

THE CODIALES (EXCLUDING *CODIUM*) (CHLOROPHYTA) FROM KENYA, TANZANIA AND THE SEYCHELLES

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ABSTRACT. — Descriptions and illustrations are provided of one species of *Boodleopsis*, seven taxa of *Bryopsis* and one species of *Trichosolen*, based on specimens collected in Kenya, Tanzania and the Seychelles Archipelago from 1985 to 1996 : *Boodleopsis pusilla*, *Bryopsis hypnoides*, *B. indica*, *B. pennata* var. *pennata*, *B. pennata* var. *leprieurii*, *B. pennata* var. *secunda*, *B. plumosa*, *B. sp.* and *Trichosolen sp.* *Bryopsis indica* is a new record for Tanzania, *Bryopsis hypnoides* is new for the Seychelles and *Trichosolen sp.* is new for Kenya.

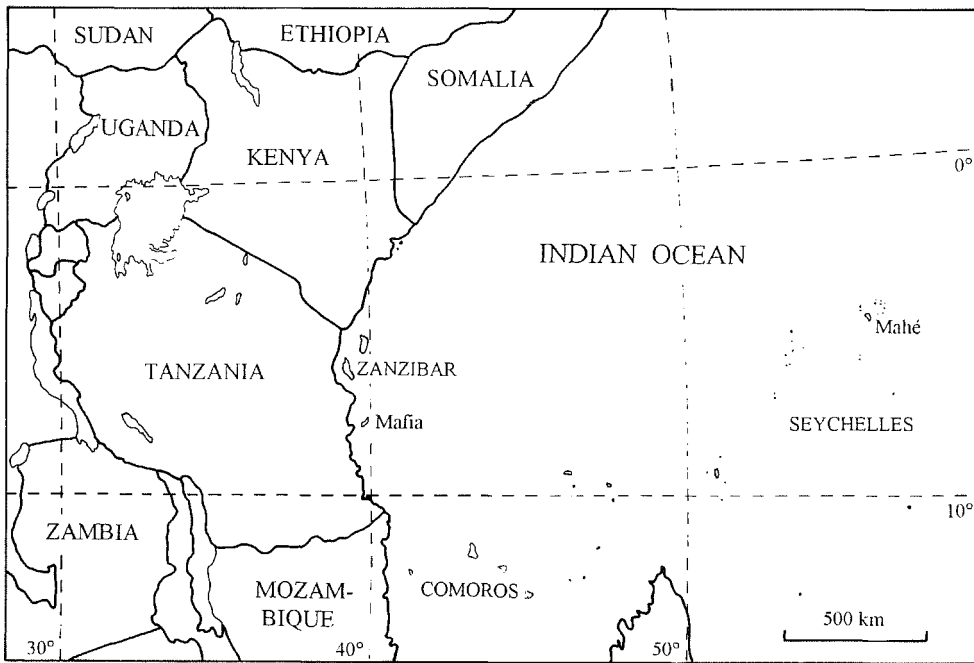
RÉSUMÉ. — *Les Codiales (excl. Codium) (Chlorophyta) du Kenya, de Tanzanie et des Seychelles.* — Les espèces suivantes, récoltées au Kenya, en Tanzanie et aux Seychelles entre 1985 et 1996, sont décrites et illustrées : *Boodleopsis pusilla*, *Bryopsis hypnoides*, *B. indica*, *B. pennata* var. *pennata*, *B. pennata* var. *leprieurii*, *B. pennata* var. *secunda*, *B. plumosa*, *B. sp.* et *Trichosolen sp.* *Bryopsis indica* est une nouvelle espèce pour la Tanzanie, *Bryopsis hypnoides* est nouvelle pour les Seychelles et *Trichosolen sp.* est nouvelle pour le Kenya.

INTRODUCTION

The aim of the present study is the inventory and description of the Codiales along the East African coast, resulting in a useful identification key. These data will be incorporated in a flora of the Chlorophyta from the western Indian Ocean, which is in preparation. Such a marine macro-algal flora, comparable to that of LAWSON & JOHN (1987) for the West African coast, is still non-existent, although indispensable as a basis for further ecological field work, monitoring and managing coastal ecosystems.

MATERIALS AND METHODS

Material was collected along the Kenyan coast by phycologists of the University of Gent (Belgium), during 9 field trips over a period of 8 years (see VAN DEN HEEDE & COPPEJANS 1996). The specimens from Zanzibar were gathered in July-August 1993 by Coppejans & Van den heede and in August 1994 by Coppejans & De Clerck. Those from Mafia Island, Pemba Island and Mbudya Island (Tanzania) were collected in January 1996 by Coppejans & De Clerck. One month (December-January) of collecting around the Seychelles took place during the Netherlands Indian Ocean Expedition 1992-1993 (COPPEJANS *et al.* 1994) (map 1).



MAP 1. — Map of the study area.

Sampling was done by wading in the intertidal zone at low tide and by snorkeling in the subtidal areas. During the Seychelles Expedition, SCUBA-diving (down to 25 m) and dredging from the ship resulted in specimens from deeper waters (COPPEJANS *et al.* 1994). Ecological data and vegetation transects or species lists were noted in situ on a plexiglass plate. Some specimens were preserved in 4% formalin/seawater for further study, but the major part of the collected specimens was dried and pressed as herbarium reference material. The main collection is deposited in the herbarium of the University of Gent (GENT, Belgium, here indicated by HEC = Herbarium Eric Coppejans), except for the Seychelles-expedition which is mainly in the Rijks-herbarium Leiden (L, the Netherlands, here indicated by SEY). Duplicates were left in the respective research institutes (the Kenya Marine and Fisheries Research Institute in Mombasa, the Institute of Marine Science in Zanzibar and the Fisheries in Mahé). The study of the material was carried out by VAN DEN HEEDÉ (1994). Macromorphological features (incl. growth pattern: repent, ascending, erect; branching pattern) were examined in both dried and preserved specimens. Anatomical characters were studied in preserved specimens when available, or in resoaked herbarium fragments.

The anatomical analysis (number of measurements: main axis $n = 10$ per specimen, pinnulae $n = 30$) was carried out on all the collected specimens with a light microscope; drawings were made by camera lucida. Identification was mainly based on the publications of JAASUND (1976), MOORJANI & SIMPSON (1988), BØRGESEN (1936, 1937, 1938, 1948, 1957), GEPP & GEPP (1911), DURAIRATNAM (1961), EGEROD (1974, 1975), and WOMERSLEY (1984). For more complete references on biogeographical distribution in the Indian Ocean see SILVA *et al.* (1996).

RESULTS

IDENTIFICATION KEY TO THE GENERA OF THE CODIALES FROM KENYA, ZANZIBAR AND THE SEYCHELLES (WESTERN INDIAN OCEAN)

- 1.a. Thallus erect, plumose, extremely supple, composed of a single, branched siphonous filament ... 2
- b. Thallus composed of branched, intricate siphonous filaments 3
- 2.a. Gametes formed in morphologically unmodified ramuli *Bryopsis*

- b. Gametes formed in specialized gametangia, separated from the ramuli by a basal septum *Trichosolen*
- 3.a. Filaments loosely intricated, forming creeping mats, medulla and cortical utricles absent *Boodleopsis*
- b. Filaments intertwined and compact resulting in a spongy thallus, consisting of a medulla and a cortex formed by utricles *Codium*

IDENTIFICATION KEY TO THE SPECIES OF *BRYOPSIS* FROM KENYA, ZANZIBAR AND THE SEYCHELLES (WESTERN INDIAN OCEAN)

- 1.a. Ramuli of last order in all directions resulting in three-dimensional apical parts *B. hypnoides*
- b. Ramuli of last order not in all directions, but in a single plane, distichous or unilateral, resulting in apical plumules; the thallus itself can be three-dimensional 2
- 2.a. Outline of plumule triangular; pinnules on 2 double, opposite rows *B. plumosa*
- b. Outline of the plumule not triangular but linear, obovate to ovate, pinnules on 2 single or double, opposite rows 3
- 3.a. Plants small, 1-3 cm, plumule oblongate to ovate, 1-3 mm broad and 2-8 mm long *B. indica*
- b. Plants larger, plumule linear-lanceolate, sometimes bent 4
- 4.a. Main axis generally curved, ramuli unilateral or partly distichous, but then the curvature of the ramuli from the most dense row parallel with the main axis, those from the sparsely set row incurved *B. pennata* var. *secunda*
- b. Main axis mostly straight, ramuli clearly distichous, on 2 opposite (sometimes double) rows 5
- 5.a. Plumule not interrupted by bare parts *B. pennata* var. *pennata*
- b. Plumule interrupted by bare parts without ramuli *B. pennata* var. *leprieurii*

DESCRIPTION OF THE SPECIES

BOODLEOPSIS Gepp & Gepp

Boodleopsis pusilla (Collins) Taylor, Joly & Bernatowicz Fig. 1, 5

Syn.: *Dichotomosiphon pusillus* Collins

Morphology: thallus composed of intertwined siphonous filaments, partly creeping, fixing

sediments and therefore becoming covered by substrate and colourless or brownish, forming dense mats, partly erect and green.

Anatomy: colourless lower filaments (75-) 90-95 (-115) μm in diameter; branching rare, dichotomous, no marked constrictions between branching points. Green erect filaments (23-) 40 (-50) μm in diameter; branching di-(rarely tri-)chotomous, rather dense, slightly swollen at the dichotomies, (15-) 19 (-25) μm in diameter at interdichotomal and infradichotomal constrictions. Plastids oval to rounded, 2.8-4.6 μm long, each with a single pyrenoid. Gametangia oval, rounded or obovate, (155-) 173 (-193) μm long and (125-) 145 (-195) μm wide, borne on a long or short pedicel [(7-) 40 (-100) μm long] on the unconstricted repent filaments.

Ecology: collected from upper to lower levels of the intertidal zone, epipellic, epipsammic or epiphytic on mangrove aerial roots.

Geographic distribution: originally described from Jamaica and Bermuda by COLLINS (1909b: 431) as *Dichotomosiphon pusillus*. Cosmopolitan in (sub-)tropical seas.

Atlantic Ocean: North Carolina (SCHNEIDER & SEARLES 1991), Bermuda (TAYLOR 1960), Florida (DAWES 1974), Bahamas (TAYLOR 1960), Brazil (TAYLOR 1960), Cuba (TAYLOR 1960), Jamaica (TAYLOR 1960, CHAPMAN 1961), Puerto Rico (TAYLOR 1960), Guadeloupe (TAYLOR 1960), West Africa (LAWSON & JOHN 1987).

Indian Ocean: Kenya (COPPEJANS & GALLIN 1989, COPPEJANS *et al.* 1992), Tanzania (LAWSON 1980), Mozambique (POCOCK 1958), Seychelles (KALUGINA-GUTNIK A. *et al.* 1992), Pakistan (SHAMEEL & TANAKA 1992), Indonesia (CHIHARA & TANAKA 1988).

Pacific Ocean: Philippines (FORTES & TRONO 1979, SILVA *et al.* 1987), Queensland, Australia (CRIBB 1954).

Specimens examined: Kenya: HEC 6741: 08/07/1987 — Gazi; HEC 8607: 17/09/1990 — Mombasa, Bamburi Bay; HEC 8762: 13/09/1991 — Kanamai.

The dimensions of our specimens agree best with those given by SCHNEIDER & SEARLES (1991: 89) for material from South East America

(lower filaments $\pm 90 \mu\text{m}$ in diameter, erect filaments $23\text{--}48 \mu\text{m}$ in diameter); they are coarser than the West African specimens described by LAWSON & JOHN (1987: 86). No other species of *Boodleopsis* has been mentioned in the area studied.

BRYOPSIS Lamouroux

Bryopsis hypnoides Lamouroux Fig. 2, 3, 6

Morphology: thallus erect, up to 10 cm high; branching generally very dense and in all directions, resulting in a three-dimensional plumule; main axis always recognizable; light to olive-green. Two extreme growth forms (with intermediates): a) extremely supple woolly tufts, no well defined conoidal outline; main axis without a bare base; b) very well individualized specimens with a marked, bare "stipe" (6–28 mm long) and a very dense, spongy, rather regular conoidal plumule (4–30 mm in diameter at its base). The only specimen from the Seychelles (SEY 477) shows an extremely branched bare main axis and small plumules of 1–8 mm in diameter.

Anatomy: main axis 230–1000 (exceptionally up to 2000) μm in diameter. Growth form a) woolly habit: side axes 125–330 μm in diameter, not constricted at the base; primary side branches irregularly placed or more or less on 2 longitudinal rows (one of these generally with more densely placed branchlets), 60–90 (–130) μm in diameter, strongly constricted at their base (30–45 μm); secondary branchlets, if present, 35–45 μm in diameter, with basal constriction to 15–23 μm . Growth form b) with conoidal plumule: side axes (60–) 100 (–155) μm in diameter, constricted at the base (30–45 μm); primary branchlets irregularly placed, 45–90 μm in diameter, constricted at the base. Plastids oval to rounded, 3.5–10 μm long, each with a single pyrenoid.

Ecology: epilithic (on coral, rocks, shells), epiphytic (on stipes of seagrasses and on larger algae) or epipsammic, from the upper part of the intertidal down to the shallow infralittoral zone.

Geographic distribution: first observation in the Mediterranean Sea by LAMOUROUX (1809:

135); cosmopolitan in warm and temperate regions.

Atlantic Ocean: Bermuda, North Carolina, Florida, Bahamas, Cayman Islands (TAYLOR 1960), Jamaica (CHAPMAN 1961), United Kingdom (HARVEY 1849, BURROWS 1991), France (DEBRAY 1899, CHALON 1905, FELDMANN 1937, COPPEJANS 1995); Mediterranean Sea (Pignatti 1962). Indian Ocean: Kenya (ISAAC 1967), Tanzania (JAASUND 1976), Madagascar (FARGHALY 1980), Mauritius (BØRGESSEN 1946), Kuwait (AL-HASAN & JONES 1989), Saudi Arabia (DE CLERCK & COPPEJANS 1994, 1996), India (UMAMAHESWARA 1969), Sri Lanka (DURAIRATNAM 1961), Iran (NIZAMUDDIN & GESSNER 1970), Pakistan (SHAMEEL & TANAKA 1992).

Pacific Ocean: Japan (DURAIRATNAM 1961), Marshall Islands (DAWSON 1957), Galapagos Islands (TAYLOR 1945), Panama (TAYLOR 1945).

Specimens examined: Kenya: HEC 5645: 10/07/1985 — Mombasa, Nyali Beach; HEC 6087: 03/02/1986 — Mombasa, Shelly Beach; HEC 6861: 15/07/1987 — Diani; HEC 6903: 17/07/1987 — Gazi; HEC 7017: 28/07/1987 — Mombasa, Nyali Beach; HEC 7044: 29/07/1987 — Kanamai; HEC 7054: 30/07/1987 — Diani; HEC 7175: 25/02/1988 — Gazi; HEC 8193: 31/07/1989 — Gazi; HEC 8299: 09/08/1989 — Gazi; HEC 8149: 21/12/1988 — Gazi; HEC 8203: 01/08/1989 — Gazi; HEC 8496: 24/08/1989 — Diani; HEC 8634: 20/09/1990 — Mombasa, Iwatine Bay; HEC 8670: 05/09/1991 — Mombasa, Mwamba Beach; HEC 9474: 15/09/1992 — Gazi; HEC 9406: 11/09/1992 — Mombasa, Iwatine Bay. Zanzibar: HEC 9916: 05/08/1993 — Paje; HEC 10479: 20/08/1994 — Uroa; HEC 10576: 23/08/1994 — Nungwi; HEC 10690: 27/08/1994 — Chwaka. Tanzania: HEC 11314: 18/01/1996 — Mbudya Island (Kunduchi Beach); HEC 11362: 21/01/1996 — Misali Island (E-coast of Pemba Island). Seychelles: SEY 477: 29/12/1992 — Poivre Atoll.

This cosmopolitan species shows a pronounced variation in habit and ecology. The plumules of HEC 7054 are not conoidal, they are narrowing towards the base and fixing sand between their

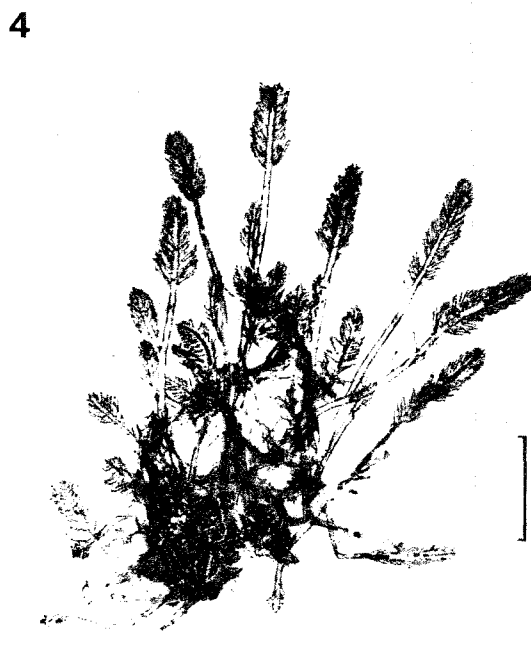
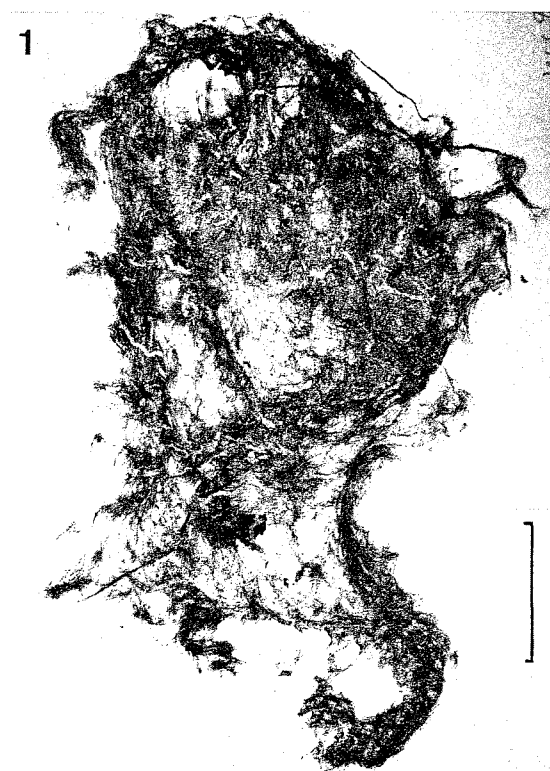


FIG. 1-4. — General morphology. Fig. 1. *Boodleopsis pusilla* (Collins) Taylor, Joly & Bernatowicz : habit of HEC 8607 (scale bar = 3 cm). Figs 2, 3. *Bryopsis hypnoides* Lamouroux. Fig. 2. Habit of a woolly thallus (HEC 8299) (scale bar = 3 cm). Fig. 3. Habit of thalli with a naked 'stipe' and a conoidal plumule (scale bar = 0,5 cm). Fig. 4. *Bryopsis indica* Gepp & Gepp : habit of HEC 6825 (scale bar = 0,5 cm).

branchlets. HEC 6087 is a sparsely branched specimen: primary ramuli strongly constricted (15 μm) at their base, placed in small groups and some of them forming a basal rhizoidal outgrowth. Morphologically *B. hypnoides* can be distinguished from the other species of *Bryopsis* found in the study area, by its three-dimensional plumule. According to JAASUND (1976: 17) the side axes have a diameter of 100-200 μm and the primary ramuli are 80-100 μm in diameter. DURAIRATNAM (1961: 26) and BURROWS (1991: 182) mention the presence of rhizoidal outgrowths at the bases of lower branches.

Bryopsis indica Gepp & Gepp

Fig. 4, 7

Morphology: small erect thalli (1-3,5 cm high) growing in dense or sparse tufts; each plant with a marked bare "stipe" and a small terminal, oblongate to ovate plumule, 1-3 (exceptionally 4) mm broad, 2-8 mm long; main axis sometimes branched and then bearing lateral plumules next to the terminal one; light to olive-green.

Anatomy: main axis 215-520 μm in diameter, bearing scars of lost branchlets along the major portion of the bare part; diameter of eventual side axes 185-230 μm , constricted to 125-170 μm at their base; desciduous ramuli relatively short (0,5-1,5 mm), mostly on 2 opposite, longitudinal, straight rows; sometimes each of these rows doubled in 2 rows of alternating branchlets; these ramuli 100-195 μm in diameter, strongly constricted at their base: (60-) 80 (-95) μm . Plastids rounded, oval, irregular or spindle-shaped, 4-18 μm long, each with a single pyrenoid.

Ecology: epilithic on vertical or overhanging walls of rock pools in the intertidal or the infralittoral fringe.

Geographic distribution: originally described from the Chagos Archipelago in the Indian Ocean by GEPP & GEPP (1909: 379).

Indian Ocean: Kenya (ISAAC 1968), Somalia (SARTONI 1976), Mauritius (BØRGESEN 1940), Seychelles (WYNNE 1995), Chagos Archipelago (GEPP & GEPP 1909), India (Dixit 1968), Maldives (Hackett 1977, Wynne 1993), Sri Lanka (cited in CRIBB 1954), Bangladesh (Islam 1976), Singapore (Teo & Wee 1983).

Pacific Ocean: Taiwan (LEWIS & NORRIS 1987), Philippines (VANNAJAN & TRONO 1977, SILVA *et al.* 1987), Japan (cited in CRIBB 1954), Australia-Queensland (CRIBB 1954), Solomon Islands (WOMERSLEY & BAILEY 1970), Marshall Islands (DAWSON 1957).

Specimens examined: Kenya: HEC 5998: 24/01/1986 — Mombasa, Mc. Kenzie Point; HEC 6825: 13/07/1987 — Tiwi; HEC 7008: 27/07/1987 — Tiwi; HEC 7301: 10/03/1988 — Shimoni, Wasini Island; HEC 8818: 22/09/1991 — Msambweni, Zanzibar; HEC 9877: 04/08/1993 — Matemwe; HEC 9917: 05/08/1993 — Paje, Tanzania; HEC 11336: 18/01/1996 — Mbudya Island (Kunduchi Beach); HEC 11418: 23/01/1996 — Pemba Island, Vitongoji.

None of the previous descriptions of this species (GEPP & GEPP 1909: 379; BØRGESEN 1940: 44; CRIBB 1954: 18; WOMERSLEY & BAILEY 1970: 271; SARTONI 1976: 120; VANNAJAN & TRONO 1977: 45) mentions the diameter of the ramuli. The habit of our specimens agrees very well with the illustrations of GEPP & GEPP (1909: fig. 10) and those of CRIBB (1954: pl. 1, fig. 2). HEC 7301 has longer (2,5 mm) and thinner ramuli (60-) 80 (-95) μm ; according to CRIBB (1954: 18) these appear to be older specimens. *B. indica* is very similar to *B. australis* Sonder where the ramuli also are on 2 double rows (although less regularly placed); WOMERSLEY & BAILEY (1970: 271) suggest that both names are synonyms. The distinction with *B. pennata* is not always evident either: the plants of this species are generally larger, the plumules longer and the ramuli coarser.

Bryopsis pennata Lamouroux var. *pennata*

Fig. 8, 9, 12, 16, 20

Morphology: thalli gregarious, frequently in dense tufts, (2-) 3-10 (-12) cm high; main axis generally unbranched, length of the bare part ("stipe") variable; plumule linear-lanceolate, distichous, 1-9 mm broad, 1,5-3 cm long; dark green, sometimes iridescent.

Anatomy: diameter of the main axis increasing towards the base, 200-690 μm ; ramuli with a rather constant length within one specimen

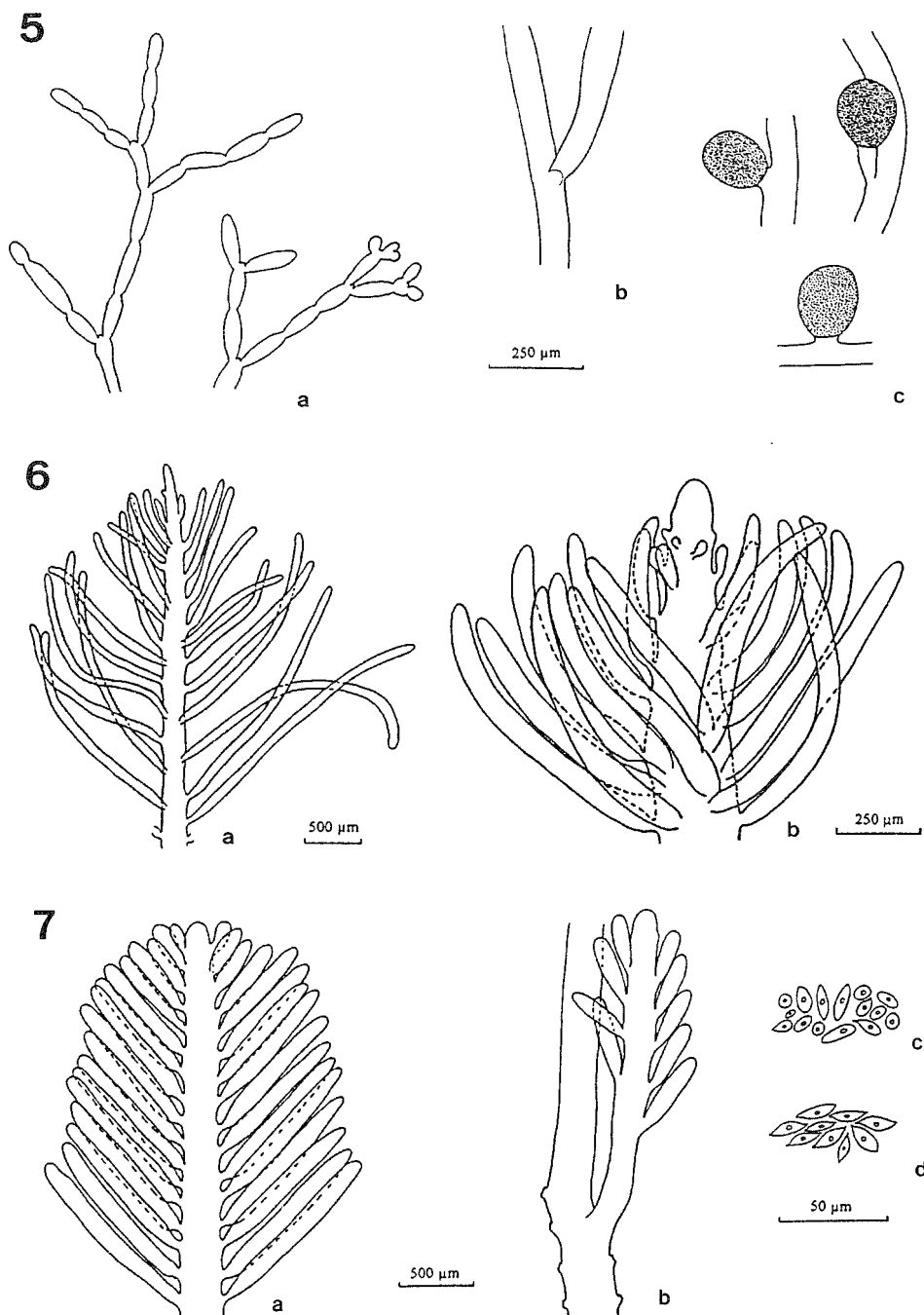


FIG. 5-7. — Camera lucida drawings. Fig. 5. *Boodleopsis pusilla* (Collins) Taylor, Joly & Bernatowicz (HEC 6741) : a. upper filaments with marked constrictions ; b. lower filaments ; c. gametangia. Fig. 6. *Bryopsis hypnoides* Lamouroux : a. apical part of a woolly thallus (HEC 8193), main axis with ramuli ; b. apical part of a thallus (HEC 9916) with a 'stipe' and a plumule, main axis with ramuli. Fig. 7. *Bryopsis indica* Gepp & Gepp : a. apical part of HEC 7008 ; b. basal part of HEC 7008, main axis with scars and 1 side axis with ramuli ; c. oval plastids (HEC 7301) ; d. spindle-shaped plastids (HEC 9917).

(1-4 mm), resulting in the linear aspect of the plumule, and with a diameter of (90-) 155-185 (-295) μm , constricted at their base (38-75 μm) and with a truncated apex. Plumule distichous, but position of the ramuli either on 2 opposite, single, straight rows, or on a single and a double row or on 2 opposite double rows.

Three collections (HEC 6822, HEC 7417 and HEC 9510) are much more slender in all respects : diameter of the main axis 195-270 (-315) μm , with thickened cell wall (1,3 μm) in the median and basal parts ; the apparently naked basal part provided with scars ; diameter of the eventually developed side axes 95-140 μm . Ramuli more or less on 2 single longitudinal, opposite, straight rows, 45-75 μm in diameter (down to 23 μm at the constricted base), 0,5-1,5 mm long. They agree with the dimensions mentioned by Lawson & John (1987 : 93).

Plastids rounded, oval or irregular, 3,5-11,5 μm long, each one with a single pyrenoid.

Ecology : epilithic on coral substrate in reef pools, sometimes under the overhanging cliff wall under the supralittoral fringe (Bostrychietum), epiphytic on seagrass stipes or even epipsammic in the low midlittoral zone or in the infralittoral fringe.

Geographic distribution : first mentioned around the Antilles by LAMOUROUX (1809 :134). Atlantic Ocean : North Carolina — Georgia — Bermuda (SCHNEIDER & SEARLES 1991), Florida (DAWES 1974), Bahamas (TAYLOR 1960), Mexico (SCHNEIDER & SEARLES 1991), Cuba (TAYLOR 1960), Jamaica (CHAPMAN 1961), Puerto Rico (TAYLOR 1960), Virgin Islands (TAYLOR 1960), Guadeloupe (TAYLOR 1960), Barbados (TAYLOR 1960), Colombia (TAYLOR 1960), France (FELDMANN 1937, COPPEJANS 1993) ; West Africa (Lawson & John 1987).

Indian Ocean : Kenya (ISAAC 1967), Seychelles (KALUGINA-GUTNIK *et al.* 1992), Oman (BARRATT *et al.* 1984), Yemen (ORMOND & BANAIMOON 1994), India (DIXIT 1968), Maldives (SIGEE 1966), Sri Lanka (BØRGESEN 1936, DURAIRATNAM 1961), Pakistan (SHAMEEL & TANAKA 1992), Malaysia (PHANG 1986).

Pacific Ocean : Philippines (SILVA *et al.* 1987), Malaysia, (CRANE 1981) Japan (DURAIRATNAM 1961), Marshall Islands (DAWSON 1957), Hawaii (EGEROD 1952).

Specimens examined : Kenya : HEC 5596 : 05/07/1985 — Mombasa, Mc. Kenzie Point ; HEC 6724 : 05/07/1987 — Mombasa, Nyali Beach ; HEC 6728 : 07/07/1987 — Mombasa, Nyali Beach ; HEC 6773 : 12/07/1987 — Mombasa, Nyali Beach ; HEC 6822 : 13/07/1987 — Tiwi ; HEC 7345 : 15/03/1988 — Mombasa, Nyali Beach ; HEC 7417 : 20/03/1988 — Malindi, Casuarina Point ; HEC 8608 : 19/09/1990 — Mombasa, Iwatine Bay ; HEC 9510 : 19/09/1992 — Malindi, Casuarina Point.

In some tufts plumules of the *pennata*-type are mixed to the *leprieurii*-type (with bare parts in the plumule) ; the identification of the specimen was then based on the dominant form, but this fact indicates that the distinction of varieties is artificial. Except for the two "slender" collections described above, the Kenyan specimens are coarser than those from the West African coast [LAWSON & JOHN 1987 : 93 : axes 240-360 μm , ramuli (47-) 60-150 μm]. HEC 6724 is a very large epiphytic specimen (up to 15 cm) with strongly ramified main axes and extremely small plumules (2 $\times$ 5 mm).

In his monographical study of the genus *Bryopsis* in the Mediterranean Sea PIGNATTI (1962) follows BØRGESEN (1911) in considering *B. pennata* as a variety of *B. plumosa* [*B. plumosa* (Hudson) C. Agardh var. *pennata* (Lamouroux) BØRGESEN]. We follow SILVA *et al.* (1996) in keeping both species separate.

Bryopsis pennata Lamouroux var. *leprieurii*
(Kützing) Collins & Hervey Fig. 10, 13

Morphology : thalli in dense tufts, 2,5-16 cm high ; main axis often branched ; plumule linear-lanceolate, distichous, 2-10 mm broad, 1-3 cm long, with short bare parts ; dark green.

Anatomy and ecology similar to var. *pennata*.

Geographic distribution : originally described from the Bermuda Islands by COLLINS & HERVEY

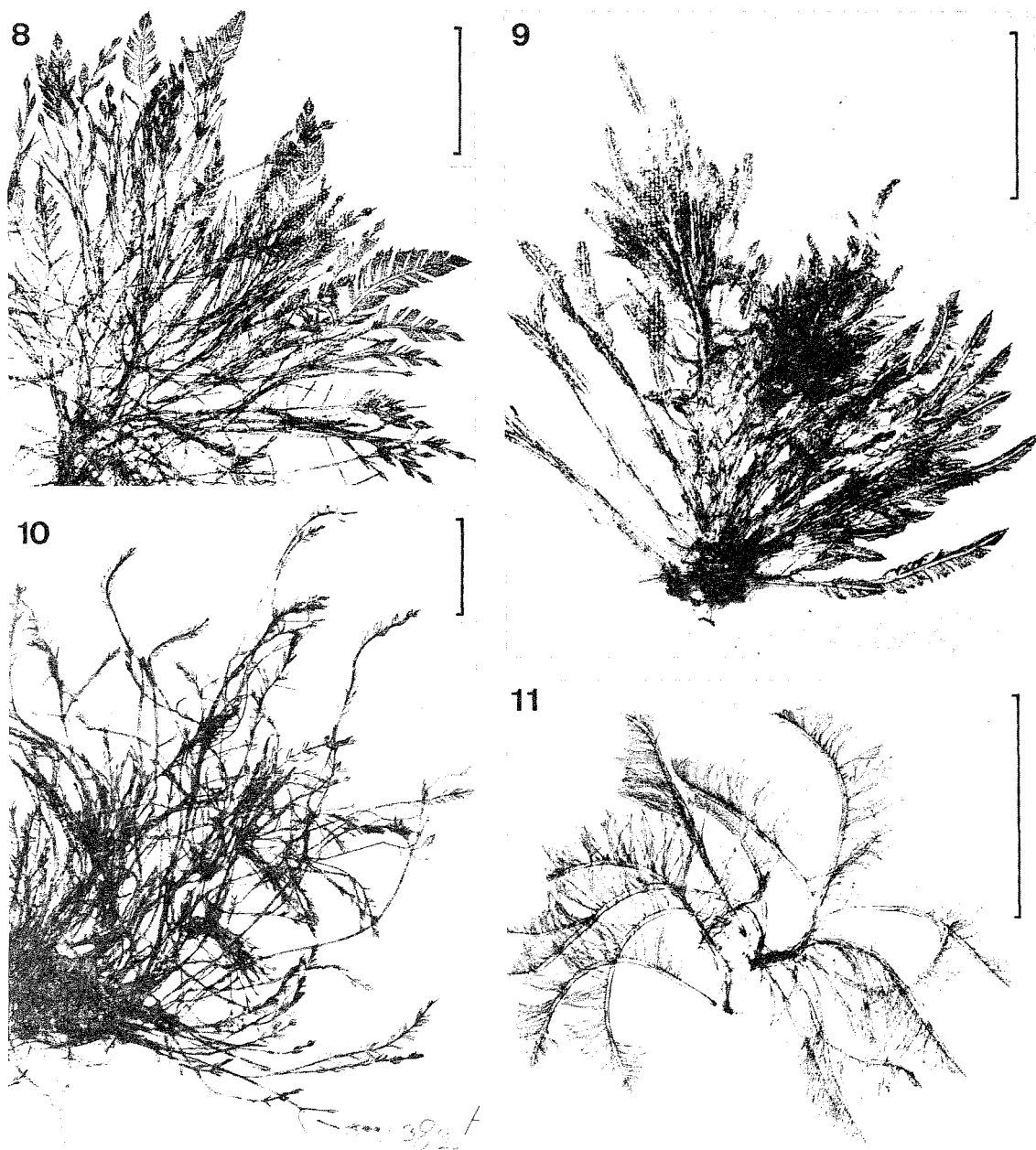


FIG. 8-11. — General morphology. Figs 8, 9. *Bryopsis pennata* Lamouroux var. *pennata*. Fig. 8. Habit of HEC 6728. Fig. 9. Habit of HEC 6773. Fig. 10. *Bryopsis pennata* Lamouroux var. *lepraeurii* (Kützinger) Collins & Hervey: habit of SEY 382A. Fig. 11. *Bryopsis pennata* Lamouroux var. *secunda* (Harvey) Collins & Hervey: habit of HEC 7018 (all scale bars 2 cm).

(1917 : 62). Cosmopolitan in temperate and (sub)-tropical seas.

Atlantic Ocean : Bermuda Islands (COLLINS & HERVEY 1917, TAYLOR 1960).

Indian Ocean : Kenya (ISAAC 1971), Tanzania (JAASUND 1976), Réunion (PAYRI 1985), Diego Garcia Atoll (RHYNE 1971), Yemen (ORMOND & BANAIMOON 1994), Singapore (TEO & WEE 1983).

Specimens examined : Kenya : HEC 7197 : 01/03/1988 — Mombasa, Mc Kenzie Point ; HEC 9417 : 12/09/1992 — Mombasa, Mc Kenzie Point. Zanzibar : HEC 10527 : 21/08/1994 — Bawe Island ; HEC 10657 : 25/08/1994 — Ras Fumba. Tanzania : HEC 11198 : 11/01/1996 — Mafia Island. Seychelles : SEY 323 : 23/12/1992 — La Digue Island ; SEY 382 : 25/12/1992 — Ile Moyenne.

Our specimens agree well with the dimensions given by JAASUND (1976 : 17) : main axis 400-500 µm in diameter, ramuli 3 mm long and 180-200 µm in diameter. *Bryopsis pennata* var. *leprieurii* differs from var. *pennata* as well as from all other *Bryopsis*-species found in the study area, by the presence of short bare parts in the plumule.

Bryopsis pennata Lamouroux var. *secunda* (Harvey) Collins & Hervey Fig. 11, 14

Syn. : *Bryopsis plumosa* (Hudson) C. Agardh var. *secunda* Harvey

Morphology : thalli in small dense tufts, 2-8 cm high ; main axis generally markedly incurved ; plumule 1-5 mm broad and 0,7-2 cm long ; dark green, sometimes iridescent.

Anatomy : diameter of the main axis increasing towards the base, 177-500 µm, bearing scars of lost branchlets ; diameter of eventual side axes 185-375 µm, constricted at their base (77-115 µm) ; ramuli 0,5-4 mm long, 90-185 µm in diameter (35-75 µm at their base). Plumules generally unilateral on the ventral side of the axis (fig. 14 a), or partly distichous with one row on the ventral side and the other row on the dorsal side of the axis (fig. 14 b, c), one of these rows with markedly more densely set ramuli ; curvature of the ramuli from the most densely set row in the same direction as the axis (fig. 14 b, c), those

from the sparsely set row incurved (fig. 14 b, c), still resulting in an asymmetric aspect.

Ecology similar to var. *pennata*.

Geographic distribution : first observation around the Bermuda Islands by COLLINS & HERVEY (1917 : 62).

Atlantic Ocean : Bermuda Islands (COLLINS & HERVEY 1917, TAYLOR 1960), Florida (TAYLOR 1960), West Indies (CHAPMAN 1961), Jamaica (CHAPMAN 1961) ; West Africa (LAWSON & JOHN 1987).

Indian Ocean : Tanzania (JAASUND 1976), Mauritius (JAGTAP 1993), Diego Garcia Atoll (RHYNE 1971), Yemen (ORMOND & BANAIMOON 1994), India (DIXIT 1968), Singapore (TEO & WEE 1983). Pacific Ocean : Philippines (SILVA *et al.* 1987), Marshall Islands (DAWSON 1957).

Specimens examined : Kenya : HEC 5834 : 13/01/1986 — Mombasa, Mc Kenzie Point ; HEC 6717 : 06/07/1987 — Mombasa ; HEC 7018 : 28/07/1987 — Mombasa, Nyali Beach ; HEC 7085 : 05/08/1987 — Lamu, Ras Kitau ; HEC 8671b : 05/09/1991 — Mombasa, Mwamba Beach ; HEC 9490 : 16/09/1992 — Msambweni. Zanzibar : HEC 10732 : 30/08/1994 — Bawe Island. Seychelles : SEY 357 : 10/12/1992 — Ile Sourie, Pointe du Sel.

B. pennata var. *secunda* is very similar to the unilateral branching form of *B. australis* Sonder ; the dimensions are very similar too, but this species is considered as endemic for Australia. *B. harveyana* J. Agardh also has a unilateral branching pattern ; this species which has been collected in Mauritius (BØRGESEN 1946 : 34) differs by the more slender ramuli (60-100 µm in diameter) being irregularly arranged in a rather broad zone.

Bryopsis plumosa (Hudson) C. Ag. Fig. 15, 19

Bas. : *Ulva plumosa* Hudson

Syn. : *Bryopsis arbuscula* Lamouroux

Morphology : thalli erect, up to 3-11 cm high, forming dense tufts ; main axes mostly straight and unbranched ; plumules triangular, 1,5-2,5 cm long, 10-12 mm wide at the basis, with distichous ramuli in a single plane ; light green.

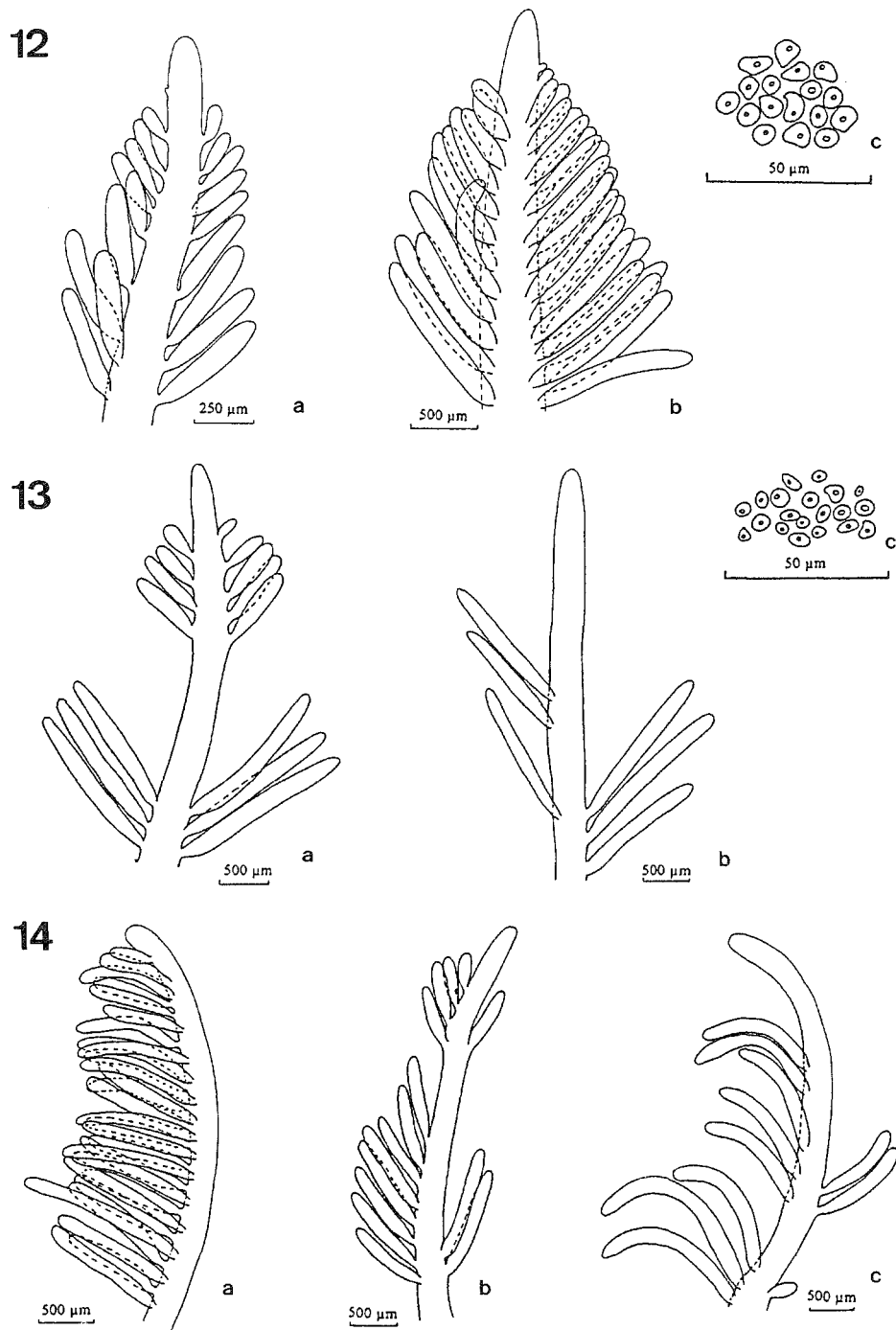


FIG. 12-14. — Camera lucida drawings. Fig. 12. *Bryopsis pennata* Lamouroux var. *pennata*: a, b. apical part of thallus (a. HEC 6822; b. HEC 5596), main axis with ramuli; c. irregular plastids (HEC 5596). Fig. 13. *Bryopsis pennata* Lamouroux var. *leprieurii* (Kützinger) Collins & Hervey: a, b. apical part of thallus (a. HEC 9417; b. HEC 7197), distichous plumule with short naked parts. Fig. 14. *Bryopsis pennata* Lamouroux var. *secunda* (Harvey) Collins & Hervey: a-c. apical parts of thallus; a. unilateral plumule (HEC 9490); b, c. partly distichous plumule with ramuli incurved in the same direction, from the same thallus (HEC 5834).

Anatomy : diameter of the main axis increasing towards the base, 345-500 μm ; ramuli present from near the base, on 2 double, longitudinal, straight rows, becoming longer from apex to base (0,5-6 mm), thus resulting in a triangular plume ; ramuli 100-160 μm in diameter, constricted at the base (38-55 μm), with blunt apices. Plastids oval or rounded, 3,5-6,5 μm long, each with a single pyrenoid.

Ecology : a single specimen, epiphytic on seagrass-stolons, in the upper midlittoral.

Geographic distribution : cosmopolitan in (sub)tropical and temperate seas.

Atlantic Ocean : Bermuda Islands (TAYLOR 1960), North & South Carolina (TAYLOR 1960), Florida (TAYLOR 1960), Mexico (TAYLOR 1960), Cuba (TAYLOR 1960), Jamaica (CHAPMAN 1961), Virgin Islands (TAYLOR 1960), Guadeloupe (TAYLOR 1960), Barbados (TAYLOR 1960). United Kingdom (HARVEY 1849, BURROWS 1991), France (DEBRAY 1899, CHALON 1905, FELDMANN 1937, COPPEJANS 1995), Italy (KOSTER 1941, Pignatti 1962) ; West Africa (LAWSON & JOHN 1987).

Indian Ocean : Kenya (ISAAC 1967), South Africa (SEAGRIEF 1988), Iraq (BØRGESEN 1934), India (Varma 1961), Laccadive Islands (JAGTAP 1987), Malaysia (PHANG & WEE 1991), Singapore (PURCHON & ENOCH 1954), Indonesia (VERHEIJ & PRUD'HOMME VAN REINE 1993), Australia (HUISMAN *et al.* 1990).

Pacific Ocean : China (TSENG 1984), Taiwan (LEWIS & NORRIS 1987), Philippines (VANNAJAN & TRONO 1977, SILVA *et al.* 1987), Australia (WOMERSLEY 1984).

Specimen examined : Kenya : HEC 8671a : 05/09/1991 — Mombasa, Mwamba Beach.

Bryopsis plumosa differs from the other distichous *Bryopsis* species by its characteristic triangular plumule. It is generally described and illustrated as being distichous (2 single, opposite, longitudinal rows of branchlets in a single plane) (KOSTER 1941 : 229 as f. *typica*, WOMERSLEY 1984 : 282, BURROWS 1991 : 183, SCHNEIDER & SEARLES 1991 : 95, COPPEJANS 1995 : 100). After the observation of 2 double rows of ramuli in the E. African specimen we checked living mate-

rial from the Boulonnais (N. France). Some of these specimens also have the ramuli placed on 2 double rows, with the branchlets of a row alternating with those of the other row of the couple. In specimens of *B. pennata* var. *pennata* from the E. African coast we observed that the position of the ramuli can either be on 2 opposite, single, straight rows, or on a single and a double row or on 2 opposite double rows. We therefore do not distinguish a new form or variety in *B. plumosa* based on the presence of these double rows as the genus *Bryopsis* has highly variable morphological characters ; we suggest to broaden the description of *B. plumosa* as to include the here described growth form. As the type material of *B. plumosa* is lost it is impossible to check which growth form was originally collected. Moreover it is not always easy to recognize the placement on 2 double rows on dried material.

Bryopsis sp.

Fig. 17, 21

Morphology : thallus erect, up to 2 cm high, forming a sparse tuft ; main axes slightly curved, unbranched, arising from repent axes ; plumules markedly unilateral, 10-13 mm long, 2 mm broad.

Anatomy : diameter of the main axis increasing towards the base, 250-445 μm ; the apparently naked basal part provided with scars of shed branchlets ; ramuli unilateral on a double row, becoming shorter from base to apex (2 to 0,1 mm), 35-55 (-85) μm in diameter, constricted at the base (23-31 μm). Plastids irregular, 4-9 μm long, each with a single pyrenoid.

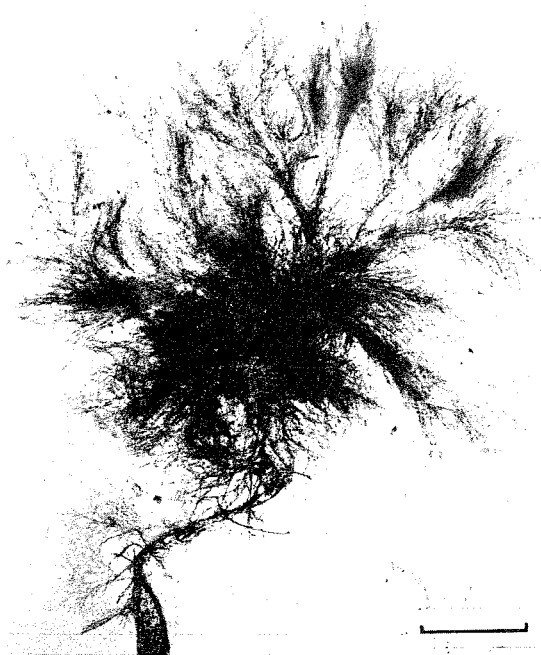
Ecology : a single specimen, epilithic on reef platform in the infralittoral zone.

Geographic distribution : Indian Ocean : Seychelles (this paper).

Specimen examined : SEY 679 : 02/01/1993 — Ile Desnœufs.

This specimen does not correspond to any described species. It is closely related to *B. harveyana* J. Agardh also presenting a unilateral plumule, but in this species the ramuli are irregularly inserted in a broad zone (BØRGESEN 1946 : 35) and they have a diameter of 80-100 μm (TSENG 1984 : 280 ; BØRGESEN 1946 : 35). The

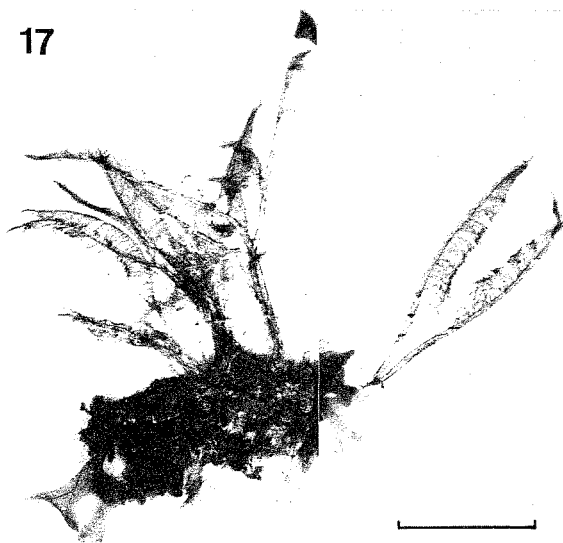
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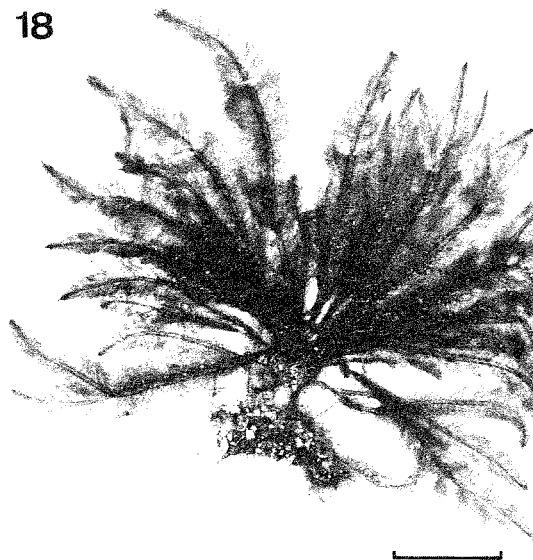


FIG. 15-18. — General morphology. Fig. 15. *Bryopsis plumosa* (Hudson) C. Agardh (HEC 8671a) (scale bar 3 cm). Fig. 16. *Bryopsis pennata* Lamouroux var. *pennata*., slender form (HEC 9510) (scale bar 1 cm). Fig. 17. *Bryopsis* sp. (SEY 679A) (scale bar 1 cm). Fig. 18. *Trichosolen* sp. (HEC 5642) (scale bar 1 cm).

ramuli of *Bryopsis* sp. are more slender than those from the unilateral *B. indica* Gepp & Gepp f. *unilateralis* Cribb (75-100 µm) and *B. pennata* var. *secunda* (92-187 µm). Because of the variability of many *Bryopsis* species and the absence of more and fertile material we do not ascertain this entity to a known species.

TRICHOSOLEN

Trichosolen sp.

Fig. 18, 22

Morphology : thallus erect, 2-6 cm high, attached to the substrate by rhizoids ; main axis mostly branched, elegant ramuli (all of equal length, 1-2,5 mm) covering the axis completely ; light green.

Anatomy : main axis gradually tapering from the base to the apex : 520-90 µm ; branching dichotomous or irregular. Ramuli irregularly placed in all directions, (20-) 23 (-27) µm in diameter, constricted at the base (to ± 15 µm), with a blunt apex. Reference specimens sterile. Plastids with irregular outline, 7-13 µm long, each with a single pyrenoid.

Ecology : epilithic on a vertical rock wall of a sandy rock pool in the low midlittoral zone.

Specimen examined : Kenya : HEC 5642 : 10/07/1985 — Mombasa, Nyali Beach.

The absence of reproductive structures (which are formed laterally on the ramuli and have a species-characteristic morphology) excludes any identification on species level. *Tricho-*

solen mucronata Børgesen, described from India, is the only known species with such large plastids (7-12 µm). BØRGESSEN (1948 : 27) described *T. mauritiana* Børgesen from Mauritius, but the plastids are only 4-7 µm long.

DISCUSSION

Boodleopsis pusilla is a tropical cosmopolitan species which could be expected to be found in the area explored by us. Its absence from the collection from Tanzania and the Seychelles therefore is remarkable.

The 59 collections of *Bryopsis* studied here belong to 7 different taxa (Table I). Those from Kenya (40 collections), collected during 9 different field trips, contain 7 taxa. *B. hypnoides* markedly is the most abundant species (17 collections) in this area, followed by *B. pennata* var. *secunda* (6 collections). Our collection contains all 5 taxa mentioned by LAWSON (1980) in his check-list for Kenya.

Field work in Zanzibar (3 field trips) resulted in 14 *Bryopsis* collections, including 4 taxa. Next to the 3 taxa described by JAASUND (1976) for Tanzania, we also collected *B. indica*.

During the Dutch Seychelles Expedition 1992-1993 (1 month), only 5 *Bryopsis* collections were gathered, containing 4 different taxa. In their list of benthic marine algae from the Seychelles Islands, KALUGINA-GUTNIK *et al.* (1992) mention only 1 species : *B. pennata*. They probably did not distinguish the 3 varieties of *B. pennata*.

TABLE I
Survey of the taxa of Bryopsis and their distribution

Nr	Species	Kenya	Tanzania	Seychelles
1	<i>B. hypnoides</i>	+	+	+
2	<i>B. indica</i>	+	+	
3	<i>B. pennata</i> var. <i>leprieurii</i>	+	+	+
4	<i>B. pennata</i> var. <i>pennata</i>	+		
5	<i>B. pennata</i> var. <i>secunda</i>	+	+	+
6	<i>B. plumosa</i>	+		
7	<i>B. sp.</i>			+
	number of species	6	4	4

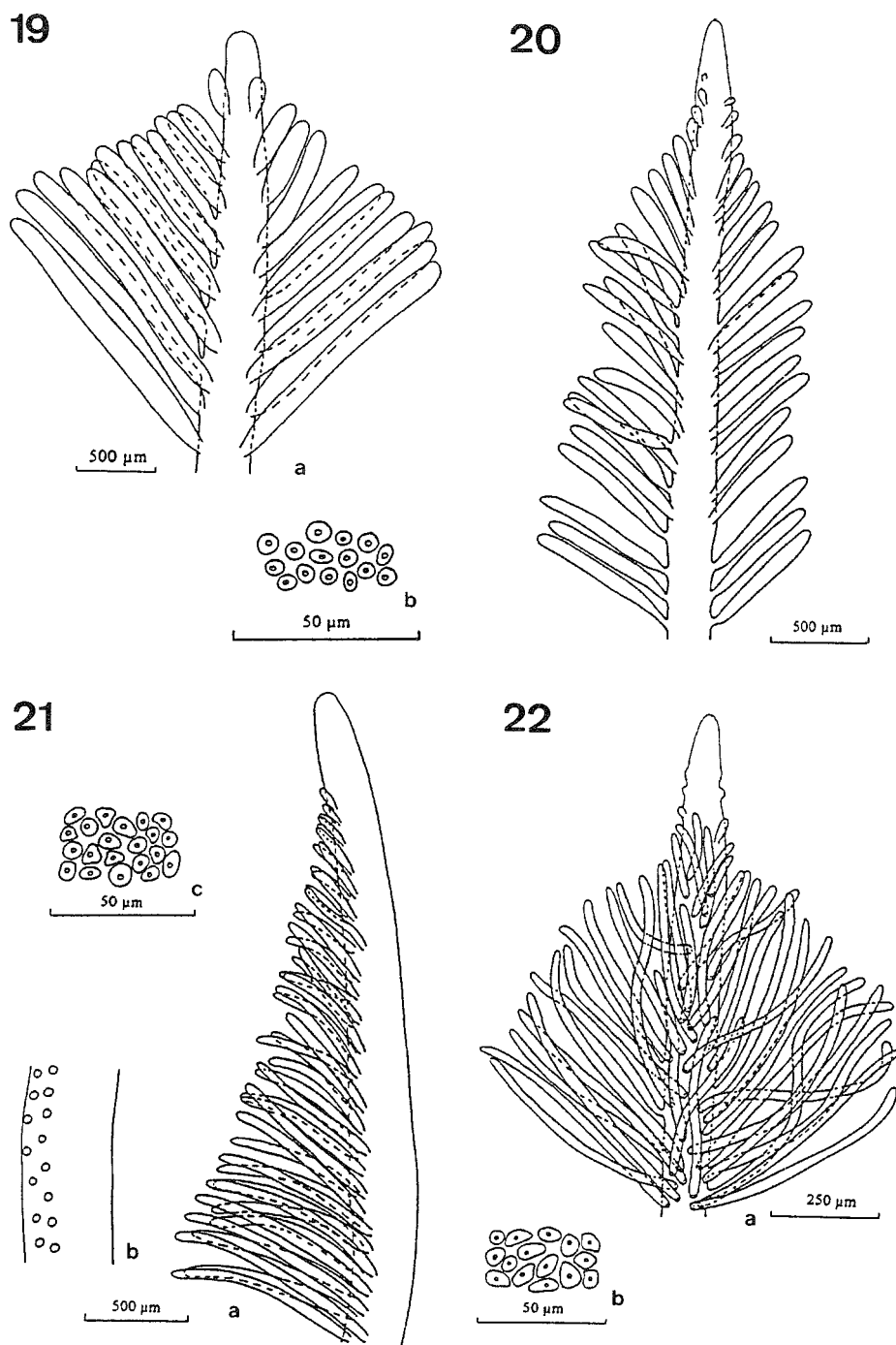


FIG. 19-22. — Camera lucida drawings. Fig. 19. *Bryopsis plumosa* (Hudson) C. Agardh (HEC 8671a): a. apical part of the thallus; b. plastids, each with a single pyrenoid. Fig. 20. *Bryopsis pennata* Lamouroux var. *pennata*: slender form: apical part of the thallus (HEC 9510). Fig. 21. *Bryopsis* sp. (SEY 679a): a. apical part of the thallus; b. basal part of the main axis with scars of lost branchlets; c. irregular plastids. Fig. 22. *Trichosolen* sp. (HEC 5642): a. apical part of the thallus, main axis with irregularly placed ramuli; b. irregular plastids.

Data on *Bryopsis* from (sub-)tropical seas are scarce, and most of the descriptions are incomplete (not mentioning dimensions). Moreover, as SETCHELL & GARDNER (1920 : 157) and BAARDSETH (1941 : 14) already stated, some of the traditionally used morphological and anatomical characters are variable in different degrees and therefore of restricted diagnostic value. Intermediates between "typical" growth forms, i.e. agreeing with described entities from literature, can generally be found, and sometimes different "varieties" are present in a single tuft, especially in *B. pennata*.

Compared to the Mediterranean region (PIGNATTI, 1962 : 13 species if *B. pennata* is considered different from *B. plumosa*), the studied area appears to be poor in *Bryopsis* species (4 species of which one with 3 "varieties"). Other tropical regions are similarly species poor : W. Africa (LAWSON & JOHN 1987) : 3 species of which *B. pennata* with 2 varieties, Florida (TAYLOR 1967) : 4 species of which *B. pennata* with 2 varieties, tropical E. America (TAYLOR 1960) : 5 species ; Philippines (SILVA *et al.* 1987) : 4 species of which *B. pennata* with 2 varieties.

Trichosolen had not previously been collected in this area ; as the specimens are sterile, they could not be identified at species level.

Together with the 14 *Codium* species described in VAN DEN HEEDÉ & COPPEJANS (1996) the total number of taxa of Codiales for the study area is 23.

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