & B. Antolic (2011). Invasive alga *Caulerpa racemosa* var. *cylindracea* makes a strong impact on the Mediterranean sponge *Sarcotragus spinosulus*. *Biological Invasions* 13: 2303–2308.



Dr. George Mathew, Kerala Forest Research Institute, Peechi, India
Dr. John Noyes, Natural History Museum, London, UK
Dr. Albert G. Orr, Griffith University, Nathan, Australia
Dr. Sameer Padhye, Katholieke Universiteit Leuven, Belgium
Dr. Nancy van der Poorten, Toronto, Canada
Dr. Karen Schnabel, NIWA, Wellington, New Zealand
Dr. R.M. Sharma, (Retd.) Scientist, Zoological Survey of India, Pune, India
Dr. Manju Siliwal, WILD, Coimbatore, Tamil Nadu, India
Dr. G.P. Sinha, Botanical Survey of India, Allahabad, India
Dr. K.A. Subramanian, Zoological Survey of India, New Alipore, Kolkata, India
Dr. P.M. Sureshan, Zoological Survey of India, Kozhikode, Kerala, India
Dr. R. Varatharajan, Manipur University, Imphal, Manipur, India
Dr. Eduard Vives, Museu de Ciències Naturals de Barcelona, Terrassa, Spain
Dr. James Young, Hong Kong Lepidopterists' Society, Hong Kong
Dr. R. Sundararaj, Institute of Wood Science & Technology, Bengaluru, India
Dr. M. Nithyanandan, Environmental Department, La Al Kuwait Real Estate. Co. K.S.C., Kuwait
Dr. Himender Bharti, Punjabi University, Punjab, India
Mr. Purnendu Roy, London, UK
Dr. Saito Motoki, The Butterfly Society of Japan, Tokyo, Japan
Dr. Sanjay Sondhi, TITLI TRUST, Kalpavriksh, Dehradun, India
Dr. Nguyen Thi Phuong Lien, Vietnam Academy of Science and Technology, Hanoi, Vietnam
Dr. Nitin Kulkarni, Tropical Research Institute, Jabalpur, India
Dr. Robin Wen Jiang Ngiam, National Parks Board, Singapore
Dr. Lionel Monod, Natural History Museum of Geneva, Genève, Switzerland.
Dr. Asheesh Shivam, Nehru Gram Bharti University, Allahabad, India
Dr. Rosana Moreira da Rocha, Universidade Federal do Paraná, Curitiba, Brasil
Dr. Kurt R. Arnold, North Dakota State University, Saxony, Germany
Dr. James M. Carpenter, American Museum of Natural History, New York, USA
Dr. David M. Claborn, Missouri State University, Springfield, USA
Dr. Karen Schnabel, Marine Biologist, Wellington, New Zealand
Dr. Amazonas Chagas Júnior, Universidade Federal de Mato Grosso, Cuiabá, Brasil
Mr. Monsoon Jyoti Gogoi, Assam University, Silchar, Assam, India
Dr. Heo Chong Chin, Universiti Teknologi MARA (UiTM), Selangor, Malaysia
Dr. R.J. Shiel, University of Adelaide, SA 5005, Australia
Dr. Siddharth Kulkarni, The George Washington University, Washington, USA
Dr. Priyadarsanan Dharma Rajan, ATREE, Bengaluru, India
Dr. Phil Alderslade, CSIRO Marine And Atmospheric Research, Hobart, Australia
Dr. John E.N. Veron, Coral Reef Research, Townsville, Australia
Dr. Daniel Whitmore, State Museum of Natural History Stuttgart, Rosenstein, Germany.
Dr. Yu-Feng Hsu, National Taiwan Normal University, Taipei City, Taiwan
Dr. Keith V. Wolfe, Antioch, California, USA
Dr. Siddharth Kulkarni, The Hormiga Lab, The George Washington University, Washington, D.C., USA
Dr. Tomas Ditrich, Faculty of Education, University of South Bohemia in Ceske Budejovice, Czech Republic
Dr. Mihaly Foldvari, Natural History Museum, University of Oslo, Norway
Dr. V.P. Uniyal, Wildlife Institute of India, Dehradun, Uttarakhand 248001, India
Dr. John T.D. Caleb, Zoological Survey of India, Kolkata, West Bengal, India
Dr. Priyadarsanan Dharma Rajan, Ashoka Trust for Research in Ecology and the Environment (ATREE), Royal Enclave, Bangalore, Karnataka, India

Fishes

Dr. Neelesh Dahanukar, IISER, Pune, Maharashtra, India
Dr. Topiltzin Contreras MacBeath, Universidad Autónoma del estado de Morelos, México
Dr. Heok Hee Ng, National University of Singapore, Science Drive, Singapore
Dr. Rajeev Raghavan, St. Albert's College, Kochi, Kerala, India
Dr. Robert D. Sluka, Chiltern Gateway Project, A Rocha UK, Southall, Middlesex, UK
Dr. E. Vivekanandan, Central Marine Fisheries Research Institute, Chennai, India
Dr. Davor Zanella, University of Zagreb, Zagreb, Croatia
Dr. A. Biju Kumar, University of Kerala, Thiruvananthapuram, Kerala, India
Dr. Akhilesh K.V., ICAR-Central Marine Fisheries Research Institute, Mumbai Research Centre, Mumbai, Maharashtra, India
Dr. J.A. Johnson, Wildlife Institute of India, Dehradun, Uttarakhand, India
Dr. R. Ravinesh, Gujarat Institute of Desert Ecology, Gujarat, India

Amphibians

Dr. Sushil K. Dutta, Indian Institute of Science, Bengaluru, Karnataka, India
Dr. Annemarie Ohler, Muséum national d'Histoire naturelle, Paris, France

Reptiles

Dr. Gernot Vogel, Heidelberg, Germany
Dr. Raju Vyas, Vadodara, Gujarat, India
Dr. Pritpal S. Soorae, Environment Agency, Abu Dhabi, UAE.
Prof. Dr. Wayne J. Fuller, Near East University, Mersin, Turkey
Prof. Chandrashekher U. Rivonker, Goa University, Taleigao Plateau, Goa, India
Dr. S.R. Ganesh, Chennai Snake Park, Chennai, Tamil Nadu, India
Dr. Himansu Sekhar Das, Terrestrial & Marine Biodiversity, Abu Dhabi, UAE

Birds

Dr. Hem Sagar Baral, Charles Sturt University, NSW Australia
Mr. H. Biju, Coimbatore, Tamil Nadu, India
Dr. Chris Bowden, Royal Society for the Protection of Birds, Sandy, UK
Dr. Priya Davidar, Pondicherry University, Kalapet, Puducherry, India
Dr. J.W. Duckworth, IUCN SSC, Bath, UK
Dr. Rajah Jayopal, SACON, Coimbatore, Tamil Nadu, India
Dr. Rajiv S. Kalsi, M.L.N. College, Yamuna Nagar, Haryana, India
Dr. V. Santharam, Rishi Valley Education Centre, Chittoor Dt., Andhra Pradesh, India
Dr. S. Balachandran, Bombay Natural History Society, Mumbai, India
Mr. J. Praveen, Bengaluru, India
Dr. C. Srinivasulu, Osmania University, Hyderabad, India
Dr. K.S. Gopi Sundar, International Crane Foundation, Baraboo, USA
Dr. Gombobaatar Sundev, Professor of Ornithology, Ulaanbaatar, Mongolia
Prof. Reuven Yosef, International Birding & Research Centre, Eilat, Israel
Dr. Taej Mundkur, Wetlands International, Wageningen, The Netherlands
Dr. Carol Inskip, Bishop Auckland Co., Durham, UK
Dr. Tim Inskip, Bishop Auckland Co., Durham, UK
Dr. V. Gokula, National College, Tiruchirappalli, Tamil Nadu, India
Dr. Arkady Lelej, Russian Academy of Sciences, Vladivostok, Russia
Dr. Simon Dowell, Science Director, Chester Zoo, UK
Dr. Mário Gabriel Santiago dos Santos, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, Vila Real, Portugal
Dr. Grant Connette, Smithsonian Institution, Royal, VA, USA
Dr. M. Zafar-ul Islam, Prince Saud Al Faisal Wildlife Research Center, Taif, Saudi Arabia

Mammals

Dr. Giovanni Amori, CNR - Institute of Ecosystem Studies, Rome, Italy
Dr. Anwaruddin Chowdhury, Guwahati, India
Dr. David Mallon, Zoological Society of London, UK
Dr. Shomita Mukherjee, SACON, Coimbatore, Tamil Nadu, India
Dr. Angie Appel, Wild Cat Network, Germany
Dr. P.O. Nameer, Kerala Agricultural University, Thrissur, Kerala, India
Dr. Ian Redmond, UNEP Convention on Migratory Species, Lansdown, UK
Dr. Heidi S. Riddle, Riddle's Elephant and Wildlife Sanctuary, Arkansas, USA
Dr. Karin Schwartz, George Mason University, Fairfax, Virginia.
Dr. Lala A.K. Singh, Bhubaneswar, Orissa, India
Dr. Mewa Singh, Mysore University, Mysore, India
Dr. Paul Racey, University of Exeter, Devon, UK
Dr. Honnavalli N. Kumara, SACON, Anaikatty P.O., Coimbatore, Tamil Nadu, India
Dr. Nishith Dharaiya, HNG University, Patan, Gujarat, India
Dr. Spartaco Gippoliti, Socio Onorario Società Italiana per la Storia della Fauna "Giuseppe Altobello", Rome, Italy
Dr. Justus Joshua, Green Future Foundation, Tiruchirappalli, Tamil Nadu, India
Dr. H. Raghuram, The American College, Madurai, Tamil Nadu, India
Dr. Paul Bates, Harison Institute, Kent, UK
Dr. Jim Sanderson, Small Wild Cat Conservation Foundation, Hartford, USA
Dr. Dan Challender, University of Kent, Canterbury, UK
Dr. David Mallon, Manchester Metropolitan University, Derbyshire, UK
Dr. Brian L. Cypher, California State University-Stanislaus, Bakersfield, CA
Dr. S.S. Talmale, Zoological Survey of India, Pune, Maharashtra, India
Prof. Karan Bahadur Shah, Budhanilkantha Municipality, Kathmandu, Nepal
Dr. Susan Cheyne, Borneo Nature Foundation International, Palangkaraya, Indonesia
Dr. Hemanta Kafley, Wildlife Sciences, Tarleton State University, Texas, USA

Other Disciplines

Dr. Aniruddha Belsare, Columbia MO 65203, USA (Veterinary)
Dr. Mandar S. Paingankar, University of Pune, Pune, Maharashtra, India (Molecular)
Dr. Jack Tordoff, Critical Ecosystem Partnership Fund, Arlington, USA (Communities)
Dr. Ulrike Streicher, University of Oregon, Eugene, USA (Veterinary)
Dr. Hari Balasubramanian, EcoAdvisors, Nova Scotia, Canada (Communities)
Dr. Rayanna Helleni Santos Bezerra, Universidade Federal de Sergipe, São Cristóvão, Brazil
Dr. Jamie R. Wood, Landcare Research, Canterbury, New Zealand
Dr. Wendy Collinson-Jonker, Endangered Wildlife Trust, Gauteng, South Africa
Dr. Rajeshkumar G. Jani, Anand Agricultural University, Anand, Gujarat, India
Dr. O.N. Tiwari, Senior Scientist, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India
Dr. L.D. Singla, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, India
Dr. Rupika S. Rajakaruna, University of Peradeniya, Peradeniya, Sri Lanka
Dr. Bharat Baviskar, Wild-CER, Nagpur, Maharashtra 440013, India

Reviewers 2019–2021

Due to paucity of space, the list of reviewers for 2018–2020 is available online.

The opinions expressed by the authors do not reflect the views of the Journal of Threatened Taxa, Wildlife Information Liaison Development Society, Zoo Outreach Organization, or any of the partners. The journal, the publisher, the host, and the partners are not responsible for the accuracy of the political boundaries shown in the maps by the authors.

Print copies of the Journal are available at cost. Write to:

The Managing Editor, JoTT,
c/o Wildlife Information Liaison Development Society,
43/2 Varadarajulu Nagar, 5th Street West, Ganapathy, Coimbatore,
Tamil Nadu 641006, India
ravi@threatenedtaxa.org

Journal of Threatened Taxa is indexed/abstracted in Bibliography of Systematic Mycology, Biological Abstracts, BIOSIS Previews, CAB Abstracts, EBSCO, Google Scholar, Index Copernicus, Index Fungorum, JournalSeek, National Academy of Agricultural Sciences, NewJour, OCLC WorldCat, SCOPUS, Stanford University Libraries, Virtual Library of Biology, Zoological Records.

NAAS rating (India) 5.64

Article

Documenting butterflies with the help of citizen science in Darjeeling-Sikkim Himalaya, India

– Aditya Pradhan, Rohit George & Sailendra Dewan, Pp. 22771–22790

Communications

Determinants of diet selection by Blackbuck *Antilope cervicapra* at Point Calimere, southern India: quality also matters

– Selvarasu Sathishkumar, Subhasish Arandhara & Nagarajan Baskaran, Pp. 22791–22802

An update on the conservation status of Tibetan Argali *Ovis ammon hodgsoni* (Mammalia: Bovidae) in India

– Munib Khanyari, Rigzen Dorjay, Sherab Lobzang, Karma Sonam & Kulbhushansingh Ramesh Suryawanshi, Pp. 22803–22812

An annotated checklist of the avifauna of Karangadu mangrove forest, Ramanathapuram, Tamil Nadu, with notes on the site's importance for waterbird conservation

– H. Byju, N. Raveendran, S. Ravichandran & R. Kishore, Pp. 22813–22822

Habitats and nesting habits of Streaked Weaver *Ploceus manyar* in select wetlands in the northern districts of Tamil Nadu, India

– M. Pandian, Pp. 22823–22833

Genetic evidence on the occurrence of *Channa harcourtbutleri* (Annandale, 1918) in Eastern Ghats, India: first report from mainland India

– Boni Amin Laskar, Harikumar Adimala, Shantanu Kundu, Deepa Jaiswal & Kailash Chandra, Pp. 22834–22840

Redefining *Pallisentis ophiocephali* (Thapar, 1930) Baylis, 1933 from two freshwater fishes of Channidae family of Hooghly District, West Bengal, India

– Prabir Banerjee & Biplob Kumar Modak, Pp. 22841–22849

A new termite species of the genus *Bulbitermes* (Blattodea: Isoptera: Termitidae) from Meghalaya, India

– Khirod Sankar Das & Sudipta Choudhury, Pp. 22850–22858

First report of the beetle *Henosepilachna nana* (Kapur, 1950) (Coleoptera: Coccinellidae) from Maharashtra with special reference to molecular phylogeny and host plants

– Priyanka B. Patil & Sunil M. Gaikwad, Pp. 22859–22865

Assessment of population, habitat, and threats to *Cycas pectinata* Buch.-Ham. (Cycadaceae), a vulnerable cycad in Bhutan

– Sonam Tobgay, Tenjur Wangdi, Karma Wangchuck, Jamyang Dolkar & Tshering Nidup, Pp. 22866–22873

Ecological niche modeling to find potential habitats of *Vanda thwaitesii*, a notified endangered orchid of Western Ghats, India

– S. William Decruse, Pp. 22874–22882

Occurrence of opportunistic invasive macroalgal genus *Caulerpa* and *Halimeda opuntia* in coral reefs of Gulf of Mannar

– Chatragadda Ramesh, Koushik Sadhukhan, T. Shunmugaraj & M.V. Ramana Murthy, Pp. 22883–22888

Short Communications

Diversity of bees in two crops in an agroforestry ecosystem in Kangsabati South Forest Division, Purulia, West Bengal, India

– Pallabi Das & V.P. Uniyal, Pp. 22889–22893

An extended distribution and rediscovery of *Rhynchosia suaveolens* (L.f.) DC. (Fabaceae) for Maharashtra, India

– Ajay K. Mishra, Vedhika Gupta, Ajay V. Rajurkar, Pankaj A. Dhole & Vijay V. Wagh, Pp. 22894–22899

Notes

New distribution records of two uncommon microhylid frogs, *Melanobatrachus indicus* Beddome, 1878 and *Mysticellus franki* Garg & Biju, 2019 from Nelliampathy, Kerala, India

– Madhura Agashe, Avraajal Ghosh, K. Dilshad, Maitreya Sil & Aniruddha Datta-Roy, Pp. 22900–22904

First record of Brilliant Flash *Rapala melida nicevillei* (Swinhoe, 1911) (Lepidoptera: Lycaenidae: Theclinae) to Meghalaya, India

– Suman Bhowmik, Atanu Bose, Jayant Ghanshyam Bhoir, Atanu Bora, Suraj Das, Shyamal Kumar Laha & Ngangom Aomoa, Pp. 22905–22907

A note on the occurrence of *Cremnochonchus conicus* (Blanford, 1870) in Mumbai, India

– Naman Kaji & Shubham Yadav, Pp. 22908–22910

Jasminum angustifolium (L.) Willd. var. *angustifolium* (Oleaceae): a new distribution record for West Bengal, India

– Keya Modak & Monoranjan Chowdhury, Pp. 22911–22915

Cyrtosia falconeri (Hook.f.) Aver. (Orchidaceae): an addition to the flora of Jammu & Kashmir, India

– Mushtaq Ahmed & Manjul Dhiman, Pp. 22916–22919

New distribution record of *Roridomyces cf. phyllostachydis* (Agaricales: Mycenaceae), a bioluminescent fungus from Namdapha National Park, Arunachal Pradesh, India

– Arijit Dutta, Sourav Gupta, Jayanta K. Roy & M. Firoz Ahmed, Pp. 22920–22923

Photographic evidence of bioluminescent mushroom *Mycena chlorophos* (Mycenaceae) from Goa, India

– Swanand R. Patil, Mirjoy M. Mathew, Abhijeet V. Patil, Ramesh N. Zarmekar, Pankaj R. Lad & Grenville Dcosta, Pp. 22924–22926

Publisher & Host

