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Diversity and distribution of seaweeds in the Kudankulam coastal waters, South-Eastern coast of India

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ABSTRACT The macroalgal resources of inter-tidal region of Kudankulam coastal waters are presented in this paper. A total of 32 taxa were recorded in the Kudankulam region: 15 belonging to Chlorophyta, 8 to Phaeophyta and 9 to Rhodophyta. *Ulva fasciata* Delil, *Sargassum wightii* Greville, *Chaetomorpha linum* (O.F. Müller) Kützing, *Hydropuntia edulis* (Gmelin) Gurgel et Fredericq, *Dictyota dichotoma* (Hudson) Lamouroux, *Caulerpa sertulariodes* (Gmelin) Howe, *Acanthophora muscoides* (Linnaeus) Bory de Saint-Vincent and *Ulva compressa* Linnaeus were the commonly occurring seaweeds in the rocky shores and other submerged hard surfaces. The seasonal abundance of seaweeds was studied by submerging wooden test panels in the coastal waters. The seaweed abundance on test panels was high during pre-monsoon and monsoon periods and low in post-monsoon season. In general, an updated checklist and distribution of seaweeds from Kudankulam region of Southeast coast of India is described.

KEY WORDS macroalgae; benthic community; coastal biodiversity; rocky shores; Indian Ocean.

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INTRODUCTION

Seaweeds are considered as ecologically and biologically important component in the marine ecosystems. Seaweeds make a substantial contribution to marine primary production and provide habitat for nearshore benthic communities (Mann, 1973; Williams & Smith, 2007).

Seaweeds are key space occupiers of rocky shores and interact with other organisms and hence play a key role in overall coastal biodiversity. They are found on rocks in the intertidal zone as a giant underwater forest. It was estimated that about 200 seaweed species support an international economy in primarily phycocolloid (algins, agars, and carrageenans) and food products valued at over billions of U.S. $ 6.2 (Zemke-White & Ohno, 1999).

Seaweeds grow abundantly along the Indian coastline particularly in rocky shore regions; rich seaweed beds occur around Visakhapatnam in the eastern coast, Mahabalipuram, Gulf of Mannar, Tiruchendur, Tuticorin and Kerala in the southern coast; Veraval and Gulf of Kutch in the western coast; Andaman and Nicobar Islands and Lakshadweep (Umamaheswara Rao, 1967; Silva et al., 1996; Sahoo, 2001).

The seaweed resources are also abundant around Mumbai, Ratnagiri, Goa, Karwar, Varkala, Vizhinjam and Pulicat in Tamil Nadu and Chilka in Orissa. About 841 taxa of marine algae were found in both inter-tidal and deep water regions of the Indian coast (Oza & Zaidi, 2001).

Seaweeds are under threat in developing countries, where they are being disturbed by a variety of human activities. Increasing concern on destruction of seaweed resources and alterations in the diversity of various life forms makes it necessary the studies on the taxonomy and species diversity for a better management of marine algae. Although systematic studies on marine algae and their distribution are

known from different coastal parts of India, not much published informations are available about the seaweeds of Kudankulam coastal waters, hence the distribution and diversity of seaweed species of Kudankulam coast is presented in this paper. Such a study in this region can be of great importance due to the emerging mega Nuclear Power Project.

Ecological survey of water bodies around a power plant is an important endeavour both from the environmental and the operational point of view. The release of warm water to the receiving water body is of concern due to the long and short-term impact on the flora and fauna.

MATERIALS AND METHODS

The investigation was carried out at Kudankulam (8° 9' 5" N and 77° 39' 59" E), Gulf of Mannar in the southeast coast of India (Fig. 1). The study area is situated on the distal end of Gulf of Mannar Biosphere Reserve. The rocky shore of Kudankulam inhabits an astonishing biodiversity, representing nearly almost all the invertebrate phyla and urochordates. Hard rocky bottom of this area greatly supports the algal diversity and provide suitable shelter and feeding ground for grazers. Seasons at Kudankulam may be classified into pre-monsoon (June-September), monsoon (October-January), and post-monsoon (February-May).

Field surveys were undertaken to the selected sampling stations of the Kudankulam region over a period of three years from 2003 to 2006. The algal samples were collected in every season during the study period by detaching a portion from the seaweed bed, kept in polythene bags with fresh seawater, transported to the laboratory and fixed in 4% formaldeyde for further studies.

The seaweeds were identified using the taxonomic keys provided by Umamaheswara Rao (1987), Desikachary et al. (1990, 1998) and Krishnamurthy (1999), and the nomenclature was updated using Appeltans et al. (2012).

The seasonal distribution of seaweeds was studied by submerging test panels for a period of one year from June 2003 to May 2004. Test panels made from teak wood with a size of 10 x 10 x 2 cm were vertically placed in a suitably designed wooden raft with grooves in such a way so as to keep a 10 cm distance between panels.

The raft with panels (in replicate, n = 6) was suspended at 2 m depth in the coastal waters using floats and sinkers. Panels were suspended during the first week of a season and retrieved during the last week of that season so as to keep the panels for 110 days in coastal waters. Each panel was studied for the seaweed species composition and biomass. The total and the differential biomass (wet weight) of the seaweeds were estimated after carefully scrapping them from the panels and weighing them.

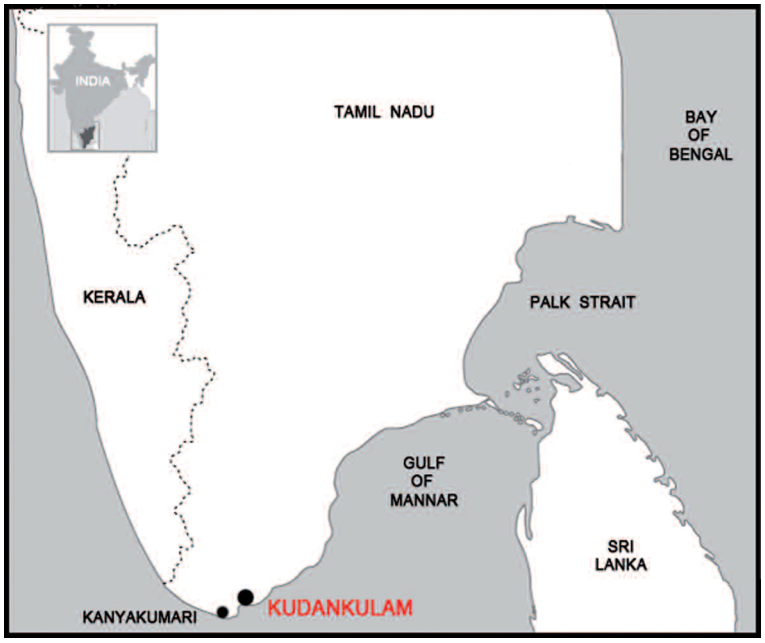

Figure 1. Map showing the study area: Kudankulam, Gulf of Mannar in the southeast coast of India.

RESULTS

A total of 32 seaweed taxa were collected from the Kudankulam region (Table 1). The Chlorophyta prevailed with 15 taxa followed by Rhodophyta (9 taxa) and Phaeophyta (8 taxa).

Ulva fasciata Delile, *Sargassum wightii* Greville, *Chaetomorpha linum* (O.F.Müller) Kützing, *Gracilaria edulis* (Gmelin) Gurgel et Fredericq, *Dictyota dichotoma* (Hudson) Lamouroux, *Caulerpa sertularioides* (Gmelin) Howe, *Acanthophora muscoides* (Linnaeus) Bory de Saint-Vincent and *Ulva compressa* Linnaeus were the commonly found seaweeds in the rocky shores and other submerged hard surfaces.

Ulva fasciata is the common green alga inhabiting the rocky shores of this region. During the monsoon season (October-January), *Ulva fasciata* forms thick mats covering the entire rocky substratum (Fig. 2).

CHLOROPHYTA

Order Ulvales
Family Ulvaceae
Ulva compressa Linnaeus, 1753
Ulva intestinalis Linnaeus, 1753
Ulva fasciata Delile, 1813
Ulva lactuca Linnaeus, 1753
Ulva reticulata Forsskål, 1775

Order Cladophorales
Family Cladophoraceae
Chaetomorpha antennina (Bory de Saint-Vincent) Kützing , 1847
Chaetomorpha linoides Kützing, 1847
Chaetomorpha linum (O.F. Müller) Kützing, 1845

Order Bryopsidales
Family Caulerpaceae
Caulerpa peltata Lamouroux, 1809
Caulerpa scalpelliformis (Brown ex Turner) Agardh, 1817
Caulerpa sertularioides (Gmelin) Howe, 1905
Caulerpa racemosa (Forsskål) Agardh , 1873

Family Halimedaceae
Halimeda macroloba Decaisne, 1841
Halimeda opuntia (Linnaeus) Lamouroux, 1816

Order Siphonocladales
Family Valoniaceae
Valoniopsis pachynema (Martens) Børgesen, 1934

PHAEOPHYTA

Order Dictyotales
Family Dictyotaceae
Dictyota dichotoma (Hudson) Lamouroux, 1809
Padina pavonica (Linnaeus) Thivy, 1960
Padinia antillarum (Kützing) Picone, 1886
Padina gymnospora (Kützing) Sonder, 1871
Stoechospermum polypodioides (Lamouroux) Agardh, 1848

Order Ectocarpales
Family Scytosiphonaceae
Colpomenia sinuosa (Mertens ex Roth) Derbès et Solier, 1851

Order Fucales
Family Sargassaceae
Sargassum ilicifolium (Turner) Agardh, 1820
Sargassum wightii Greville, 1848

RHODOPHYTA

Order Gracilariales
Family Gracilariaceae
Hydropuntia edulis (Gmelin) Gurgel et Frdricq, 2004
Gracilaria corticata (Agardh) Agardh, 1852
Gracilaria debilis (Forsskål) Børgesen, 1932

Order Gigartinales
Family Solieriaceae
Sarconema filiforme (Sonder) Kylin, 1932

Family Cystocloniaceae
Hypnea valentiae (Turner) Montagne, 1841

Family Phyllophoraceae
Ahnfeltiopsis densa (J.Agardh) Silva et De Cew,1992

Order Ceramiales
Family Rhodomelaceae
Acanthophora muscoides (Linnaeus) Bory de Saint-Vincent, 1828
Palisandra perforata (Bory de Saint-Vincent) Nam, 2007

Order Corallinales
Family Corallinaceae
Amphiroa sp.

Table 1. Checklist of seaweed taxa found in Kudankulam coastal waters.

Figure 2. Intertidal rocky reef covered by *Ulva fasciata* in Kudankulam coastal waters.

Figure 3. Growth of *Ulva fasciata*, *Caulerpa racemosa*, *Sargassum wightii* and *Gracilaria corticata* in the rocky shores of stydy area.

Chaetomorpha linum, and *Caulerpa sertularioides* are the other dominant green seaweeds taxa observed during this period of study.

The brown seaweeds (Phaeophyta) are represented by 8 taxa and *Sargassum wightii* is the dominant one. *Dictyota dichotoma* and *Padina antillarum* (Kützing) Picone are also abundantly observed on the intertidal rocky reefs. A rich growth of *Sargassum* sp.pl. was observed during pre-monsoon and monsoon months (Fig. 3). *Sargassum* sp. pl. was harvested during October-December period by the local people. *Colpomenia sinuosa* (Mertens ex Roth) Derbès et Solier was commonly observed on the artificial substrata submerged in the seawater.

Rhodophyta of the Kudankulam coastal waters consisted of 9 taxa. *Gracilaria corticata* (Ag.) Agardh, *Hydropuntia edulis* (Gmelin) Gurgel et Fredericq, and *Acanthophora muscoides* (Linnaeus) Bory de Saint-Vincent were the dominant red seaweeds observed during this study period. *Amphiroa* sp. and *Hypnea valentiae* (Turner) Montagne were also commonly observed on the rocks. *Gracilaria* sp.pl. were abundantly observed during May-October period. *Acanthophora muscoides* and *Hypnea valentiae* were abundant during November-January period on the rocky shores.

The test panels immersed during June 2003 and examined at the end of September 2003 (pre-monsoon) showed a total algal biomass value of 13.14±2.9 g/dm^2 (Table 2). The macro-algal community of the panels submerged during this period was dominated by *Ulva fasciata* (5.3±1.7 g/dm^2) and *Ulva compressa* (3.18±0.9 g/dm^2) (Table 2). *Hydropuntia edulis* (2.5± 0.78 g/dm^2) was also observed as one of the dominant groups in this panel series. *Sargassum wightii*, *Padina antillarum* and *Hypnea valentiae* were also observed. The panels exposed during the monsoon season (October-January) showed a biomass value of 19±2.3 g/dm^2, dominated by *Ulva compressa* (4.7±0.9 g/dm^2) and *Acanthophora muscoides* (3.8±0.71 g/dm^2).

The biomass of *Ulva fasciata* Delil on this panel series was 1.92±0.72 g/dm^2, while *Hypnea valentiae* recorded a very low biomass value of 0.6±0.09 g/dm^2. *Sargassum wightii* was also observed on the panels with a biomass of 0.81±0.12 g/dm^2.

The panels submerged during the post-monsoon season (February-May 2004) showed a seaweed biomass of 6.3±1.2 g/dm^2. *Hydropuntia edulis*, showed a biomass value of 1.87±0.087 g/dm^2 followed by *Acanthophora muscoides* (1.71±0.48 g/dm^2). The biomass of *Ulva compressa* on post-monsoon panels was 1.6±0.2 g/dm^2 (Table 2). *Ulva fasciata* and *Hypnea valentiae* were also observed on the panels submerged during post-monsoon season.

DISCUSSION

Studies on the diversity and distribution of seaweeds in Indian waters were carried out by several authors (Untawale et al., 1989; Kalimuthu et al., 1995; Jayachandran & Ramaswamy 1997; Kaliaperumal & Kalimuthu, 1997; Stella Roslin et al., 1997; Selvaraj & Selvaraj, 1997; Mohammed et al., 1999; James et al., 2004; Krekar, 2004; Rath & Adhikary, 2006). Southeast coast of India is a unique marine habitat characterized by a high biodiversity. Results of the present study indicate the occurrence of 32 seaweed taxa in the Kudanku-

	Pre-monsoon season	Monsoon season	Post-monsoon season
Total algal biomass	13.14±2.90	19.00±2.30	6.30± 1.20
Ulva fasciata	5.30±1.70	1.92±0.72	0.70±0.04
Ulva compressa	3.18±0.90	4.70±0.90	1.60±0.20
Hydropuntia edulis	2.50± 0.78	4.70±0.90	1.87±0.09
Acanthophora muscoides	---	3.80±0.71	1.71±0.48
Sargassum wightii	---	0.81±0.12	---
Hypnea valentiae	---	0.60±0.090	---

Table 2. Biomass of seaweeds settled on the wooden test panels submerged in pre-monsoon, monsoon and post-monsoon season period at Kudankulam coast. The wet biomass values are expressed as g/dm^2. Missing values (---) indicates very low biomass values in that season.

lam coastal waters; most of the seaweeds such as *Sargassum wightii*, *Ulva fasciata*, *Gracilaria corticata* and *Chaetomorpha linum*, are abundantly observed on the rocks during the pre-monsoon (June-September) and monsoon months (October-January). The richness of seaweed resources is due to the intertidal rocky reefs available in the Kudankulam region. The seaweed flora observed in the present study is similar to that reported from the nearby Tiruchendur coast (Chennubhotla et al., 1991).

Marine ecologists have a long history of using artificial substrate and habitats to test hypothesis about sessile plants and animals (Osman, 1977; Sutherland & Karlson, 1977). In this study, settlement panels were used to analyse the seasonal distribution of macroalgal communities. The seaweed biomass on test panels was high during pre-monsoon and monsoon seasons. In an earlier study (Satheesh & Wesley, 2007), we have reported that *Gracilaria* sp., *Enteromorpha* sp., and *Ulva* sp., showed dense settlement during pre-monsoon and post monsoon months on test panels.

The observed pattern of seasonal distribution is likely to be related to the life history of the alga, particularly the dispersal abilities of its spores. The supply from macroalgal propagule may influence the abundance of algae in littoral habitats (Worm et al., 2001). As the test panels provide limited space for the settlement of marine organisms including seaweeds, the seasonal biomass of only a few species could be observed in this study.

Gradual rise in the anthropogenic influence, impact of the possible thermal discharge from the emerging nuclear power station and the indiscriminate collection of algae (mostly *Sargassum* sp.) may be the cause of concern for the biodiversity of algal species at Kudankulam coast. Both frond bleaching and cell plasmolysis of algae were observed in thermal effluent discharge areas (North, 1969; Lobban et al., 1985).

These negative effects may reduce the survival and growth of seaweeds, resulting in extensive reductions in the number of species of marine algae (Wood & Zieman, 1969).

The present study could be useful as new baseline record for future biomonitoring studies in this coast. Further systematic studies on the seaweed resources may provide useful data for the conservation of marine algal resources in this region.

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