



Studies on Three Species of *Dictyota* (Phaeophycota) 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, Pakistan

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

Abstract: Three species of *Dictyota* i.e. *D. ceylanica* Kützinger, *D. ciliolata* Kützinger and *D. linearis* (C. Agardh) Greville were collected from the coastal areas of Karachi (Pakistan) during March 2007 and October 2009. They were investigated in detail for their morphology, anatomy and reproduction. Anatomically their thalli were studied in detail for the first time which revealed some interesting features.

Keywords: Marine algae, Phaeophycota, *Dictyota*, Anatomy, morphology, reproduction

1. INTRODUCTION

Like other areas of Arabian Sea, the coastline of Pakistan is also rich in the species diversity of brown algal genus *Dictyota* J. V. Lamouroux, *nom. cons.* [1, 2]. Several species were reported to grow in the seashore waters of Karachi [3, 4], but no detailed study has been made in this connection. During 2006-2009 a large collection survey of brown seaweeds was made from various coastal areas of Karachi, where three species were collected. They were investigated in detail for their morphology, anatomy and reproduction as presented here.

2. MATERIALS AND METHODS

The specimens were collected from Buleji, the coastal area of Karachi (Pakistan) during March 2007 and October 2009, and preserved in 4 % formaldehyde-seawater solution. The herbarium sheets of the materials were prepared and deposited in the Herbarium (FUU-SWH), Department of Botany, Federal Urdu University of Arts, Science & Technology, Karachi, Pakistan. In order to study internal structures, cross sections (C.S.) of the fresh material were obtained by freehand cutting with shaving blades, which were stained, mounted, slides

were prepared and examined under microscope, photographs were taken and developed, and photographic plates were prepared as described recently [5].

3. RESULTS

The collected specimens on general observation and microscopic examination revealed the presence of three species of *Dictyota*, which may be distinguished as follows:

1. Dark coloured lines on thallus surface 2
No such lines on thallus surface...*D. ceylanica*
2. Thallus profusely branched*D. ciliolata*
Thallus dichotomously branched..*D. linearis*

These species differ from one another in several body characters, as shown in the Table I. Their general characters and anatomical features are given below.

1. *Dictyota ceylanica* Kützinger 1859: 11

References

Misra 1966: 139, 1967: 233, Jaasund 1976: 41,

Silva *et al.* 1987: 75, 1996: 588, Begum & Khatoon 1988: 295, Shameel & Tanaka 1992: 37, Ormond & Banaimoon 1994: 117, De Clerck 2003: 52, Abbas & Shameel 2012: 37 [1, 3, 5-12].

Morphological characters

Thalli reddish brown, erect, flat, dichotomously branched, surface smooth, margins undulate with prominent ridges; apex emarginated with a triangular notch, apex of lobes obtuse; base trenched by means of a compact holdfast; thallus 8–10 cm long, 2–5 mm broad at the apex, 0.8–1.2 cm broad at middle and 1.0 - 1.8 cm broad at the base; dichotomy 0.5–1.5 cm apart, angle between dichotomy rounded at lower portion (Fig. 1).

Anatomical features

In surface view: thallus surface dark brown, peripheral cells cubical and rectangular, arranged horizontally; sori scattered on both surfaces of the thalli, dark brown, rounded or oval or cubical in shape (Fig. 2).

In the apical portion: thallus consists of peripheral layers enclosing a single layered medulla; peripheral cells small, cubical, thin walled, with dense phaeoplasts, 20–25 μm in length and 17.5–25.0 μm in breadth; medullary cells large, quadratic or thick walled, poor in contents, 100–125 μm in length and 100.0–112.5 μm in breadth (Fig. 3)

In the middle part: peripheral cells small, cubical, thin walled, with dense phaeoplasts, 25.0–37.5 μm in length and 12.5–25.0 μm in breadth; medullary cells large, thick walled, poor in contents, cubical, 112.5–125.0 μm in length and 110.0–122.5 μm in breadth (Fig. 4).

In the basal portion: peripheral cells small, thin walled, cubical, with dense phaeoplasts, 20–25 μm in length and 25–30 μm in breadth; medullary cells large, thick walled, cubical, poor in contents, 87.5–125.0 μm in length and 87.5–100.0 μm in breadth; marginal medullary cell long, thin-walled, poor in contents, rectangular, 25 - 100 μm in length and 20–50 μm in breadth (Fig. 5).

Reproductive structures

Thalli dioecious; antheridia present in sori, club-shaped, dark brown in colour, cylindrical, upper portion swollen, 5–10 antheridia present in a sorus,

sori scattered on both surfaces of the thallus; antheridia 87.5–125.0 μm in length and 25–37.5 μm in breadth (Fig. 6).

Type locality

Sri Lanka.

Habitat

Benthic on mid-littoral rocks and edges of pools at Goth Haji Ali, Buleji (*Leg.* Alia Abbas 18-10-2008).

Local distribution

Karachi: Buleji.

Distribution in the Indian Ocean

India, Kenya, Pakistan, Seychelles, South Africa, Sri Lanka, Tanzania and Yemen.

Remarks

This species is of rare occurrence at the coast of Karachi. Although it was collected earlier as drift material from Buleji coast but was not taxonomically described [3]. The present study is the first taxonomic and anatomical investigation of this species from the coast of Pakistan. Its identification was confirmed by Prof. Dr. Olivier De Clerck (pers. comm.).

2. *Dictyota ciliolata* Kützing 1859: 12

Synonym

Dictyota ciliata J. Agardh 1841: 5, *nom. illeg.*

References

Børgesen 1914: 211, Durairatnam 1961: 37, Misra 1966: 136, 1967: 233, Earle 1969: 155, Jaasund 1976: 41, Silva *et al.* 1987: 75, 1996: 588, Begum & Khatoon 1988: 295, Shameel & Tanaka 1992: 37, De Clerck 2003: 58, Begum 2010: 176, Abbas & Shameel 2012: 40 [1, 3, 5-10, 12-16].

Morphological characters

Thalli dark brown in colour, orbicular in shape, profusely branched, branches arise from all sides of the thallus; margins entire, base acuminate and dichotomously branched; apex of branches emarginated, apex of lobes obtuse and broad below the tip, surface smooth; attached with the help of a cuneate compact disk, 4 mm long and 3 mm broad;

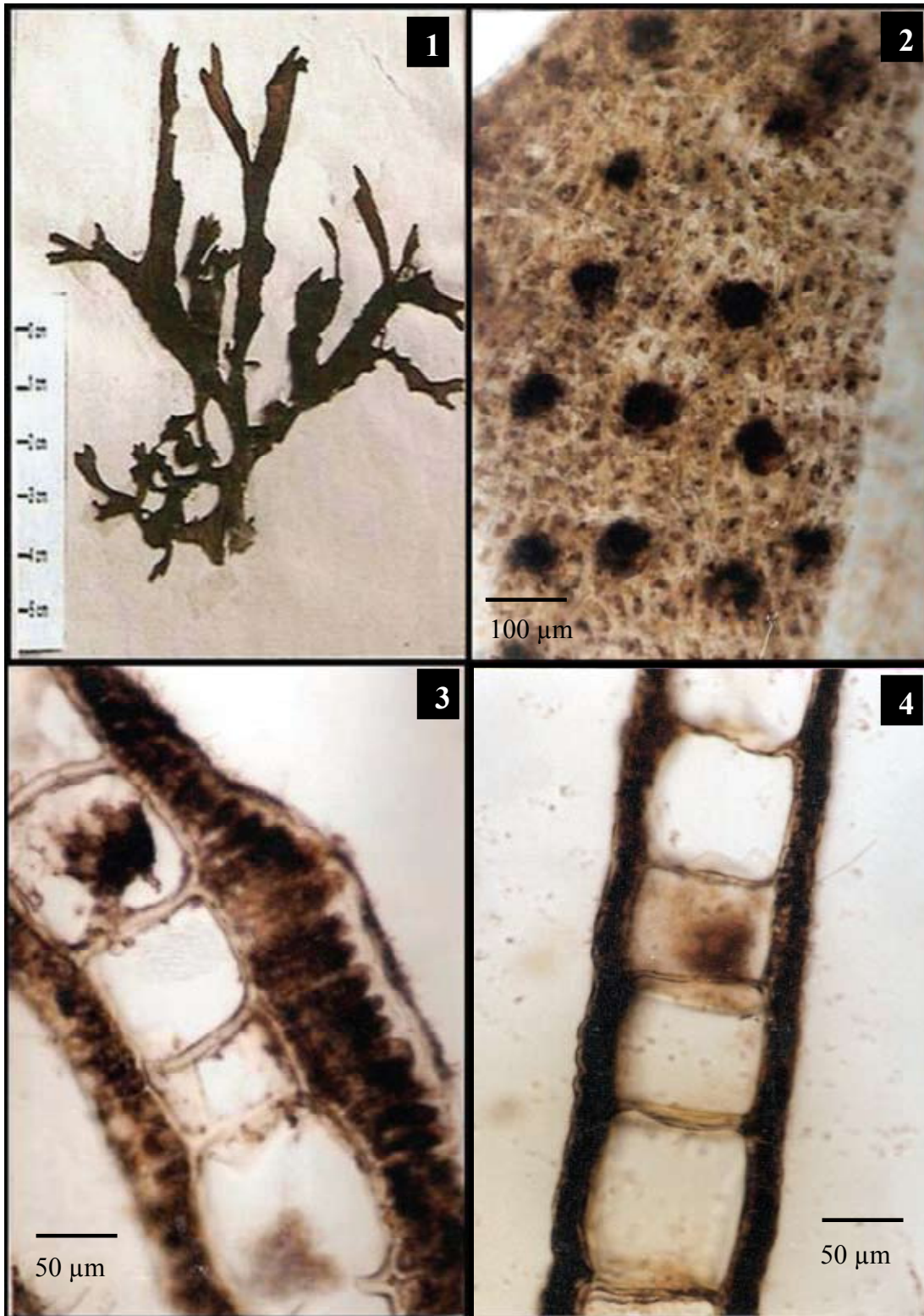


Fig. 1-4. *Dictyota ceylanica*: 1. Habit of the thallus; 2. Surface view of thallus; 3. C.S. of apical portion; 4. C.S. of middle part of thallus.

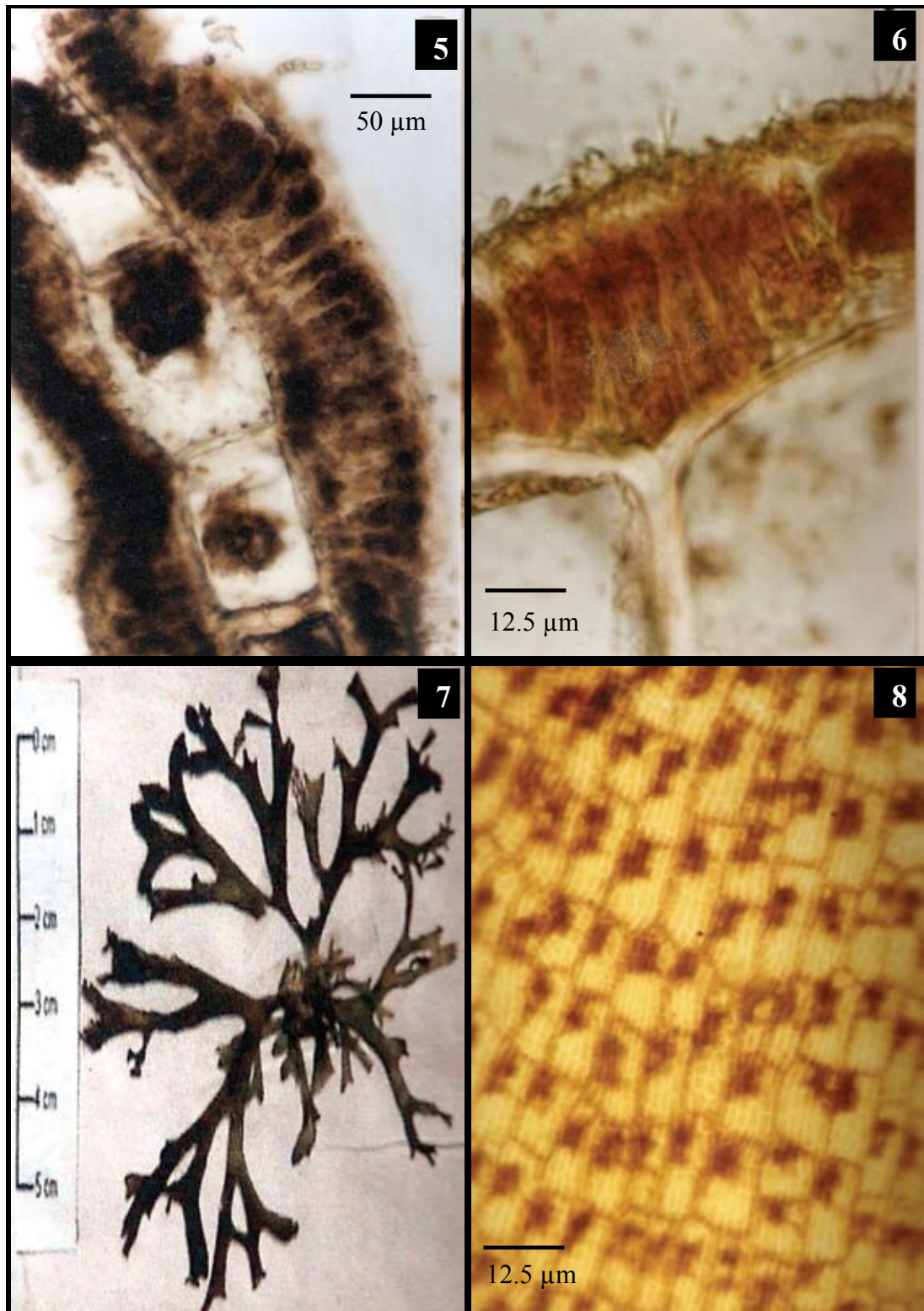


Fig. 5-6. *Dictyota ceylanica*: **5.**C.S. of basal portion containing antheridial sori on both surfaces; **6.** Antheridia in enlarged view.

Fig. 7-8. *Dictyota ciliolata*: **7.** Habit of the thallus, **8.** Surface view of thallus.

thallus 5–6 cm high, 2–4 mm broad at the apex, 3–4 mm broad at the middle, and 1–2 mm at the base; small proliferations arise from basal and upper parts of the thallus; dark brown lines present on the thallus surface (Fig. 7).

Anatomical features

In surface view: rectangular blocks forming horizontal and vertical lines; peripheral cells arranged in longitudinal rows, small, rectangular, 15–30 μm in length and 10.0–22.5 μm in breadth (Fig. 8). Thallus in its entire length consists of upper and lower peripheral layers and a central single layered medulla.

In the apical portion: peripheral layers consist of small, cubical or squarish, thin walled cells, with dense chromatophores, cell-wall thickness 2.5 μm , 22.5–25.0 μm in length and 15.0–20.0 μm in breadth; single layered medulla consists of large, squarish, thick walled cells, poor in contents, cell-wall thickness 5.0–7.5 μm , 62.5–87.5 μm in length and 75.0–87.5 μm in breadth (Fig. 9).

In the middle part: peripheral cells small, cubical, thin walled, with dense phaeoplasts, 7.5–17.5 μm in breadth, cell-wall thickness 2.5 μm , some large cells are present where cell-wall of medulla is formed, large in size, 25 μm in length and 25 μm in breadth; medullary cells large, cubical, thick walled, poor in contents, cell-wall thickness 7.5–10.0 μm , 75–100 μm in length and 75.0–87.5 μm in breadth; marginal medullary cell small, semi-circular, 15.0–27.5 μm in length and 22.5–30.0 μm in breadth.

In the basal portion: peripheral cells small, cubical or squarish, thin walled, with dense phaeoplasts, cell-wall thickness 2.5 μm , 10.0–22.5 μm in length and 10–25 μm in breadth; medullary cells large, cubical, thick walled, poor in content, cell-wall thickness 7.5 μm , 50.0–87.5 μm in length and 50.0–87.5 μm in breadth. Cells of dorsal peripheral layer large, cubical, slightly elongated, loosely arranged, light brown, cells in the ventral layer small, flattened or cubical, dark brown in colour (Fig. 10). On both sides of thallus, peripheral layers covered with a layer of epiphytes or deposition of calcareous material. Marginal medullary cell cubical or slightly rounded, small, thick-walled, 20.0–37.5 μm in length and 20.0–32.5 μm in breadth (Fig. 11).

Reproductive structures

Reproductive bodies were not observed, collected thalli were only in the vegetative stage.

Type locality

La Guaira, Venezuela

Habitat

Benthic on mid-littoral rocks and edges of rocky pools at Goth Haji Ali, Buleji (Leg. Alia Abbas 18-10-2008).

Local distribution

Karachi: Manora, Buleji, Cape Monze and Goth Manjar.

Distribution in the Indian Ocean

Australia, India, Kenya, Kuwait, Madagascar, Pakistan, Réunion, Singapore, Sri Lanka, Tanzania and Yemen.

Remarks

The conspecificity of *Dictyota ciliolata* Kützing and *D. ciliata* J. Agardh was proposed by J. Agardh and he erroneously retained the latter name on the basis of the date of priority. But this name is *nom. illeg.*, because it is a later homonym of *D. ciliata* Lamouroux 1809: 41 [10], therefore the correct name for the present species would be *D. ciliolata*. Its identification was confirmed by Prof. Dr. Olivier De Clerck (pers. comm.).

3. *Dictyota linearis* (C. Agardh) Greville 1830: 13

Basionym

Zonaria linearis C. Agardh 1817: 20

Synonyms

Dichophyllum linearis (C. Agardh) Kützing 1843: 338, *Dictyota angustissima* Kützing 1859: 10.

References

Nizamuddin 1981: 47, Silva *et al.* 1987: 76, 1996: 594, Begum & Khatoon 1988: 303, De Clerck 2003: 150 Abbas & Shameel 2012: 69 [3, 5, 9-12, 17].

Morphological characters

Thalli olive green in colour; up to 15 cm long, 5-10 mm broad at the base, 3-8 mm broad at the middle and 2–4 mm broad at the apex; surface smooth,

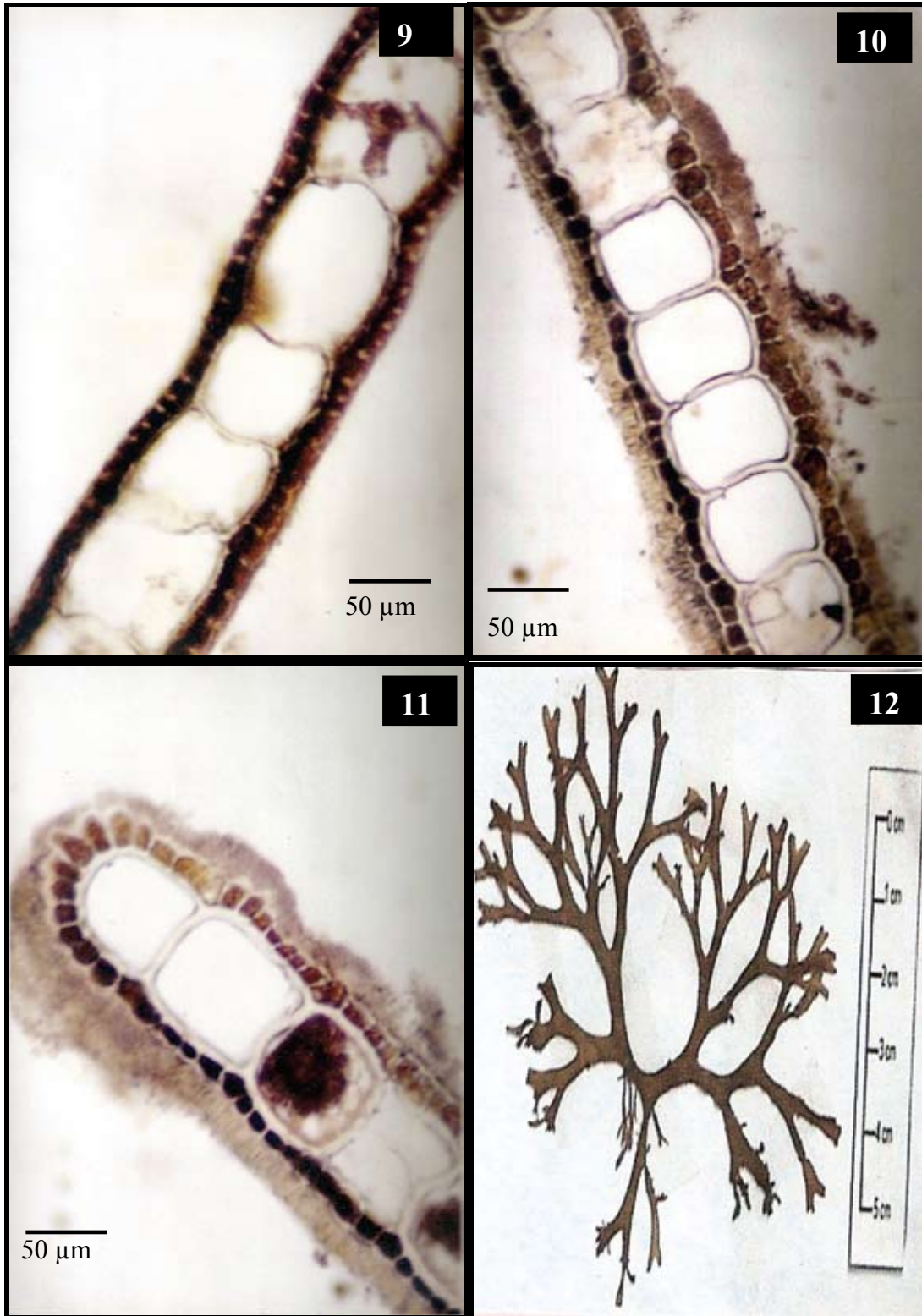


Fig. 9-11. *Dictyota ciliolata*: **9.** C.S. of apical portion; **10.** C.S. of basal part showing different peripheral layers; **11.** Marginal medullary cell in the basal portion with deposition on the thallus.
Fig. 12. *D. linearis*: Habit of the thallus.

margins entire or slightly undulate, a number of proliferations arise from the margins and from the apex; dichotomously branched, dichotomy 0.4-2.0 cm apart; dark coloured vertical lines present on the surface of the thallus; thalli broader at the base and narrow at the apex; attached with the help of a small, solid holdfast (Fig. 12).

Anatomical features

In surface view: peripheral cells dark coloured, variable in size and shapes, cubical, rectangular, polygonal and hexagonal, with dense phaeoplasts, 17.5–37.5 μm in length and 12.5–37.5 μm in breadth (Fig. 13); dark blackish brown spots present in such a way that dark coloured vertical lines appear on the surface of the thallus.

In the apical portion: thallus width 125 μm , composed of 3 layers *i.e.* upper and lower peripheral layers and a single medullary layer; peripheral cells small, thin walled, dark brown, with dense phaeoplasts, flask shaped, upper portion narrow and lower portion broad, intercellular spaces present, 12.5-25.0 μm in length and 12.5–20.0 μm in breadth (Fig. 14); medullary cells thick-walled, cell-wall thickness 2.5 μm , cubical, poor in contents or a single, large, dense phaeoplast present, 45.0–72.5 μm in length and 32.5–75.0 μm in breadth (Fig. 15). In the margin single, small, thick walled medullary cell, poor in contents, cubical or slightly rounded, 47.5–65.0 μm in length and 50 -60 μm in breadth.

In the middle part: thalli consists of 3 layers *i.e.* upper and lower peripheral layers and a single medullary layer; peripheral cells small, thin walled, flask shaped, upper portion narrow and lower portion broad, dark coloured with dense phaeoplasts, 15.0-27.5 μm in length and 7.5–12.5 μm in breadth; medullary cells large, thick walled, poor in contents, cubical or squarish, variable in size, 50.0–75.0 μm in length and 77.0–82.5 μm in breadth (Fig. 16). In the margin medullary cell small, slightly rounded, intercellular spaces absent, thick walled, poor in contents, 40.5–57.5 μm in length and 42.5–55.0 μm in breadth.

In the basal portion: thalli composed of 3 layers, *i.e.*, upper and lower peripheral layers and a single medullary layer; peripheral cells small, thin walled, dark brown, cubical or squarish, some cells slightly

rounded, intercellular spaces present, 7.5–12.5 μm in length and 5.0–10.0 μm in breadth (Fig. 17); medullary cells large, thick walled, poor in contents, cubical, or slightly rounded, 25.0-42.5 in length and 22.5–45.0 μm in breadth. In the margin medullary cell small, thick walled, poor in contents, cubical or rounded, 75.0-105.0 μm in length and 50.0–75.0 μm in breadth (Fig. 18).

Reproductive structures

Oval or rounded dark brown, stalked, sporangia arise from peripheral cells, present on both surfaces (Fig. 19), found singly, 45.5–75.5 μm in length and 50.0–62.5 μm in breadth (Fig. 20).

Syntype localities

Cádiz, Spain; “ad oras Americae”.

Habitat

Collected as drift material and benthic on mid-littoral rocks and edges of the rocky pools at Goth Haji Ali, Buleji (Leg. Alia Abbas 17- 3-2007, 14 -3-, 24-10- & 29- 11-2008, 26 -1-, 7 -3-, 31-3- & 16 -10- 2009).

Local distribution

Karachi: Manora and Buleji.

Distribution in the Indian Ocean

Malaysia, Pakistan, South Africa and Tanzania.

Remarks

Sonder [18] has reported a variety from Australia, which he named as *D. linearis* var. *minor* Sonder. It is a *nom. inval.* because he did not provide any description or illustration for this taxon [10]. Similarly, Salim [19] also reported *D. littoralis* Anand from Karachi coast of Pakistan. It is also *nom. inval.*, as no description of this species is available anywhere. Therefore, De Clerck [12] considered the occurrence of this species in the Indian Ocean as doubtful. The species *D. linearis* has so far been reported from the coast of Pakistan only in the Arabian Sea and apart from the report of Begum & Khatoon [3] has not been described by any other researcher. This is the first taxonomic investigation and a detailed anatomical study of this species from Pakistan.

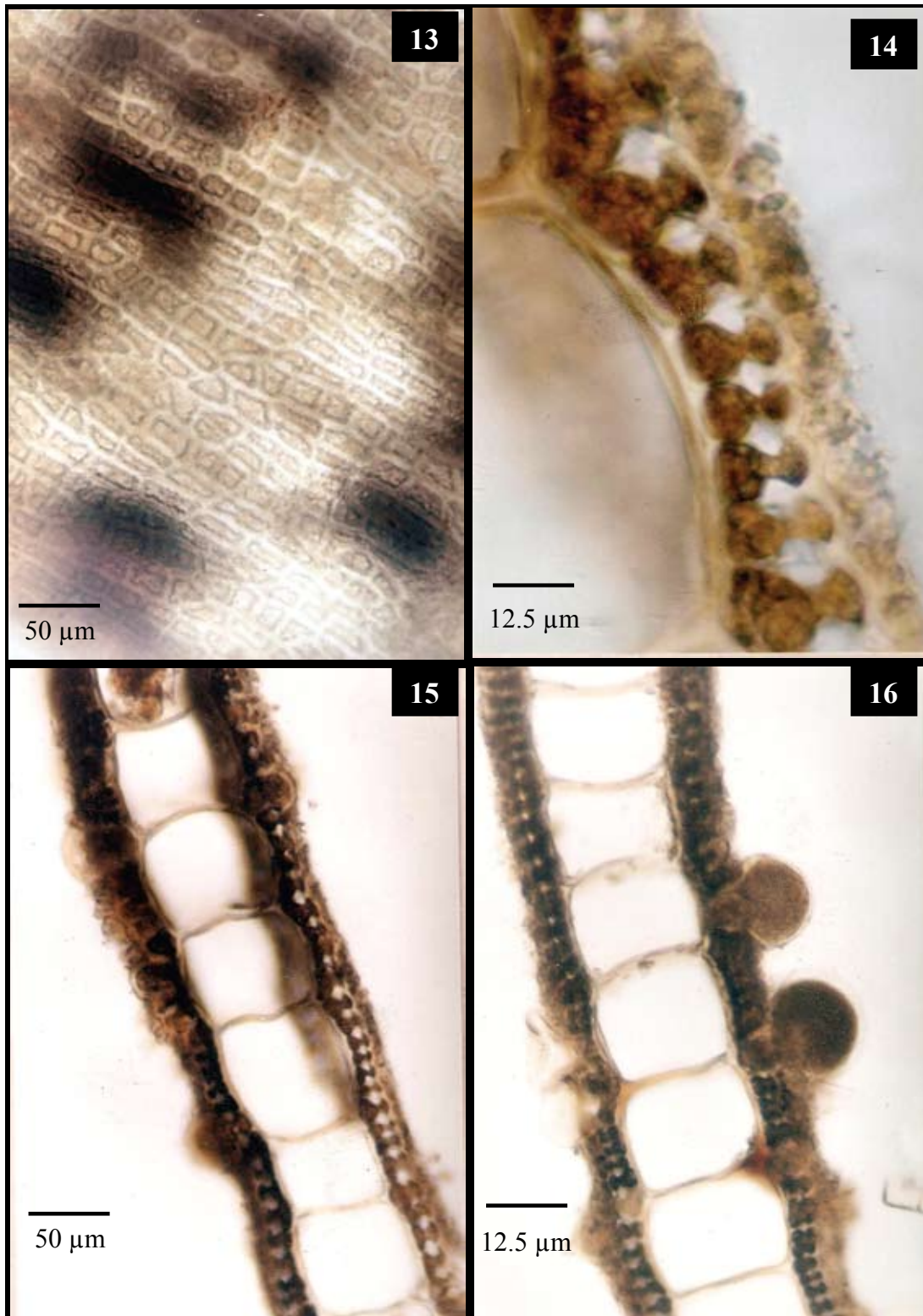


Fig. 13-16. *D. linearis*: 13. Surface view of thallus; 14. C. S. of apical portion exhibiting flask shaped peripheral cells; 15. Medullary cells in the apical part; 16. C.S. of middle part.

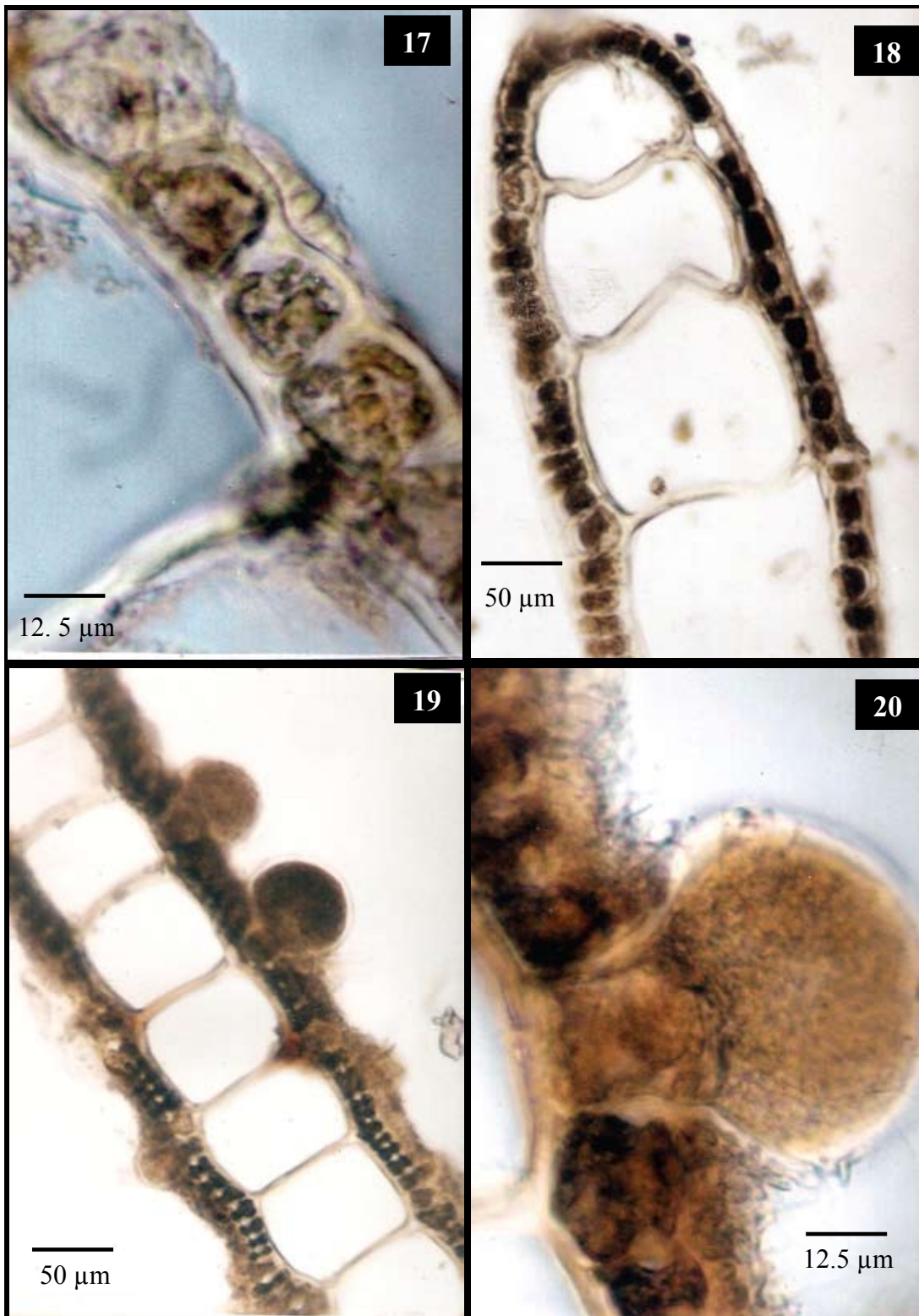


Fig. 17-20. *Dictyota linearis*: **17.** Peripheral cells in the basal part; **18.** C.S. of basal portion with marginal cells; **19.** C.S. of thallus with sporangia on both surfaces; **20.** Sporangium arising from a peripheral cell.

Table 1. Comparison of characters about investigated species of Dictyota.

Thallus characters	<i>D. ceylanica</i>	<i>D. ciliolata</i>	<i>D. linearis</i>
Colour	Reddish	Dark brown	Olive green
Height (cm)	8-10	5-6	Up to 15
Breath (cm)			
Upper part	2-5	2-4	2-4
Middle part	8-12	3-4	3-8
Basal part	10-18	1-2	5-10
Surface	Smooth	Smooth	Smooth
Margins	Undulate with ridges	Entire	Slightly undulate
Branching	Dichotomous	Profusely branched	Dichotomous
Proliferations	Absent	Arise from upper & Basal parts	Arise from margins & Apex
Apex of lobes	Obtuse	Obtuse	
Holdfast	Compact	Cuneate	Solid

3. DISCUSSION

Dictyota is a commonly occurring genus of the family Dictyotaceae (order Dictyotales, class Dictyophyceae, phylum Phaeophycota; *vide* [20]) at the coast of Pakistan. It is a key component of many coastal ecosystems of tropical to warm temperate areas [21]. It is characterized by parenchymatous, flattened thalli which grow by a single transversely oriented apical cell, and is distinguished from its allied genera such as *Dilophus*, *Glossophora*, *Glossophorella*, and *Pachydictyon* by the structure of peripheral and medullary layers, as well as the relative abundance of surface proliferations. Several species of *Dictyota* were observed to grow at the coast of Karachi [1, 3, 4]. Additionally, three more species were collected and investigated here, which are distinguished from one another in several thallus characters (Table 1).

Taxonomy of *Dictyota* has a long and troubled history. The inability to distinguish morphological plasticity from fixed diagnostic traits which separate its different species has severely confounded species delineation [22, 23]. The traditional distinction of various species has repeatedly been criticized by phycologists, the absence of sound molecular data has so far discouraged any new taxonomic proposal. Phylogenetic analysis of *rbcl* gene,

partial 26S rDNA sequence and combined data sets were carried out on several European species of *Dictyota* [21, 23]. Similar studies on the specimens from Pakistan might reveal their exact taxonomic position.

5. ACKNOWLEDGEMENTS

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