

MORPHOTAXONOMY AND ECOLOGY OF MARINE RED ALGAE FROM THE MAKRAN COAST OF PAKISTAN

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Abstract

The Makran coast of Balochistan was thoroughly surveyed for marine algae. The collection was made from six locations along coastline of Pasni, Gwadar, Singhar, Pishukan, Sur Bunder and Jiwani areas. Abundant algal flora was found during this study in 2017-18. Seventeen red seaweeds were identified from the Makran coast namely i.e., *Galaxaura rugosa*, *Gracilaria foliifera*, *G. canaliculata*, *G. pygmaea*, *Sarconema furcellatum*, *Solieria robusta*, *Agardhiella subulata*, *Meristotheca populosa*, *Hypnea valentia*, *Hypnea muciformis*, *Rhodymenia pseudopalmeta*, *Champia compressa*, *Ceramium manorensis*, *Acanthophora spicifera*, *Polysiphonia fucoides*, *Laurencia pinnatifida*, *Sarcodia dichotoma*. Three species are recorded for the first time from Pakistan, these include *Galaxaura rugosa*, *Agardhiella subulata*, and *Rhodymenia pseudopalmeta*. Ecological distribution and morpho-taxonomic description of these species is given here. Most of the species were found drifted at the shore. However, some red algal species were found attached to stones or rocks during spring season.

Key words: Seaweeds; Rhodophyta; Ecology; Morphology; Coastline of Balochistan, Pakistan.

Introduction

Balochistan, the province of Pakistan has a coastline about 750 Km which is extended from Hub river near Karachi to Gwadar bordering Iran along the northern Arabian Sea, it is sub-divided into Makran and Lasbella coasts. Makran coast includes Gwadar Bays, Jiwani, Pasni and Ormara. Climate is semi-arid – arid sub tropical with low hills ranging in piedmont plains (Anon., 2016).

The Balochistan coastline has dense marine algal growth (Shameel & Tanaka, 1992). Extensive studies have been carried out from Karachi and adjacent coastal areas of Pakistan (Zahid *et al.*, 1981; Begum & Khatoon, 1988, 1992; Shameel *et al.*, 2000; Abbas & Shameel, 2013), Lasbella (Shameel, 1987; Shameel & Hussain, 1987). Shameel & Nizamuddin (1972) reported a new red seaweed *Haloplegma anwerii* from the coast of Karachi. Zahid *et al.*, (1981) studied *Polysiphonia* species in detail. In another similar studies, Hussain (1992) described the morphological, anatomical and postfertilization variations in different red algae with a special reference to Nemaliales from Karachi coast. Saifullah *et al.*, (1997) investigated different algal species including epiphytic red algae commonly found on mangroves at Makran coastal region of Balochistan. However, no comprehensive studies were carried out on the marine algal flora of Balochistan coastal areas. Only two synoptic survey reports were published from Gwadar coast and its nearby coastlines (Saifullah & Nizamuddin, 1977; Shameel *et al.*, 1996). Therefore, this study was conducted to check the unexplored algal flora of Makran coast. A large number of species belonging to different divisions (Bacillariophyta, Chlorophyta, Phaeophyta and Rhodophyta) were recorded whereas in this paper species belonging to Rhodophyta are described for their ecology and morpho-taxonomic features.

Material and Methods

Seaweed samples were collected from various locations on sandy bays, rocky hills, shallow rocky or sandy ponds / pools and podium at littoral and sub littoral

zones of Pasni, Gwadar, Singhar, Pishukan, Sur Bunder and Jiwani areas during March and September, 2018 from Makran coast of Balochistan along Northern Arabian Sea. Collection was done by hand and through net as free floating, benthic, epiphytic epipellic/ epilithon as attached free floating or drifted.

The collected algal samples were brought to laboratory, washed with tap water to clean the debris and exotic materials and then preserved in 5% formalin or 70% methanol in jars and some were mounted carefully on herbarium sheet. Thalli of larger seaweeds were squashed with 1% aniline blue in 5% HCl to examine transverse section of thalli, slides were prepared by mounting these in glycerin, distilled water and acetic acid, then all the slides were sealed using cutex nail polish. Slides were studied using light microscope for species identification. The identification was done through available literature (Anand, 1943; Smith, 1944; Silva *et al.*, 1966; Boney, 1966; Kaliaperumal *et al.*, 1995; Shameel *et al.*, 1996).

Results and Discussion

A comprehensive two years seasonal algal collection from Makran coast of Balochistan was done in 2017-18. Previously a few species from Gwadar have been reported (Saifullah & Nizamuddin, 1977; Shameel *et al.*, 1996). Therefore, this study was conducted to check the unexplored algal flora from six localities of Makran coast. A large number of species belonging to divisions Bacillariophyta, Chlorophyta, Phaeophyta and Rhodophyta were recorded. However, in this paper species belonging to Rhodophyta are described for their ecology and morpho-taxonomic features.

A total of seventeen red seaweeds belonging to class Rhodophyta distributed in 7 families and 5 orders were recorded. These species are *Galaxaura rugosa* (J. Eills and Solander) J. V. Lamouroux, *Gracilaria foliifera* (Forsskål) Børgesen, *G. canaliculata* Sond., *G. pygmaea* Børgesen, *Sarconema furcellatum* Zanardini, *Solieria robusta* (Greville) Kylin, *Agardhiella subulata* (C. Agardh) Kraft & M. J. Wynne, *Meristotheca populosa* (Montagne) J. Agardh,

Hypnea Valentia (Turner) Montagne, *Hypnea muciformis* (Wulfen) Lamouroux, *Rhodymenia pseudopalmata* (J. V. Lamouroux) P. C. Silva, *Champia compressa* Harvey, *Ceramium manorensis* P. Anand, *Acanthophora spicifera* (Vahl) Borgesen, *Polysiphonia fucoides* (Hudson) Greville, *Laurencia pinnatifida* (Hudson) J. V. Lamouroux, *Sarcodia dichotoma* Borgesen. Taxonomic and morphological description of all identified seaweeds are given below:

Division: Rhodophyta Wettstein

Class: Florideophyceae Cronquist, 1960

Order: Bonnemaisoniales J. Feldman *et G. Feldmann*, 1942

Family: Galaxauraceae Parkinson 1983 (Plate 1: fig. 1a, 1b)

1- *Galaxaura rugosa* (J. Eills and Solander) J. V. Lamouroux, 1816 (Plate 1: fig. 1 a & b)

(= *Corallina rugosa* J. Ellis & Solander 1786)

(Chou & Zhuohua, 1983: 86; Huisman, 1990: 156; Coppejans *et al.*, 2009: 160; Nyunt & Soe-Htun, 2014:3)

Morphology

Thallus cushion like, caespitose, calcareous, erect, 5–6 cm long, wide, sometimes clumped up to 40 cm; commonly consisted of reddish hollow and cylindrical branches. Yellowish pits present at the tips. Branching is sub dichotomous.

Cortex not distinct, with elongated assimilatory filaments, 3–4 lobed cells; short, indistinct; cells 15–30 µm long and 15–20 µm wide, medullary cells 16–35 µm long and 17–31 µm wide.

Ecology: Widespread in the warm seas growing as large tufts on rocky substratum and old corals within the intertidal region in shallow water up to 3m depth in sheltered areas.

Local distribution: Specimens were collected as drifted material from the shores of Jiwani and Pasni.

Order: Gigatinales Schmitz *in Engler*, 1892

Family: Gracilariaceae Nageli, 1847

2- *Gracilaria foliifera* (Forsskål 1775) Børgesen, 1932 (Plate 1: fig. 2)

(= *Fucus foliifer* Forsskal)

(Kaliaperumal *et al.*, 1995: 9; Kundu *et al.*, 2017: 39)

Morphology

Thallus is bushy, up to 15 cm long, cartilaginous. brownish to red in colour; branching dichotomous to sub-dichotomous, sometimes irregularly pinnately branched, with fronds brittle and thin; with smooth and proliferous margins. Holdfast discoid. Stipe is up to 1mm in thickness and 0.6–1.5 cm wide which gradually expands into blade. Abrupt transition of cortex to 4–5 rounded to somewhat flattened medullary cells. Cortex is comprised 1–2 pigmented cell layers. Medullary cells are large at the center.

Ecology: Widespread in shallow water bayou on dead corals and rocks in large tufts. It is also anchored on shells and stones in sandy areas in intertidal to sublittoral zones. It can be harvested throughout the year in moderate quantities.

Local distribution: Collected from the Pasni along the Makran coastline.

3- *G. canaliculata* Sond, 1871 (Plate 1: fig. 3)

(Rao, 1974: 677; Wynne, 1995:280; Iyer *et al.*, 2004: 526)

Morphology

Thallus erect, rigid, fragile, cartilaginous, light or dark rose; up to 53 mm tall, holdfast discoid with 1 or 2 axes. Stipe short and terete, 6 mm in length, inconspicuous generally. Sub dichotomously branched, arcuate often. Branches at base 1 mm while at apex 3 mm in diameter, upper branches cylindrical.

Cell size transition from cortex - medulla abrupt all over the thallus. Pit connections secondary, not conspicuous in subsurface layer, infrequent in outermost. Cortex 1–2 cells. Medulla 18 cells in width, cells polygonal - spherical, light staining, up to 370 µm in length and 310 µm wide; medulla 13 cells wide, polygonal or spherical, becomes large at the center.

Ecology: Growing in rock pools in intertidal region at a depth 0.6–1 m. Sometimes found attached on rocks in subtidal zones. It occurs throughout the year.

Local distribution: Fresh specimens were collected from Singhar Gwadar.

4- *G. pygmaea* Borgesen, 1937 (Plate 1: fig. 4)

(Boergesen, 1937: 328; Nelson, 1987: 97)

Morphology

Thallus attached to the substratum by a thin spreading disc, fronds 5–10 cm long, 4 mm wide, compressed except near the base. Purple red in colour, branching in an irregular dichotomous manner; branches rise from the edges of either alternately or 2–3 serially from the same side, apices acute or bifid. The cortex consists of densely packed small cell, large oblong cell present at the center, 170–200 µm in diameter, cells not elongated vertically.

Ecology: Grows in the sandy bottom rock pools of warm and quiet shallow bays or on stones in muddy beds of lower littoral region in coastline waters during the whole year.

Local distribution: Collected as drifted from Singhar Gwadar.

Family: Solieriaceae J. Agardh, 1876

5- *Sarconema furcellatum* Zanardini, 1858 (Plate 1: fig. 5)

(Kaliaperumal, 1995: p. 13; Hayee & Shameel, 1996: 124).

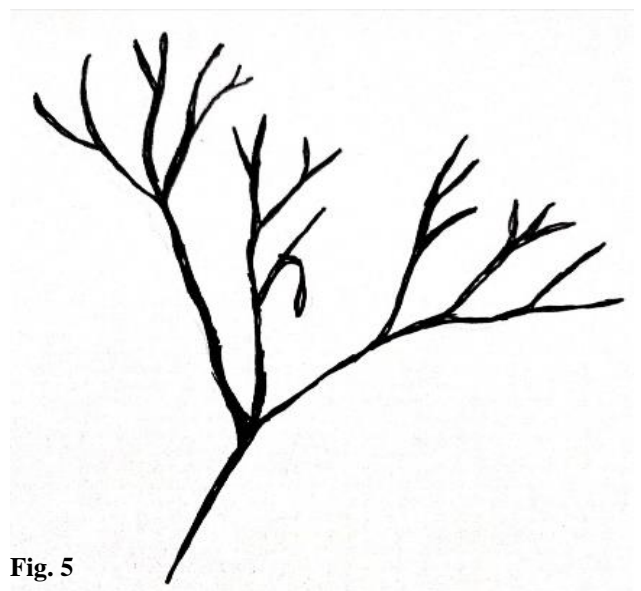
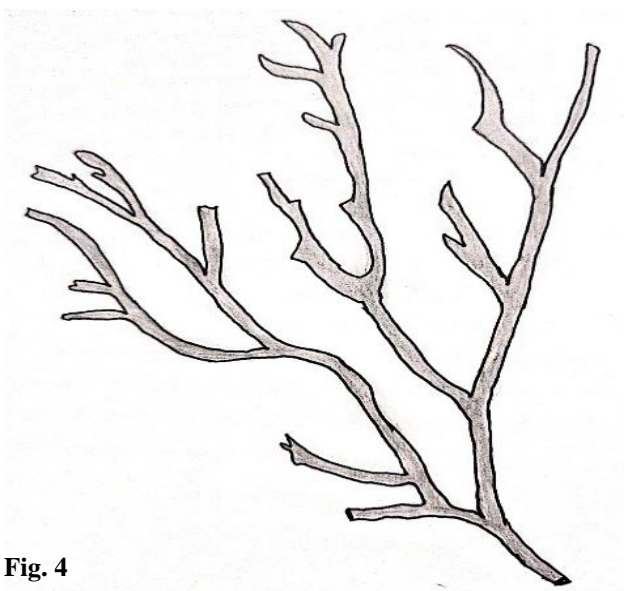


Plate 1. Showing Fig.1a. *Galaxaura rugosa*. Fig.1b. A part of thallus. Fig. 2. *Gracilaria foliifera*. Fig. 3. *G.canaliculata*. Fig. 4. *G.pygmaea*. Fig. 5. *Sarconema facellatum*.

Morphology

Thallus tufted, 15 cm tall, up to 2 mm wide, profusely dichotomously tapering branches, multiaxial, resulting in dense wide intricate tufts; brick red to yellowish red in colour. Thallus is attached by strong branched hold fast. Cortex two layered outer has small cells while inner cells large, loosely arranged. Medulla filamentous.

Ecology: It grows as attached on shell and stones in intertidal and low water marks near shores. It occurs almost in all months of the year but in lesser quantities.

Local distribution: specimens were collected from Pasni along Makran coastline Balochistan.

6- *Solieria robusta* (Greville, 1830) Kylin, 1932 (Plate 2: fig. 6)

(= *Agardhiella robusta* (Greville 1830) Borgesen 1932) (Shameel & Tanaka, 1992:48; Shameel *et al.*, 1996:228; Hayee-Memon & Shameel, 1996: 125; Ganzon-fortes, 2006: 238).

Morphology

Thallus grey red to yellowish brown, upright, up to 25 cm tall, anchored by a branched holdfast; stipe 0.7-10 cm, numerous primary axes arising from the upper part of thallus. Branching trichotomous, umbellate, sometimes sub dichotomous, opposite and pinnate; branches terete, fleshy, 3.5 mm across, upcurved. Freshly grown branchlets at the apex appear like thick spines. Intertwined filaments arranged loosely to form medulla, 24 µm in wide. Cortex 2 or 3 cells; subcortical layers, connected with pits, isodiametric and large, 116µm in diameter, 1 or 2 small, ovoid outer cortical cell layers with no pits.

Ecology: It occurs in a variety of wave energies and depth. Commonly found as benthic on rocks under moderate water movements in intertidal region.

Local distribution: Recorded from Pasni Makran coast.

7- *Agardhiella subulata* (C. Agardh) Kraft & M. J. Wynne, 1979 (Plate 2: fig. 7)

(= *Sphaerococcus subulatus* C. Agardh) (Klepachi, 1995: 169)

Morphology

Thallus commonly erect, fleshy, terete, usually reaches up to 40 cm height; branching alternate, branches taper at the tips, axes up to 4 mm wide. Cortex is well differentiated in to outer and inner layer of cells. 4 or 5 cortex layers comprised of spherical – ovoid cells, cells multinucleate, become large in size in the center of the thallus, outer cortex single layered, with ellipsoidal, small uninucleate cells. Medulla with elongated, multinucleate cells. Apical cells ellipsoidal, 12–15 µm in diameter. Pit connections present.

Ecology: This seaweed inhabited in the intertidal to subtidal region as epilithic on rocks. It is available in through out the year in harvestable quantity.

Local distribution: Specimens were collected as intermingled in fishing nets from the Pasni coast Balochistan.

8- *Meristotheca populosa* (Montagne) J. Agardh, 1872 (Plate 2: fig. 8)

(= *Kallymenia papulose* Montagne) (Faye *et al.*, 2005)

Morphology

Plants foliose, consisted of flattened dichotomously branched or lobed irregularly appearing in segments of various shapes with undulate margins. Fronds 8–10 cm long, sometimes reaching up to 40 cm in height, 1–5cm in width. Fronds multiaxial. Cortex pseudoparenchymatous, medulla filamentous. Plants are dioecious. Ellipsoidal Spermatangia are found on all the male plant surface. Carposporangia arranged in rows on female plant.

Ecology: It grows in subtidal rock pools at a depth up to 20m. It occurs all round the year but not in harvestable quantity.

Local distribution: Collected as drift from Pishukan, Gwadar.

Family: Hypneaceae J. Agardh 1851

9- *Hypnea valentiae* (Turner 1809) Montagne 1843 (Plate 2: fig. 9)

(= *Fucus valentiae* Turner) (Borgesen, 1934a: 17; Abbott & Hollenberg, 1992: 489; Shameel & Hussain, 1987: 297; Shameel & Tanaka, 1992: 49; Kaliaperumal, 1995: 12; Hayee-Memon & Shameel, 1996: 128).

Morphology

Thallus is erect, bushy, loosely branched, main axis distinct and cylindrical, 10 –25 cm long; with irregular terminal branchlets arranged around axis; usually simple and filiform but sometimes may be forked. Cortex cells large surrounding the medulla which is comprised of longitudinal filaments, with single small assimilating cell layer at periphery.

Ecology: Growing as epilithon on rocks, pebbles and stones in the subtidal and intertidal regions. This alga is common found through out the year in abundant growth.

Local distribution: Collected as drifted along with other seaweeds from Pasni along Makran coastline Balochistan.

10- *Hypnea muciformis* (Wulfen, 1789) Lamouroux, 1813 (Plate 2: fig. 10)

(= *Fucus muciformis* Wulfen) (Shameel & Hussain, 1987: 297; Sliva *et al.*, 1987:49; Shameel *et al.*, 1996:228)

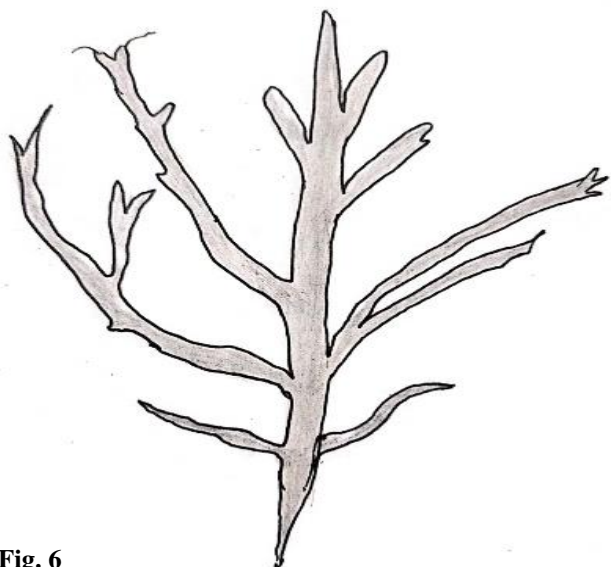


Fig. 6



Fig. 7

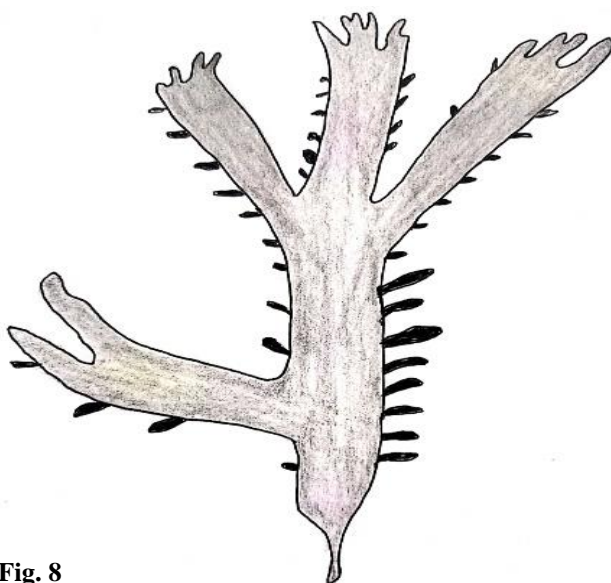


Fig. 8



Fig. 9

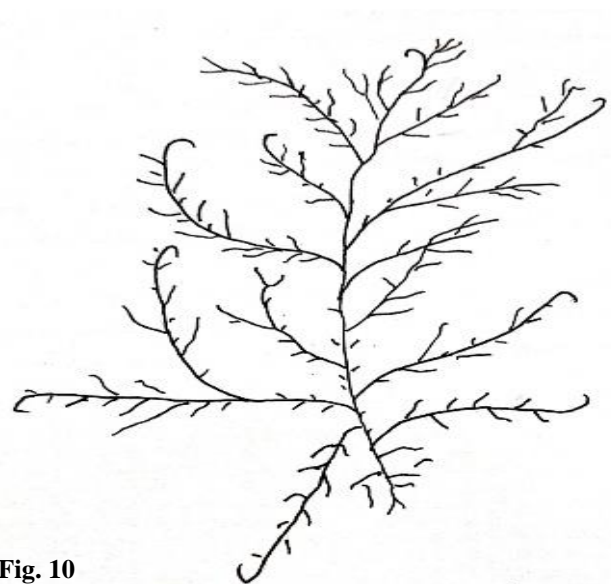


Fig. 10



Fig. 11

Plate 2. Showing Fig. 6. *Solieria robusta*. Fig. 7. *Agardhiella subulata*. Fig. 8. *Meristotheca populosa*. Fig. 9. *Hypnea Valentia*. Fig. 10. *H. muciformis*. Fig. 11. *Rhodymenia pseudopalmata*.

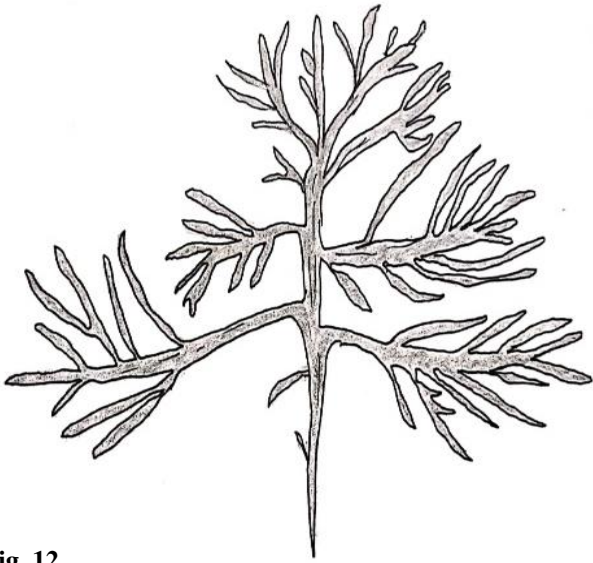


Fig. 12

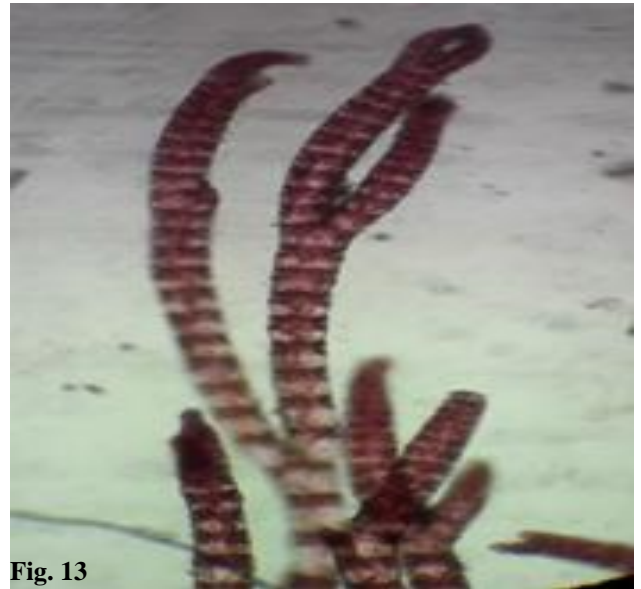


Fig. 13



Fig. 14

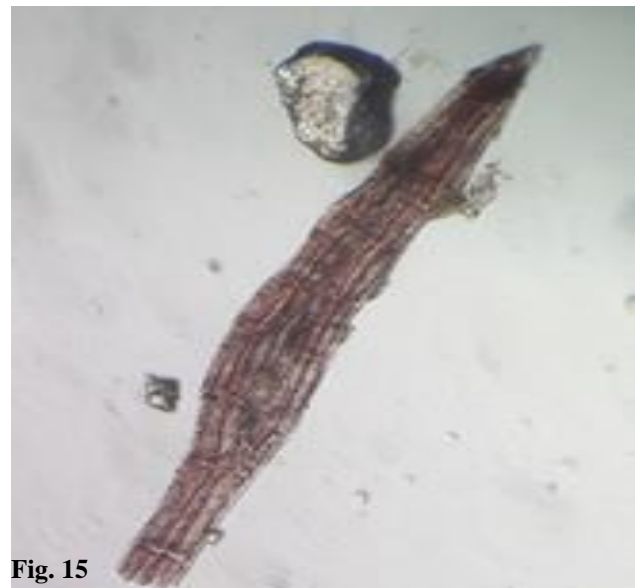


Fig. 15

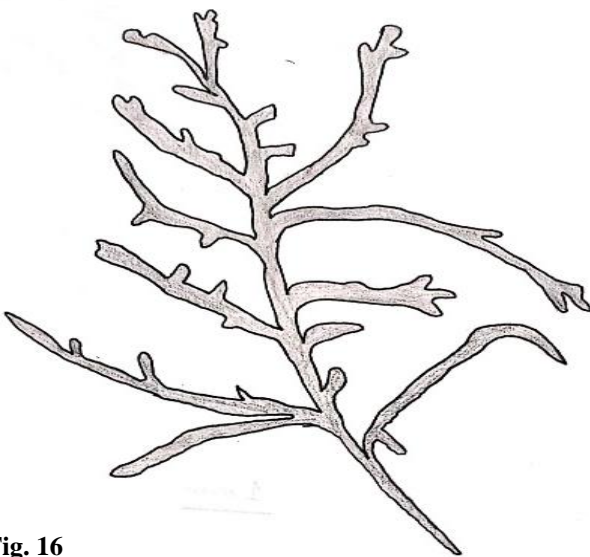


Fig. 16

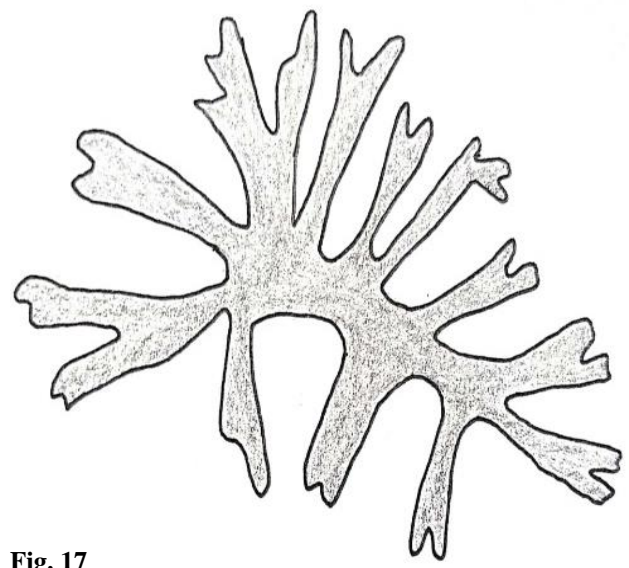


Fig. 17

Plate 3. Showing: Fig. 12. *Champia compressa*. Fig. 13. *Ceramium manorensis*. Fig. 14. *Acanthophora spicifera*. Fig. 15. *Polysiphonia fucooides*. Fig. 16. *Osmundea pinnatifida*. Fig. 17. *Sarcodia dichotoma*.

Morphology

Plants 10–30 cm in length, purple red in colour, bushy, cylindrical and spreading. Fronds cartilaginous, filiform, profusely and irregularly branched. Tips of lateral branches appear as hook like tendrils, help the thallus to elongate and reach other seaweeds. Cortex has 6–7 layers of small cells towards outside and large and angular cells towards centre, up to 38 μm wide, these surround few central cells, up to 18 μm in diameter.

Ecology: Attached on shells, dead corals, stones and rocks in the sheltered regions in water lagoons in sublittoral zone. This alga is available in all four seasons of the year.

Local distribution: Collected from Sur Bander, Jiwani and Pasni seashore.

Order: Rhodymeniales Schmitz in Engler, 1892

Family: Rhodymeniaceae Harvey, 1849

11- *Rhodymenia pseudopalmata* (J.V.Lamouroux) P.C.Silva, 1952 (Plate 2: fig. 11)
(= *Fucus pseudoplasmatus* J.V.Lamouroux)
(Haroun *et al.*, 2002)

Morphology

Thallus has a membranous rose red frond, rather stiff, fan-shaped. Up to 100 mm tall, dichotomously lobed, with wide axils, round apices, margins smooth. Cortex 2–3 celled layers medulla 3–5 celled layers. Base discoid giving short and long stoloniferous holdfast.

Ecology: Grows on hard substratum in shady water pools within intertidal to subtidal zones. This alga also grows as an epiphyte on the stipes of other seaweeds.

Local distribution: Collected as drifted material from Singhar, Gwadar.

Family: Champiaceae

12- *Champia compressa* Harvey, 1838 (Plate 3: fig. 12)
(Hassoun *et al.*, 2018)

Morphology

Plants are 2–10 cm long, colour pale red, opposite branching, alternate below, verticillate; 1–4 axes from holdfast, axes are segmented, terete at their base, diameter 500 μm , reaching up to 2.5 mm at apices, ramuli up to 2 mm wide. Cortex with cells in two layers outer with small cells and inner with large cells. Medulla filamentous. Cystocarps sessile, ovoid, with a visible beak-shaped ostiole. Carposporangia ovoid–polygonal. Tetrasporangia spherical, formed in the sori.

Ecology: It grows as benthic in sandy bottom rock pools, epiphytic in upper and midlittoral zone. This alga was recorded in winter season.

Local distribution: Collected from Sur Bander and Pishukan shorelines.

Order: Ceramiales Oltmanns, 1904

Family: Ceramiaceae Dumortier, 1822

13- *Ceramium manorensis* P. Anand, 1943 (Plate 3: fig. 13)
(Anand 1981:28; Satpati *et al.*, 2012: 50)

Morphology

Thallus forming dense clusters of erect fronds branched, alternate branching at lower part, dichotomous terminals, ramuli not bent inwards, infrequently spreading, apices acute, obtuse, nodes corticated transverse section shows 3–5 rows of cells, cells of central row large with a diameter of ca 2 μm .

Ecology: It grows as epiphyte on other red algae *Hypnea valentiae* in lower and sub littoral. It is found abundantly in summer season.

Local distribution: Specimens were collected from the coast of Pasni.

Family: Rhodomelaceae J.E. Areschoug, 1847

14- *Acanthophora spicifera* (Vahl) Borgesen, 1910 (Plate 3: fig. 14)
(= *Fucus spicifera* M. Vahl)
(Shameel *et al.*, 1996: 228)

Erect forming tufts with spiny branches, 4–10 cm in height, 1–3 mm wide, dark green to reddish, alternately or irregularly branched. Determinate branchlets spirally and regularly arranged on main axes. Cortex with 3–5 layers of small cells at the periphery and large in the middle. Holdfast large and irregular shaped. Tetra sporangia ovate and terete, arising on spiny branchlets.

Ecology: It occurs as benthic on buoys and epilithic on the stones and rocks in intertidal to midlittoral rocks. It is found in all four seasons in exploitable quantity.

Local distribution: Collected from Singhar (Gwadar) and Jiwani.

15- *Polysiphonia fucooides* (Hudson) Greville, 1824 (Plate 3: fig. 15)
(= *Conferva fucooides* Hudson)
(Shameel *et al.*, 1996)

Thallus heterotrichous, consisting of small dense branches of cylindrical tufts, up to 30 cm in length, purple red or red. Transverse section shows Uniaxial filaments surrounded by 11–21 pericentral cells, cortication absent above but present at the base.

Ecology: This algal species grows on rocky substrata and as epiphytic on other algae in water pools in littoral zone. It is commonly found in summer in small quantities.

Local distribution: Specimens were collected as drifts from Pasni shores.

16- *Osmundea pinnatifida* (Hudson) Stackhouse, 1809 (Plate 3: fig. 16)

(=*Fucus pinnatifidus* Hudson)

(*Laurencia pinnatifida* (Hudson) J. V. Lamouroux)

(Taskin, 2013:718)

Morphology

Thallus small in size, up to 5 cm, 2 mm in diameter, tapering towards the base, reddish purple in colour, compressed slightly, bi-tripinnate, branches bear short branchlets, mostly tuber like, apices obtuse, simple or lobed; tetrasporangium scattered towards the apices of the ramuli. Cells in thallus composed of an epidermis of small and rounded cells, 25–32 µm in diameter with a central tissue of large cells, 75–80 µm in diameter, central cell is only clearly seen cell in the section of the young branches.

Ecology: This alga is perennial, grows as epilithic on rocky shores in intertidal subtidal zones. It covers a large area as greenish – yellow to reddish brown tufts on rocks and pools.

Local distribution: Collected as drifted from Singhar, Gwadar

Order: Plocamiales

Family: Sarcodiaceae

17- *Sarcodia dichotoma* Borgeson, 1933 (Plate 3: fig. 17)

(Hameed & Ahmed, 1999:202)

Morphology

Plants solitary or in tufts, thallus flat, fleshy, membranaceous, dichotomously branched or irregularly lobed, up to 20 cm long, 5–9 mm wide, margins with proliferations. Tetraspores scattered over the surface of the thallus, cystocarps globule to spherical, found along the margins, sometimes scattered all over the surface. In cross section, the thallus is composed of cortex of small cells surrounding rounded, large medullary cells. Tetra sporangia zonate immersed in the cortical tissue, brown – purple. Gelatinous to cartilaginous consistency.

Ecology: Epilithic found in rocky pools of lower littoral zone. It can be found abundantly in summer.

Local distribution: Sur Bander and Singhar, Gwadar.

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(Received for publication 8 January 2020)