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Notes on *Dictyota dichotoma*, *D. menstrualis*, *D. indica* and *D. pulchella* spec. nova (*Phaeophyta*)

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With 9 Figures

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Key words: *Dictyota dichotoma*, *Dictyota indica*, *Dictyota menstrualis*, *Dictyota pulchella* spec. nova, *Phaeophyta*, Seaweeds. – Chromosome numbers, interbreeding, intraspecific variation.

Summary

HÖRNIG I. & SCHNETTER R. 1988. Notes on *Dictyota dichotoma*, *D. menstrualis*, *D. indica* and *D. pulchella* spec. nova (*Phaeophyta*). – *Phyton (Austria)* 28 (2): 277–291, 9 figures. – English with German summary.

In the North Atlantic *Dictyota dichotoma* (HUDSON) LAMOUROUX is limited to the eastern coasts (Europe, Africa and the Mediterranean Sea). *D. divaricata* LAMOUROUX is a synonym of *D. dichotoma*. Nevertheless, the name *D. divaricata* still is used for plants from the tropics. Between "*D. divaricata*" from the Caribbean Sea and *D. dichotoma* which both have $n = 16$ chromosomes exists an interbreeding barrier. So, the Caribbean "*D. divaricata*" does not belong to the *D. dichotoma* complex, and we consider the first as a neglected species: *D. pulchella* HÖRNIG & SCHNETTER spec. nova. – *D. indica* SONDER ex KÜTZING from the Caribbean similar to some forms of *D. dichotoma* has $n = 9$ chromosomes. – A neotype is designated for *D. dichotoma* var. *menstrualis* HOYT.

Zusammenfassung

HÖRNIG I. & SCHNETTER R. 1988. Notizen über *Dictyota dichotoma*, *D. menstrualis*, *D. indica* und *D. pulchella* spec. nova (*Phaeophyta*). – *Phyton (Austria)* 28 (2): 277–291, 9 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Das Vorkommen von *Dictyota dichotoma* (HUDSON) LAMOUROUX ist im Nordatlantik auf die Ostküsten beschränkt (Europa, Afrika und das Mittelmeer). *D. divari-*

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cata LAMOUROUX ist ein Synonym von *D. dichotoma*. Trotzdem wird der Name *D. divaricata* noch für Pflanzen aus den Tropen benutzt. Zwischen „*D. divaricata*“ aus der Karibischen See und *D. dichotoma*, die beide $n = 16$ Chromosomen besitzen, besteht eine Kreuzungsbarriere. Daher gehört die karibische „*D. divaricata*“ nicht zum *D. dichotoma*-Komplex, und wir betrachten die erstere als eine bisher übersehene Art: *D. pulchella* HÖRNIG & SCHNETTER spec. nova. – *D. indica* SONDER ex KÜTZING aus der Karibik, die einigen Formen von *D. dichotoma* ähnelt, besitzt $n = 9$ Chromosomen. – Für *D. dichotoma* var. *menstrualis* HOYT wird ein Neotypus bestimmt.

The genus *Dictyota* was established by LAMOUROUX 1809 who included in this taxon species now belonging to genera like *Lobophora* J. AGARDH, *Padina* ADANSON, *Stypopodium* KÜTZING, *Taonia* J. AGARDH, *Cutleria* GREVILLE and even some *Rhodophyta*. The actual generally accepted generic concept concerning *Dictyota* is mainly based on J. AGARDH 1881 who described *Dilophus* as a new genus considering plurilayered medullae in the latter the most important character for its separation from *Dictyota*, limited to species with unistratose medullae. Only a few authors (e. g. SETCHELL & GARDNER 1925) did not agree with this opinion. In this paper we discuss some taxonomic problems within the genus *Dictyota* in the restricted sense of J. AGARDH 1881.

Pleomorphism in *Dictyota* caused descriptions of many species during the 19th century. Generally, most of the new species names soon were reduced to synonyms [see synonyms of *D. dichotoma* (HUDSON) LAMOUROUX, Tab. 3]. For the European coasts most authors (e. g. FUNK 1927, HAMEL 1931–1939) distinguish two species, *D. dichotoma* and *D. linearis* (C. AGARDH) GREVILLE. NIZAMUDDIN 1981 additionally recognized *D. pusilla* LAMOUROUX 1809: 43 as a third European species. Further, in a list of species from Sicily (GIACCONE & al. 1985) *D. major* TAYLOR is mentioned. In a recent publication SCHNETTER, HÖRNIG & WEBER-PEUKERT 1987 briefly communicated as a result of culture experiments that there exists only one *Dictyota* species in the European North Atlantic and in the Mediterranean Sea. Plants from the tropical of temperate western North Atlantic hitherto named *D. dichotoma* could be shown to belong to a separate species: *D. menstrualis* (HOYT) SCHNETTER, HÖRNIG & WEBER-PEUKERT 1987, not interbreeding with European *D. dichotoma* isolates. WEBER-PEUKERT 1985 communicated results of autecological studies in *D. dichotoma* (“strain *D. dichotoma* E”) and *D. menstrualis* (“strain *D. dichotoma* K”).

Recently, herbarium specimens of the Smithsonian Institution, Washington, could be studied. This material supports the opinion of SCHNETTER & al. 1987 concerning the status of *D. menstrualis*.

D. divaricata LAMOUROUX 1809 was described as a new species from the Mediterranean Sea. Subsequently, most authors treating of the taxonomy of European *Dictyota* species considered *D. divaricata* as a synonym of *D.*

dichotoma (e. g. DE TONI 1885). In spite of this fact, the name *D. divaricata* is still widely used for plants occurring in the tropical Atlantic, Pacific and Indian Oceans (e. g. TAYLOR 1960, JAASUND 1970, SCHNETTER 1976, LAWSON & JOHN 1982, SCHNETTER & BULA 1982). Because we found neither morphological nor anatomical differences between narrow thalli of *D. dichotoma* (hitherto named *D. linearis* or *D. pusilla*) and thalli of "*D. divaricata*" collected in the Caribbean Sea, due to overlapping characteristics relevant for species delimitation, culture experiments were carried out.

TAYLOR 1960 discussed possible relations between *D. indica* SONDER ex KÜTZING and *D. dichotoma*. Untypical plants of *D. cervicornis* KÜTZING may be similar to *D. indica* in habit. Therefore herbarium material and an isolate from the Caribbean Sea corresponding to the description of the first taxon were compared with *D. dichotoma*, Caribbean "*D. divaricata*" and *D. cervicornis*.

This paper contains results of a doctoral thesis of I. H.

Material and Methods

About 40 isolates of *Dictyota* corresponding to the thallus shapes of *D. dichotoma* var. *dichotoma*, *D. dichotoma* var. *intricata*, *D. linearis* and *D. pusilla* from the Mediterranean Sea and from the European Atlantic coast, furthermore 5 isolates of *D. divaricata* and one isolate each of *D. indica* and of *D. cervicornis* from the tropical western North Atlantic (Tab. 1) were cultured under controlled conditions as described by WEBER-PEUKERT 1985.

The European material was collected and isolated taking into account strictly the descriptions of *D. dichotoma* var. *dichotoma*, *D. dichotoma* var. *intricata*, *D. linearis* and *D. pusilla*, mainly as given by HAMEL 1931–1939 and NIZAMUDDIN 1981. Interbreeding experiments were carried out with fertile gametophytes of these four European *Dictyota* taxa from the Mediterranean Sea, with *Dictyota dichotoma* var. *dichotoma* from the Spanish Atlantic coast and with *D. divaricata* from the Caribbean Sea (see Table 1).

For chromosome counting well growing gametophytic thalli were treated with acenaphthene and LiCl and Feulgen-stained (see SCHNETTER & al. 1987).

Further, herbarium specimens of the above mentioned taxa, including part of the specimens examined by NIZAMUDDIN 1981 and probably the isotype of *D. linearis* (LASSEN, letter 1984), and possible syntypes of *D. dichotoma* var. *menstrualis* (NORRIS, letter 1987) were studied.

The lengths of cortical and medullary thallus cells of living and herbarium material were measured within the second internodia below the apex (WEBER-PEUKERT 1985).

Results and Discussion

The *Dictyota dichotoma*-complex

Circumscriptions of European representatives of the genus *Dictyota* vary considerably from author to author. HAMEL 1931–1939 distinguishes between the species *D. dichotoma* and *D. linearis*. Besides typical *D.*

Table 1.

Cultivated material.

Dictyota dichotoma var. *dichotoma*

- France, St. Malo, leg. Ruckelshausen, IX-1982
 Spain, Celorio, leg. Weber-Peukert, IV-1979
 Spain, Mallorca, Pto. Fornells, leg. Hörnig, III-1985
 France, Corse, Pto. Pollo, leg. Hörnig, IX-1982
 Italy, Monopoli, leg. Schnetter, IV-1982
 Yugoslavia, Rovinj, leg. Hörnig, III-1983 (2 isolates)
 Greece, Kephallonia, leg. Schnetter, XI-1983
 Greece, Santorin, Akrotiri, leg. Hörnig, X-1983
 Spain, Teneriffe, Pto. de la Cruz, leg. Hörnig, V-1984

Dictyota dichotoma var. *intricata*

- France, Banuyls, leg. Athanasiadis, VII-1983
 Yugoslavia, Rovinj, leg. Hörnig, III-1983 (11 isolates)
 Greece, Kephallonia, leg. Schnetter, XI-1983 (9 isolates)
 Spain, Teneriffe, Pto. de la Cruz, leg. Hörnig, V-1984

"*Dictyota linearis*", "*Dictyota pusilla*"

- Greece, Kephallonia, leg. Schnetter, XI-1983 (7 isolates)
 Spain, Teneriffe, Pto. de la Cruz, leg. Hörnig, V-1984

Dictyota pulchella spec. nov.

- Colombia, Sta. Marta, leg. Schnetter, IX-1979
 Colombia, Sta. Marta, leg. Schnetter, VIII-1981
 Colombia, Bahia de Neguanje, leg. Schnetter, I-1985
 Guadeloupe, Pigeon, leg. Hörnig, V-1985 (2 isolates)

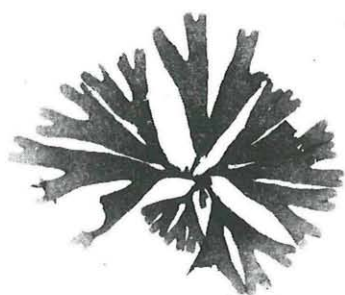
Dictyota indica

- Colombia, Bahia de Neguanje, leg. Schnetter, III-1986

Dictyota cervicornis

- Colombia, Sta. Marta, leg. Schnetter X-1979.

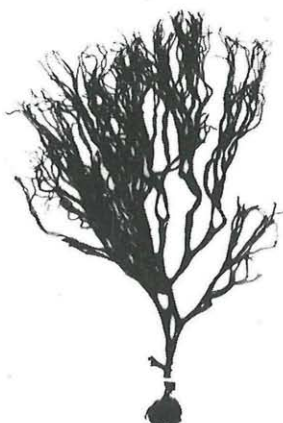
Fig. 1. Broad form of *Dictyota dichotoma* (considered by GIACCONE & al. 1985 as *D. major* TAYLOR). — Fig. 2. *D. dichotoma* (HUDSON) LAMOUROUX var. *dichotoma*. — Fig. 3. *D. dichotoma* (HUDSON) LAMOUROUX var. *intricata* (C. AGARDH) GREVILLE. — Fig. 4. Narrow form of *D. dichotoma* var. *intricata*: "*D. linearis* (C. AGARDH) GREVILLE". — Fig. 5. Narrow form of *D. dichotoma* var. *intricata* (considered by NIZAMUDDIN 1981 as *D. pusilla* LAMOUROUX). — Fig. 6. *D. menstrualis* (HOYT) SCHNETTER, HÖRNIG & WEBER-PEUKERT, neotype of *D. dichotoma* (HUDSON) LAMOUROUX var. *menstrualis* HOYT. — Fig. 7. *D. pulchella* HÖRNIG & SCHNETTER, spec. nov., isotype. — Fig. 8. *D. indica* SONDER ex KÜTZING, chromosomes (2n = 18), a) photograph, b) drawing. — Fig. 9. *D. pulchella*, chromosomes (n = 16), a) photograph, b) drawing. — Bar in Figs. 1–7: 1 cm; in Figs. 8, 9: 10 µm.



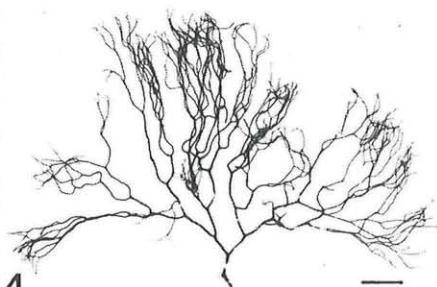
1



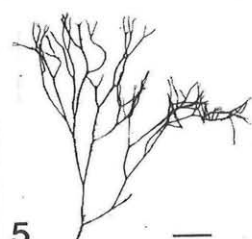
2



3



4



5



a

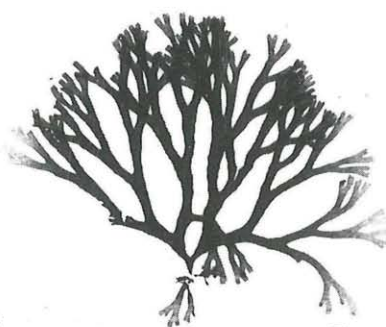


9

b



7



6



a



b

dichotoma with broader thalli and rounded apices he recognizes the variety *intricata*, with narrow and often twisted thallus ends. *D. linearis* in the sense of HAMEL 1931–1939: 347 ff. corresponds to KÜTZING's figures of this taxon (KÜTZING 1859: tab. 21, fig. II) and of *D. angustissima* KÜTZING 1859: tab. 21, fig. IV, comprising uniformly narrow thalli and narrow thalli distally a little broadened. FUNK 1927 also makes a distinction between *D. dichotoma* and *D. linearis*. His interpretation of *D. dichotoma* is limited to *D. dichotoma* var. *dichotoma*. Forms, which are similar to *D. dichotoma* var. *intricata* in the sense of HAMEL 1931–1939, according to the interpretation of FUNK 1927: 362, fig. 20 e belong to *D. linearis*. A second form of *D. linearis* mentioned by FUNK 1927: 362, fig. 20 f corresponds to *D. angustissima* (KÜTZING 1859: tab. 21, fig. IV). *D. pusilla* LAMOUROUX was reestablished in 1981 by NIZAMUDDIN. Besides a thallus shape different from *D. linearis* (*D. pusilla* throughout slender, *D. linearis* with broad terminal segments) he quotes for *D. pusilla* an arrangement of tetrasporangial "sori in a single linear row along the central parts of the segments" while in *D. linearis* the "sori, containing sporangia" are "transversely arranged"; that means the central row of sporangia shows interruptions (NIZAMUDDIN 1981: 49–50). We cannot confirm the differences observed between the taxa *D. pusilla* and *D. linearis* by NIZAMUDDIN. Besides characteristic "*D. linearis*" from the Rijksherbarium Leiden and the Herbarium M. L. & R. SCHNETTER and living material (see Table 1), we had at hand part of the material that served NIZAMUDDIN as base for his studies (Herbarium Kiel, folder "*D. linearis*", sheet A–D).

Both *D. linearis* and *D. pusilla* show the same pattern of tetrasporangia, either in a linear row, as described by J. AGARDH 1894 for *D. linearis*, or in a partly interrupted line, as quoted for *D. linearis* by C. AGARDH 1823 and HAMEL 1931–1939. The two types of sporangial arrangement can even be found on the same thallus.

D. major TAYLOR is quoted by GIACCONE & al. 1985 for the Mediterranean Sea. The material determined by GIACCONE we had at hand shows the typical *D. dichotoma* habit, but the thallus branches are extremely broad, with slight dentations on the margin (Fig. 1). They do not completely correspond to the description given by TAYLOR 1945 for *D. major*, but strikingly resemble *D. latifolia* KÜTZING 1859: tab. 12, fig. I, which represents a broad form of *D. dichotoma*. Slightly dentate thallus margins could also be found in typical *D. dichotoma* plants (e. g. Herbarium M. L. & R. SCHNETTER, Nos. A-685-G, A-2007-G, A-2250-G from the Ionian Sea). Also the cell dimensions of the plants named *D. major* from the Mediterranean Sea match the cell sizes of *D. dichotoma* (Tab. 2).

Identical chromosome numbers ($n = 16$ in gametophytes, see also GIRAUD 1956) in all European *Dictyota* plants and the absence of interbreeding barriers between the different European forms of *Dictyota*, sym-

Table 2.

Length of medullary cells (L_m) and cortical cells (L_c) and L_m/L_c -ratio in *Dictyota dichotoma* var. *dichotoma*, *D. dichotoma* var. *intricata*, *D. pulchella*, *D. indica* and *D. cervicornis*. L_m and L_c in μm (confidence limit 99%). Means of 100 measurements.

D. dichotoma var. *dichotoma*

	L_m	L_c	L_m/L_c
Cultivated material			
France: St. Malo	116.8 ± 2.5	48.4 ± 1.3	2.4
Spain: Asturias	78.7 ± 2.8	40.5 ± 0.8	2.0
Corse: Pto. Pollo	114.1 ± 3.5	56.4 ± 1.8	2.1
Italy: Apulia	91.8 ± 1.7	42.0 ± 0.7	2.2
Yugoslavia: Rovinj	117.3 ± 8.1	58.7 ± 1.2	1.9
Greece: Kephallonia	93.4 ± 4.8	43.2 ± 1.3	2.2
Canary Islands: Teneriffe	109.6 ± 2.9	49.1 ± 0.7	2.2
Herbarium material			
France: Atlantic	129.7 ± 6.2	55.7 ± 1.2	2.4
Mediterranean	91.1 ± 4.6	40.5 ± 1.6	2.3
Italy	123.2 ± 3.6	42.7 ± 1.0	2.9

D. dichotoma var. *intricata*

Cultivated material			
France: Banuyls	140.6 ± 4.1	50.2 ± 1.2	2.8
Yugoslavia: Rovinj	100.6 ± 2.2	34.3 ± 1.3	3.0
Greece: Kephallonia	155.3 ± 2.9	45.6 ± 0.8	3.4
Canary Islands: Teneriffe	147.2 ± 7.0	43.2 ± 1.1	3.4
Herbarium material			
France: Atlantic	110.7 ± 3.3	37.9 ± 1.6	2.6
Mediterranean	141.2 ± 6.4	45.1 ± 2.2	3.2
Italy	125.8 ± 3.9	35.0 ± 0.9	3.6

as "*D. linearis*"

Cultivated material			
Greece: Kephallonia	161.2 ± 3.7	41.0 ± 1.0	3.9
Greece: Kephallonia	134.6 ± 4.2	33.1 ± 1.2	4.1
Canary Islands: Teneriffe	115.2 ± 1.0	33.1 ± 0.9	3.5

Herbarium material
Lund No 48910, probably
isotype, "ad Gades"

142.3 ± 0.4	44.0 ± 0.3	3.2
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as "*D. pusilla*"

Herbarium material			
Yugoslavia: Split	132.3 ± 2.5	39.2 ± 1.1	3.4
Adria	146.5 ± 6.0	37.8 ± 0.6	3.9
Italy: Genua	126.3 ± 5.8	40.5 ± 0.7	3.1
Morokko: Tanger	116.8 ± 3.1	33.1 ± 0.8	3.5

as "*D. major*"

Herbarium material

Italy: Sicily, Siracusa	82.1 ± 6.2	32.6 ± 1.9	2.5
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D. pulchella

Cultivated material

Colombia: Sta. Marta	153.3 ± 4.9	37.9 ± 1.5	4.1
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Typus	131.8 ± 1.8	31.5 ± 0.8	4.4
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D. indica

Cultivated material

Colombia	147.8 ± 0.7	48.7 ± 0.2	3.1
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Herbarium material

Colombia	155.0 ± 0.7	39.1 ± 0.3	4.0
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D. cervicornis

Cultivated material

Colombia: Sta. Marta	124.7 ± 16.3	31.5 ± 2.2	4.0
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patric at least in the Mediterranean Sea, result in a continuum of forms that does not really permit a distinction of different species. The taxa *D. dichotoma*, *D. linearis* and *D. pusilla* (and *D. major*, only in the interpretation of GIACCONE & al. 1985) must be considered as forms of one polytypic species, *D. dichotoma* (see SCHNETTER & al. 1987). However there seems to exist a geographic gradient concerning the width of thallus branches. In the northern part of the European area of *D. dichotoma* (Atlantic coast from the Channel to Mid-Norway) thalli with broad branches are predominating, while in the south (especially in the Mediterranean Sea) thalli with narrow and thalli with broad branches are growing in mixed stands (observed e. g. near Argostolion, Kephallonia, Greece). According to our experiments the thallus shape is very variable and may be altered within a short time under changed culture conditions. E. g., variations in light intensity, temperature or nutrient concentration, in a natural range, cause changes in colour, total growth, internodal length and width of divergence angle (WEBER-PEUKERT, unpublished results).

Differences are not limited to the habit of plants. Medullary and cortical cells of thalli with narrow branches are longer than those of thalli with broad branches, and a still more striking difference exists between the length-ratio of medullary: cortical cells of both thallus forms (Tab. 2).

By means of thallus shape and cell sizes we therefore propose to distinguish in *D. dichotoma* two varieties: the throughout broad *D. dichotoma* var. *dichotoma* with rounded thallus apices (Fig. 2) and *D. dichotoma* var. *intricata* (including *D. linearis* and *D. pusilla*). The thalli of this variety are narrow all over or, when broad at the base, have narrowed and often twisted ends with rounded to acute tips (Figs. 3–5).

Dictyota menstrualis (HOYT) SCHNETTER, HÖRNIG & WEBER-PEUKET

Dictyota menstrualis could be proofed to be a species different from *D. dichotoma* (SCHNETTER & al. 1987: 195). Additionally to our former studies, now we had herbarium material from the Smithsonian Institution at hand, collected and determined by HOYT (Nos. 33618–33625; 33629–33631; 33633–33635; 42551; 42552; 42554; 42558; 43581 = P.B.A. 1641; 69623 = P.B.A. 1641; 33626–33628) and SCHNEIDER (No. 14346).

The material collected by HOYT represents "probably syntypes of *D. dichotoma* var. *menstrualis* HOYT" (NORRIS, letter 1987). They all show the characteristics of *D. menstrualis*. HOYT 1927 apparently did not select a type specimen for *D. dichotoma* var. *menstrualis* (NORRIS, letter 1987). In the herbaria of the Duke University, Durham, and of the Smithsonian Institution, Washington, no type material could be found (SEARLES, letter 1984; NORRIS, letter 1987). The specimens from the Smithsonian Institution collected by HOYT in part may be syntypes. Nevertheless, there seems to be no real proof for this opinion.

In accordance to VOSS & al., International Code of Botanical Nomenclature 1983: art. 7.4, herbarium specimen No. 33622 (female gametophyte) from the Smithsonian Institution was designated as the neotype of *Dictyota dichotoma* var. *menstrualis* (Fig. 6).

Dictyota pulchella spec. nova

Due to the fact that *D. dichotoma* is the only *Dictyota* species in the Mediterranean Sea, *D. divaricata* LAMOUROUX 1809: 43 ("Habitat in mare Mediterraneo") is a synonym of *D. dichotoma* (see also DE TONI 1895). Therefore we tried to find out if plants named "*D. divaricata*" from the western tropical Atlantic are belonging to the *Dictyota dichotoma* complex too, or if they represent a different species. In culture "*D. divaricata*" shows a slightly heteromorphic life cycle. Thalli of tetrasporophytes are in general narrower than those of gametophytes and have the same breadth all over. Gametophytic thalli are broader with abruptly narrowing distal parts. In cultured material the thallus breadth in tetrasporophytes is 200–336 µm, in female gametophytes 399–521 µm and in male gametophytes 422–568 µm. Measurements of cells resulted in medullary cells 4–5 times longer than cortical cells. – The chromosome number is $n = 16$ (Fig. 9).

So, morphological features and the chromosome number do not permit to distinguish "*D. divaricata*" from narrow *D. dichotoma* forms. Nevertheless, there is a very effective interbreeding barrier between *D. dichotoma* and "*D. divaricata*" plants from the Western tropical North Atlantic. Tetrasporophytes come to exist, but their tetraspores are not able to germinate. So, tropical Atlantic "*D. divaricata*" does not belong to the *Dictyota dichotoma* complex.

Table 3.

Synonyms of *D. dichotoma* var. *dichotoma* and *D. dichotoma* var. *intricata*.

Dictyota dichotoma (HUDSON) LAMOUROUX var. *dichotoma*
LAMOUROUX 1809: 42.

Basionym: *Ulva dichotoma* HUDSON 1762: 476.

Synonyms:

Dichophyllum dichotomum KÜTZING 1843: 337; fide DE TONI 1895: 263.

Dichophyllum vulgare KÜTZING 1849: 553.

Dictyota affinis KÜTZING 1849: 554; 1859: tab. 12, fig. II.

Dictyota acuta KÜTZING 1845: 271; 1859: tab. 13, fig. I.

Dictyota aequalis KÜTZING 1845: 271; 1859: tab. 21, fig. I.

Dictyota aequalis var. *minor* KÜTZING 1859: tab. 11, fig. II.

Dictyota attenuata KÜTZING 1859: tab. 11, fig. I.

Dictyota dichotoma f. *latifrons* HOLMES & BATTERS 1890; fide NEWTON 1931: 212.

Dictyota dichotoma var. *volubilis* LENORMAND ex DE TONI 1895: 263.

Dictyota elongata KÜTZING 1859: tab. 11, fig. II.

Dictyota latifolia KÜTZING 1859: tab. 12, fig. II, non *Dictyota latifolia* J. AGARDH ex J. AGARDH 1894: 65, nom illeg.

Dictyota sibenicensis ZANARDINI 1843: 38; fide DE TONI 1895: 263; the figure of KÜTZING 1859: pl. 9, fig. IVa may also represent a *Dilophus* species.

Dictyota verrucosa SUHR in Herb. SONDER ex KÜTZING 1859: tab. 19, fig. I.

Dictyota volubilis KÜTZING 1849: 554; 1859: tab. 13, fig. II.

Dictyota volubilis HENRIQUES non KÜTZING, HENRIQUES 1881; fide MESQUITA-RODRIGUES 1963: 47.

Dictyota vulgaris KÜTZING 1845: 270; 1859: tab. 10, fig. II.

Fucus dichotomus BERTOLONI 1818: 314; fide C. AGARDH 1823: 133.

Fucus zosteroides LAMOUROUX 1805: 25; fide C. AGARDH 1823: 133

Haliseris dichotoma SPRENGEL 1827: 328; fide GREVILLE 1830: 57.

Neurocarpus annularis SCHOUSBOE in BORNET 1892: 227; fide DE TONI 1895: 263.

Neurocarpus areolatus SCHOUSBOE in BORNET 1892: n. 180; fide DE TONI 1895: 263.

Zonaria dichotoma C. AGARDH 1823: 133.

Dictyota laciniata LAMOUROUX 1809 a: 41 may be *D. dichotoma* too, but the description is not sufficient.

Ulva punctata STACKHOUSE in GOODENOUGH & WOODWARD 1797: 236; C. AGARDH 1823: 133 is *Nitophyllum punctatum* (STACKHOUSE) GREVILLE (see also HAUCK 1885: 170).

Dictyota dichotoma (HUDSON) LAMOUROUX var. *intricata* (C. AGARDH) GREVILLE 1830: 58

Basionym: *Zonaria dichotoma* var. *intricata* C. AGARDH 1823: 134, see PAPENFUSS 1944: 339.

Synonyms:

Dictyota angustissima SONDER ex KÜTZING 1859: tab. 21, fig. IV.

Dictyota cirrhosa SUHR 1839: 67; see KÜTZING 1849: 555; 1859: tab. 19, fig. I.

Dictyota dichotoma var. *implexa* (DESFONTAINES) GRAY 1821: 341; fide PAPENFUSS 1944: 338.

- Dictyota dichotoma* var. *implexa* (LAMOUROUX) J. AGARDH 1848: 92 nom. illeg. as the epitheton *implexa* is based on *Fucus implexus* DESFONTAINES (see also PAPENFUSS 1944: 338).
- Dictyota dichotoma* var. *implexa* (DESFONTAINES) J. AGARDH; see SEOANE-CAMBA 1965: 85, nom. illeg. as AGARDH based this variety on *Dictyota implexa* LAMOUROUX.
- Dictyota dichotoma* f. *intricata* (KÜTZING) SCHMIDT 1931: 34, nom. illeg.
- Dictyota divaricata* LAMOUROUX 1809 a: 43.
- Dictyota fibrosa* KÜTZING 1859: tab. 15, fig. II.
- Dictyota implexa* (DESFONTAINES) LAMOUROUX 1809: 43.
- Dictyota intricata* KÜTZING 1859: tab. 15, fig. I.
- Dictyota linearis* (C. AGARDH) GREVILLE 1830: XLIII.
- (Erroneous: *D. linearis* (C. AGARDH) LAMOUROUX, see FELDMANN 1931: 217.)
- Dictyota linearis* (C. AGARDH) J. AGARDH 1848: 90, nom. illeg.
- Dictyota ornata* ZANARDINI in Herb. SONDER ex KÜTZING 1859: tab. 26, fig. I.
- Dictyota pusilla* LAMOUROUX 1809: 43.
- Dictyota striolata* KÜTZING 1849: 554; 1859: tab. 17., fig. II.
- Dictyota verrucosa* SUHR in Herb. SONDER ex KÜTZING 1859: tab. 19, fig. I.
- Dictyota vulgaris* var. *intricata* KÜTZING 1849: 554.
- Fucus implexus* DESFONTAINES 1800: 423; fide LAMOUROUX 1809: 43, and PAPENFUSS 1944.
- Zonaria linearis* C. AGARDH 1823: 134.

Due to these results, at least the algae from the Caribbean Sea hitherto named "*D. divaricata*" are to be considered as a separate, still undescribed species which is clearly delimited from *D. dichotoma*.

Dictyota linearis is quoted also for the Caribbean Sea (e. g. BØRGESSEN 1914, TAYLOR 1960, CHAPMAN 1963, SCHNETTER 1976). We consider "*D. linearis*" from the western tropical Atlantic also as belonging to *D. pulchella*, mainly because its sporophyte has a "*D. linearis*"-shape. Herbarium material (Herbarium M. L. & R. SCHNETTER) examined in this respect proofed this thesis, as "*D. linearis*-forms", when fertile, always bear tetrasporangia.

D. pulchella is expected to grow on the tropical African Atlantic coast too [LAWSON & JOHN 1982, see *D. divaricata*; the specimen figured on page 143 seems to be rather untypical. Herbarium material, British Museum (Natural History) No. 6729], as well as *D. dichotoma* (PRICE, JOHN & LAWSON 1978). It will cause great difficulties to separate, especially in herbarium material, narrow forms of these two species.

Dictyota pulchella HÖRNIG & SCHNETTER, spec. nova (Fig. 7)

Diagnosis: Frondes dichotomae, membranaceae, erectae, altitudine circa 7 cm, tribus stratis cellularum compositae, semper medullae monostromaticae, plerumque angulis inter ramos divaricatis. Cellulae corticis plerumque (29–) 39 (– 46) µm longae et (19–) 21 (– 22) µm latae, medullae

plerumque (105–) 157 (–192) μm longae et (58–) 73 (–85) μm latae, ratio longitudinum cellularum medullae: corticis (3.7–) 4.0 (–4.4). Segmenta partibus basalibus medianisque gametophytorum 1.5–2.5 mm lata, superioribus abrupte angustata in ramificationibus et circiter 0.1–0.4 mm lata; segmenta sporophytorum subuniformiter 0.2–0.8 mm lata. Oogonia antheridiaque in soris. Tetrasporangia (44–) 60 (–86) μm diam. sine cellulis involucribus. Numerus chromosomatum $n = 16$.

Plantae typicae in loco dicto "Punta La Loma, Santa Marta, Colombia", legit R. SCHNETTER, A-185, 27. X. 1966, e mari 0.5 m profundo. Holotypus: COL. Isotypi: L; Herb. M. L. & R. SCHNETTER.

Dictyota indica SONDER ex KÜTZING

D. indica was described in 1859 by KÜTZING (tab. 17, fig. I). The type-specimen originates from the West Indies ("Havanna").

As discussed by several authors, *D. indica* may strongly resemble or even belong to another species, e. g. *D. dichotoma* or *D. cervicornis* (TAYLOR 1960; EARLE 1969; PRICE, JOHN & LAWSON 1978). In the field, there is often no possibility to distinguish the species. Because the tetrasporangia of *D. indica* are not surrounded by involucrial cells, the sporophytic thalli can be separated easily from *D. cervicornis* with a microscope (see JAASUND 1970).

In most cases there is no possibility to distinguish *D. indica* plants from *D. dichotoma* taking into account only the thallus shape. Our cultured material of *D. indica* shows, in contrast to *D. dichotoma*, no high variability of the thallus shape. Cell-sizes differ from those of *D. dichotoma* and *D. menstrualis* (Tab. 2).

In the Caribbean Sea *D. indica* was selected taking into account the drawings of KÜTZING 1859 and VICKERS 1908. Raising gametophytes was not possible up to now; so interbreeding experiments could not be carried out.

The number of chromosomes in *D. indica* tetrasporophytes is $2n = 18$ (Fig. 8). That means a haploid chromosome number of $n = 9$. Therefore, *D. indica* seems to be clearly separated from the *D. dichotoma* complex.

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Es wird das Keimungsverhalten und das Überleben von ca. 60 von genau definierten Kalk- und Silikatstandorten gesammelten alpinen Pflanzen nach Aussaat auf natürlichen und menschlich bedingten Schutthalden (Schipisten) in der geologisch überaus mannigfaltigen Umgebung von Davos untersucht. Daneben wird die Keimung der Samen unter kontrollierten Bedingungen im Klimaschrank durch 100 Tage verfolgt. Die Samen kamen teils unbehandelt, teils mit Gibberellin vorbehandelt oder skarifiziert (oder beides kombiniert) zur Aussaat. Wie kaum anders zu erwarten zeichnet sich das Keimverhalten durch große, auf lokalen Standortsfaktoren beruhende Diversität und eine von den Bedingungen zur Zeit der Samenreife, dem Zustand der Mutterpflanze etc. abhängige Variabilität aus. Gibberellin fördert zwar die Keimung, beeinflusst aber die spätere Entwicklung nachteilig, Gibberellin und Skarifikation können sich in ihrer Wirkung unterstützen. Das Verhalten im Felde ist von der taxonomischen Stellung unabhängig, gemeinsam ist allen untersuchten Samen eine lange Lagerfähigkeit, was die Bildung von für die Populationsdynamik wichtigen „Samenbanken“ im Boden begünstigt. „Gesichert“ erscheinende Stellen im Gelände sind nicht immer für die Etablierung der Keimlinge optimal. Abdeckung mit CURLEX (eine biologisch abbaubare Holzfaserdecke) senkt zwar die Keimzahl drastisch (Beschattung), begünstigt jedoch die spätere Entwicklung. Die Ergebnisse sind für die biologische Erosionsbekämpfung und die Erstellung geeigneter Samenmischungen für die Stabilisierung von Schutthalden von Wichtigkeit.

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