

Research Paper

Diversity and Distribution of Seaweeds in the West Bengal Coast, India

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ABSTRACT

The marine ecosystem is one of the essential components of biodiversity and plays a vital role in the global life support systems. The coastline of West Bengal is c. 220 km in length in the Northern part of the East coast of India and supports the UNESCO heritage Mangrove site, *i.e.*, Sundarban Biosphere Reserves. Seaweeds are marine macroalgae and play a crucial role in the marine food chain and sustainability of marine ecosystems. During the present study, 23 coastal localities were surveyed between 2019-2022, and 28 taxa of seaweeds were recorded, which include 20 taxa of Chlorophyceae (71%) and eight taxa of Rhodophyceae (29%). No, Phaeophyceae member was recorded. The crucial genera include *Ulva*, *Chaetomorpha*, *Cladophora*, *Rhizoclonium*, *Codium*, *Gelidium*, *Gracilaria*, *Catenella*, *Ceramium*, *Bostrychia*, and *Polysiphonia*. Further, a red alga *Gracilaria gracilis* (Gracilariaceae) has been reported here as a new addition to the seaweed flora of the state. In the present paper, an attempt has been made to discuss the diversity and distribution of seaweed resources in West Bengal.

HIGHLIGHTS

- ① 28 taxa of Seaweeds recorded from the West Bengal coast.
- ① *Gracilaria gracilis* (Gracilariaceae) is reported as an addition to the algal flora of West Bengal.
- ① Sundarban Biosphere Reserves supports the maximum diversity of seaweeds in association with mangroves.

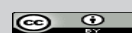
Keywords: Seaweeds, West Bengal Coast, Sundarban, Chlorophyceae, Rhodophyceae

India is one of the seventeenth megadiverse countries in the world and is endowed with a coastline of about 7500 km length. The mainland coastline is divided into the East coast (c. 2652 km long) and the West coast (c. 3216 km long), and the Islands constitute c. 1620 km length (Rao and Mantri, 2006). The vast coastline consists of a massive network of backwaters, estuaries, creeks, lagoons, mangroves, and coral reefs, which supports many marine flora and fauna. The Indian coastline harbors about 865 taxa of seaweeds (Rao and Gupta, 2015). The coastline of West Bengal is located in the northern part of the east coast of India and lies in the Bay of Bengal. It has about 220 km in length and is spread into 3 coastal districts *i.e.*, East Midnapore,

South 24 Parganas, and North 24 Parganas. Besides, West Bengal is the only state in India that touches the Himalayas in the northern part and Sea in the southern part. Located in the Gangetic basin areas, the coastline is interrupted by several major rivers, namely Bhagirathi, Hoogli, Malta, Saptamukhi, Haribhanga, and many other tributaries of the Ganges. The coastline stretches from the Digha coast in the southern end to the Sundarban Biosphere Reserves at the northern end of the Bay of Bengal.

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Seaweeds are marine macroalgae and are exclusively found in marine habitats and estuaries. It is usually lithophilic in nature and grows mainly on rocks, coralline beds, reefs, pebbles, shells, and dead corals in the shallow intertidal sub-tidal and deep sea water up to a depth of 150 m or up to a depth that can receive more than 0.12% of the incident light (Markager and Sand-Jensen, 1992). However, it is also found growing on other habitats as epiphytes on mangroves, seagrasses, and coastal wastes like ropes, plastic nets, cloths, etc. Based on the presence of photosynthetic pigments, colors, and reserve food materials, seaweeds are classified into three classes viz. Chlorophyceae (green algae), Phaeophyceae (brown algae), and Rhodophyceae (red algae). Being a primary producer in aquatic ecosystems, seaweeds along with other marine flora, play an essential role in the marine food chain and sustainability of marine ecosystems.

The conservation of biodiversity, including marine bioresources, is a global concern. *The life below water* has been included as an essential component of the Sustainable Development Goals (SDG) of the United Nations. However, only sporadic information is available on the marine flora of many maritime states, for which survey, explorations, and documentation is essential for its conservation and sustainable utilization. Globally, around 72,500 algae have been estimated, of which about 45,000 algae have been reported (Guiry, 2012). Among these, seaweeds constitute about 11,000 taxa, comprising 7,200 taxa of Rhodophyceae, 2,000 taxa of Phaeophyceae, and 1,800 taxa of Chlorophyceae (<http://www.seaweed.ie/>). From India, 865 taxa of seaweeds, including 442 taxa of Rhodophyceae, 212 taxa of Chlorophyceae, and 211 taxa of Phaeophyceae (Rao and Gupta, 2015).

The perusal of literature reveals that though considerable works have been done on the taxonomic aspects of the seaweed resources of many maritime states like Tamil Nadu (Chennubhotla, 1977; Palanisamy, 1998; Krishnamurthy and Baluswami, 2010; Ganesan *et al.* 2019), Kerala (Panikkar *et al.* 2006; Panikkar and Ampili, 2011, Palanisamy *et al.* 2020), Karnataka (Agadi, 1985, 1986; Untawale *et al.* 1989; Palanisamy and Yadav, 2017; Yadav and Palanisamy, 2020), Goa (Periera and Almeida, 2014, Palanisamy and Yadav, 2019), Maharashtra (Dhargalkar *et al.* 1980, 2001; Piwalatkar, 2010),

Gujarat (Desai, 1967; Jha *et al.* 2009; Kamboj *et al.* 2019), Andaman & Nicobar islands (Muthuvelan *et al.* 2001), Diu island (Mantri and Rao, 2005), Andhra Pradesh (Rao and Sriramulu, 1964, 1968; Kumar and Palanisamy, 2021 a & b) and Odisha (Adhikary and Sahu, 1992; Sahoo *et al.* 2001, 2003). Similarly, the algal diversity of the West Bengal coast has also been reported by various researchers (Naskar and Santra, 1985; Santra and Pal, 1988; Pal *et al.*, 1988; Chattopadhyay and Pal, 1995; Pal, 2000; Naskar *et al.*, 2000; Mukhopadhyay and Pal, 2002; Sen and Naskar, 2003; Sen *et al.* 2003; Saptati *et al.* 2012, 2013; Sengupta and Pal, 2016; Sinha *et al.*, 2016; Yadav and Majumdar, 2020; Yadav *et al.* 2020). However, many parts of West Bengal are unexplored or sporadically explored. Therefore, in the present study, an attempt has been made to provide updated information on the diversity and distribution of seaweed resources in the West Bengal.

MATERIALS AND METHODS

Collection of seaweeds

The present taxonomic study is mainly based on the field exploration and study of the relevant literature on the algal diversity of the study area (Fig. 1) carried out during the years 2019- 2022. All the important field materials such as field books, note book, polythene bags (zipped), standard plastic containers, buckets, trays, mounting boards, blotting papers, newspapers, forceps, needles, brushes, markers, soft cotton cloth, iron mess frames, ropes, fevicol (SH), camera, GPS, reference books, scales and preservatives (ethyl alcohol and formalin) were carried during field tours. The collection of fresh samples were done during low tides from 23 coastal localities in West Bengal (Table 1). The fresh seaweed samples were collected with proper care from various algal substrata like rocks (natural and artificially laid cement blocks), coastal wastes such as ropes, and plastic wastes, and also from various parts of the mangroves like pneumatophores, barks, branches in the Sundarban Biosphere Reserves (Fig. 2). During exploration, important field observations such as habit, habitats, nature of the field, vegetation pattern, association with other plants, GPS position (using GARMIN 12 channel XL), etc. were recorded and photographed using a digital camera (Nikon COOLPIX L120).

**Table 1:** List of places surveyed for collection of seaweeds in West Bengal coast

Sl. No.	Coastal places surveyed	GPS data	Status of seaweed vegetation
1	Udaypur (West Bengal-Odisha border area)	21° 36' 59.2" N & 87° 28' 93.1" E	+
2	Dheusagar	21° 36' 96.5" N & 87° 29' 98.2" E	+
3	Mohana	21° 37' 76.6" N & 87° 32' 93.3" E	+
4	Shankarpur Fishery harbor side	21° 38' 13.9" N & 87° 34' 24.8" E	+
5	Shankarpur beach	21° 38' 26.3" N & 87° 34' 88.8" E	+
6	Mandarmoni Fishery harbor	21° 40' 05.6" N & 87° 42' 92.3" E	–
7	Mandarmoni beach	21° 40' 05.7" N & 87° 42' 92.4" E	+
8	Junput	21° 43' 11.7" N & 87° 48' 94.3" E	+
9	Tajpur	21° 38' 68.1" N & 87° 36' 72.5" E	+
10	Old Digha	21° 37' 41.7" N & 87° 31' 75.2" E	+
11	New Digha	21° 37' 41.6" N & 87° 31' 75.3" E	+
12	Namkhana	21° 43' 75.6" N & 88° 12' 08.6" E	–
13	Sagardwip – Venuvan Jetty Ghat	21° 40' 62.1" N & 88° 08' 78.2" E	+
14	Sagardwip – Temple Ghat	21° 38' 19.7" N & 88° 04' 30.3" E	–
15	Bokkhali	21° 33' 49.1" N & 88° 16' 09.5" E	+
16	Sundarban BR - Amlamethi	22° 03' 64.8" N & 88° 44' 36.3" E	+
17	Sundarban BR - Island I near Jhorkhali	22° 01' 09.3" N & 88° 44' 40.0" E	–
18	Sundarban BR - Island II near Jhorkhali	22° 00' 93.4" N & 88° 44' 22.9" E	+
19	Sundarban BR - Jhorkhali coastal mangroves	22° 00' 58.9" N & 88° 42' 84.4" E	+
20	Sundarban BR – Island 1	22° 00' 63.4" N & 88° 43' 88.2" E	+

21	Sundarban BR – Island 2	22° 00' 35.1" N & 88° 43' 27.5" E	+
22	Sundarban BR - Dobanki camp	21° 59' 33.5" N & 88° 45' 24.4" E	+
23	Sundarban BR - Canning	22° 18' 47.8" N & 88° 40' 35.1" E	+

+ Present; – Absent.

Preservation of seaweed samples

All the collected seaweed samples were adequately washed with water and kept in plastic containers and zipped covers. The thoroughly washed samples were poisoned in 4% Formalin and 1% Ethyl Alcohol and were carefully preserved in wet and dry forms following the standard herbarium techniques (Srinivasan, 1969; Dhargalkar and Kavlekar, 2004). The wet preserved samples were kept in plastic containers (100 ml, 250 ml, 500 ml, and 1000 ml) with proper labels and tightly sealed. Whereas the dry preservation of the samples was done in the form of herbarium specimens (Fig. 3). All the collected samples were assigned a particular field number.

Identification of samples

All the processed seaweed samples were scrutinized and identified following the field observation and standard references such as *Phycologia Indica: The Icons of Indian Seaweeds* (Srinivasan 1969, 1973); *Rhodophyta* (Desikachary *et al.* 1990, 1998); *Catalogue of the Benthic Marine Algae of the Indian Ocean* (Silva *et al.* 1996); Krishnamurthy (2000); Kraft (2007), Palanisamy *et al.* (2020), recent publications from the study area and other online resources such as Algaebase, (<https://www.algaebase.org>), WoRMS (<https://www.marinespecies.org>), <https://www.seaweed.ie> and Macroalgal Herbarium Portal (<https://macroalgae.org>), etc. All the preserved seaweed samples are deposited at the Central National Herbarium (CAL), Botanical Survey of India, Howrah, India.

RESULTS AND DISCUSSION

Seaweed diversity

During the present study, twenty-eight taxa of seaweeds, comprising of twenty taxa of Chlorophyceae (71%) and eight taxa of Rhodophyceae (29%) were recorded under 13 genera, 9 families

Table 2: List of seaweed taxa enumerated from the West Bengal coast

Sl. No.	Name of the taxa	Family	Distribution
Chlorophyceae (green algae)			
1	<i>Ulva clathrata</i> (Roth) C. Agardh	<i>Ulvaceae</i>	Sundarban BR
2	<i>Ulva compressa</i> L.		Sundarban BR, Digha, Mohana, Tajpur, Mandarmoni, Junput, Shankarpur.
3	<i>Ulva flexuosa</i> Wulfen		Sundarban BR, Digha, Tajpur, Mohana, Mandarmoni, Junput, Udaypur, Tajpur
4	<i>Ulva intestinalis</i> L.		Sundarban BR, Mandarmoni.
5	<i>Ulva lactuca</i> L. [<i>Ulva fasciata</i> Delile]		Sundarban BR
6	<i>Ulva linza</i> L.		Digha, Mohana, Tajpur, Udaypur, Sundarban BR
7	<i>Ulva linza</i> L. var. <i>bicornuta</i> H.V. Joshi & V. Krishnam.		Digha, Sundarban BR
8	<i>Ulva prolifera</i> O.F. Muell.		Sundarban BR, Udaypur, Digha, Mohana, Dheusagar, Shankarpur, Mandarmoni, Tajpur, Gangasagar Island
9	<i>Chaetomorpha aerea</i> (Dillwyn) Kuetz. [<i>Chaetomorpha crassa</i> (C. Agardh) Kuetz.]	<i>Cladophoraceae</i>	Digha, Sundarban BR, Mohana, Tajpur, Mandarmoni, Udaypur, Shankarpur
10	<i>Chaetomorpha gracilis</i> Kuetz.		Sundarban BR (Satpati <i>et al.</i> (2013)
11	<i>Cladophora glomerata</i> (L.) Kuetz.		Sundarban BR (Mukherjee and Pal, 2018)
12	<i>Chaetomorpha tortuosa</i> (Dillwyn) Kleen		Sundarban BR (Satpati <i>et al.</i> (2013)
13	<i>Rhizoclonium crassipellitum</i> West & G.S. West		Sundarban BR (Satpati <i>et al.</i> (2013)
14	<i>Rhizoclonium fontanum</i> Kuetz.		Sundarban BR (Satpati <i>et al.</i> (2013)
15	<i>Rhizoclonium hieroglyphicum</i> (G. Agardh) Kuetz.		Sundarban BR (Satpati <i>et al.</i> (2013)
16	<i>Rhizoclonium pachydermum</i> Kjellm.		Sundarban BR (Satpati <i>et al.</i> (2013)
17	<i>Rhizoclonium riparium</i> (Roth) Harv.		Sundarban BR (Satpati <i>et al.</i> (2013)
18	<i>Rhizoclonium antillarum</i> Kuetz.		Sundarban BR (Satpati <i>et al.</i> (2013)
19	<i>Pseudorhizoclonium africanum</i> (Kuetz.) Boedeker		Sundarban BR (Satpati <i>et al.</i> (2013)
20	<i>Codium geppiorum</i> O.C. Schmidt	<i>Codiaceae</i>	Sundarban BR (Sen <i>et al.</i> (2003)
Rhodophyceae (Red Algae)			
21	<i>Gelidium pusillum</i> (Stackh.) Le Jolis	<i>Gelidiaceae</i>	Sundarban BR (Satpati <i>et al.</i> (2012)
22	* <i>Gracilaria gracilis</i> (Stackh.) Steentoft, L.M. Irvine & Farnham	<i>Gracilariaceae</i>	Sundarban BR (Canning)
23	<i>Catenella caespitosa</i> (With.) L. Irvine [<i>Catenella repens</i>]	<i>Caulacanthaceae</i>	Sundarban BR
24	<i>Catenella nipae</i> Zanardini		Sundarban BR
25	<i>Ceramium manorense</i> P. Anand	<i>Ceramiceae</i>	Sundarban BR (Satpati <i>et al.</i> (2012)
26	<i>Bostrychia simpliciuscula</i> Harv. ex J. Agardh	<i>Rhodomelaceae</i>	Sundarban BR (Satpati <i>et al.</i> (2012)
27	<i>Polysiphonia mollis</i> Hook.f. & Harv.		Sundarban BR (Satpati <i>et al.</i> (2012)
28	<i>Compsopogon caeruleus</i> (Balb. ex C. Agardh) Mont.	<i>Compsopogonaceae</i>	Sundarban BR (Satpati <i>et al.</i> (2012)

*New addition; [] Important synonyms; BR - Biosphere Reserves.



Fig. 1: Map of West Bengal coastline showing study area

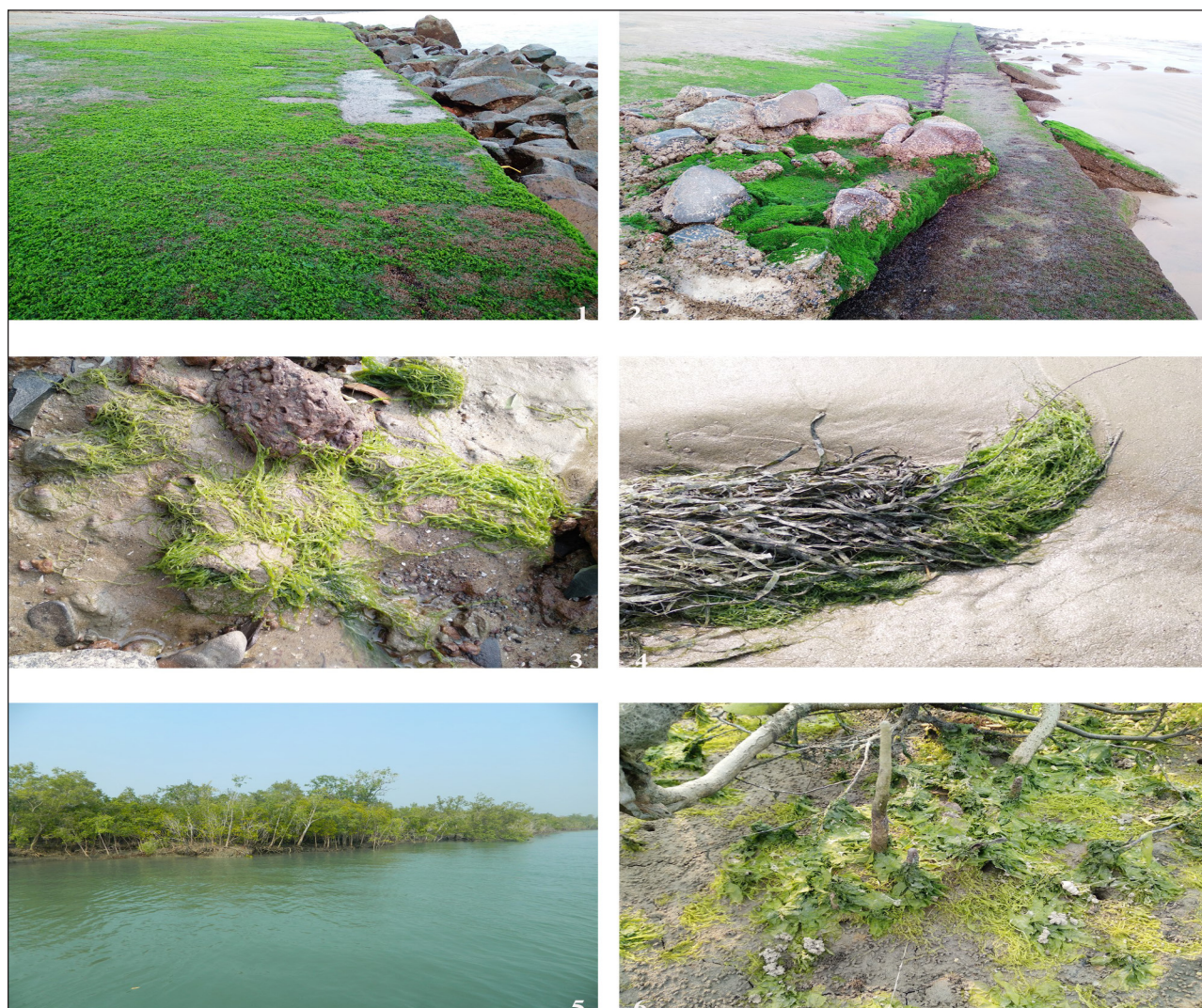


Fig. 2: Various habitats of seaweeds: (1) Luxuriant growth of *Ulva* at Digha coast; (2) Seaweeds growing on rocks at Shankarpur coast; (3) *Ulva* spp. Growing on scattered rocks at Tajpur coast; (4) Green seaweeds growing on coastal waste at Mandarmoni; (5) Panoramic view of Mangrove forest in Sundarban BR; (6) Mixed growth of green seaweeds on mangroves

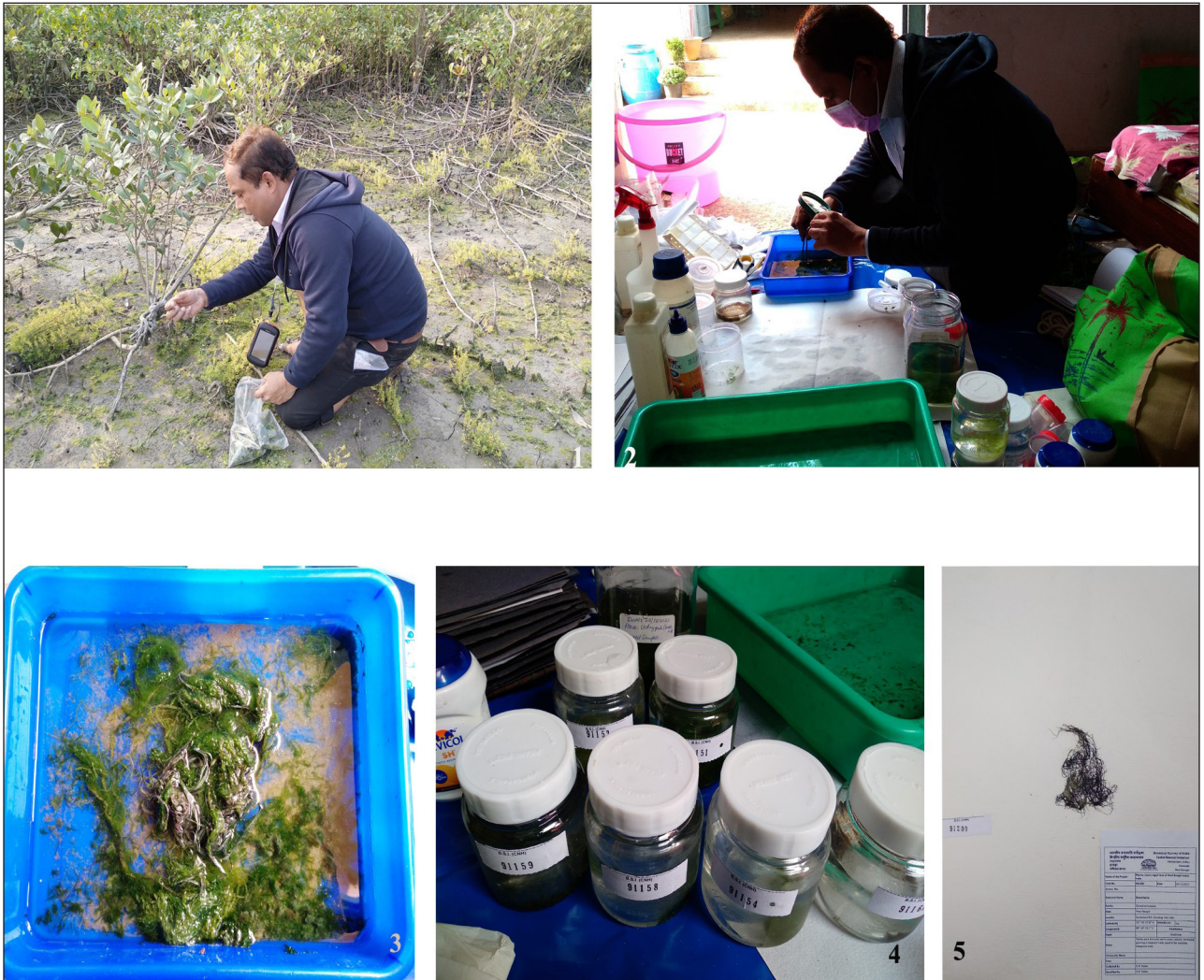


Fig. 3: Processing of algal specimens: (1) Collection of seaweed samples; (2-3). Cleaning and poisoning of collected samples; (4) Wet preserved samples; (5) A herbarium specimen (dry preservation)

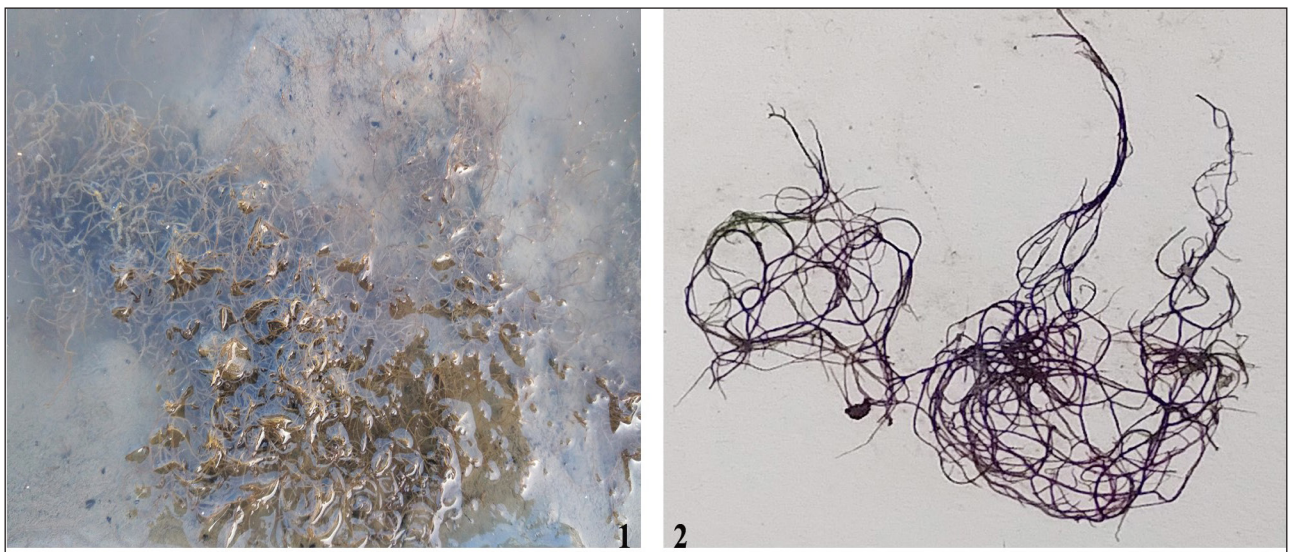
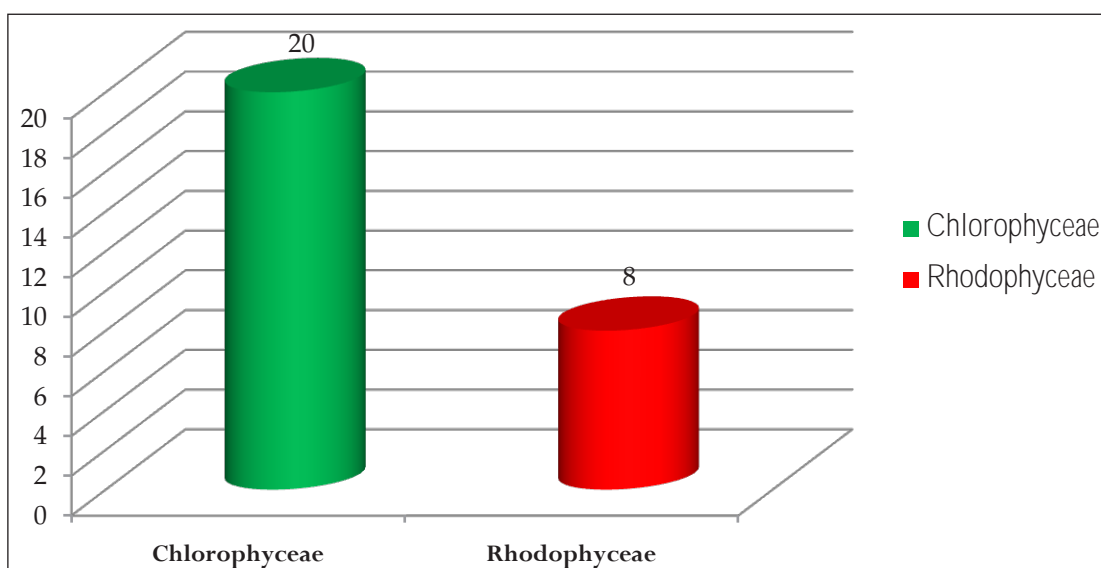
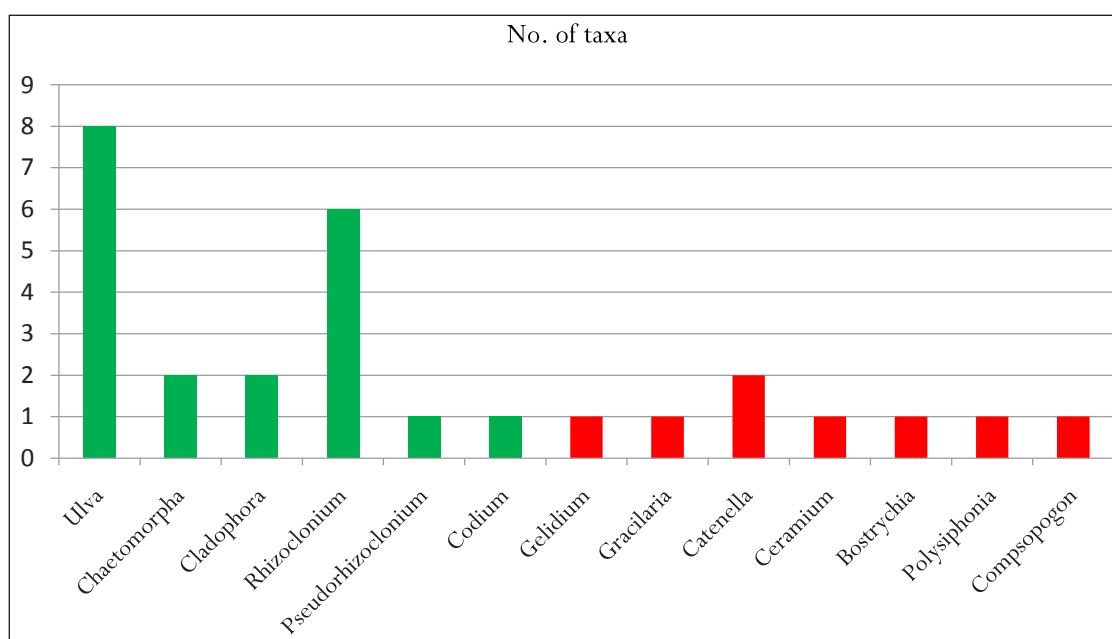


Fig. 4: *Gracilaria gracilis* (Gracilariaceae): (1) Habit; (2) Dry preserved sample on herbarium sheet



Graph 1: Showing diversity of seaweeds (green and red) in the West Bengal coast



Graph 2: Showing diversity of taxa recorded under various genera in the West Bengal coast

and 8 orders (Table 2, Graph 1). No Phaeophyceae member was recorded. The crucial genera include *Ulva*, *Chaetomorpha*, *Cladophora*, *Rhizoclonium*, *Codium*, *Gelidium*, *Gracilaria*, *Catenella*, *Ceramium*, *Bostrychia*, and *Polysiphonia*. Among genera, *Ulva* shows the highest diversity with 8 taxa, followed by *Rhizoclonium* with 6 taxa, *Chaetomorpha*, *Cladophora* and *Catenella*, each with 2 taxa and the remaining genera with only one species (Graph 2). Some of the taxa which could not be collected freshly have been included here based on the reference.

The study also revealed that a red alga *Gracilaria gracilis* (Gracilariaceae) was not reported from West Bengal hitherto. Therefore, it is reported here as a new addition to the seaweed flora of the state (Fig. 4). This species grew in stagnant water bodies in the Canning area of the Sundarbans. From India, it was earlier reported from the states of Gujarat and Tamil Nadu. It is economically a vital seaweed and has been reported with many pharmaceutical potentials such as Antioxidant activities, biotechnological, nutraceutical, and pharmaceutical applications (Francavilla *et al.* 2013). Therefore, further research

is required on this species for its proper conservation and sustainable utilization.

Distributional pattern

The present study revealed ample variation like the coastline and diversity and distribution of seaweeds in West Bengal. The southern part of the coastline, like Digha, Udaypur, Mohana, Tajpur, Shankarpur, Mandarmoni, Namkhana, and Bokkhali, are mostly sandy and supported with very limited natural and artificially laid stones and exhibits less diversity of seaweeds. Whereas the northern part of the coastline is the Sundarban Biosphere Reserve in the Gangetic estuaries, where mangroves act as substrata for the seaweeds and show maximum diversity of seaweeds.

Further, it is also observed that because of the influx of ample freshwater bodies in the Sundarban Biosphere reserves in the Bay of Bengal, the diversity and biomass of green seaweeds were more as compared to the red seaweeds. The study also revealed that the diversity of seaweeds on the West Bengal coast is very less, unlike that found in the southern maritime states like Tamil Nadu, Kerala, Karnataka, Goa, etc. This is because of the lack of suitable rocky substrata on the West Bengal coast.

CONCLUSION

The present study revealed the presence of 28 taxa of seaweeds from the West Bengal coast. The diversity and distribution of seaweeds depend on many factors, like the availability of suitable substrata, coastal topography, salinity, etc. The maximum diversity of seaweeds was recorded in the Sundarban Biosphere Reserves as compared to the southern coastal parts because of the abundance of suitable Mangrove substrata. The Sundarban Biosphere Reserve (SBR) is the world's renowned mangrove forest and a UNESCO heritage site (<https://www.sundarbanbiosphere.org>). The mangroves of the Sundarbans support significant biodiversity. Because of the estuaries, the biomass of the green seaweeds, particularly the species of *Ulva* and *Chaetomorpha* in the SBR was found to be abundant. Further, an economically crucial red alga *Gracilaria gracilis* (Gracilariaceae) was reported as a new addition to the seaweed flora of West Bengal. During the present study, it is also observed that presently, the diversity and distribution of

seaweeds in the West Bengal coast is much less compared to the southern maritime states. However, there are many economically important seaweeds like the species of *Ulva*, *Chaetomorpha*, *Cladophora*, *Gracilaria*, *Catenella* etc., which may be promoted for artificial cultivation and its sustainable utilization to support the coastal communities.

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