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Status of seagrass ecosystems in India

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ABSTRACT

India, one of the countries with prominent seagrass resources, is represented by 16 species of seagrass with an approximate cover of 500 sq km at isolated locations along the coast, lagoons, backwaters and estuaries. Molecular taxonomic studies confirmed the distribution of these species and further studies at the population level are warranted, as there are possibilities to erect 6 new species. Gulf of Mannar, Palk Bay, Andaman and Nicobar, Lakshadweep islands and Gulf of Kutch are the major seagrass areas characterized by unique ecological variation. Though there is no comprehensive study on the seagrass associated floral and faunal composition in the country, about 1250 species of flora and fauna including endangered dugong and green turtles are reported from this fragile ecosystem. Ecology, productivity and biomass of seagrass of the country are well documented at major seagrass sites leaving the other minor seagrass areas least studied. Mapping of seagrass in Andaman and Nicobar and Lakshadweep islands and Tamilnadu coast are well documented but holistic mapping of seagrass in the entire country is still not attempted. The research on seagrass in India gained momentum in the recent past, but it still needs to go a long way to address the major research questions and transforming them as management plans.

1. Introduction

Seagrass, the marine flowering plants capable of completing its lifecycle fully submerged underwater, represents a dominant biological community along the shallow coastal areas of the world. This unique and productive coastal habitat occurs in isolated coastal, backwater, lagoon and estuarine systems in India. Rightly termed as biological sentinels for its capacity to indicate the status of ecosystem health; it is also known as ecological engineers for its role in modifying and stabilizing the ecosystem. Though there are plenty of floral and faunal species depending on the seagrass beds, only limited attempts have been made in the past to collect scientific data on the associated species. Dugong and green turtles are dependent on seagrass for food and are in the limelight on conservation priorities for quite long time, but data on their actual population size based on scientific census is missing. On one side, an alarming decline of dugong population has been reported from all locations where it occurs, leading to the existence of only 200 individuals in the country (Sivakumar, 2013). On the other hand, increase in the population of green turtle poses threat to the existence of seagrass ecosystem in the Lakshadweep Islands.

There is no report at all on the seagrass ecosystem service values, which requires immediate attention. Seagrass are reported to provide 28 ecosystem services and several of these services vary across genera and bioregions (Nordlund et al., 2016). Research on seagrass in India moved towards exploring biotechnological potentials from conventional ecological studies, leaving conservation and management of seagrass under more pressure. In India, seagrass ecosystem has gained meagre attention with respect to scientific, conservation or management issues when compared with other coastal habitats such as the coral reefs, mangroves etc. India stands in 16th position in terms of number of publications on seagrass (York et al., 2016), while countries with small coastal area and EEZ are leading in the number of publications. This is because of the implementation of motivated, effective, specialized programs for seagrass in the respective countries. In fact, Australia doubled its publication on seagrass after its strategic review on seagrass conducted in the year 1999. While number of publications alone is not the crucial factor, development of strategies that ensure conservation and management of the fragile ecosystem requires scientific grounds. This paper presents the status of research on seagrass ecosystems, its diversity, distribution, functions, associated species, and legislation towards conservation in India and stresses the importance of giving larger attention to this critical ecosystem.

2. Taxonomy

India with its coastline of about 8000 km harbours seagrass at

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isolated locations including bays, open seas, estuaries, lagoons and backwaters. The occurrence of seagrass in India has been recorded since 1880s (Hooker, 1888, 1893). However, seagrass studies have started to take prominence only by 1950s with continuous efforts by different groups of researchers. The literature on Indian seagrass are available since 1959, nevertheless exact number of species distributed in the country is still under question, largely because of the misidentification, recognition of sub species and other reasons. Compilation of the published results provides list of 22 seagrass species in India. However, species like *Ruppia rostellata, Zostera marina, Portresia coarchtata, Urochondra setulosa, Syringodium acoroides, Thalassodendron ciliatum* are removed from the list for the following reasons: *Z. marina* is a typical temperate species and its distribution in tropical region is doubtful; *P. coarchtata* and *U. setulosa* are grasses growing in the marshy environment; *Stratiotes acoroides* was wrongly identified as *Syringodium acoroides*, which is the old name for *Enhalus acoroides;* and *T. ciliatum* reported from Palk Bay is confirmed as the male plant of *Cymodocea serulatta*. *R. rostellata* is a synonym of *R. maritima*. *Halodule minor* was reported from the Andaman Islands (D'Souza et al., 2013, 2015) and also from the Chilika Lake (Priyadarsini et al., 2014). After the above modifications, 16 species belonging to 7 genera (*Ruppia, Enhalus, Halophila, Thalassia, Syringodium, Cymodocea and Halodule*) have been recognized, against the 14-species reported earlier (Kannan et al. 1999; Lucas et al., 2012; Dilipan et al., 2016b).

2.1. Genetic and molecular taxonomy

Applying morphological characters and taxonomic keys for species differentiation are laborious and time-consuming, sometimes leading to miss interpretation of closely related species. Recent progress in molecular taxonomic tools are more universal, time-saving, consistent and reliable. Molecular methods using one or several appropriate genes are gaining increasing importance because they yield quick and in most cases, unequivocal results.

Lucas et al. (2012) analyzed 14 species of seagrass of India to develop a DNA barcoding system. They demonstrated that the tree and character-based approaches of the *rbc*L sequence fragment is capable of resolving up to family and genus level while *mat*K sequences were reliable in resolving species and partially the ecotype level. Addition of third loci *trn*H/*psb*A in the barcoding system did not help in resolving the complexity of classification. Nguyen et al. (2015) have reported that ITS could be applied as a DNA barcode for seagrass instead of the *rbc*L/*mat*K system previously proposed.

Studies indicate that RAPD technique can be used not only as the tool for the analysis of genetic diversity, but also to resolve taxonomic issues of Indian seagrass (Dilipan et al., 2016a). The primers 3003A, 3010 A and 5852 A are the best primers for molecular identification of the Indian seagrass, which needs to be tested further with different populations (Dilipan et al., 2016a). Though the occurrence of *H. ovata* in the Bay of Bengal was questioned for quite some time, AFLP results confirmed that *H. ovalis* and *H. ovata* are distinct species found distributed in 5 different parts of the Bay. *H. ovalis* (collected at lagoon, estuary and open sea) and *H. ovalis* subsp. *ramamurthiana* are genetically different (Nguyen et al., 2013). This warrants more studies at population level, as the possibility of finding new species still exists.

The 18S rDNA data indicates the independent origin of temperate and tropical seagrass with the genus *Halophila* as the intermediate group. *Halophila* group represents the basal form among seagrass due to their complex morphological characters whereas *Enhalus* is considered as the most recently originated seagrass species (Larkum and Den Hartog, 1989). In that context, the marine Hydrocharitaceae group of *Enhalus, Thalassia* and *Halophila* have been considered as two groups, namely, *Enhalus/Thalassia* and *Halophila* subfamilies. A revised taxonomy for seagrass reflecting the phylogenetic characters based on from molecular and conventional data is therefore warranted (Dilipan et al., 2016b).

Karyomorphological study (Vanitha et al., 2016) on seagrass in the country confirmed the number of chromosomes of 11 species of seagrass namely, *Halodule pinifolia, H. uninervis* and *H. wrightii* (2n = 44), *Syringodium isoetifolium* (2n = 20), *Cymodocea rotundata* (2n = 14), *C. serrulata* (4n = 28) and *Enhalus acoroides, Halophila beccarii, H. ovalis* sub sp. *ovalis, H. ovalis* sub sp. *ramamurthiana*, *H. ovata* and *T. hemprichii* (2n = 18). All the above species are diploid, except *Cymodocea serrulata,* which is a tetraploid. The above study also emphasized the need

Table 1
Distribution of seagrasses in various sites of India.

S.No.	Species	Gujarat	Maharashtra	Goa	Karnataka	Kerala	Tamil Nadu			Andhra Pradesh	Orissa	West Bengal	Lakshadweep	Andaman Islands	Nicobar Islands
							Gulf of Mannar	Palk Bay	Other sites						
1.	*Enhalus acoroides*	–	–	–	–	+	+	+	–	–	–	–	+	+	+
2.	*Halophila ovalis*	+	–	+	–	+	+	+	+	+	+	+	+	+	+
3.	*H. ovata*	+	–	–	–	–	+	+	–	+	+	+	+	+	+
4.	*H. decipiens*	–	+	–	–	–	+	+	–	–	–	–	+	+	–
5.	*H. stipulacea*	–	–	–	–	–	+	+	–	–	–	–	–	+	–
6.	*H. beccarii*	+	+	+	+	+	+	+	+	+	+	+	–	–	–
7.	*H. ovalis ramamurthiana*	–	–	–	–	–	–	+	+	+	+	–	–	–	–
8.	*H. minor*	–	–	–	–	–	–	–	–	–	+	–	–	+	–
9.	*Thalassia hemprichii*	+	–	–	–	–	+	+	–	–	–	–	+	+	+
10.	*Syringodium isoetifolium*	–	–	–	–	–	+	+	+	–	–	–	+	+	+
11.	*Cymodocea serrulata*	+	–	–	–	–	+	+	+	–	–	–	+	+	+
12.	*C. rotundata*	–	–	–	–	–	+	+	+	–	–	–	+	+	+
13.	*Halodule pinifolia*	+		–	–	–	+	+	+	+	+	+	+	+	+
14.	*H. uninervis*	+	–	–	–	–	+	+	+	+	+	+	+	+	+
15	*H. wrightii*	–	–	–	–	–	+	+	+	+	–	+	–	–	–
16.	*Rupia maritima*	+	–	–	–	–	+	–	–	–	+	–	–	–	–
Total		8	2	2	1	3	14	14	9	7	8	6	10	12	9

+: present; -: absent.