



Morpho-anatomical Studies on Two Peculiar Brown Algae from Karachi Coast of Pakistan

Alia Abbas^{1*} and Mustafa Shameel²

¹Department of Botany, Federal Urdu University of Arts, Science and Technology, Gulshan-e-Iqbal, Karachi-75300

²Department of Botany, University of Karachi, Karachi -75270, Pakistan

Abstract: Two dictyolean brown algae, *Padina antillarum* (Kützing) Piccone and *Stoechospermum ploypodioides* (J. V. Lamouroux) J. G. Agardh, were collected from Manora, Hawksbay and Buleji, the coastal areas near Karachi during March 2007-May 2010 and investigated for their morphology, anatomy and reproductive structures. This is the first detailed study of these species from the coast of Pakistan. The present specimens were investigated in detail for the measurement, size and shape of surface cells, presence and absence of intercellular spaces, cell-wall thickness *etc.*

Keywords: Marine algae, Phaeophycota, Dictyotales, *Padina*, *Stoechospermum*, morphology, anatomy, reproduction

INTRODUCTION

Although the occurrence of the algal genera, *Padina* Adanson and *Stoechospermum* Kützing were first reported from the coast of Karachi Pakistan very early [1], but only a few studies were made on the taxonomy of their various species [2-4]. Only recently attention has been paid on this aspect, and a taxonomic survey of their species growing in the coastal waters of Karachi was carried out [5-8]. In this connection two peculiar species were collected, which were not described earlier. They have now been investigated in detail for their morphology and anatomy.

MATERIALS AND METHODS

The specimens were collected from Manora, Hawksbay and Buleji, the coastal areas of Karachi (Pakistan) during March 2007 and May 2010, and preserved in 4 % formaldehyde-seawater solution. In order to study internal structures, cross sections (C.S.) were obtained by freehand cutting with shaving blades, which

were stained with aniline blue and mounted in glycerine. The semi-permanent slides were sealed with nail polish and examined under microscope (Nikon PFX, Japan). The photographs were taken by Nikon F 601 camera and developed in a photolab with *hp* scanner. The photographic plates were prepared in Adop Photoshop 7.0 with the help of a computer. The herbarium sheets of the materials are deposited in the herbarium (FUU-SWH), Department of Botany, Federal Urdu University of Arts, Science & Technology, Karachi, Pakistan.

RESULTS

The general observation and microscopic examination of the collected specimens indicated following characters of the two investigated species.

1. *Padina antillarum* Kützing Piccone 1886: 36

Basionym

Zonaria antillarum Kützing 1859: 29.

Synonym

Padina tetrastromatica Hauck 1887: 43.

References

Børghesen 1935: 35, 1939: 80, Anand 1940: 5, Durairatnam 1961: 36, Salim 1965: 195, Misra 1966: 158, 1967: 233, Krishnamurthy & Joshi 1970: 11, Saifullah 1973: 140, Islam 1976: 41, Jaasund 1976: 45, Shameel & Afaq-Husain 1987: 295, Silva *et al.* 1987: 79, 1996: 601, Begum & Khatoon 1988: 298, Shameel *et al.* 1989: 179, 2000: 84, Shameel & Tanaka 1992: 39, Ormond & Banaimoon 1994: 117, Shaikh & Shameel 1995: 22, Shameel 2000: 51, Nizamuddin & Begum 2006: 231, Begum 2010: 242, Aisha & Shameel 2010: 330 [3, 4, 6, 7, 9-27].

Morphological characters

Thalli olive green or dark green in colour, dichotomously or irregularly branched; margins smooth or slightly undulate, apex enrolled, surface smooth; sporangia present in double sporangial lines, sporangial lines and hair lines alternate to each other; attached with the help of a small, compact, holdfast, 0.5 – 1.5 cm broad and 0.7 – 2.0 cm long; thallus divided into many lobes, upto $\frac{3}{4}$ part of the thallus, many clefts present on the thallus; thalli 7 – 15 cm long, 7 – 12 cm broad at the apex, 10 – 12 cm broad at the middle and 7.5 – 10.0 cm broad at the base (Fig. 1).

Anatomical features

In surface view: thalli dark brown, peripheral cells cubical or rectangular, 7.5 – 20.0 μm in length and 7.5 – 15.0 μm in breadth; double sporangial lines present at specific intervals (Fig. 2), sporangial lines alternate with the hair lines (Fig. 3).

In the apical portion: thallus consists of 2 – 3 layers *i.e.* upper and lower peripheral layers and one layered cortex; peripheral cells cubical or squarish, thin walled, cell size more or less equal, with dense phaeoplasts, 17.5 – 25.0 μm in length and 20 – 25 μm in breadth (Fig. 4);

cortical cells large, rectangular or slightly cubical, thin walled, poor in contents, intercellular spaces absent, 25.0 – 32.5 μm long and 12.5 – 25.0 μm broad (Fig. 5).

In the middle part: thallus consists of 3 – 4 layers; upper and lower peripheral layers composed of cubical or quadratic, thin walled cells, with dense phaeoplasts, peripheral and cortical cells more or less equal in size, 17.5 – 27.5 μm in length and 17.5 – 22.5 μm in breadth; two layered cortex composed of cubical or squarish, thin walled cells, inter-cellular spaces absent, poor in contents, 15 – 25 μm long and 12.5 – 15.0 μm broad (Fig. 6).

In the basal portion: thallus composed of 4 (-5) layers; upper and lower peripheral layers consist of cubical, thin walled cells, with dense phaeoplasts, 12.5 – 25.9 μm in length and 10.0 – 22.5 μm in breadth; 2 (-3) layered cortex consists of squarish or cubical cells (Fig. 7), inter-cellular spaces absent, poor in contents, 12.5 – 25.0 μm long and 10.0 – 27.5 μm broad, cells thick walled (Fig. 8).

Reproductive structures

Sporangia non-indusiate, dark brown or reddish brown, stalked, arise from peripheral cells, 20 – 60 μm in length and 15 – 35 μm in breadth (Fig. 9); tetrasporangia found in sori, sporangial lines present on both surfaces of the thallus (Fig. 10).

Type locality

Locality not specified: (*Padina tetrastromatica* = Meith (Maydh), Somalia).

Habitat

Collected as drift material or benthic in shallow sandy pools at Manora (*Leg.* Alia Abbas 6-4-2009); Goth Haji Ali, Buleji (*Leg.* Alia Abbas 17-3-2007, 18-3-2008, 24-1- & 31-3-2009).

Local distribution

Karachi: Manora, Hawksbay, Buleji and Paradise Point; Balochistan: Sonmiani, Sur Bunder and Gawader.

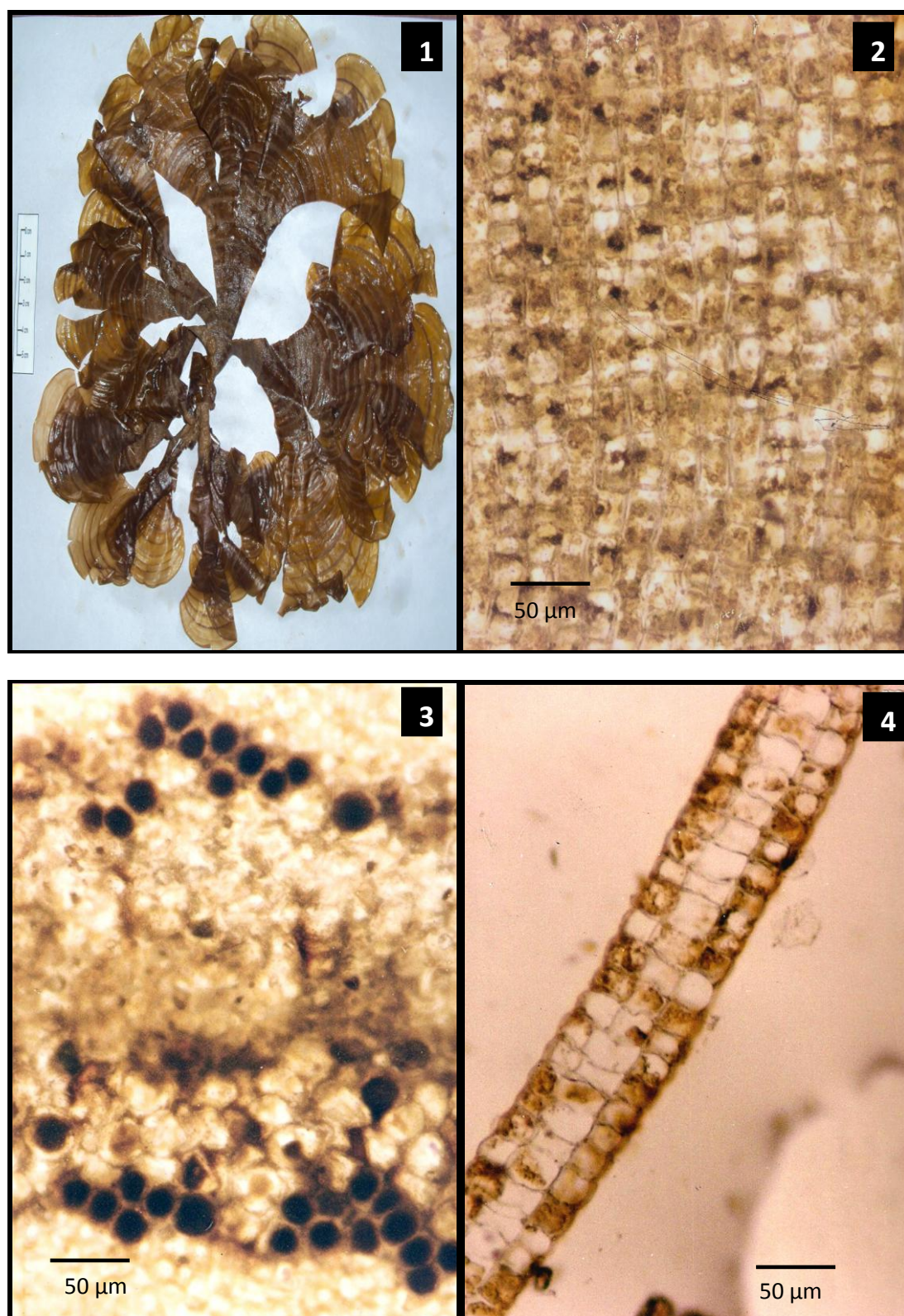


Fig. 1-4. *Padina antillarum*: **1.** Habit of the thallus, **2.** Surface view of thallus, **3.** Sporangial lines on the surface, **4.** C.S. of apical portion of thallus.

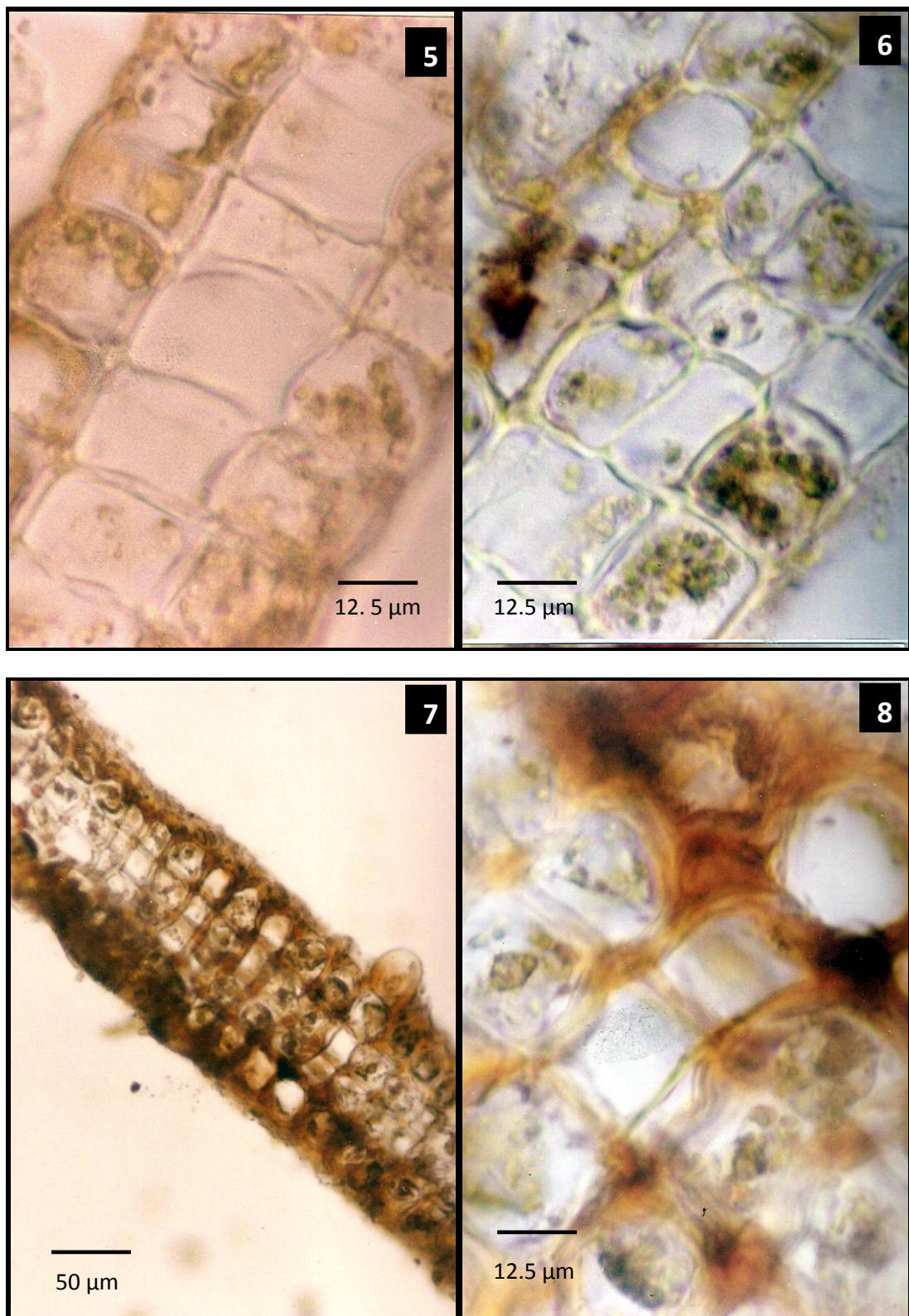


Fig. 5-8. *Padina antillarum*: **5.** Enlarged view of apical portion, **6.** C.S. of middle part of thallus, **7.** C.S. of basal portion, **8.** Thick walls present in the basal part.

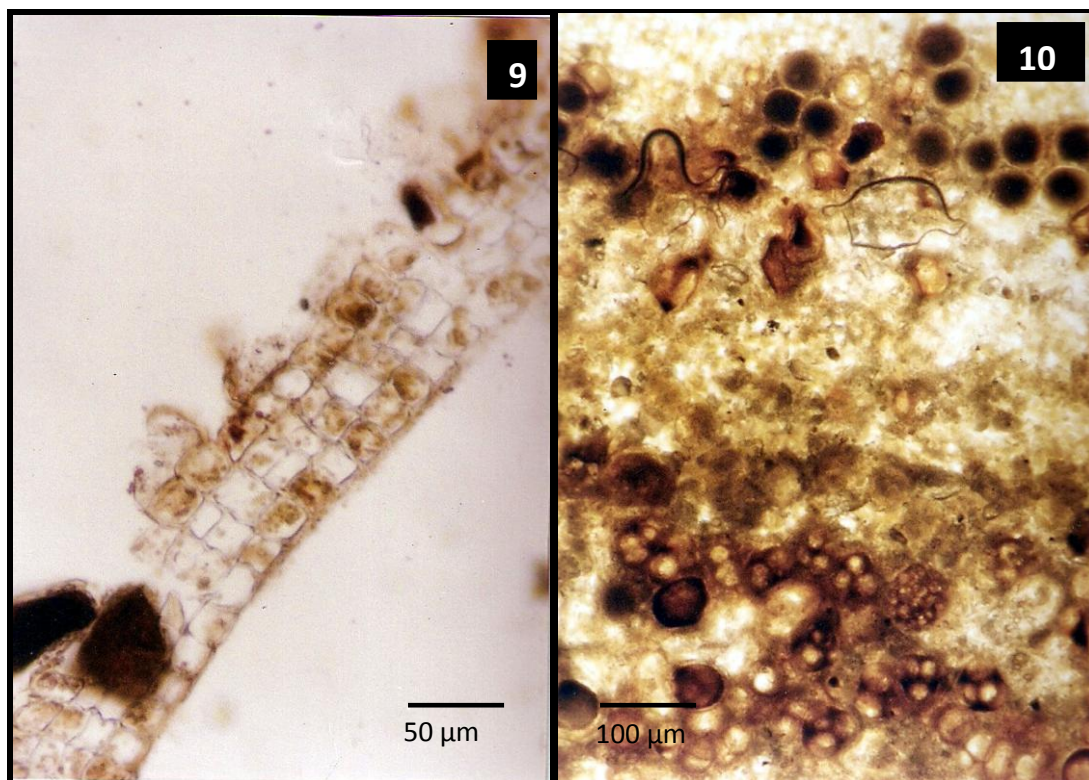


Fig. 9-10. *Padina antillarum*: 9. Sporangia arising from peripheral cells, 10. Tetrasporangia in sori.

Distribution in the Indian Ocean

Andaman Islands, Diego Garcia Atoll, India, Indonesia, Iran, Kenya, Kuwait, Laccadive Islands, Malaysia, Nicobar Islands, Pakistan, Seychells, Singapore, Somalia, South Africa, Sri Lanka, Tanzania and Yemen.

2. *Stoechospermum polypodioides* (J. V. Lamouroux) J. G. Agardh 1848: 100

Basionym

Dictyota polypodioides G. V. Lamouroux 1809: 44.

Synonyms

Zonaria polypodioides (Lamour.) C. A. Agardh 1820: 136, *Zonaria marginata* C. A. Agardh 1824: 266, *Dictyota marginata* (C. A. Agardh) Greville 1830: xliiii, *Dictyota maculata* J. G. Agardh 1841:446, *Stoechospermum marginatum* (C. A. Agardh) Kützing 1843: 339, *Stoechospermum maculatum* (J. Agardh) J. G. Agardh 1848:99, *Stoechospermum patens* Hering ex J. G. Agardh 1848: 99.

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Børgesen 1934: 28, Durairatnam 1961: 33, Misra 1966: 161, 1967: 233, Krishnamurthy & Joshi 1970: 11, Jaasund 1976: 45, Nizamuddin & Perveen 1986: 124, Shameel 1987: 513, 2000: 52, Shameel & Afaq-Husain 1987: 295, Begum & Khatoon 1988: 299, Shameel *et al.* 1989: 179, 1996: 227, 2000: 85, Shameel & Tanaka 1992: 39, Ormond & Banaimoon 1994: 117, Shaikh & Shameel 1995: 25, Silva *et al.* 1996: 610, De Clerck & Coppejans 1997: 338, Abbas & Shameel 2008: 2567, Begum 2010: 272 [1-6,11-15, 18-26, 28-31].

Morphological characters

Thalli greenish brown in colour, erect, tufted, linear, ligulate; 5 - 26 cm in height, attached with rhizoids emerging from holdfast up to 1 cm broad (Fig. 11); fronds flat, 0.3 – 1.5 cm broad at the apex, 1 – 2 cm broad at the middle and 2 – 5 mm broad at the base; dichotomously branched, dichotomy at 2.0 – 6.5 cm apart, attenuated, cuniate below; lateral margins of branches entire, apical margins involute, surface smooth; growth of thalli by means of marginal meristem; sporangial

sori arranged in longitudinal rows along the margins; distance of sori from margins 1 – 2 mm, sori 1 – 3 mm broad (Fig. 12).

Anatomical features

In surface view: surface cells small and quadratic, polygonal, dark brown, thin walled; group of cells arranged in different manners, 7.0-22.5 μm in length and 5-20 μm in breadth (Fig. 13).

In the apical portion: thallus consists of 6 – 7 layers including upper and lower peripheral layers; peripheral cells are small, quadratic with dense phaeoplasts, enclosing 4 – 5 layered cortical cells. Cortical cells are more or less isodiametric and equal in size, poor in contents, thin walled, 12.5 – 47.5 μm long and 10.5 – 40.5 μm broad (Fig. 14).

In the middle part: thallus consists of 11 – 12 layers, cells of peripheral layers are small, rectangular, compact, have no intercellular space with dense phaeoplasts, 12.5 – 25.0 μm in length and 12.5 – 25.0 μm in breadth; the 9 – 10 layered cortical cells are present at the central portion of the thallus; in the central region of cortical cells 9 - 10 layers are large, polygonal or rectangular with intercellular spaces, poor in contents, 75.0 – 87.5 μm long and 25.0 – 42.5 μm broad (Fig. 15). Number of layers gradually decreases from centre to margins; only 3 layered cortex is present at the dichotomy, the cortical cells present at the dichotomy are divided into two portions: central portion with large, elongated cells, 150 – 200 μm in length and 67.5 – 100 μm in breadth, and on either side of central cells are narrow, elongated cells, 75 – 130 μm long and 25 – 62 μm broad (Fig. 16).

In the basal portion: 10 – 12 layers are present including single layered peripheral cells, which are small, slightly elongated or quadratic, with dense phaeoplasts, 15 – 25 μm in length and 10.0 – 17.5 μm in breadth (Fig. 17); they enclose 8 – 10 layered cortical cells,

which are polygonal, large, parenchymatous, poor in contents, 25 – 125 μm long and 25 – 75 μm broad, thick walled (Fig. 18); cell-wall thickness is 7.5 – 17.5 μm (Fig. 19).

Reproductive structures

Thalli monoecious, reproductive bodies occurring in the form of marginal sori; antheridia cylindrical, dark brown, 17.5 – 12.0 μm in length and 12.5 – 37.5 μm in breadth (Fig. 20); oogonia club-shaped, dark brown, 25 – 75 μm long and 12.5 – 30.0 μm broad, associated with hairs; hairs distributed among oogonia, 75.0 – 137.5 μm in length and 12.5 – 50.0 μm in breadth, tips of hairs in 3 – 4 different shapes: swollen, curved and bifurcated (Fig. 21); tetrasporangia dark brown, globular, stalked, large, 22.5 – 37.5 μm long and 17.5 – 30.0 μm broad; hairs also distributed among tetrasporangia (Fig. 22).

Type locality

Locality unknown: (*Zonaria marginata*= “Ex coll. Forskåhleana”, Red Sea).

Habitat

Collected as drift material from the sandy beach at Manora (Leg. Alia Abbas 6-4-2009); Hawksbay (Leg. Alia Abbas 14-4-2010); Goth Haji Ali, Buleji (Leg. Alia Abbas 17-3-2007, 15-3- & 24-7-2008, 31-3-2009, 12-2-, 24-3-, 22-4- & 19-5-2010).

Local distribution

Karachi: Manora, Hawksbay, Buleji, Paradise Point, Cape Monze, Goth Mubarak, Goth Manjar; Balochistan: Gadani, Sonmiani, Miani Hor, Ras Malan, Sur Bunder, Gawadar and Jiwani.

Distribution in the Indian Ocean

Australia, Egypt, Eritrea, Ethiopia, India, Indonesia, Iran, Kenya, Madagascar, Mauritius, Mozambique, Oman, Pakistan, Red Sea, Somalia, South Africa, South-East Arabian Coast, Sri Lanka, Tanzania and Yemen.

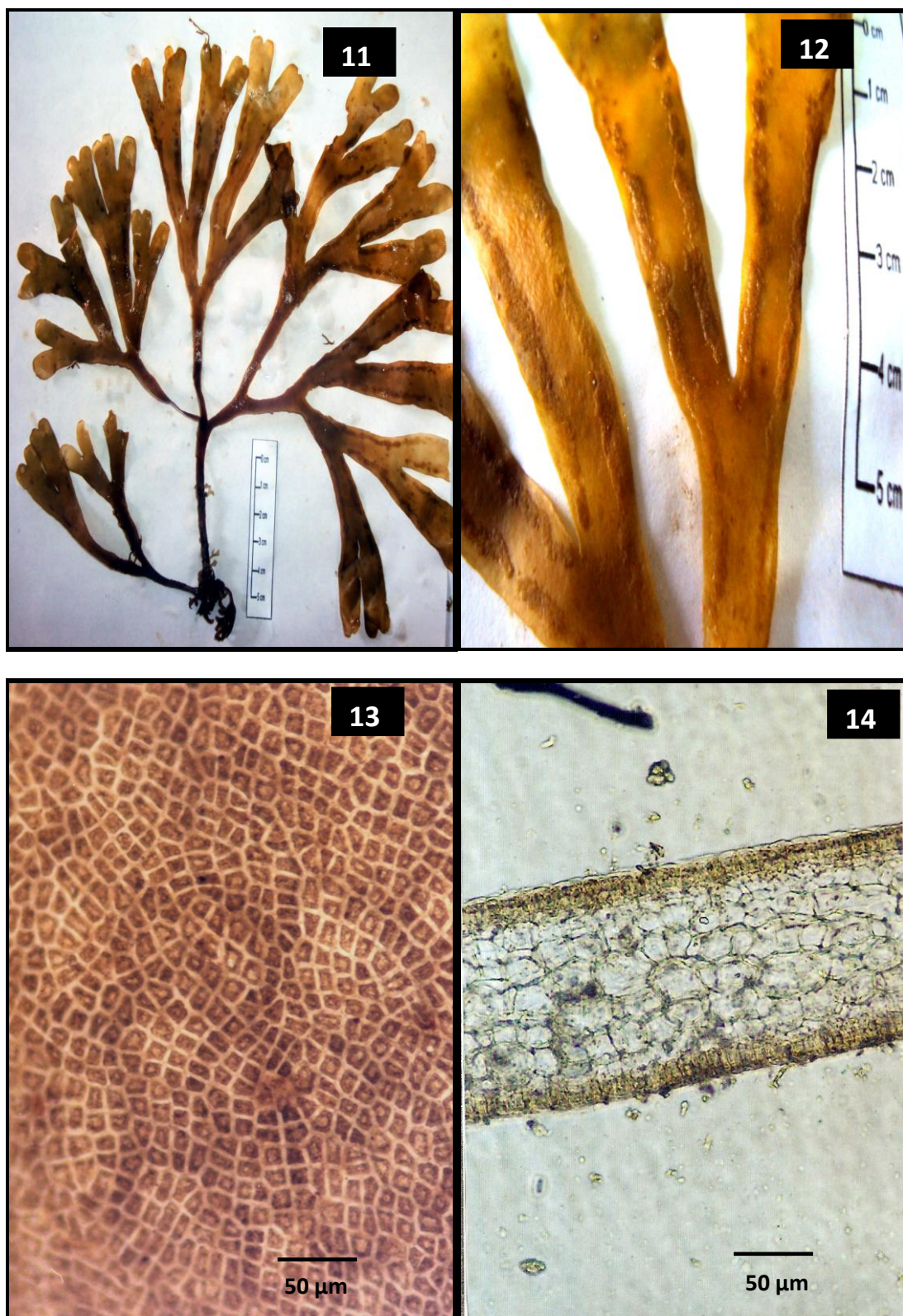


Fig. 11-14. *Stoechospermum polypodioides*: **11.** Habit of the thallus, **12.** Thallus with sporangial sori, **13.** Surface view of thallus, **14.** C.S. of apical portion.

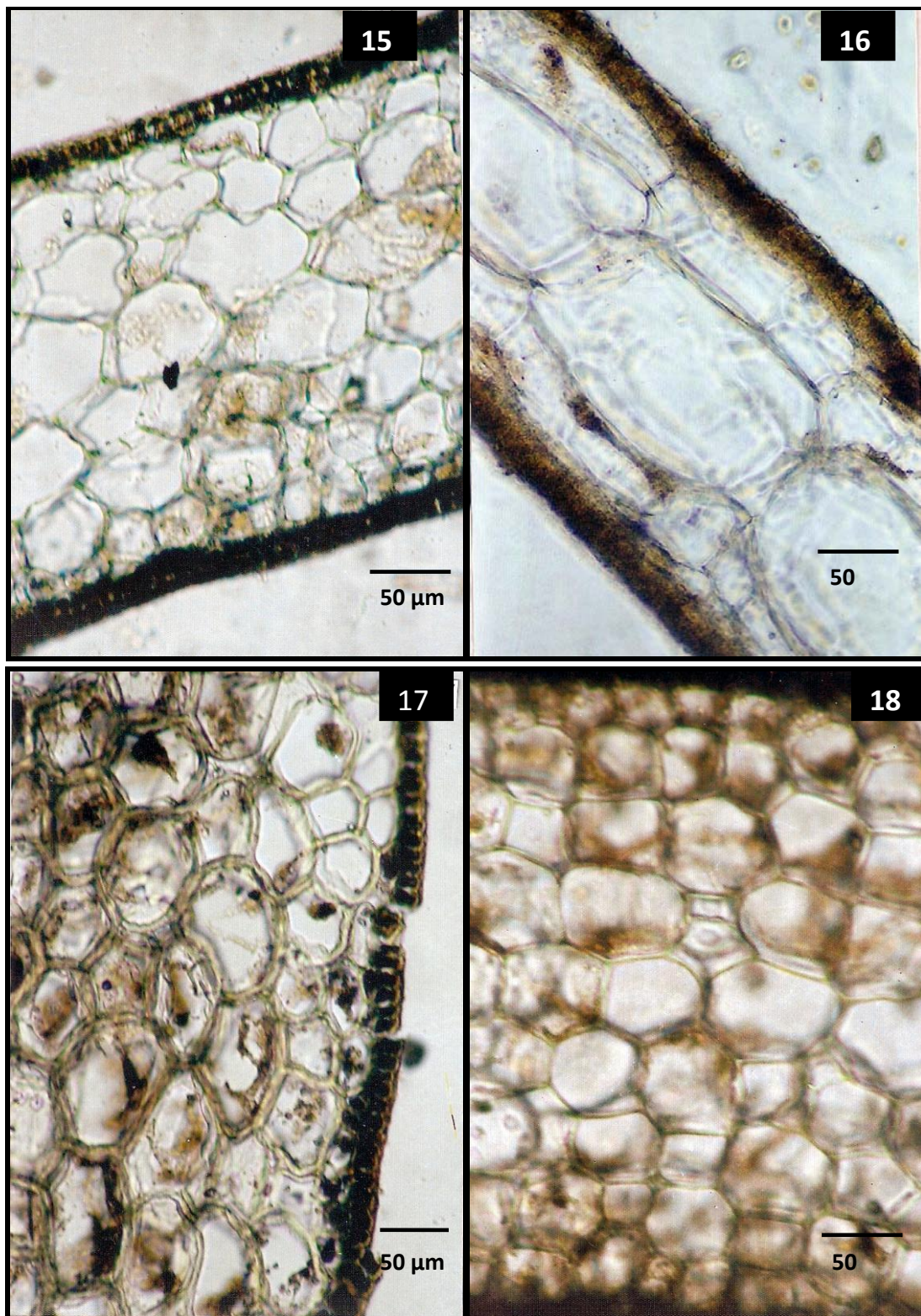


Fig. 15-18. *Stoechospermum polypodioides*: **15.** C.S. of middle part of the thallus, **16.** C.S. at 3-layered dichotomy, **17.** C.S. of basal portion showing peripheral cells, **18.** 12-layered thallus at the basal part.

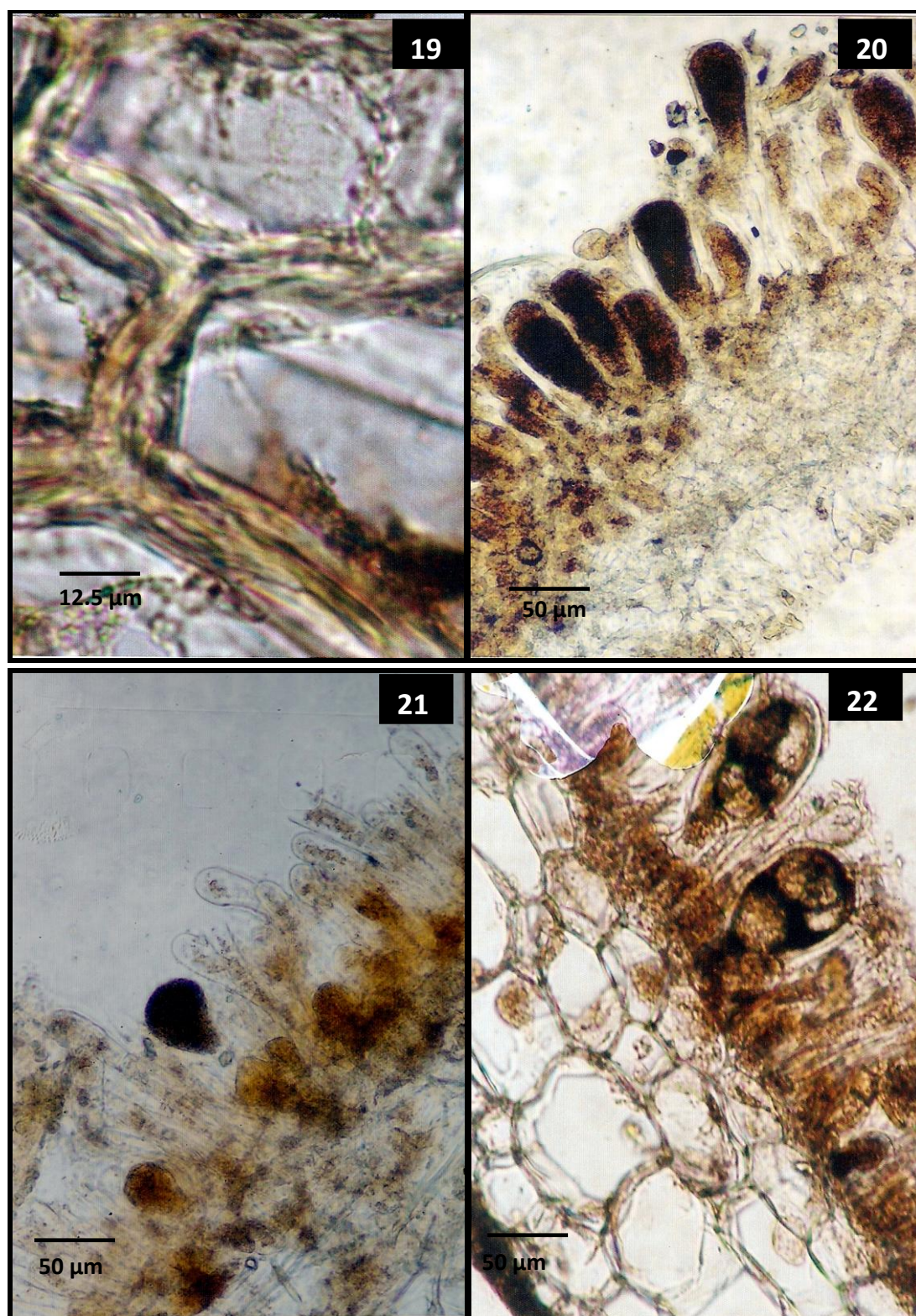


Fig. 19-22. *Stoechospermum polypodioides*: 19. Cell-wall thickness at basal portion of thallus, 20. C.S. of thallus showing antheridia, 21. Oogonia associated with Hairs 22. Tetrasporangia associated with hairs.

DISCUSSION

Padina antillarum and *Stoechospermum polypodioides* are marine algae of the family Dictyotaceae (order Dictyotales, class Dictyophyceae, phylum Phaeophycota [32]. The population of *P. antillarum* growing at the coast of Pakistan was initially considered as *P. tetrastromatica* [3, 4, 9]. The present specimens were investigated in detail for the measurement, size and shape of surface cells, presence and absence of intercellular spaces in the peripheral and cortical cells, cell-wall thickness *etc.* All these characters were not described by the previous workers [4, 27]. Wynne argued that *P. tetrastromatica* is a synonym of the earlier *P. antillarum* [33]. It was observed in the recent studies [6, 7] that the Karachi specimens are quite different from Wynne's illustrations, therefore these workers considered the specimens as *P. tetrastromatica*. But our material showed a resemblance, therefore the present specimens have been treated as *P. antillarum*. Prof. Dr. Gerald T. Kraft agreed with this treatment (pers. comm.). However, molecular analysis using *rbcL* and mitochondrial *COX3* genes as molecular markers may confirm the identification of this species, as has recently been carried out on several species of *Padina* from Japan [34, 35].

Stoechospermum Kützing is now a monospecific genus, which was based on the type species *S. marginatum* (C. Agardh) Kützing. Gradually its four more species were reported: *S. maculatum* J. Agardh, *S. patens* Hering *ex* J. Agardh, *S. polypodioides* (Lamouroux) J. Agardh and *S. suhrii* Kützing. But *S. suhrii* was transferred to the genus *Dictyota* [36], *S. maculatum* and *S. patens* were reduced to synonyms of *S. marginatum* [37]. Recently, the examination of type specimen of *S. polypodioides* revealed it to be conspecific with *S. marginatum*, and the anteriority of *Dictyota polypodioides* Lamouroux on *Zonaria marginata* C. Agardh (the basionyms of the two mentioned species) resulted in *S. marginatum* to be a synonym of *S. polypodioides* [31].

This is the first study made on the specimens of *S. polypodioides* growing in the

coastal waters of Pakistan. All the reports and investigations carried out in the past on Pakistani specimens of *S. marginatum* [e.g. 2-30, 38] should now be considered as about *S. polypodioides*. Absence of hairs in the sporangial sori were reported in the specimens of *S. marginatum* from Sri Lanka [11], whereas occurrence of hairs was described only in the oogonial sori in the Indian specimens [13]. In the specimens of *S. polypodioides* from Pakistan the hairs are present among oogonia and tetrasporangia both. Our specimens are characterised by the presence of hairs of 3 – 4 different shapes in the reproductive organs, 9–10 layered and very thick-walled cortical region in the basal portion of the thallus and a 3-layered cortex of very large central cells at dichotomy. These characters were not observed previously [2 & 4].

Previously the peripheral cells were measured in *S. marginatum* as 5 – 18 µm long and 8 – 12 µm broad, cortical cells as 28 – 188 µm in length (breadth was not mentioned) and sporangia as 65 – 115 µm long and 15 – 60 µm broad [2]. But in our specimens peripheral cells were observed as 15 – 25 µm in length and 10.0 – 17.5 µm in breadth, cortical cells as 25 – 200 µm long and 25 – 75 µm broad and sporangia as 22.5 – 37.5 in length and 17.5 – 30.0 µm in breadth. Rows of sori were not measured previously but peripheral cells were reported in *S. marginatum* as 13 – 17 µm in length and 10 – 14 µm in breadth, and cortical cells as 68 – 102 µm in diameter in cross section [4]. Our specimens differed from both these previous studies. The thalli of *S. polypodioides* growing on a shallow reef flat in the southern Red Sea (Eritrea) were found to exhibit highly seasonal pattern of growth and reproduction related to the seasonal variation in the environment, especially temperature [39].

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