

## GENUS *DICTYOTA* (DICTYOPHYCEAE, PHAEOPHYCOTA) FROM THE COASTAL WATERS OF PAKISTAN

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### ABSTRACT

Thalli having the flattened, striped species were collected from coastal waters of Pakistan, 15 species of genus *Dictyoya* (Dictyotales, Phaeophyta) have been reported here on the bases of morphological, anatomical and reproductive characters.

**KEYWORDS:** Algae, Phaeophycota, Genus *Dictyota*, Taxonomy, Arabian Sea.

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### INTRODUCTION

Karachi coast have rocky seashores and favour the growth of brown seaweed. Brown algae at the coast of Karachi was first reported by Anand (1940). *Dictyota* is frequently occurring member of the family Dictyotaceae found growing benthic as well as drifted constituent of a community at shallow rocky pools with sandy bottom from mid to lower littoral zones. There are a number species reported to grow from Karachi coast (Salim, 1965; Begum and Khatoon, 1988; Shaikh and Shameel, 1995), Lasbela (Shameel, 1987; Shameel and Afaq-Husain, 1987; Shameel *et al.*, 1989), Makran (Shameel *et al.*, 2000; Shameel, 2000) and other coastal areas of Pakistan (Shameel and Tanaka, 1992). Most of previous researches were simple surveys and detail taxonomic study of this genus was required. Therefore, the present study was based on detailed taxonomic studies of the *Dictyota* species which were collected from the different localities of Pakistan coast.

### MATERIALS AND METHODS

The collections were conducted from various coastal regions of Karachi and Jiwani. Algal thalli were collected from rocks and collected as drift form then preserved in 4 % formaldehyde. The sections are made from the different parts of thalli into thin slices with the help of blade by free hand section. Sections were stained in 1% aniline blue for few minutes, one or two drops of 1M hydrochloric acid were added for few seconds and washed with seawater. The sections were then mounted in a solution of 75 % glycerin with aniline blue (75 mL Glycerin + 20 mL aniline blue + 5 mL distilled water). The slides were sealed with the sealing material (Cutex) and observed under microscope.

### **Genus *Dictyota* Lamouroux 1809: 331, nom. cons.**

Thallus dichotomous, irregularly or regularly laterally branched, complanate; angle of dichotomy obtuse, acute or rounded; basally attached by rhizoidal matted holdfast; growth takes place by single apical cell; cortical region has squarish to rectangular single layered structure with dense phaeoplasts; peripheral region with generally squarish cells,

rarely filled with phaeoplasts; phaeophycotean hairs present in tufts, scattered all over the thallus surface; proliferations are most common in the genus at Karachi Coast; sometimes margin has dentation also; asexual reproductive structures always tetrasporangia, scattered over thallus surface, sexual reproductive organs oogonia and antheridia.

In the present research, fifteen species have been collected, identified and taxonomically described; out of fifteen species one new combination and one is newly reported. The species of genus as follows:

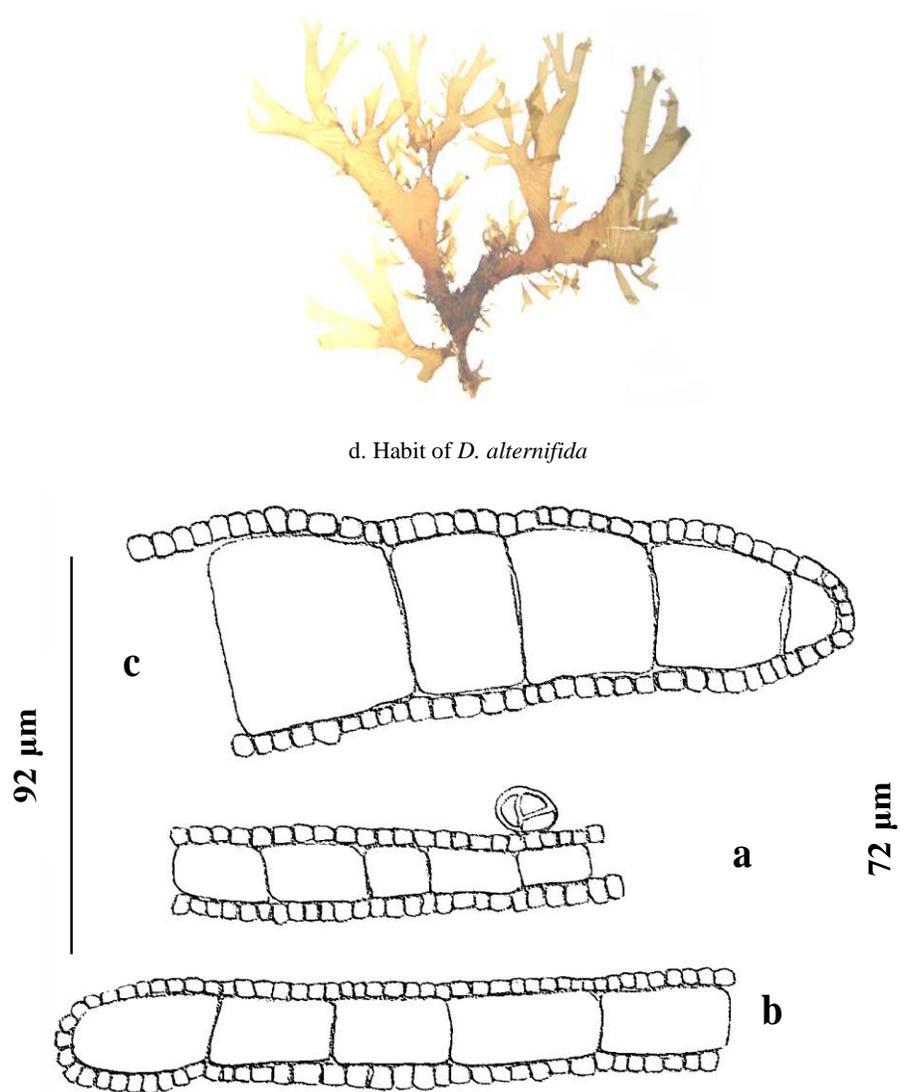
- |     |   |                         |
|-----|---|-------------------------|
| 1.  | Margin of thallus entire -----  | 2                       |
|     | Margin of thallus with dentation and proliferations ----- <i>D. alternifida</i> |                         |
| 2.  | Branches divergent -----  | <i>D. divaricata</i>    |
|     | Branches do not divergent -----   | 3                       |
| 3.  | Thallus thick and broad -----   | <i>D. maxima</i>        |
|     | Thallus thin as well as broad -----   | 4                       |
| 4.  | Attached with cuneate compact disc -----  | <i>D. ciliolata</i>     |
|     | Attached with cuneate compact disc -----  | 5                       |
| 4.  | Forming prostrate clump -----   | <i>D. bartayresiana</i> |
|     | Not forming prostrate clump -----   | 6                       |
| 5.  | Thallus base broad -----  | <i>D. ceylanica</i>     |
|     | Thallus thin as well as broad -----   | 7                       |
| 6.  | Proliferations form dichotomy -----   | <i>D. intricata</i>     |
|     | Proliferations do not form dichotomy -----                                      | 8                       |
| 8.  | Attached with filamentous holdfast -----  | <i>D. diemensis</i>     |
|     | Attached with matted holdfast -----   | 9                       |
| 9.  | Thallus narrow and entangled -----  | <i>D. indica</i>        |
|     | Thallus not narrow and entangled -----  | 10                      |
| 10. | Branches repeatedly dichotomous -----   | <i>D. cervicornis</i>   |
|     | Branches not repeatedly dichotomous -----                                       | 11                      |
| 11. | Thallus margin with spine and teeth -----                                       | <i>D. ciliata</i>       |
|     | Thallus margin without spine and teeth -----                                    | 12                      |
| 12. | Thallus without proliferation -----   | 13                      |
|     | Thallus with proliferation -----  | <i>D. hauckiana</i>     |
| 13. | Thallus strip flat -----  | <i>D. flabellatum</i>   |
|     | Thallus strip not flat -----  | 14                      |
| 15. | Thallus with regular dichotomy -----  | <i>D. dichotoma</i>     |
|     | Thallus without regular dichotomy -----   | <i>D. linearis</i>      |

***Dictyota alternifida* J. Agardh 1894:80**

Fig. 1a-d

**References:** Agardh, 1894: 80, Womersley 1967: 207, 1987: 198, Shameel *et al.*, 1996: 226, 2000: 84, Shameel, 2000: 51.

**Description:** Thallus 10.0-15.5 cm high; growing epilithic on muddy rocks, attached by rhizoidal matted holdfast; dichotomously branched with acute tips; lower portion quiet broad, tappers towards apex; older portion densely proliferated while younger portion rarely proliferated; in younger part proliferation tips are rounded, later become dichotomous.



**Fig. 1.** *Dictyota alternifida* J. Agardh: **a** and **b**. Transverse sections of thallus with apical cell, **c**. transverse section of thallus with a tetrasporangium, **d** habit.

Thallus structure composed of three layered structure; upper and lower bordering layers have small squarish cells with condensed phaeoplasts, 12-15 $\mu$ m in length, 12-23  $\mu$ m in breadth; central layer with large squarish cells, have less phaeoplasts, 81-107  $\mu$ m long and 71-100  $\mu$ m wide; phaeophycotean hairs were not recorded.

The reproductive organs in these specimens were tetrasporangia, very few of them were observed in this investigation. Tetrasporangia oval to semi-spherical in shape, 41-61  $\mu$ m in diameter, present only on one surface of the thallus. The sexual reproduction were not observed in these specimens. A single apical cell take part in growth.

**Type locality:** Port Phillip Heads, Victoria.

**Habitat ecology:** Thalli were observed growing epilithic on muddy rocks, forming light to dark brown clumps.

**Local distribution:** Buleji, Hawkes Bay and Jiwani.

**Distribution:** Australia and Pakistan.

***Dictyota bartayresiana* Lamouroux 1809:43**

Fig. 2a-k, 11B

**Synonyms:** *Dictyota bartayresii* Lamouroux 1809:331.

**References:** Lamouroux, 1809: 43, Agardh, 1894: 66, Weber-van Bosse, 1913: 182, Børgesen, 1914: 209, 1934: 29, 1935: 36, 1937a: 27, 1941: 51, Durairatnam, 1961: 37, Salim, 1965: 193, Misra, 1966: 133, 1967: 233, Krishnamurthy and Joshi, 1970: 11, Islam, 1976: 35, Jaasund, 1976: 39, Silva *et al.*, 1987: 75, 1996: 586, Begum and Khatoon, 1988: 294, Shameel and Tanaka, 1992: 37.

**Description:** Thallus have up to 5 cm high; basally attached with the help of rhizoidal filaments; from the margin proliferation like rhizoidal filaments also provide attachment to thalli, due to this character it forms prostrate clump on rocky ledges; thallus gives rise dichotomous branches, follows strictly dichotomous branching which forms acute angle of dichotomy, branches almost equal in width from base to apex; tips of branches flat or obtuse; margin and surface of thallus smooth.

Thallus is composed of three layers of cells; upper and lower marginal layers consist of small squarish cells which are almost uniform in size, (11-) 28-34  $\mu\text{m}$  in long, 11-28(-46)  $\mu\text{m}$  in wide, central part of thallus contain rectangular cells which are also uniform in size and radially as well as transversely arranged, (46-) 80-102  $\mu\text{m}$  long and (46-) 91-114(-148)  $\mu\text{m}$  wide; each central large cell has four to six peripheral cells on both sides in upper part, whereas the lower part has one to two peripheral cells per central cell; phaeophycotean hairs were not recorded.

The asexual reproductive bodies *i.e.* tetrasporangia were observed. Tetrasporangia spherical to elongated in shape, 34-68  $\mu\text{m}$  in long, 45-80  $\mu\text{m}$  in wide, present only on one surface and scattered on the thallus. Phaeophycotean hairs were not observed.

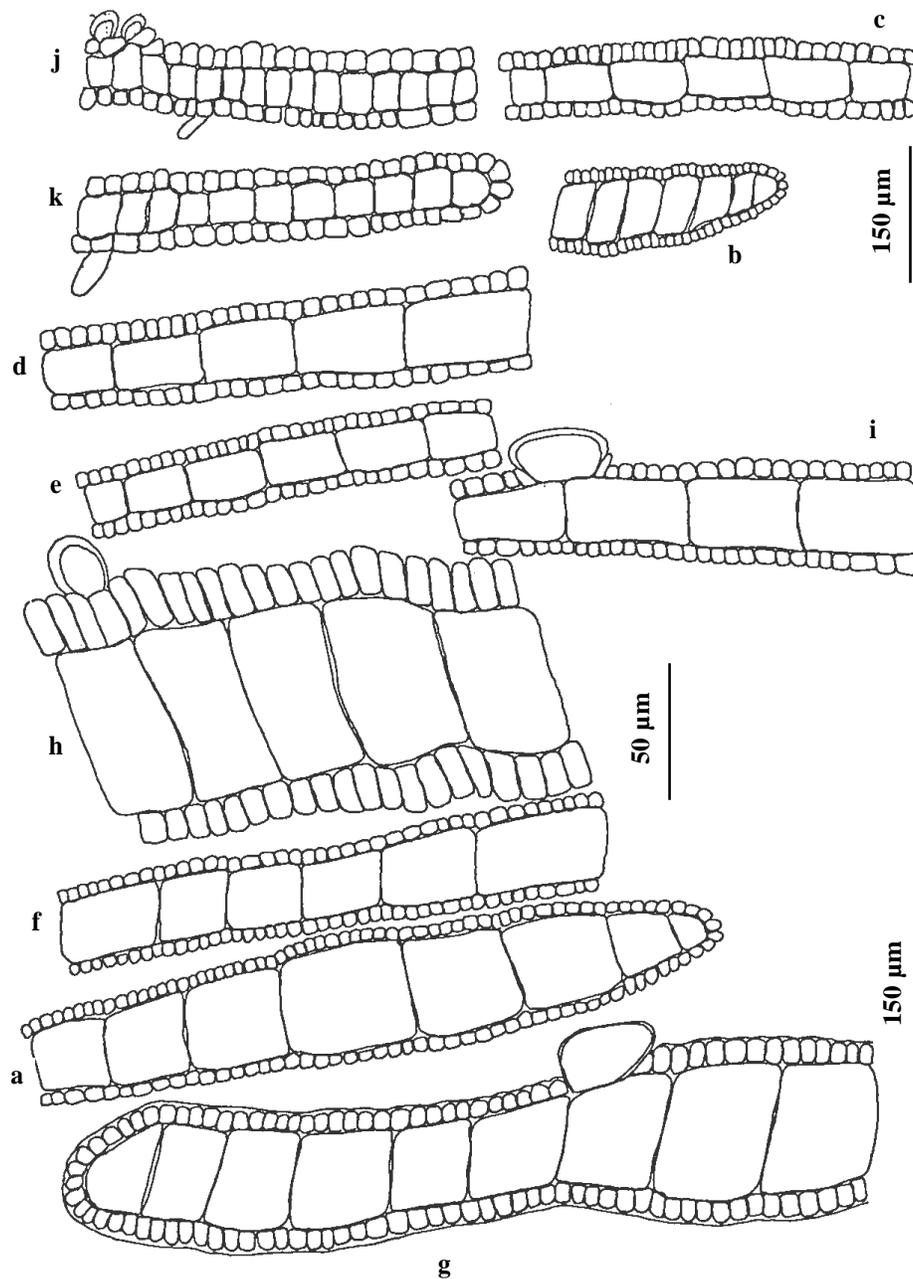
Growth in these specimens takes place by a single large convex shaped apical cell. The cell divides transversely as well as vertically to give rise the parenchymatous thalloid structure.

**Type locality:** Antilles, West Indies.

**Habitat ecology:** Thalli were found growing epilithic on sandy rocks of shallow pools along with the members of the orders Dictyotales and Fucales.

**Local distribution:** Buleji, Manora and Nathiagali

**Distribution:** Australia, Bangladesh, Diego Garcia Atoll, East Indies, India, Indonesia, Japan, Kenya, Malaysia, Maldives, Mauritius, Mexico, New Zealand, Pakistan, Réunion, Seychelles, Singapore, Somalia, South Africa, Sri Lanka, Tanzania, Thailand, The Philippines and Tropical and sub-tropical eastern coast of North America.



**Fig. 2.** *Dictyota bartayresiana* Lamouroux: **a** and **b**. Transverse sections of thallus with single apical cell, **c-f**. transverse sections of the middle part of thallus, **g**. transverse section of thallus with tetrasporangium and apical cell, **h** and **i**. transverse sections of thallus with tetrasporangia, **j** and **k**. transverse sections of thallus (lower part).

***Dictyota cervicornis* Kützing 1859: 11**

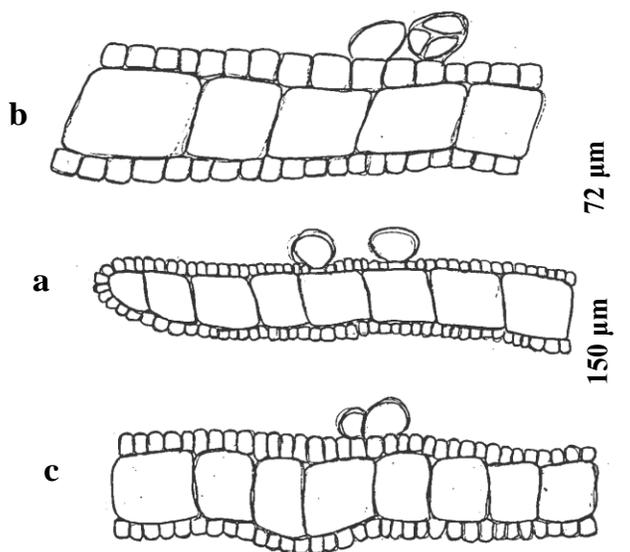
Fig. 3a-c, 11A

**Synonyms:** *Dictyota indica* Sonder *ex* Kützing, 1859: 8, *Dictyota pardalis* Kützing, 1859: 16.

**References:** Børgesen, 1914: 21, Durairatnam, 1961: 38, Misra, 1961: 139, Salim, 1965: 193, Earle, 1969: 161, Krishnamurthy and Joshi, 1970: 11, Nizamuddin and Gessner, 1970: 5, Jaasund, 1976: 39, Shameel and Afaq-Hussain, 1987: 295, Silva *et al.*, 1987: 75, 1996: 587, Begum and Khatoon, 1988: 295, Shameel *et al.*, 1989: 179, 1996: 226, 2000: 84, Shameel and Tanaka, 1992: 38, Shaikh and Shameel, 1995: 20.

**Description:** Thallus up to 13 cm high, erect, attached with the help of rhizoidal filaments, which are quite similar with proliferations; older part of the thallus broad, but younger part narrow and repeatedly dichotomously branched forming narrow obtuse angle; tips of branches obtuse and divergent; usually at apex instead of dichotomous branches a cluster of branches develop which are said to be proliferatous, this type of proliferation formation is quite common in these specimens, laterally very few proliferations are formed.

Anatomically these specimens are characterized by three layers; upper and lower peripheral layers have small, squarish cells, compactly arranged, 11-23  $\mu\text{m}$  in length, 11-23  $\mu\text{m}$  in breadth; the central layer with squarish cells, also closely arranged, 80-144  $\mu\text{m}$  long, 80-114(-136)  $\mu\text{m}$  broad; content of peripheral cells densely filled whereas few phaeoplasts found in cells of central region; each cortical cell generally covered by 5-6 peripheral cells; phaeophycotean hairs were not recorded in these specimens.



**Fig. 3. *Dictyota cervicornis* Kützing:** a. Transverse section of thallus with apical cell and undivided sporangia, b. transverse section of thallus with divided and undivided sporangia, c. transverse section of thallus with undivided tetrasporangia.

The specimens have been studied without sexual reproductive structures. But asexual reproductive bodies were commonly found to appear only on one surface. The asexual reproductive structures *i.e.* tetrasporangia were spherical or oval bodies, which appear singly but rarely as cluster of two or three in numbers, 69-80  $\mu\text{m}$  in length, 80-91  $\mu\text{m}$  in breadth; phaeophycotean hairs not observed. The characteristics of the genus is that growth takes place by a single apical cell, one side of apical cell is flat and the other convex; further growth occurs through transverse and longitudinal divisions of this large apical cell.

**Type locality:** Key West, Florida, U.S.A.

**Habitat ecology:** Thallus was growing on the muddy rocks of shallow waters, and also found in drifted form.

**Local distribution:** Buleji; Hawkes Bay; Jiwani and Sandspit.

**Distribution:** India, Indonesia, Iran, Kenya, Kuwait, Malaysia, Mauritius, Mozambique, Pakistan, Seychelles, Singapore, Sri Lanka, Tanzania, The Philippines, West Indies and Yemen.

#### ***Dictyota ceylanica* Kützinger, 1859: 11**

Fig. 9B

**References:** Misra, 1966: 139, 1967: 233; Jaasund, 1976: 41; Silva *et al.*, 1987: 75, 1996: 588; Begum and Khatoon, 1988: 295; Shameel and Tanaka, 1992: 37; Ormond and Banaimoon, 1994: 117; De Clerck, 2003: 52; Abbas and Shameel, 2014: 49.

**Description:** The colour of thalli reddish brown, upright, horizontal, dichotomously branched, surface smooth, margins undulate with prominent ridges; apex 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.

**Type locality:** Unknown

**Habitat ecology:** Attached on mid-littoral rocks and edges of pools.

**Local distribution:** Buleji.

**Distribution:** Arabia Sea

#### ***Dictyota ciliata* J. Agardh, 1841: 53**

Fig. 12B

**References:** J. Agardh, 1841: 51, 1882: 94, 1894: 75, Børgesen, 1914: 211, Durairatnam, 1961: 37, Misra, 1966: 136, Earle, 1969: 155, Jaasund, 1976: 41; Silva *et al.*, 1987: 75, 1996: 588, Begum and Khatoon, 1988: 295, Shameel and Tanaka, 1992: 37.

**Description:** Thallus up to 18 cm high, basally attached with a rhizoidal holdfast; lower portion broad, tapers at upper portion, dichotomously branched forming acute angle, tips flat and little obtuse; upper part sub-dichotomously branched; small and hard teeth or spines are distributed at younger part of thallus, in older part few teeth and dichotomous proliferations frequently present; reproductive organs scattered all over the thallus surface.

Thallus consists of three layers of cells; upper and lower peripheral layers with small squarish cells which are almost uniform in size, (11-)17-23  $\mu\text{m}$  in length, (11-)23-34  $\mu\text{m}$  in breadth, with dense appearance as compared to central cells. In surface view cells appear somewhat rectangular, 23-34  $\mu\text{m}$  long and 11-23  $\mu\text{m}$  broad; central cells quite large, squarish, more or less iso-diametric, with less amount of phaeoplasts, (57-)

159-171  $\mu\text{m}$  in length, (55-)136-171  $\mu\text{m}$  in breadth. Phaeophycotean hairs were not recorded in these specimens.

In these specimens the sexual reproductive organs were not observed. The asexual reproductive bodies *i.e.* tetrasporangia were observed, rounded in shape, (45-)59-68 (-102)  $\mu\text{m}$  in diameter. Phaeophycotean hairs were not observed. As a character of the genus growth takes place by a single apical cell, which is found in this species also.

**Type locality:** St. Croix, Virgin Islands.

**Habitat ecology:** It grows epilithic on muddy rocks of shallow and sheltered pools along with other members of Dictyotales.

**Local distribution:** Manora (*Leg.* Nizamuddin 6-12-1961, *Leg.* N. Khatoon 12-12-1982, *Leg.* Aisha 12-12-1989); Buleji (*Leg.* Begum and Khatoon 22-10-1983, *Leg.* Aisha 30-11-1993).

**Distribution:** Australia, India, Kenya, Kuwait, Madagascar, Pakistan, Réunion, Singapore, Sri Lanka, Tanzania, The Philippines, West Indies and Yemen.

***Dictyota ciliolata* Kützting, 1859: 12**

Fig. 9C

**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 and Khatoon, 1988: 295; Shameel and Tanaka, 1992: 37; De Clerck, 2003: 58; Abbas and Shameel, 2014: 49.

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

**Habitat:** Attached on mid-littoral rocks and edges of rocky pools.

**Local distribution:** Buleji, Manora, Cape Monze and Goth Manjar.

**Distribution:** Arabian Sea, India, Kuwait, Sri Lanka and Yemen.

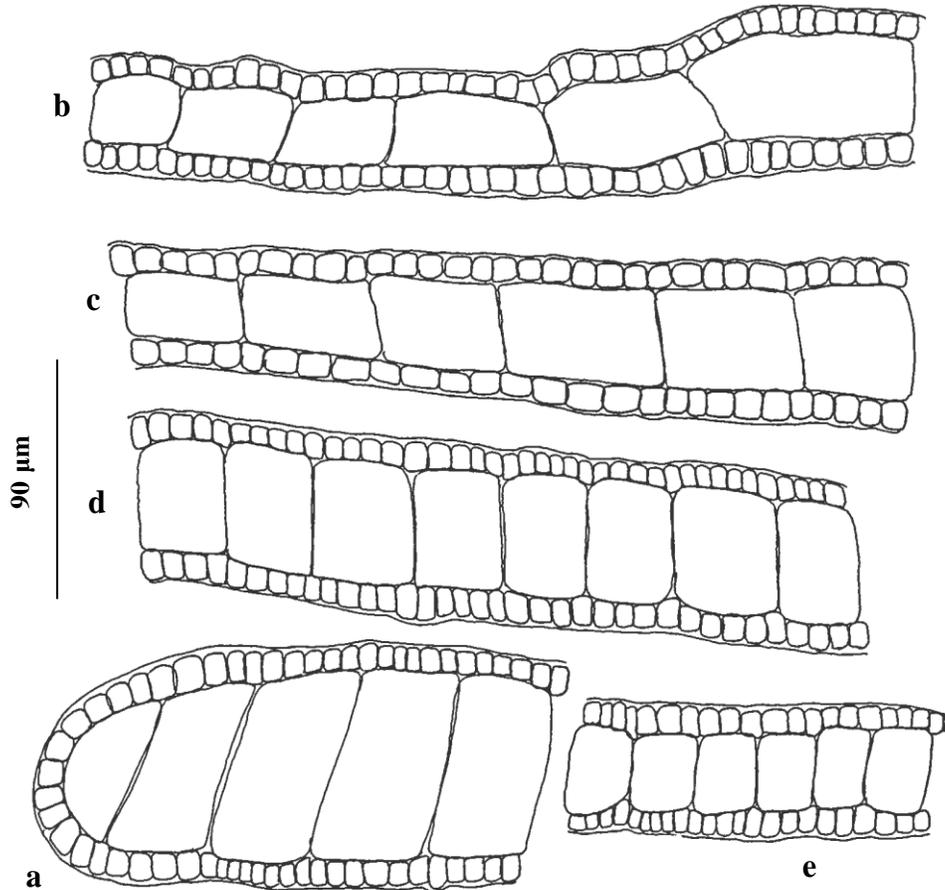
***Dictyota dichotoma* (Hudson) Lamouroux, 1809: 42**

Fig. 4a-e, 9A

**Basionym:** *Ulva dichotoma* Hudson 1762: 476.

**Synonyms:** *Zonaria dichotoma* (Hudson) C. Agardh, 1817: 20, *Dictyota apiculata* J. Agardh, 1894: 67, *Dictyota vivesii* Howe, 1911: 497.

**References:** Lamouroux, 1809: 42, Agardh, 1894: 67, Nasr, 1947: 79, Børgesen, 1953: 15, Durairatnam, 1961: 38, Lindauer *et al.*, 1961: 140, Salim, 1965: 193, Misra, 1966: 132, 1967: 233, Womersely, 1967: 208, 1987: 194, Krishnamurthy and Joshi, 1970: 11, Saifullah, 1973: 140, Islam, 1976: 36, Kornmann and Sahling, 1977: 161, Nizamuddin, 1981: 41, Shameel and Afaq-Husain, 1987: 295, Silva *et al.*, 1987: 76, 1996: 589, Begum and Khatoon, 1988: 295, Shameel *et al.*, 1989: 179, 2000: 84, Shameel and Tanaka, 1992: 37, Verheij and Prud'homme van Reine, 1993: 424, Shaikh and Shameel, 1995: 15, Shameel, 2000: 51.



**Fig. 4.** *Dictyota dichotoma* (Hudson) Lamouroux: **a.** Transverse section of thallus with apical cell, **b-e.** transverse sections of thalli.

**Description:** Thallus height up to 8 cm, attachment with the fibrous and somewhat flat filamentous holdfast; yellowish to dark brown in colour; branches strictly dichotomous, dichotomy develops after every 5-7 mm; surface smooth margins entire; tips of branches bifid and rounded, angle of dichotomy narrow and obtuse; lower part of thallus much dark; thalli forming mass on rocks or clumps and entangled, margin rolled; broad at basal part, but taper towards the apex, few proliferations formed.

Thallus composed of three layers of cells; peripheral upper and lower layers made up of small squarish cells, 11-23 µm in length, 11-23 µm in breadth, containing dense amount of phaeoplasts; the cortex and medulla are represented by a single layer of large rectangular to squarish cells, (46-)57-114 µm long and 57-114 µm wide, having less amount of phaeoplasts; each large central cell is covered by four to six peripheral squarish cells; phaeophycotean hairs were not recorded.

The reproductive organs either sexual or asexual were not recorded in the collected specimens. The specimens have single apical cell with convex and flat sides, growth takes place by longitudinal and transverse divisions of this apical cell.

**Type locality:** Walney Island, Lancashire, England.

**Habitat ecology:** It was growing epilithic on the rocks open to low tides, forming clump of thallus along with *Valoniopsis pachynema* (Mertens) Børgesen, *Caulerpa faridii* Nizamuddin and *Caulerpa sertularioides* (Gmelin) Howe.

**Local distribution:** Hawkesbay, Manora and Nathiagali.

**Distribution:** Australia, Bangladesh, India, Indonesia, Japan, Kenya, Madagascar, Malaysia, Maldives, Mauritius, Myanmar, Pakistan, Seychelles, South Africa, Sri Lanka, Tanzania, Thailand, The Philippines, West Indies and Yemen.

### *Dictyota diemensis* Kützting

Fig. 11C and D

**Synonyms:** *D. naevosa* sensu Harvey, 1862, Pl. 186. Womersley, 1967: 209, 1987: 192.

**Description:** Plants up to 17cm high, attached by rhizoidal holdfast, cuneate below. Plant dichotomously branched, segments become 15 mm broad before bifurcation, otherwise more or less uniform in width 7mm throughout the thallus. Lower segments broad, thick and greenish brown; upper ones thin, yellow to greenish brown. Apices narrow, acute, incurved; sinuses deep narrowly rounded; margin slightly wavy, rarely bears dentations and proliferations at the lower part of the thallus.

In C.S upper part 90-110 micro meter thick; medullary cells 78-80 micro meter high and broad. Lower part 130-140 micro meter thick; medullary cells 78-80 micrometer, 120 micrometer broad; assimilatory cells 12-16 micrometer high and broad.

Antheridial sori yellowish brown and ovoid in C.S. Antheridia 50 micrometer high, 15 micrometer broad; involucre 55 micrometer high, 12 micrometer broad.

**Ecology:** Collected in drifted form.

**Local distribution:** Manora

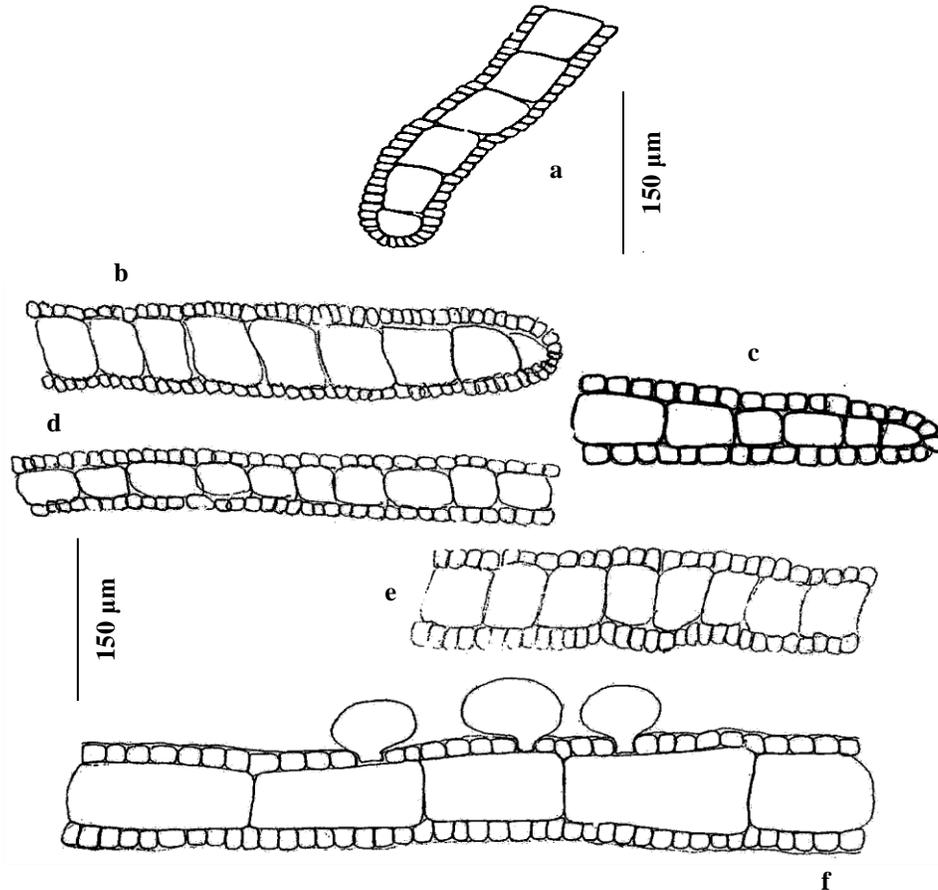
**Distribution:** Arabian Sea: Karachi (Pakistan). Pacific Ocean: Australia.

### *Dictyota divaricata* Lamouroux, 1809: 43

Fig. 5a-f, 9D

**References:** Lamouroux, 1809: 43, 1825: 14, Børgesen, 1939: 81, 1941: 50, 1953: 16, Dawson, 1961: 407, Misra, 1966: 135, 1967: 233, Krishnamurthy and Joshi, 1970: 11, Nizamuddin and Gessner, 1970: 5, Islam, 1976: 36, Jaasund, 1976: 41, Silva *et al.*, 1987: 76, 1996: 591, Begum and Khatoun, 1988: 296, Shameel and Tanaka, 1992: 37.

**Description:** Thallus 2.7-11.0 cm high, 1-3 cm wide; attached with the help of rhizoidal filaments; fronds erect, strictly dichotomously branched, forming thick cluster of branches, which are entangled with each other forming large and small patches on the rocks, angle of dichotomy wide; the tips of branches acute and divergent; proliferations very few at older part of the fronds; margin entire; thallus surface smooth, dark brown to olive green in colour.



**Fig. 5.** *Dictyota divaricata* Lamouroux: **a, b.** Transverse section of thallus with apical cell, **c-e.** transverse sections of thalli **f.** ransverse section of thallus with developing and undivided tetrasporangia.

Thallus composed of three layers of cells, thickness of cells remains same throughout thallus; upper and lower layers of cells small squarish in shape, compactly arranged, having dense phaeoplasts, 34  $\mu\text{m}$  in length, 11-17  $\mu\text{m}$  in breadth; central layer of cells having less amount of phaeoplasts, large and almost squarish in shape; each large cortical cell covered by four small peripheral cells, 68-91  $\mu\text{m}$  long, 91-113  $\mu\text{m}$  wide; phaeophycotean hairs were not recorded in these specimens.

The sexual reproductive organs were not observed in the specimens gathered during different seasons from the coast of Karachi. The asexual reproductive bodies *i.e.* tetrasporangia were recorded, spherical in shape, scattered all over the surface of thallus, found only on one surface, 45-91  $\mu\text{m}$  in diameter. Phaeophycotean hairs were not observed. The thallus has a single large apical cell, which by its repeated divisions that may be transverse or longitudinal forms small stripe like dichotomous thallus.

**Type locality:** Mediterranean Coast of France.

**Habitat ecology:** It is found in drifted condition as well as grows on rocks, which are present near the high water mark.

**Local distribution:** Buleji, Manora and Nathiagali.

**Distribution:** Bahrain, Bangladesh, El-Salvador, India, Iran, Japan, Kenya, Kuwait, Mauritius, Nicobar Islands, Pakistan, Saudi Arabia, Seychelles, Tanzania, The Philippines and Yemen.

***Dictyota flabellate* (Collins) Setchell et. Gardner, 1924: 12**

Fig. 10A

**References:** Salim, 1965: 193; Begum and Khatoon, 1988: 303; Silva *et al.*, 1996: 592; De Clerck, 2003: 150.

**Description:** Thalli olive green, erect, flat, surface smooth; up to 7 cm long, 0.5–1.5 cm broad at the apex, 1.2–2.0 cm broad at the middle and 2–5 mm broad at the base; dichotomously branched, dichotomy 0.8–2.2 cm apart; margins undulate, deeply emarginated; lobes at the tip acuminate, shape oblanceolate, lobes of dichotomy unequal; attached with the help of a compact rhizomatous holdfast, 3 mm long and 2 mm broad.

**Habitat:** Benthic on mid-littoral rocks or edges of rocky pools.

**Local distribution:** Karachi: Manora and Buleji.

**Distribution:** Around Arabian Sea, Pakistan only.

***Dictyota hauckiana* Nizamuddin, 1975: 349**

Fig. 6a-1 10B

**Synonyms:** *Taonia atomaria* (Gooden et Woodward, 1797: 53) J. Agardh, 1848: 101, *Dictyota atomaria* Hauck, 1884: 235 *nom. illeg.*

**References:** Agardh, 1894: 70, Børgesen, 1932: 69, 1935: 39, 1937a: 27, Durairatnam, 1961: 38, Salim, 1965: 193, Misra, 1966: 141, 1967: 233, Krishnamurthy and Joshi, 1970: 10, Nizamuddin, 1975: 349, Shameel, 1987: 513, 2000:51, Shameel and Afaq-Husain, 1987: 295, Begum and Khatoon, 1988: 296, Shameel *et al.*, 1989: 179, 1996: 226, 2000: 84, Shameel and Tanaka, 1992: 38, Shaikh and Shameel, 1995: 18, Silva *et al.*, 1996: 593.

**Description:** Thalli large 15-35cm in height, 2-4 cm wide, yellowish brown to dark brown in colour, surface rough or uneven; basally attached with matted rhizoids forming discoid holdfast, numerous branches arising from single holdfast; basal part of thallus cuneate, older or basal part thick as compared to upper part; branches dichotomous, forming obtuse dichotomy, branches narrow at base gradually broad at upper part; proliferations more commonly present from base to apex, frequently appear as teeth like structure, arising at an interval of 2-5mm, 0.5-3.0 cm in length, 0.2-0.5cm in breadth; tetrasporangia and sporangia scattered on the thallus surface.

Thallus composed of three layers in thickness; upper and lower layers consist of small, squarish cells, almost iso-diametric in size, 11-34  $\mu\text{m}$  in length, 11-23  $\mu\text{m}$  in breadth; lower portion of thallus shows some di- or tri- layered structure in some portions in central as well as in peripheral regions; whereas upper and middle parts have typical *Dictyota* like structure *i.e.* three layered; central or medullary layer generally has rectangular cells, somewhere squarish cells also present, 45-100  $\mu\text{m}$  high, 100-136  $\mu\text{m}$

wide, having dense phaeoplasts; phaeophycotean hairs are present in group or cluster in cavities, 23-34  $\mu\text{m}$  long, 11  $\mu\text{m}$  broad; surface view showing sporangia and tetrasporangia, cells are rectangular to squarish in shape, 23-34  $\mu\text{m}$  in height, 1-23  $\mu\text{m}$  in width.

The asexual reproductive organs *i.e.* tetrasporangia found only on one surface of thallus, develop from upper peripheral layer, appear as spherical in shape, 7-9  $\mu\text{m}$  in height, 7-11  $\mu\text{m}$  in breadth; sporangia present in sori, club-shaped, present only on one surface of thallus, 57-114  $\mu\text{m}$  high, 34-46  $\mu\text{m}$  wide, occurring in 3-6 numbers. The specimens have single apical cells for growth, as all members of the genus *Dictyota* show apical growth, but in lower region of this species growth also occur in the central as well as peripheral regions, due to which these areas become di- and tri-stromatic.

**Type locality:** Malabar Hill, Mumbai, India.

**Habitat ecology:** The specimens were generally found in drifted condition along with *Codium* spp., *Sargassum* spp., *Spatoglossum* *variabile* and some *Halymenia* spp.

**Local distribution:** Buleji, Hawkes Bay, Manora, Nathiagali and Jiwani.

**Distribution:** Danish West Indies, India, Pakistan, Seychelles and Sri Lanka.

***Dictyota indica* Sonder ex Kützing, 1859: 8**

Fig. 10C

**References:** Børgesen, 1914: 21; Durairatnam, 1961: 38; Salim, 1965: 193; Misra, 1966: 137, 1967: 233; Earle, 1969: 161; Krishnamurthy and Joshi, 1970: 11; Nizamuddin and Gessner, 1970: 5; Shameel and Afaq-Husain, 1987: 295; Silva *et al.*, 1987: 76, 1996: 587; Begum and Khatoon, 1988: 297; Shameel *et al.*, 1989: 179; Shameel and Tanaka, 1992: 38; Shaikh and Shameel, 1995: 20.

**Description:** Thalli dark brown or greenish brown in colour; surface smooth, margins entire, or rarely some small proliferations arise from the margins; dichotomously branched, branches erect, flat, tip of dichotomy pointed, dichotomy 0.5-3.5 cm apart; angle of branches rounded; upper portion narrow, and lower part broad and thick; branches spirally twisted at their middle and basal parts; thalli attached with the help of a small and compact holdfast; thalli 6-30 cm in height, 1-2 mm broad at the apex, 2-4 mm broad at middle and 3-6 mm broad at the base.

**Habitat:** Found as drift material and benthic on mid – littoral rocks and edges of the rocky pools.

**Local distribution:** Karachi: Manora, Hawkes Bay, Buleji, Naugaza Mazar and Cape Monze.

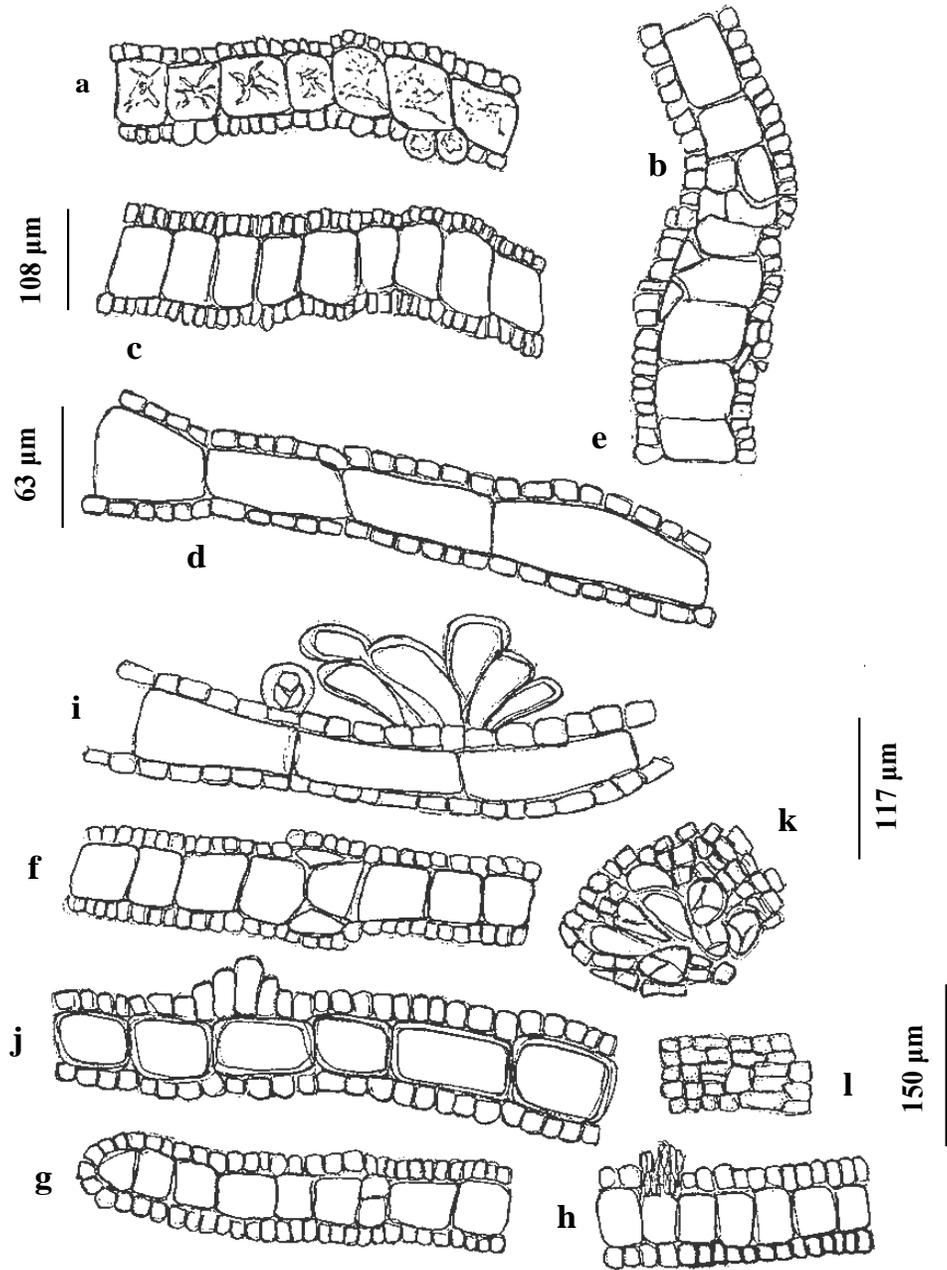
**Distribution:** Around Arabian Sea, India, Iran, Pakistan and Sri Lanka.

***Dictyota intricata* Aisha and Shameel**

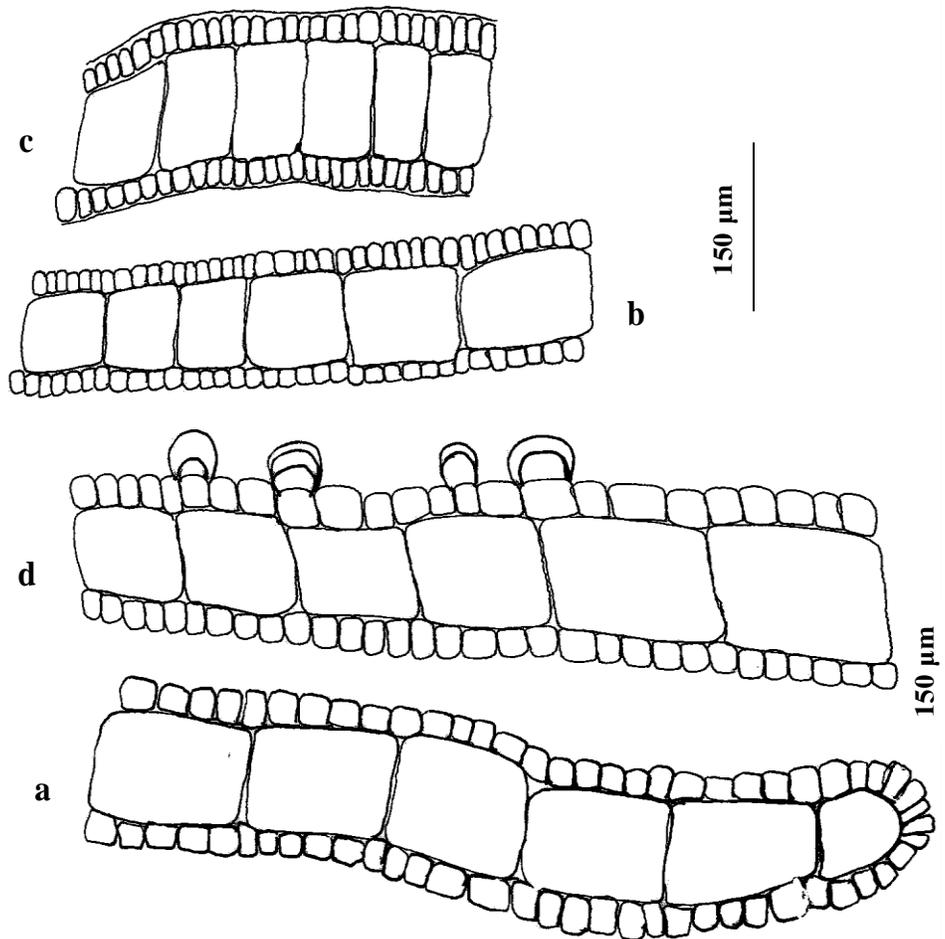
Fig. 7a-d, 12A

**Basionym:** *Zonaria dichotoma* (Hudson) C. Agardh var. *intricata* C. Agardh, 1820: 134.

**Synonyms:** *Fucus implexus* Desfontaines 1799: 423, *Dictyota dichotoma* var. *implexa* (Desfontaines) Gray, 1821: 341, *Dictyota dichotoma* (Hudson) Lamouroux var. *intricata* (C. Agardh) Greville, 1830: 58, *Dictyota vulgaris* (Kützing) Kützing var. *intricate* (C. Agardh) Kützing 1845: 270.



**Fig. 6.** *Dictyota hauckiana* Nizamuddin: **a.** Transverse section of thallus with apical cell and transverse division, **b-d.** transverse sections of thalli, **e** and **g.** transverse sections of thalli showing longitudinal and transverse divisions, **h.** transverse section with tuft of phaeophycotian hairs, **i.** transverse section with a group of sporangia, **j.** transverse section of thallus showing divided sporangia and a sorus of sporangia, **k.** Cells in surface view, **l.** cell in surface view along with tetrasporangia and sporangia.



**Fig. 7.** *Dictyota intricata* Aisha and Shameel: **a.** Transverse section of thallus with apical cell, **b.** and **c.** transverse sections of thalli **d.** transverse section of thallus with undivided tetrasporangia.

**References:** Børgesen, 1937a: 27, Papenfuss, 1944: 338, Misra, 1966: 133, Krishnamurthy and Joshi 1970: 11, Nizamuddin, 1981: 45, Begum and Khatoon, 1988: 296, Silva *et al.*, 1996: 590.

**Description:** Thalli 8(-11) cm high, attached with the help of branched bunch of thin filaments; fronds 3-4(-5) cm broad, yellowish to dark brown in colour, basally broad, gradually become narrow towards the upper part; dichotomously branched, tips round, branches forming acute but narrow angle; sometime apex of branches in upper part of the thallus become flat, give rise frequent proliferations, which are also dichotomously branched forming acute and narrow angle of dichotomy; tips of proliferations rounded and divaricate, lateral proliferations common but appear like hairs which are usually present in lower part of the thallus.

Thickness of thalli comprises of three layers of cells; upper and lower layers consist of small squarish cells filled with dens phaeoplasts, 11-23  $\mu\text{m}$  in length as well as in breadth; cortex and medulla represented by a single layer of large cells which are also squarish in shape, 57-68  $\mu\text{m}$  long, 68-102  $\mu\text{m}$  broad, usually without phaeoplasts but some time very few plastids were present, each central cell covered by 4-5 cells of peripheral region; phaeophycotean hairs were not recorded in these specimens.

In the present species sexual reproductive organs were not observed. The asexual reproductive bodies *i.e.* tetrasporangia are present, spherical in shape, (11-) 23-34  $\mu\text{m}$  in height, (23-) 34-57  $\mu\text{m}$  in width. Tetrasporangia are found singly as well as in clusters and distributed all over the surface of thallus. In the genus *Dictyota* as a rule growth takes place by a single apical cell which repeatedly longitudinally as well as transversely divides and re-divides to form a thin dichotomous thallus.

**Type locality:** Cádiz, Spain.

**Habitat ecology:** It was found epilithic on the rocks of shallow pools, and also collected in the drifted form.

**Local distribution:** Buleji; Nathia gali.

**Distribution:** England, France, Greece, India, Italy, Kenya, Libya, Pakistan, Saudi Arabia, Sicily, South Africa and Yugoslavia.

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

Fig. 10D

**References:** Nizamuddin, 1981: 47; Silva *et al.*, 1987: 76, 1996: 594; Begum and Khatoon, 1988: 303; De Clerck, 2003: 150; Abbas and Shameel, 2014: 49.

**Description:** 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, 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.

**Habitat:** Benthic on mid – littoral rocks and edges of the rocky pools and found as drift material.

**Local distribution:** Buleji and Manora.

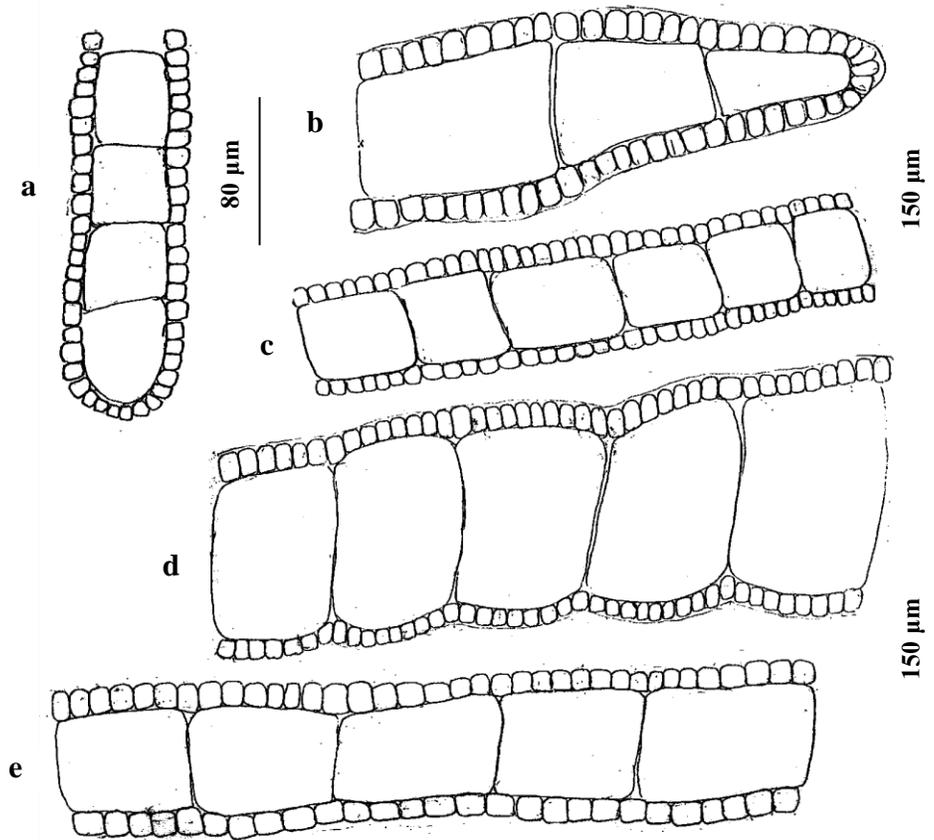
**Distribution:** Pakistan

#### *Dictyota maxima* Zanardini, 1872: 132

Fig. 8a-e, 12C

**References:** Børgesen, 1935: 38, 1937b: 317, Durairatnam, 1961: 38, Misra, 1966: 140, 1967: 233, Krishnamurthy and Joshi, 1970: 11, Begum and Khatoon, 1988: 297, Shameel and Tanaka, 1992: 38, Shaikh and Shameel, 1995: 21, Silva *et al.*, 1996: 595.

**Description:** Thallus thick and flat, up to 8 cm high, 1.5-2.0 cm wide, olive green to yellowish brown; attached by cluster of thin filaments; branches strictly dichotomous, dichotomy formed by usually obtuse and broad angles; tips obtuse and bifid; upper part of thallus has very few but the lower part with frequent small teeth; surface smooth, sometime proliferations appear like small teeth but it is not a common feature; reproductive structures distributed all over the surface of the thallus.



**Fig. 8.** *Dictyota maxima* Zanardini: **a** and **b**. Transverse sections of thalli with apical cell (of two different shapes) **c-e**. transverse sections of thalli.

Thallus differentiated into three layers of cells, in which upper and lower ones made up of small squarish cells, having densely filled phaeoplasts, appear as dark cells, 11-45(-80)  $\mu\text{m}$ , in length, 11-23  $\mu\text{m}$  in breadth; the central medullary layer composed of large squarish cells, sometime also rectangular in shape, (46-)57-102(-114)  $\mu\text{m}$  long, 57-114  $\mu\text{m}$  broad; in upper part of thallus medullary region becomes di- or tri-stromatic, phaeoplasts very few, each central cell covered by 4-8 peripheral cells; phaeophycotean hairs absent.

The asexual reproductive organs in these specimens were tetrasporangia, sac-like structures and appear in groups, 4-5  $\mu\text{m}$  in length, 5-6  $\mu\text{m}$  in breadth, present all over the surface of the thallus. Gametangia, the sexual reproductive bodies were also observed, present in sori, cylindrical in shape, with obtuse tips, 20-30  $\mu\text{m}$  long, 7-10  $\mu\text{m}$  wide; sori were present on both the surfaces of thallus. Phaeophycotean hairs were not observed. This species has a single large apical cell, which divides and re-divides to form a foliose or expanded structure of thallus.

**Type locality:** "Tangion Datu"[Cape Datu] boundary between Sarawak, Malaysia and West Kalimantan, Indonesia.

**Habitat ecology:** The vegetation of this species was observed growing epilithic, in association with other Dictyotalian members and sometimes with some green algae like *Valoniopsis pachynema* (Mertens) Børgesen.

**Local distribution:** Buleji, Manora and Nathiagali.

**Distribution:** East Indies, India, Pakistan and Sri Lanka.



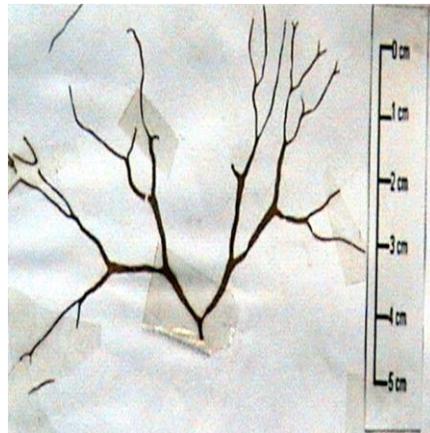
A. *Dictyota dichotoma*



B. *Dictyota ceylanica*



C. *Dictyota ciliolata*



D. *Dictyota divaricata*

**Fig. 9.** A. *Dictyota dichotoma*, B. *Dictyota ceylanica*, C. *Dictyota ciliolata*, D. *Dictyota divaricata*



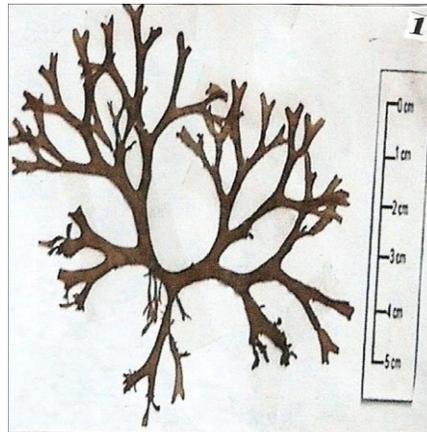
A. *Dictyota flabellatum*



B. *Dictyota haukiana*



C. *Dictyota indica*



D. *Dictyota linearis*

**Fig. 10.** A. *Dictyota flabellatum*, B. *Dictyota haukiana*, C. *Dictyota indica*, D. *Dictyota linearis*.

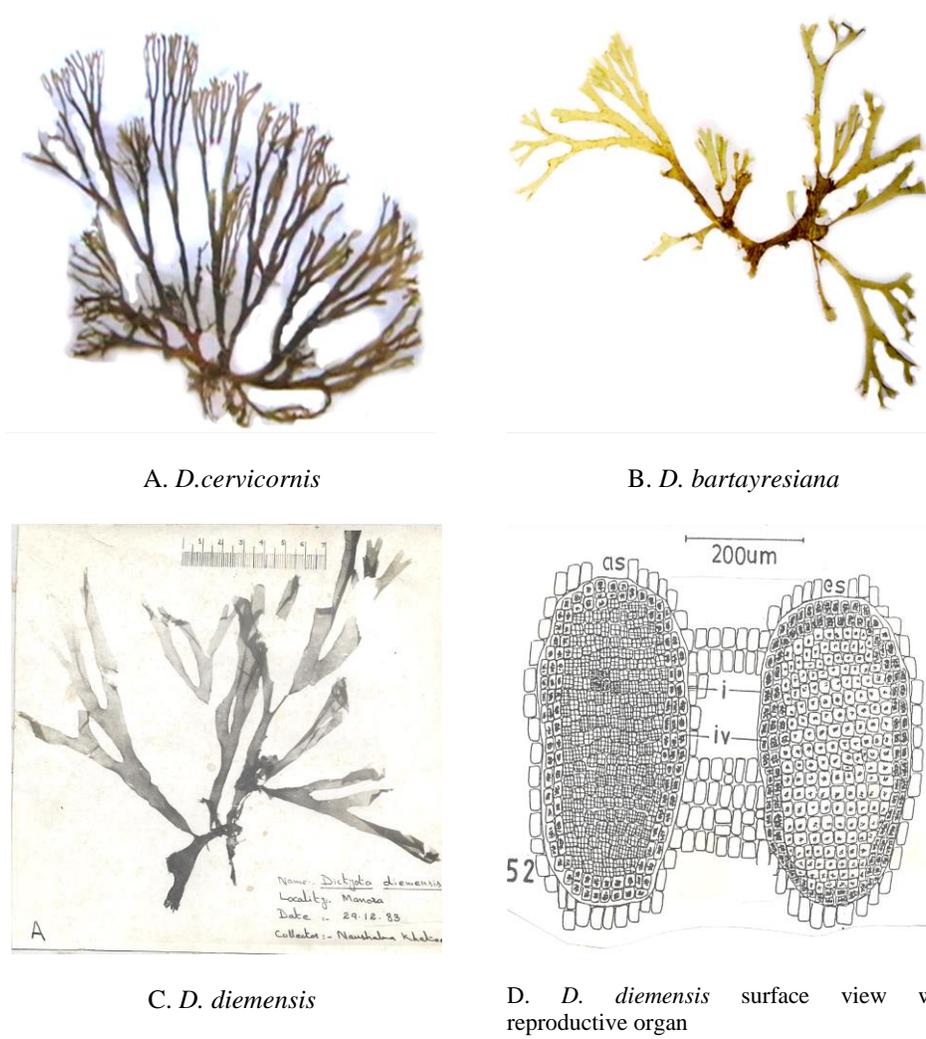


Fig. 11. A. *Dictyota cervicornis*, B. *Dictyota bartayresiana*, C. *Dictyota diemensis*, D. *Dictyota linearis*.

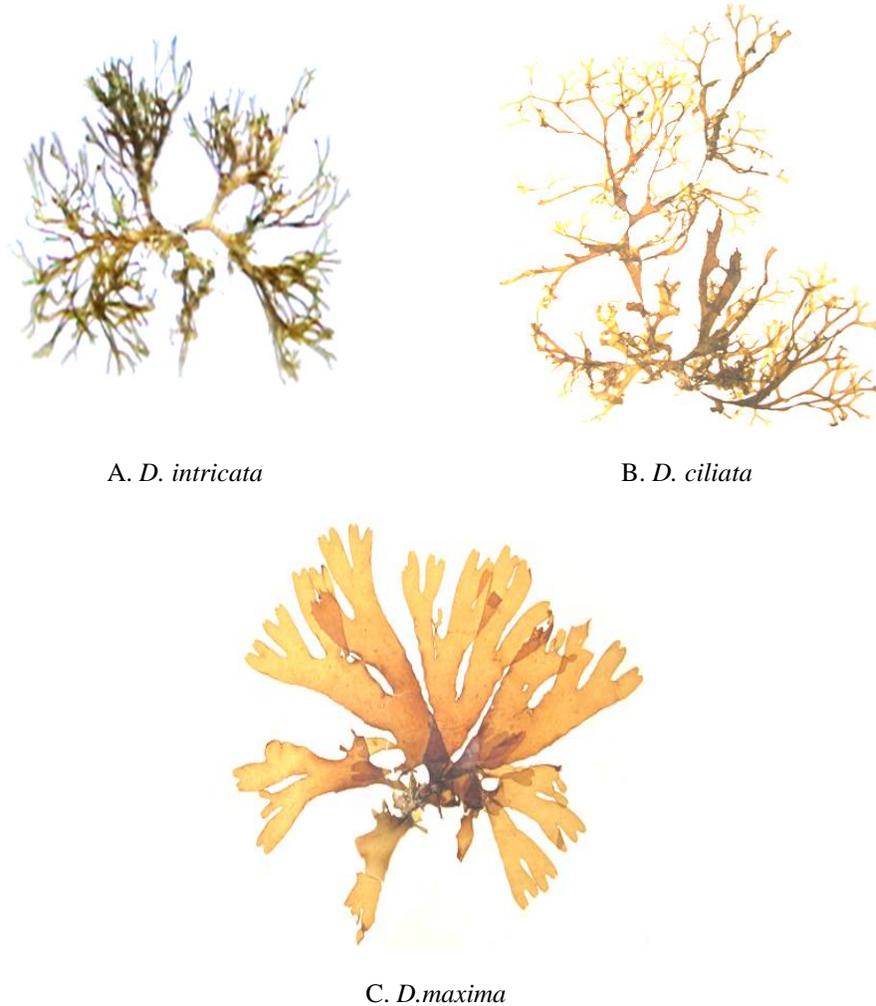


Fig. 12. **A.** *Dictyota intricata*; **B.** *Dictyota ciliata*; **C.** *Dictyota maxima*.

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