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Diversity and distribution of seaweeds in selected reefs and island in Gulf of Kachchh

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ABSTRACT

Gujarat has a longest coastline of about 1650 km among all the maritime states in India. The Gulf of Kachchh (22°15' - 23°40' N; 68°20' - 70°40' E) is the biggest gulf along the west coast of India in the Arabian Sea and it is endowed with 42 islands fringing with corals and mangroves which provide congenial habitat for seaweed growth. In the present study, the diversity and distribution of seaweeds were enumerated in the four selected islands namely Chhad, Dedeka-Mundeka, Goose, Narara. The study was carried out during January 2013 to May 2014. The parameters analysed for seaweeds through line transect and quadrat method were frequency, density and percent algal cover. Totally 70 species were recorded of which 24 species belonged to Chlorophyta, 15 species to Phaeophyta and 31 species to Rhodophyta. The numbers of seaweeds found in Chaad, Dedeka-Mundeka (Dk-Mk), Goose and Narara were 44, 49, 33 and 31 respectively. An updated checklist of species in four islands is provided.

Introduction

Gujarat coast is having two gulfs namely Gulf of Kachchh (GoK) and Gulf of Khambhat (GoKh). Both of the Gulfs are highly diversified due to their varied coastal features including physiography, geomorphology and coastal processes. The shoreline of the GoK has an extensive mudflats and is highly inundated during the high tide which has tidal amplitude up to 6-7 m. There are 42 islands in the GoK (GEER, 2004). Some of these islands having rich algal vegetation are submerged and gets exposed during low tide. Seaweeds are macrothallic, multicellular; large benthic alga that are differentiated from most microscopic size algae (Smith, 1944). They constitute ecologically and

economically important component in marine ecosystem and make a substantial contribution to marine primary production and provide habitat to nearshore benthic communities (Mann, 1973; Williams and Smith, 2007). These plants form an important renewable resource in the marine environment and have been a part of human civilization from time immemorial (John Peter Paul and Raja, 2011). It was estimated that about 90% of the species of marine plants are algae and about 40% of the global photosynthesis is contributed from algae (Anderson, 1992). The total standing stocks along the different coastal states of India is reported to be 6,77,308 tonnes (wet weight) including 1,260 tonnes of drift seaweed (Krishnamurthy, 1969).

Seaweed extracts are used as stabilizers and stiffeners in food industry, cosmetics, pharmaceutical industry and biotechnology (Jeeva and Kiruba, 2009; Wiencke and Bischof, 2012). About 6000 species of red seaweeds (Rhodophyceae), 2000 species of brown seaweeds (Phaeophyceae) and 1200 species of green seaweeds (Chlorophyceae) have been reported globally and the world production of seaweeds has been estimated at about 21×10^{13} kg/year (Kaliaperumal, 2007).

Studies on the diversity and distribution of seaweeds in Indian marine coasts were carried out by several workers (Untawale *et al.*, 1989; Kalimuthu *et al.*, 1995; Selvaraj and Selvaraj, 1997; Jnanendra Adhikary, 2006; Satheesh and Wesley, 2012). The first checklist of Indian marine benthic algal species containing 520 species was published by Krishnamurthy and Joshi (1970). It includes only 153 species of seaweeds belonging to 95 genera from Gujarat coast. Subsequently, Untawale *et al.* (1983) Sahoo *et al.* (2001) and Oza and Zaidi (2001) brought out the updated check-lists based on the reports published in different journals. The checklist by Sahoo *et al.* (2001) contains a total number 770 species from Indian coast, of which 280 species (36%) were from Gujarat coast. The latest systematic account lists 1153 species distributed among 271 genera. Jha *et al.* (2009) reported 198 species of seaweeds belonging to 101 genera along the Gujarat

coast in western India. This includes 62 genera and 109 species of Rhodophyta followed by 23 genera and 54 species of Chlorophyta and 16 genera and 35 species of Phaeophyta.

Gujarat Ecological Commission (GEC-2012) surveyed 12 islands namely Bhaider, Ajad, Boriya, Dhani, Chank, Kalubhar, Panero, Pashu, Gandiya-Kado, Noru, Kharametha and Chusna along the Gulf of Kachchh and recorded totally 78 species of seaweeds of which 26 species belong to Chlorophyta, 17 species to Phaeophyta and 35 species to Rhodophyta. Although biodiversity of seaweeds was studied along the Gujarat coast, the islands of Gulf of Kutch largely remained unexplored due to their remote locations (Mantri *et al.*, 2003, 2004). Work related to seaweeds diversity and distribution with special emphasis on taxonomy of Family Caulerpaceae under Chlorophyta was carried out in Samiani Islands by Mantri *et al.* in 2003 and 2004. A total of 72 species of seaweeds belonging to 26 families and 46 genera were recorded from the coastal zone of Port Okha coast, Gujarat (Cheema *et al.*, 2014).

Materials and Methods

The location and brief description of selected sites are given in Figure 1 and Table 1. The line transects were established perpendicular to the shoreline. The quadrats (1m^2) were laid at interval of

Table-1. Brief description of study area

Selected Sites	General Feature	Latitude	Longitude	Area (ha.)	Algae cover area(ha)
Chhad	It is a submerged reef	N22°32'.70-32°34'.80	E69°57'.50-70°00'.20	2449.20	527.28
Dedeka-Mundeka	These two islands are group of submerged island	N 22°30'.8-22°33'.2	E69°51'.8-69°56'.2	4446.00	1372.80
Goose	It is oval shaped submerged reef	N22°28'.6-22°30'.6	E69°47'.0-69°50'.4	867.636	283.92
Narara	It is well connected to main land due to encroachment. Now it is a part of mainland.	N22°25'.80-22°28'.3	E69°42'.10-69°44'.70	5333.72	1221.48



Fig. 1. Locations surveyed in Gulf of Kachchh, Gujarat

20 m in transects during January, 2013 to March, 2014. The length and number of transects varied depending on the area of reefs, vegetation and islands. The sampling points were potentially selected in such a way that every species in the study area would get good chance of getting sampled. The whole area was also explored diagonally to reveal diversity more opportunistic. The position of each selected site and quadrats were marked with a Garmin GPS map 76CSX receiver. All the seaweed specimens were collected in polythene bags with seawater and identified by referring standard taxonomy books (Jha *et al.*, 2009; Sahoo *et al.*, 2001) and web base source (www.algaebase.org). The herbaria of algal samples were prepared using standard techniques and deposited in the GEER Foundation, Gandhinagar, Gujarat for future reference. The number of seaweed species and total number of quadrats were counted to determine the quantitative assessment of ecological parameters such as frequency, density and % cover. A comparative assessment of the four sites was carried out on the basis of these parameters. These three criteria were analysed following formula given below.

Frequency: Total number of quadrats in which species occurred / Total number of quadrats studied.

Density: Total Number of Species / Total number of quadrats studied.

Algal % cover: Total % cover / Total area studied.

Results

The present diversity and distribution study involving three selected reefs namely Chhad, Goose, Narara and one island Dedeka-Mundeka (DM) of the GoK revealed a total number of 70 species of seaweeds at these sites of which 24 species belonged to Chlorophyta, 15 species to Phaeophyta and 31 species to Rhodophyta (Fig. 2). Totally 44, 49, 33 and 31 species of macro algae were recorded in Chhad, DM, Goose and Narara respectively (Fig. 2, Table-2). Among these four surveyed areas, DM exhibited highest seaweed diversity with maximum number of Rhodophyta (23 species) and Phaeophyta (14 species). Moreover *Pneophyllum conicum*, a coralline red alga was found at this island only (Table-4). Chhad had maximum number of Chlorophyta (17 species) when compared to Goose (9 species) and Narara (11 species) (Table-2) and *Acetabularia calyculus*, a very rare species was recorded in Chhad (Table-4). The results showed that the number of taxa varied in different reefs and one island of the selected region. However, in the entire three reefs and one

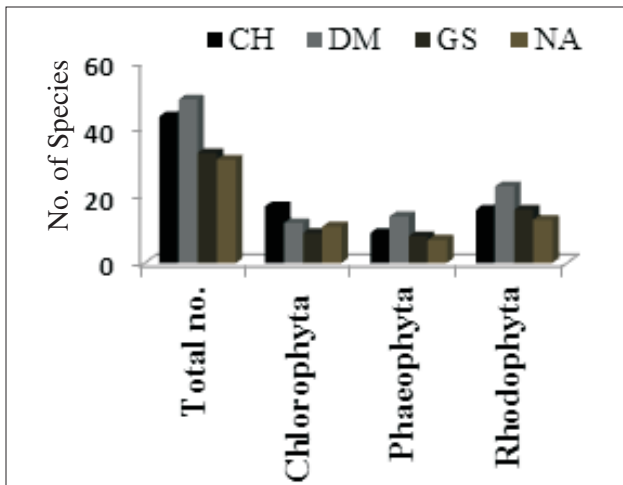


Fig. 2. Seaweed species at four sites in Gulf of Kachchh

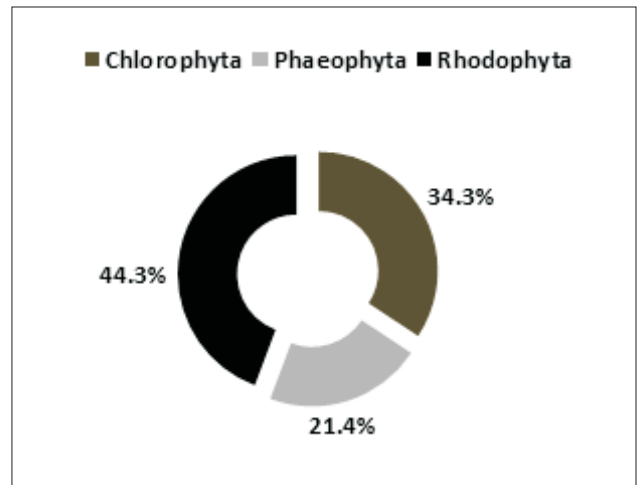


Fig. 3. Total percentage of distribution of seaweeds in four sites

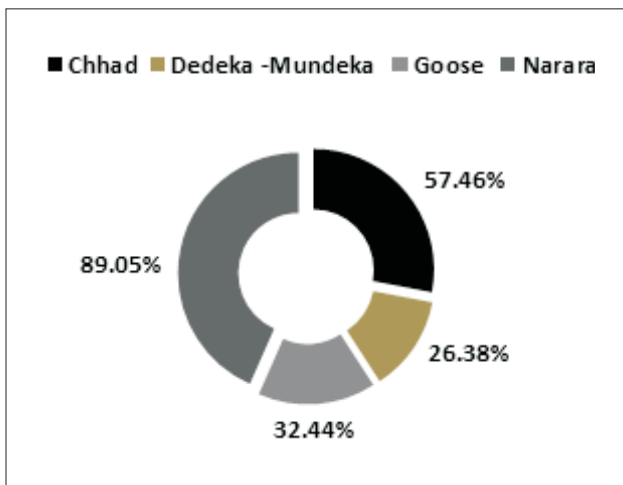


Fig. 4. Total percent cover of seaweeds in four sites

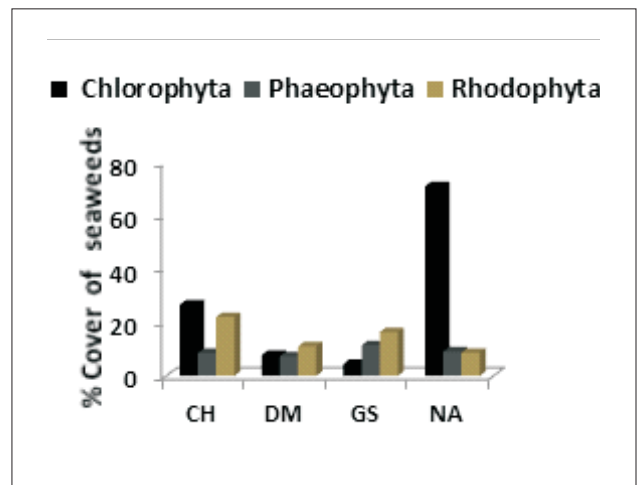


Fig. 5. Percentage cover of seaweeds in four sites

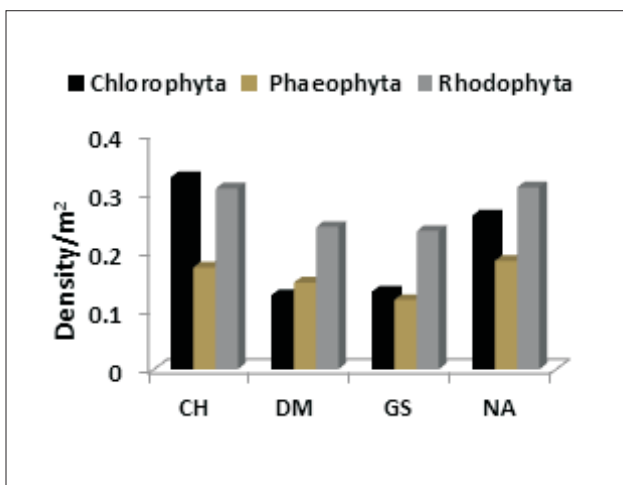


Fig. 6. Density of seaweeds at four sites

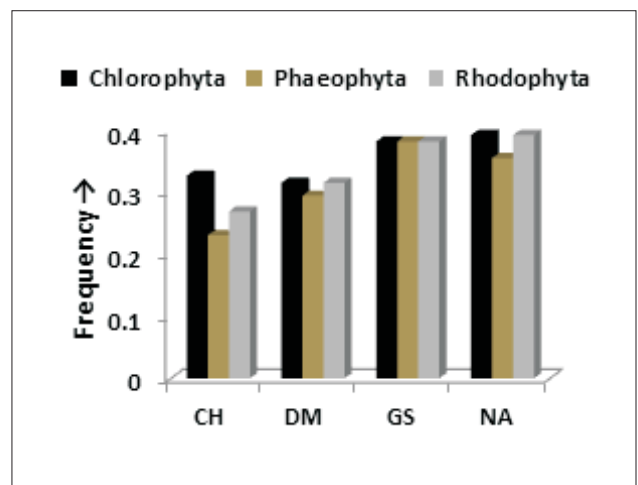


Fig. 7. Frequency of seaweeds at four sites

Table-2. Number of genera and species of seaweeds recorded at four sites in Gulf of Kachchh

Name of the sites	Chlorophyceae		Phaeophyceae		Rhodophyceae	
	Genera	Species	Genera	Species	Genera	Species
Chhad	6	17	7	10	11	17
DM	6	12	8	14	14	23
Goose	6	9	6	8	12	16
Narara	7	11	5	7	10	13

Table-3. Algal percent cover of three groups of seaweeds in selected localities

Place	Chlorophyta	Phaeophyta	Rhodophyta
Chhad(CH)	26.8	8.5	22.1
DM	7.9	7.4	11.1
Goose(GS)	4.6	11.5	16.4
Narara(NA)	71.1	9.2	8.7

island Rhodophyceae were dominant than Chlorophyceae and Phaeophyceae (Table-2).

The occurrence of different classes of seaweeds in the selected three reefs and one island in Gulf of Kachchh was 34.3% of Chlorophyceae, 21.4% of Phaeophyceae and 44.3% of Rhodophyceae (Fig. 3). A comparative analysis revealed that in Narara, the total average algal percent cover was 89.05 of which Chlorophyta covered 71.18% and the growth of this group was abundant (Fig. 4). In Chhad, the algal percent cover of Chlorophyta was 26.8%. The percent cover of Phaeophyta was 11.5% in Goose and Rhodophyta was 22.1% in Chhad (Table-3 and Fig. 5). The value of density and frequency for Chlorophyceae, Phaeophyceae and Rhodophyceae varied in four sites (Fig. 6). The density of Chlorophyta ($D=0.32/m^2$ in Chhad $D = 0.26/m^2$ in Narara) and Rhodophyta ($D=0.30/m^2$ in Chhad, $D=0.30/m^2$ in Narara) were comparatively higher than Phaeophyta at surveyed area of all the four sites (Fig. 6). The frequency of occurrence of Chlorophyta and Rhodophyta was comparatively more than that of Phaeophyta at all the four selected sites (Fig. 7). Among the seaweeds collected from the four surveyed areas, 18 species namely *Caulerpa racemosa*, *Caulerpa taxifolia*,

Chaetomorpha crassa, *Enteromorpha intestinalis*, *Ulva lactuca* and *Ulva reticulata* (Chlorophyta), *Cystoseira indica*, *Dictyota dichotoma*, *Iyengaria stellata*, *Padina boergesenii*, *Sargassum cinereum* (Phaeophyta), *Acanthophora dendroides*, *Ceramium cruciatum*, *Digenea simplex*, *Gracilaria corticata*, *Hypnea valentiae* and *Laurencia obtusa* (Rhodophyta) were most common.

Discussion

The distinct geomorphology with rock, sand-silt and mud on the bottom of the reef, islands and the sediment effluent of these sites greatly support high algal diversity and give an excellent shelter of marine organism. A study on 'Seaweed diversity along the islands of Gulf of Kachchh' was carried out in this region (GEC, 2012). All 42 islands were proposed to map for seaweed diversity. Out of 42 islands, 12 islands viz. Ajad, Kalubhar, Boriya, Kharametha Chusna, Noru, Bhaider, Pashu, Dhani, Panero, Paga, Chank, and Gandiya-Kado were covered (GEC, 2012). Recently, GEER Foundation has covered total 20 islands out of 42 islands in Gulf of Kachchh. This is the first report of diversity, distribution and quantitative assessment of relevant parameters of seaweeds of Chhad, Dedeka-Mundeka, Goose and Narara in the Gulf of Kachchh. In the present study, 70 species of seaweeds were recorded from 4 sites of GoK. Narara is the largest reef with vegetation area of 1221.48 ha. (GEER, 2004) but the diversity (total seaweed species-31, Figure - 2) was less than other three surveyed sites. It may be due to encroachment and anthropogenic activities. In the case of submerged reefs such as Chhad, Goose and DM (island), which are not directly connected to mainland and comparatively more undisturbed have high seaweed diversity. The present study will be useful for creating data base on the diversity and distribution of seaweeds, which is the first attempt in this area.

Table-4. List of seaweeds recorded at four sites in Gulf of Kachchh

S.No.	Family	Scientific Name	Ch	DM	Gs	Na
Chlorophyta						
1	Polyphysaceae	<i>Acetabularia calyculus</i> Lamouroux	+	-	-	-
2	Caulerpacae	<i>Caulerpa microphysa</i> (Weber van Bosse) J. Feldmann	+	+	-	-
3	Caulerpacae	<i>Caulerpa racemosa</i> (Forsskal) J. Agardh	+	+	+	+
4	Caulerpacae	<i>Caulerpa racemosa</i> (Forsskal) J. Agardh var. <i>macrophysa</i> (Sonder ex Kuetzing) Taylor	+	+	-	-
5	Caulerpacae	<i>Caulerpa racemosa v. occidentalis</i> (J. Agardh) Boergesen	+	-	-	-
6	Caulerpacae	<i>Caulerpa scalpelliformis</i> (R. Brown ex Turner) C. Agardh var. <i>denticulata</i> (Decaisne) Weber - van Bosse	+	-	-	-
7	Caulerpacae	<i>Caulerpa taxifolia</i> (Vahl) C. Agardh	+	+	+	+
8	Caulerpacae	<i>Caulerpa verticillata</i> J. Agardh	-	-	-	+
9	Cladophoraceae	<i>Chaetomorpha crassa</i> J. Agardh Kuetzing	+	+	+	+
10	Codiaceae	<i>Codium dwarkense</i> Boergesen	+		+	+
11	Siphonocladaceae	<i>Cladophoropsis javanica</i> (Kuetzing) P. Silva	-	+	-	-
12	Siphonocladaceae	<i>Struvea anastomosans</i> (Harvey) Piccone & Grunow ex Piccone	-	-	-	+
13	Cladophoraceae	<i>Chaetomorpha spiralis</i> Okamura	+	-	-	-
14	Cladophoraceae	<i>Cladophora vagabunda</i> (Linnaeus) van den Hoek	-	+	-	+
15	Cladophoraceae	<i>Cladophora</i> sp.	+	-	-	-
16	Ulvaceae	<i>Enteromorpha compressa</i> (Linnaeus) Nees	+	+	+	-
17	Ulvaceae	<i>Enteromorpha intestinalis</i> (Linnaeus) Nees	+	+	+	+
18	Ulvaceae	<i>Enteromorpha prolifera</i> (O.F. Muller) J. Agardh	+	-	-	-
19	Ulvaceae	<i>Enteromorpha linza</i> (Linnaeus) J. Agardh	+	-	-	-
20	Ulvaceae	<i>Ulva lactuca</i> Linnaeus	+	+	+	+
21	Ulvaceae	<i>Ulva fasciata</i> Delile	-	-	-	+
22	Ulvaceae	<i>Ulva rigida</i> C. Agardh	-	+	-	-
23	Ulvaceae	<i>Ulva reticulata</i> Forsskal	+	+	+	+
24	Halimedaceae	<i>Halimeda tuna</i> (Ellis & Solander) Lamouroux	-	-	+	-
Phaeophyta						
25	Scytosiphonaceae	<i>Colpomenia sinuosa</i> (Martens ex Roth) Derbes & Solier	-	+	-	-
26	Scytosiphonaceae	<i>Rosenvingea intricata</i> (J. Agardh) Boergesen	+	+	-	-
27	Scytosiphonaceae	<i>Hydroclatharus clathratus</i> (C. Agardh) Howe	+	+	-	-
28	Scytosiphonaceae	<i>Iyengaria stellata</i> (Boergesen) Boergesen	+	+	+	+
29	Dictyotaceae	<i>Dictyota cervicornis</i> Kuetzing	+	+	-	-
30	Dictyotaceae	<i>Dictyota ciliolata</i> Kuetzing	-	-	+	-
31	Dictyotaceae	<i>Dictyota dichotoma</i> (Hudson) Lamouroux	+	+	+	+
32	Dictyotaceae	<i>Dictyota pinnatifida</i> Kuetzing	-	+	-	-
33	Dictyotaceae	<i>Padina boryana</i> Thivy	+	+	+	+
34	Dictyotaceae	<i>Padina boergesenii</i> Allender & Kraft	+	+	+	+
35	Cystoseiraceae	<i>Cystoseira indica</i> (Thivy & Doshi) Mairh	+	+	+	+
36	Sargassaceae	<i>Sargassum cinctum</i> J. Agardh	+	-	-	+
37	Sargassaceae	<i>Sargassum prismaticum</i> Chauhan	-	+	-	-
38	Sargassaceae	<i>Sargassum cinereum</i> J. Agardh	+	+	+	+
39	Sargassaceae	<i>Sargassum swartzii</i> C. Agardh	-	+	+	-

Rhodophyta						
40	Rhodomelaceae	<i>Acanthophora dendroides</i> Harvey	+	+	+	+
41	Rhodomelaceae	<i>Acanthophora najadiformis</i> (Delile) Papenfuss	+	+	-	-
42	Rhodomelaceae	<i>Acanthophora spicifera</i> (Vahl) Borgesen	+	+	+	-
43	Rhodomelaceae	<i>Digenea simplex</i> (Wulfen) C. Agardh	+	+	+	+
44	Rhodomelaceae	<i>Laurencia obtusa</i> (Hudson) Lamouroux	+	+	+	+
45	Rhodomelaceae	<i>Lopocladia lallemandi</i> (Montagne) Schmitz	-	+	-	-
46	Ahnfeltiaceae	<i>Ahnfeltia plicata</i> (Hudson) Fries	+	+	-	-
47	Corallinaceae	<i>Amphiroa anceps</i> (Lamarck) Decaisne	-	+	-	-
48	Corallinaceae	<i>Amphiroa fragilissima</i> (Linnaeus) Lamouroux	-	+	+	+
49	Corallinaceae	<i>Pneophyllum conicum</i> (E. Y. Dawson) Y. M. Keats	-	+	+	-
50	Ceramiales	<i>Centroceras clavulatum</i> (C. Agardh) Montagne	-	+	-	-
51	Ceramiales	<i>Ceramium cruciatum</i> Collins & Harvey	+	+	+	+
52	Ceramiales	<i>Spyridia alternans</i> Borgesen	+	-	-	-
53	Ceramiales	<i>Spyridia filamentosa</i> (Wulfen) Harvey	+	+	-	-
54	Champiaceae	<i>Champia compressa</i> Harvey	-	+	-	-
55	Champiaceae	<i>Champia indica</i> Borgesen	-	+	+	+
56	Champiaceae	<i>Champia globulifera</i> Borgesen	-	+	-	+
57	Gelidiales	<i>Gelidium micropterum</i> Kuetzing	+	-	+	+
58	Gracilariaceae	<i>Gracilaria corticata</i> (J. Agardh) J. Agardh	+	+	+	+
59	Gracilariaceae	<i>Gracilaria salicornia</i> (C. Agardh) Dawson	-	+	-	-
60	Gracilariaceae	<i>Gracilaria verrucosa</i> (Hudson) Papenfuss	-	-	-	+
61	Hypneaceae	<i>Hypnea esperi</i> Auctorum	+	+	+	-
62	Hypneaceae	<i>Hypnea spinella</i> (C. Agardh) Kuetzing	+	+	-	+
63	Hypneaceae	<i>Hypnea musciformis</i> (Wulfen) Lamouroux	-	+	-	-
64	Hypneaceae	<i>Hypnea valentiae</i> (Turner) Montagne	+	+	+	+
65	Peyssonneliaceae	<i>Peyssonnelia obscura</i> Weber-van Bosse	+	+	+	-
66	Rhodymeniaceae	<i>Rhodymenia sonderi</i> P. Silva	+	-	-	-
67	Solieriaceae	<i>Sarconema filiforme</i> (Sonder) Kylin	+	-	-	-
68	Galaxauraceae	<i>Scinaia complanata</i> (Collins) Cotton	-	-	+	-
69	Galaxauraceae	<i>Scinaia fascicularis</i> (Borgesen) Huisman	-	-	+	-
70	Galaxauraceae	<i>Scinaia monoliformis</i> J. Agardh	-	-	+	+

+ Present; - Absent; Ch - Chhad; DM - Dedeka-Mundeka; Gs - Goose; Na - Narara

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