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## Seaweeds of the Snellius-II Expedition (E. Indonesia) : the genus *Caulerpa* (Chlorophyta-Caulerpales) \*

by

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KEY-WORDS. — Algae ; *Caulerpa* ; Indonesia ; Snellius-II Expedition.

SUMMARY. — The representatives of the genus *Caulerpa*, collected during the Snellius-II Expedition (1984) in the Banda, Sawu and Flores Seas (Indonesia) are described and illustrated. Twelve species have been individualized, some including several growth forms (resulting in 26 entities) : *C. brachypus* (2 ecads), *C. cupressoides* (6 ecads), *C. elongata*, *C. fergusonii*, *C. lentillifera*, *C. lessonii*, *C. microphysa*, *C. racemosa* (7 ecads), *C. serrulata* (2 ecads), *C. sertularioides*, *C. taxifolia* (2 ecads), *C. verticillata*. An identification key is also added.

RÉSUMÉ. — *Algues marines de l'Expédition Snellius-II (Indonésie orientale) : le genre Caulerpa (Chlorophyta-Caulerpales).* — Les représentants du genre *Caulerpa*, récoltés lors de l'Expédition Snellius-II (1984) dans les mers de Banda, Sawu et Flores (Indonésie) sont décrits et illustrés. Il s'agit de 12 espèces dont certaines présentent plusieurs morphoses (résultant en 26 entités) : *C. brachypus* (2 écades), *C. cupressoides* (6 écades), *C. elongata*, *C. fergusonii*, *C. lentillifera*, *C. lessonii*, *C. microphysa*, *C. racemosa* (7 écades), *C. serrulata* (2 écades), *C. sertularioides*, *C. lessonii*, *C. microphysa*, *C. racemosa* (7 écades), *C. serrulata* (2 écades), *C. sertularioides*, *C. taxifolia* (2 écades), *C. verticillata*. Une clef d'identification est également ajoutée.

SAMENVATTING. — *Zeewieren van de Snellius-II Expeditie (O.-Indonesië) : het genus Caulerpa (Chlorophyta-Caulerpales).* — De vertegenwoordigers van het genus *Caulerpa*, ingezameld tijdens de Snellius-II Expeditie (1984) in de Banda, Sawu en Flores Zeeën (Indonesië) worden beschreven en geïllustreerd. Het gaat om 12 soorten waarvan enkele meerdere groeivormen bezitten (een totaal van 26 eenheden) : *C. brachypus* (2 ecaden), *C. cupressoides* (6 ecaden), *C. elongata*, *C. fergusonii*, *C. lentillifera*, *C. lessonii*, *C. microphysa*, *C. racemosa* (7 ecaden), *C. serrulata* (2 ecaden), *C. sertularioides*, *C. taxifolia* (2 ecaden), *C. verticillata*. Naast de beschrijvingen wordt ook een determinatiesleutel gegeven.

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### Introduction

General data on the organisation of the Snellius-II Expedition, as well as details on the sampling sites and an almost complete species list of plants are given in COPPEJANS & PRUD'HOMME VAN REINE (1991).

The results on the Dasycladales and the Caulerpales (except *Caulerpa* and *Halimeda*) have been published previously (COPPEJANS & PRUD'HOMME VAN REINE 1989a, 1989b).

### Materials and methods

Seaweeds were collected as mentioned in COPPEJANS & PRUD'HOMME VAN REINE (1989b, p. 121) at Ambon, Pulau Maisel, Tukang Besi Islands, Sumba, Komodo, Sumbawa, Taka Bone Rate and Salayer (COPPEJANS & PRUD'HOMME VAN REINE 1992, fig. 1, p. 156) by E. Coppejans, F. Heys, A. Kadi, W. Prud'homme van Reine and P. Zen.

Herbarium specimens have been deposited in different herbaria : L, JAK, AMB, GENT (COPPEJANS & PRUD'HOMME VAN REINE 1989b, p. 121).

The drawings are original and made by the first author.

Supplementary illustrations and descriptions of *Caulerpa* spp. can be found in BØRGESEN (1907), CHAPMAN (1961), COPPEJANS & BEECKMAN (1989, 1990), COPPEJANS & MEINESZ (1988), CRIBB (1958), DURAIRATMAN (1961), EGEROD (1946, 1975), GILBERT (1942), HARVEY (1858), MEINESZ *et al.* (1981), MENEZ & CALUMPONG (1982), MURRAY (1891), NIZAMUDDIN (1964, 1967), SARTONI (1978), SVEDELIUS (1906), TAYLOR (1928, 1960, 1967), WEBER-VAN BOSSE (1898), YAMADA (1940).

### Results

#### IDENTIFICATION KEY OF *CAULERPA* LAMOUROUX FROM THE SNELLIUS-II EXPEDITION

- 1.a. Erect parts entire, blade-like, ligulate or lanceolate, with smooth margin or provided with small marginal teeth ..... 2
- b. Erect part variously branched, divided or incised ..... 3
- 2.a. Blades up to 4-5 (- 9) cm long ..... *C. brachypus*
- b. Blades smaller than 2.5 cm ..... *C. brachypus* ecad *parvifolia*
- 3.a. Branchlets either peltate or vesicle-like (spherical, clavate, turbinate, or discoid) ..... 4
- b. Branchlets filiform or spiny or strap-like and with dentate margin or strongly compressed and with pinnate aspect ..... 14

- 4.a. Branchlets peltate (stalk-like lower portion abruptly expanded into a horizontally spread disciform structure) ..... 5
- b. Branchlets not peltate but vesicle-like ..... 6
- 5.a. Diameter of the disciform structures up to 3 mm .....  
..... *C. racemosa* ecad *peltata-peltata*
- b. Diameter of the disciform structures up to 1 cm .....  
..... *C. racemosa* ecad *peltata-macrodisca*
- 6.a. Branchlets gradually enlarged from base to apex (clavate), with rounded or flattened apex ..... 7
- b. Branchlets (sub-)spherical or dorso-ventrally compressed and sessile on the erect shoots or abruptly expanded into a (sub-)spherical top from the terete or constricted stalk-like lower portion (pear shaped) ..... 10
- 7.a. Apices of the branchlets at least blunt, more generally flattened or even hollowed ..... *C. racemosa* ecad *turbinata*
- b. Ends of the branchlets rounded ..... 8
- 8.a. Branchlets crowded, radially arranged, narrowly clavate .....  
..... *C. racemosa* ecad *laetevirens*
- b. Branchlets not crowded, on 2 (sub-)opposite rows ..... 9
- 9.a. Thallus slender, rachis terete, with a naked basal part (0.5-1 cm) and a series of (sub-) opposite branchlets ..... *C. racemosa* ecad *corynephora*
- b. Thallus slender, erect shoots frequently complanate to foliose and then irregularly constricted ; clavate branchlets generally rare and irregularly placed, or more frequent and (sub-)opposite .....  
..... *C. racemosa* ecad *corynephora-lamourouxii*
- 10.a. Vesicle-like branchlets small (up to 2 mm in diameter) and never placed on 2 opposite rows ; either a constricted pedicel or plasts with pyrenoids .....  
..... 11
- b. Vesicle-like branchlets larger ; neither a constricted pedicel nor plasts with pyrenoids ..... 12
- 11.a. Stalk-like portion markedly constricted ; numerous vesicle-like branchlets very densely packed,  $\pm$  in longitudinal rows along the rachis ; plasts without pyrenoids ..... *C. lentillifera*
- b. Stalk-like portion not constricted ; vesicle-like branchlets less numerous, more irregularly grouped ; plasts with pyrenoids ..... *C. microphysa*
- 12.a. (Sub-)sessile spherical branchlets either extremely rare and irregularly placed (to absent) or more frequent and (sub-)opposite ; erect shoots frequently at least partly naked, rachis slightly to markedly compressed and irregularly constricted ..... *C. racemosa* ecad *racemosa-lamourouxii*
- b. Branchlets numerous, densely set (without naked portions on the upright branches, except for the basal part), rachis terete ..... 13

- 13.a. Branchlets on 2 opposite longitudinal rows, laterally compressed, with marked segmentation of the rachis ..... *C. fergusonii*  
b. Branchlets irregularly placed, not compressed, erect shoots 1-4 cm high, bearing shortly stipitate, pearshaped branchlets with a spherical upper part 1-4 mm wide ..... *C. racemosa* ecad *racemosa*
- 14.a. Branchlets in whorls ..... 15  
b. Branchlets not in whorls ..... 16
- 15.a. Verticils conspicuous, well separated ; branchlets rather long and elegant, supple, with (2-)3(-4) terminal mucrons ; stoloniferous part naked .....  
..... *C. verticillata*  
b. Verticils small and crowded, resulting in a lycopod-like aspect ; branchlets short and stiff, pseudodichotomous with a single mucron on each apex ; stoloniferous part also (partly) covered by short branchlets ..... *C. elongata*
- 16.a. Upright branches markedly compressed and (pseudo-) dichotomous .....  
..... 17  
b. Upright branches terete or only slightly compressed ; the branchlets also terete, reduced to mucrons or compressed ..... 20
- 17.a. Frond plane, margin densely set with upwardly directed branchlets ; these either terete or reduced to mucronate teeth ..... 18  
b. Frond mostly spirally twisted ; margin set with laterally directed (or slightly upwardly) broadly attached mucronate teeth ..... 19
- 18.a. Frond shortly stipitate ; rachis markedly compressed, broad ; branchlets terete, upwardly curved, constricted at the base, gradually tapering into a mucronate apex ..... *C. lessonii*  
b. Frond with a long (several cm), terete, naked stipe ; rachis markedly compressed ; branchlets reduced to upwardly directed, mucronate, broadly attached teeth ..... *C. cupressoides* ecad *flabellata*
- 19.a. Upright branches with a short (< 1 cm) terete stipe and markedly compressed, (sub-)dichotomous, mostly spirally twisted, frequently horizontally spread fronds ; marginal teeth well marked and serial .....  
..... *C. serrulata* ecad *serrulata*  
b. Upright branches with long (several cm) unbranched terete stipe and long, narrow (sub)dichotomous, compressed, spirally twisted vertical fronds ; marginal teeth very small, distant ..... *C. serrulata* ecad *boryana*
- 20.a. Branchlets terete, spiny or reduced to mucrons ..... 21  
b. Branchlets complanate (at least slightly compressed laterally) ..... 28
- 21.a. Branchlets short (1-3 mm), spiniform, on 2 opposite or 3 longitudinal rows, or reduced to irregularly placed mucrons ..... 22  
b. Branchlets longer (4-5 mm), on 2 opposite rows ..... 27



- 22.a. Upright branches terete, subdichotomous, frequently irregularly curled, covered by numerous perpendicular mucronate warts ..... *C. cupressoides* ecad *urvilliana*
- b. Branchlets more developed, directed towards the apex of the rachis, on longitudinal rows, at least in part of the frond ..... 23
- 23.a. At least the basal branchlets markedly inflated, generally not longer than the diameter of the rachis, densely packed ..... *C. cupressoides* ecad *mamillosa*
- b. No inflated branchlets ..... 24
- 24.a. Frond rather robust, spiniform branchlets up to two times as long as the diameter of the rachis, slightly constricted at the base, generally at least in some fronds on 3 longitudinal rows ..... *C. cupressoides* ecad *cupressoides*
- b. Frond rather slender, branchlets not constricted at the base, on 2 opposite rows ..... 25
- 25.a. Frond with a long (several cm), terete, naked stipe ; branchlets reduced to upwardly directed, mucronate, broadly attached teeth ..... *C. cupressoides* ecad *flabellata*
- b. Stipe shorter ; branchlets terete, longer ..... 26
- 26.a. Branchlets up to two times as long as the diameter of the rachis ..... *C. cupressoides* ecad. *lycopodium-disticha*
- b. Branchlets generally 3-4 (but up to 6) times as long as the diameter of the axis ..... *C. cupressoides* ecad *lycopodium-elegans*
- 27.a. Total width of the frond not exceeding 4 mm ..... *C. cupressoides* ecad *lycopodium-elegans*
- b. Total width of the frond generally 1-1.5 cm (rarely down to 7 mm) ..... *C. sertularioides*
- 28.a. Branchlets sickle-shaped, slightly constricted at the base, with straight parallel sides in the middle part, upwardly curved and gradually tapering into a spine at the apex ; branchlets not overlapping ..... *C. taxifolia* ecad *taxifolia*
- b. Branchlets markedly wider in the middle part, without parallel sides, rather abruptly tapering into an upwardly curved terminal spine ; branchlets frequently touching or even overlapping in the widest part ..... *C. taxifolia* ecad *mexicana*

NOMENCLATORIAL REMARK

WEBER-VAN BOSSE (1898) already stressed the variability of *C. cupressoides* (p. 326) and of *C. racemosa* (p. 359) : «Dans le *C. cupressoides* j'ai reconnu plusieurs variétés, qui correspondent pour la plupart aux espèces de M. J. Agardh. La plupart des variétés ont diverses formes, qui relient ces variétés

entre elles et au type de l'espèce. Le nombre de ces formes transitoires peut être considérable, et constituer toute une série, dont le dernier représentant s'éloigne quelquefois loin du type ...»; «Dans l'espèce du *C. racemosa* j'ai reconnu plusieurs variétés qui pour la plupart correspondent aux espèces déjà décrites par d'autres auteurs, mais qu'il m'a semblé impossible de maintenir comme espèces, à cause de l'inconstance de caractères, et du grand nombre de formes transitoires. Dans chaque variété j'ai reconnu une ou plusieurs formes ; il serait facile d'augmenter le nombre de ces formes, car la variabilité des caulerpes à ramules clavéformes est immense, mais je craindrais d'encombrer la systématique d'une manière inutile, et de décrire des individus isolés ...».

Since then, numerous authors have confirmed these observations, f. ex. W. R. TAYLOR (1960, p. 151) about *C. racemosa* : «This famous, ubiquitous tropical species is amongst the most variable in its variable genus».

After the study of our collections in Papua New Guinea, Indonesia, The Maledives and Kenya, we fully agree with WEBER-VAN BOSSE'S (1898, p. 325) statement : «Cette absence totale de constance dans les caractères est si grande, qu'on a de la peine à trouver deux échantillons identiques, provenant de localités diverses, et quand on s'est occupé pendant quelque temps de ces caulerpes, on pourra quatre fois sur cinq, dire plus facilement le nom de la localité d'où provient un nouvel échantillon, que le nom de l'espèce à laquelle elle devrait appartenir d'après les indications de M. J. Agardh.»

Moreover in some cases the upright shoots of the same stolon can have a different morphology depending on e.g. the local light intensity. PETERSON (1972) and CALVERT (1976) were the first to describe transplant of wild plants of *Caulerpa* in light controlled aquaria. Their results were recently reconfirmed by OHBA & ENOMOTO (1987) : light and temperature determine the morphology of *C. racemosa*, at least within a certain range. Supplementary experiments on the influence of salinity, hydrodynamism, emersion time, etc., on the morphology of *C. cupressoides* or *C. racemosa* (or other species) might indicate more relationships between ecological parameters and morphology in these taxa.

Therefore we follow the suggestion of PETERSON (1972, p. 84) that — at least some of — the varieties and forms of *C. racemosa* should be considered as ecological phenotypes (ecophenes or ecads) and not as genotypes. We expand the use of ecads for some growth forms in *C. cupressoides* and *C. serrulata*, knowing that numerous intermediates exist. EGEROD (1975) already stated that «The continued employment of varietal» (here ecad) «designation within the species can serve the function of conveying information relative to the morphological expression given to the species in a given locality and habitat».

In other *Caulerpa* species, intermediates between varieties or forms are unknown ; in such cases we stick to the traditional varietal designation.

DESCRIPTIONS

The taxa have been arranged alphabetically.

*Caulerpa brachypus* Harvey (Fig. 1 A-C, 7 A)

Stolons stout, 1.5-2.5 mm in diameter, bearing erect, shortly stipitate, rather fleshy, ligulate fronds, 5-6(-9) cm × 7-8 mm, originally simple, but frequently (sub-)dichotomous or proliferating at the apex; frond margins irregularly constricted, some completely smooth, others provided with serially placed, small, simple, mucronate spines; frond apex broadly rounded, blunt or incised (young dichotomy).

Reference specimens. 10826 : 18/9/1984, E of Komodo, Selat Linta, 8°35 S 119°34'E, centre of coastal reef-flat.

*Caulerpa brachypus* Harvey ecad *parvifolia* [fa *parvifolia* (Harvey) Cribb]  
(Fig. 7 B)

Stolons very thin, 0.5 mm in diameter, bearing erect, shortly stipitate, simple, elliptic fronds, 10-13 (-25) mm long and c. 3 mm broad, with serially placed, relatively well developed, simple, mucronate teeth; frond apex rounded or blunt.

Reference specimens. 11358 : 27/9/1984, NE of Taka Bone Rate, middle of reef flat of Taka Garlarang reef, 6°27'S 121°14'E.

Discussion. — Numerous descriptions of intermediates between *C. brachypus* and related taxa have been published. PAPENFUSS & EGEROD (1957, p. 86) synonymized *C. brachypus* with *C. parvifolia* Harvey, *C. anceps* Harvey ex J. Agardh, *C. mauritiana* Børgesen, *C. simplex* Levring and *C. stahlia* Weber-van Bosse. CRIBB (1958, p. 209), however, named the specimens with a thinner rhizome and smaller erect fronds as *C. brachypus* forma *parvifolia*. See also the descriptions of *C. parvifolia* by Harvey (1860, plate CLXXII) and by WEBER-VAN BOSSE (1898, p. 281).

*Caulerpa cupressoides* (Vahl) C. Agardh

Well developed specimens growing in rather dense groups because of the frequently ramified, smooth, terete stolons, up to 2 mm in diameter; downwardly directed branches with terminal rhizoids well developed and numerous; erect branches of variable length depending on ecological factors, terete to somewhat compressed, unramified and naked at the base, irregularly to (sub-)dichotomously ramified above; these upper parts covered by 2-3 (rarely more) rows of upwardly curved branchlets with mucronate tips; these short (1 mm), spiniform, conoid, mamilllose, seminaviculate or longer (2-3 mm) and linear.

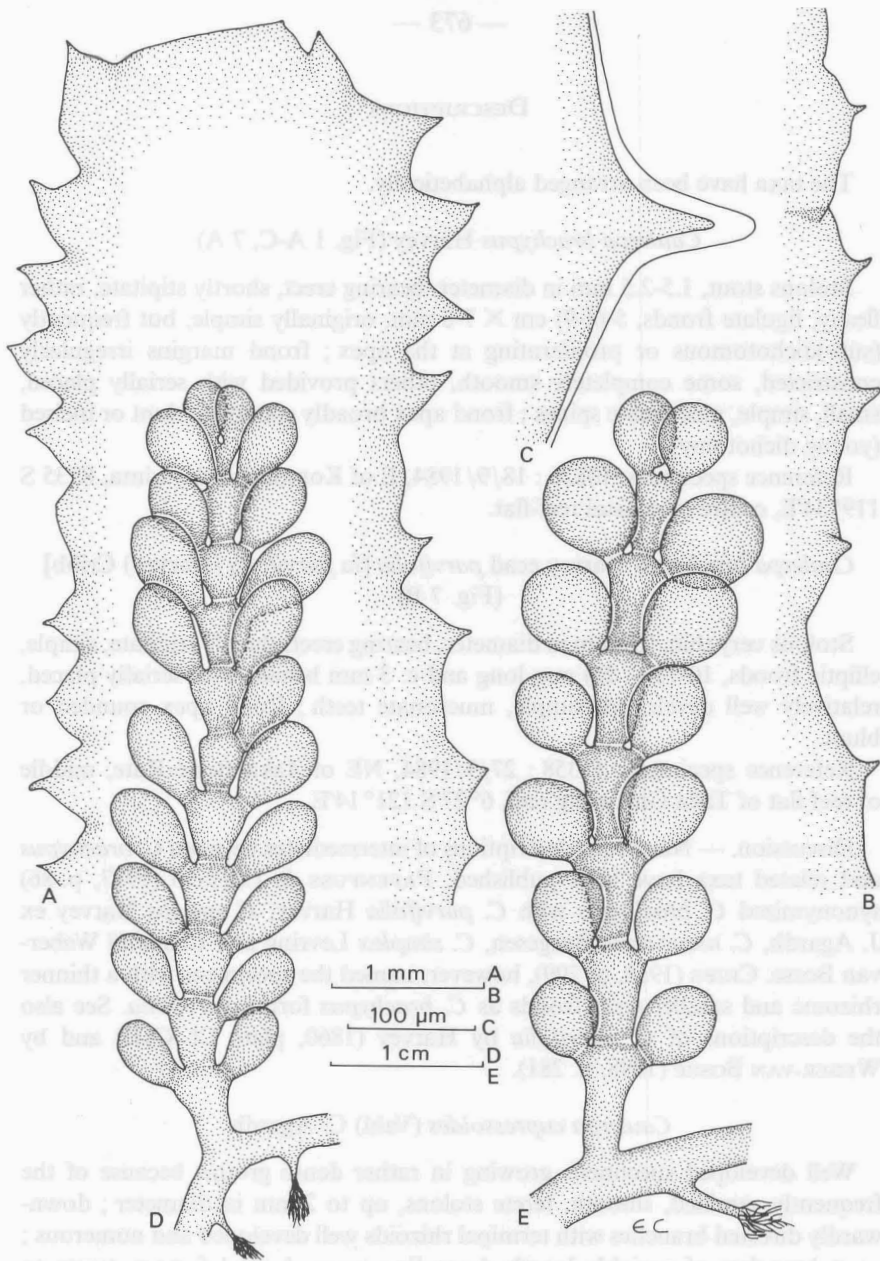


Fig. 1. — *Caulerpa brachypus* Harvey  
 A. Apex and margins of a frond with serially placed mucronate spines (11358A);  
 B. Margin with less developed spines (10826E);  
 C. Detail of a mucron of B.  
*Caulerpa fergusonii* Murray  
 D. Upright branch with clavate branchlets (10620E);  
 E. Same with roundish branchlets (10878E).

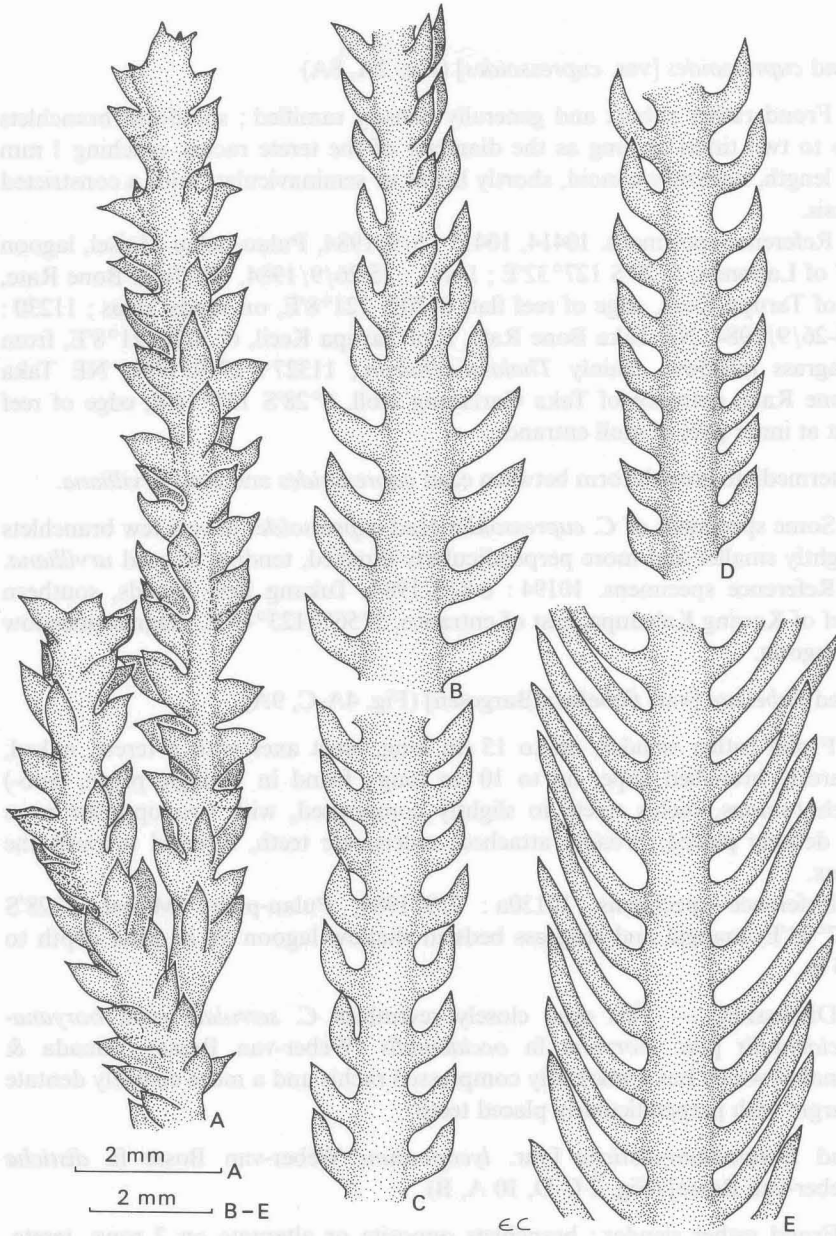


Fig. 2. — *Caulerpa cupressoides* (Vahl) C. Agardh  
 A. *ecad cupressoides* : typical aspect with 3(-numerous) rows of branchlets (11230E) ;  
 B. Upper part : *ecad cupressoides*, lower part ; *ecad lycopodium-disticha* (10129E) ;  
 C. *ecad lycopodium-disticha* with short branchlets opposite on 2 rows (10417E) ;  
 D. *ecad lycopodium-disticha* with short branchlets alternate on 2 rows (10417E) ;  
 E. *ecad lycopodium-elegans* with long branchlets on 2 rows (10481E).

ecad *cupressoides* [var. *cupressoides*] (Fig. 2A, 8A)

Frond rather robust and generally densely ramified ; spiniform branchlets up to two times as long as the diameter of the terete rachis, reaching 1 mm in length, narrowly conoid, shortly linear or seminaviculate with a constricted basis.

Reference specimens. 10414, 10415 : 5/9/1984, Pulau-pulau Maisel, lagoon W of Laponda, 5°29'S 127°32'E ; 11211 : 25-26/9/1984, NE Taka Bone Rate, S of Tarupa Kecil, edge of reef flat, 6°30'S 121°8'E, on sandy areas ; 11230 : 25-26/9/1984, NE Taka Bone Rate, S of Tarupa Kecil, 6°30'S 121°8'E, from seagrass meadow, mainly *Thalassodendron* ; 11327 : 27/9/1984, NE Taka Bone Rate, entrance of Taka Garlarang atoll, 6°28'S 121°18'E, edge of reef flat at inner part of atoll entrance.

Intermediate growth form between ecad *cupressoides* and ecad *urvilliana*.

Some specimens of *C. cupressoides* ecad *cupressoides* have a few branchlets slightly smaller and more perpendicularly directed, tending to ecad *urvilliana*.

Reference specimens. 10194 : 6-8/9/1984, Tukang Besi Islands, southern reef of Karang Kaledupa, east of entrance, 5°56'S 123°48'E, seagrass meadow in lagoon.

ecad *flabellata* [var. *flabellata* Børgesen] (Fig. 4A-C, 9A)

Frond rather slender, up to 15 cm long, erect axes with a terete, naked, scarcely branched stipe, up to 10 cm long ; frond in a single plane, (sub-)dichotomous, rachis terete to slightly compressed, with two opposite rows of densely placed, broadly attached, mucronate teeth, directed towards the apex.

Reference specimens. 10130a : 7/9/1984, Pulau-pulau Maisel, 5°28'S 127°31'E, mangal and seagrass beds in shallow lagoon W of Mai, depth to 1.5 m.

Discussion. — This ecad closely resembles *C. serrulata* ecad *boryana-occidentalis* [var. *boryana* fa *occidentalis* (Weber-van Bosse) Yamada & Tanaka] which has a markedly compressed rachis and a more coarsely dentate margin with perpendicularly placed teeth.

ecad *lycopodium-disticha* [var. *lycopodium* Weber-van Bosse fa *disticha* Weber-van Bosse] (Fig. 2 C-D, 10 A, B)

Frond rather slender ; branchlets opposite or alternate on 2 rows, terete, without basal constriction, linear, upwardly curved, up to two times as long as the diameter of the somewhat compressed rachis.

Reference specimens. 10417 : 5/9/1984, Pulau-pulau Maisel, lagoon W of Laponda, 5°29'S 127°32'E ; 11039 : 21/9/1984, N of Sumbawa, Bay of Sanggar, 8°05'S 118°6.7'E ; 11049 : as 11039 but 8°20.3'S 118°16.4'E, depth



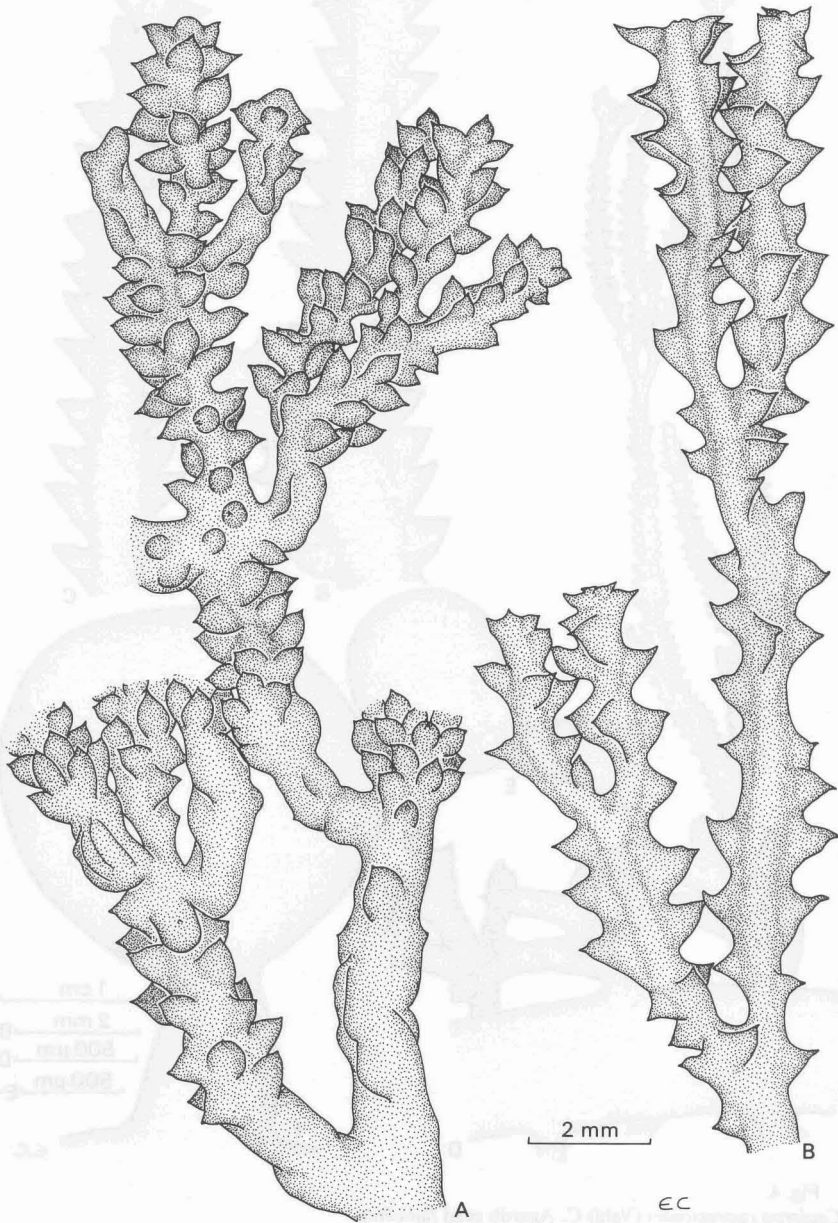


Fig. 3. — *Caulerpa cupressoides* (Vahl) C. Agardh  
A. ecad *mamillosa* with markedly inflated branchlets (10396E);  
B. ecad *urvilliana* with short, wide-conical, mucronate, warty branchlets (10194A).

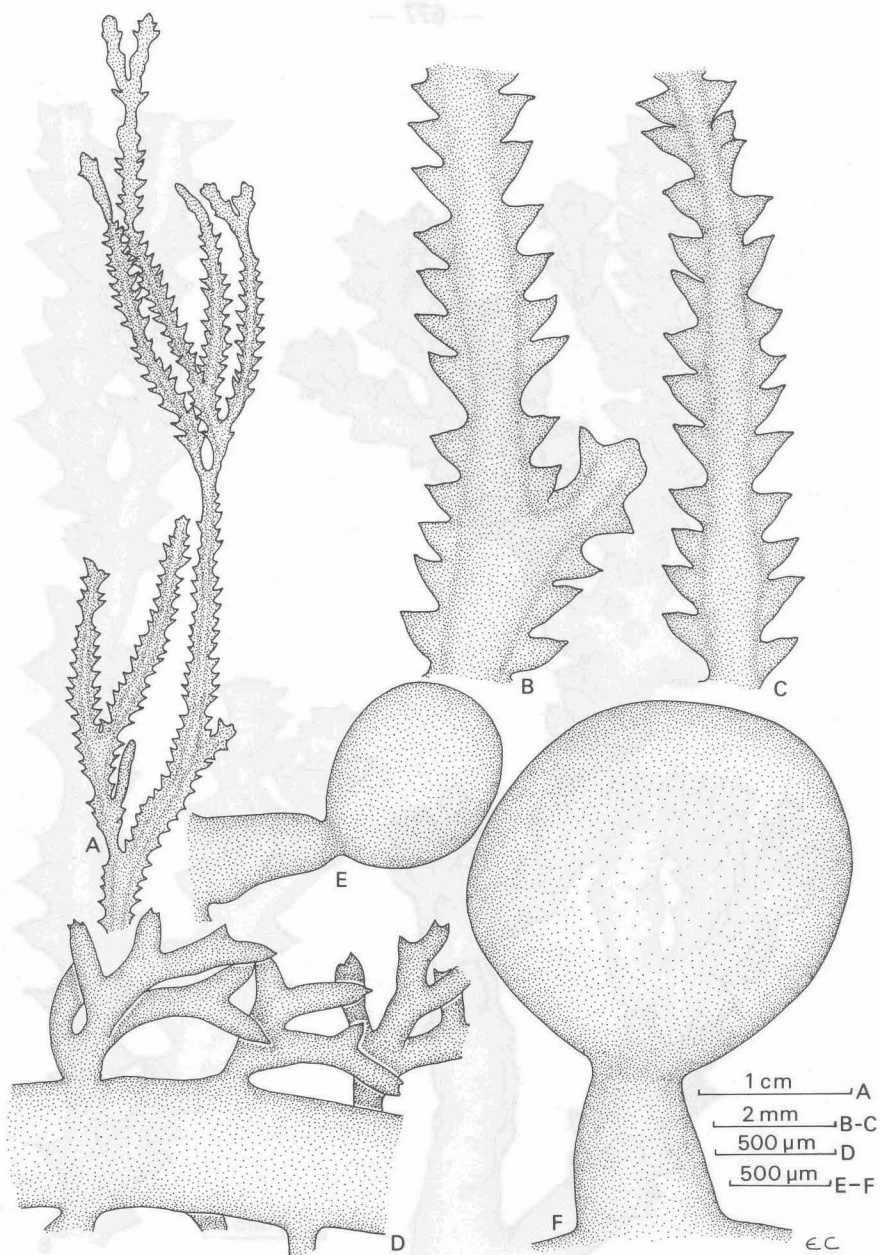


Fig. 4.

*Caulerpa cupressoides* (Vahl) C. Agardh ead *flabellata*

A. Apical part of an erect branch (10130E) ;

B. C. Details of other fronds from the same specimen.

*Caulerpa elongata* Weber-van Bosse

D. Detail of the stolon with short, recurved branchlets (10827E) ;

*Caulerpa lentillifera* J. Agardh

E. ± clavate branchlet with long pedicel (10871E) ;

F. Large, subspherical branchlet with short pedicel (11576E).

to 8 m ; 11362 : 27/9/1984, NE Taka Bone Rate, middle of reef flat Taka Garlarang, 46°27'S 121°14'E.

ecad *lycopodium-elegans* [var. *lycopodium* Weber-van Bosse fa *elegans* (Crouan frat.) Weber-van Bosse] (Fig. 2 E, 11 A)

Frond slender ; branchlets as in f. *disticha* but generally 3-4 (up to 6) times as long as the diameter of the somewhat compressed rachis.

Reference specimens. 10128, 10129 : 7/9/1984, Pulau-pulau Maisel, very shallow lagoon W of Mai, 5°28'S 127°31'E, mangal and seagrass beds, depth to 1.5 m ; 10481, 10482 : 13/9/1984, NE coast of Sumba, E of Melolo, 9°54'S 120°42.5'E, sandy reef flat and gradual slope, with scattered corals, depth to 12 m ; 10824 : 18/9/1984, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat ; 11390 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses ; 11513 : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, from reef crest, snorkeling ; 11580 : as 11513 but from coral sand with dense algal vegetation and large seagrasses, much silt.

Intermediate between ecad *lycopodium-disticha* and ecad *lycopodium-elegans*

Reference specimens. 10632 : 14-15/9/1984, NE coast of Sumba, beach and stony littoral of Melolo, 9°52.5'S 120°40.3'E ; 10825 : 18/9/1984, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat.

Discussion. — In some specimens the stolons bear some erect branches with the characters of ecad *lycopodium-elegans* and others with those of ecad *lycopodium-disticha*. Moreover some fronds have a somewhat more compressed rachis, making them very similar to *C. serrulata* ecad *pectinata* or *C. lessonii*. SVEDELIUS (1906, pp. 98-99, 116-117) also treats this problem of gradual morphological variation, concluding that «it may be possible for *C. Lessonii* and *C. Lessonii* f. *tuticorinensis* to be in the nature of parallel forms of equal rank, both deriving from a *cupressoides* form and with a tendency to form flat bilateral branches», and «they are to be looked for, on the one side, especially among the *cupressoides* series and particularly amongst var. *lycopodium* Weber-van Bosse, and var. *disticha* Weber-van Bosse ; on the other, also among the *C. Freycinettii* [*C. serrulata*] series var. *pectinata*». As we consider the specimens belonging to the different ecads of *C. cupressoides* having a terete or only slightly compressed rachis, those specimens with similar morphology but with a markedly compressed or even complanate rachis are here placed into *C. lessonii* or *C. serrulata*.

ecad *mamillosa* [var. *mamillosa* (Montagne) Weber-van Bosse] (Fig. 3 A, 8 B)

Upright fronds generally stout and densely branched ; at least the basal branchlets densely and irregularly packed, markedly inflated, generally not longer than the diameter of the rachis.

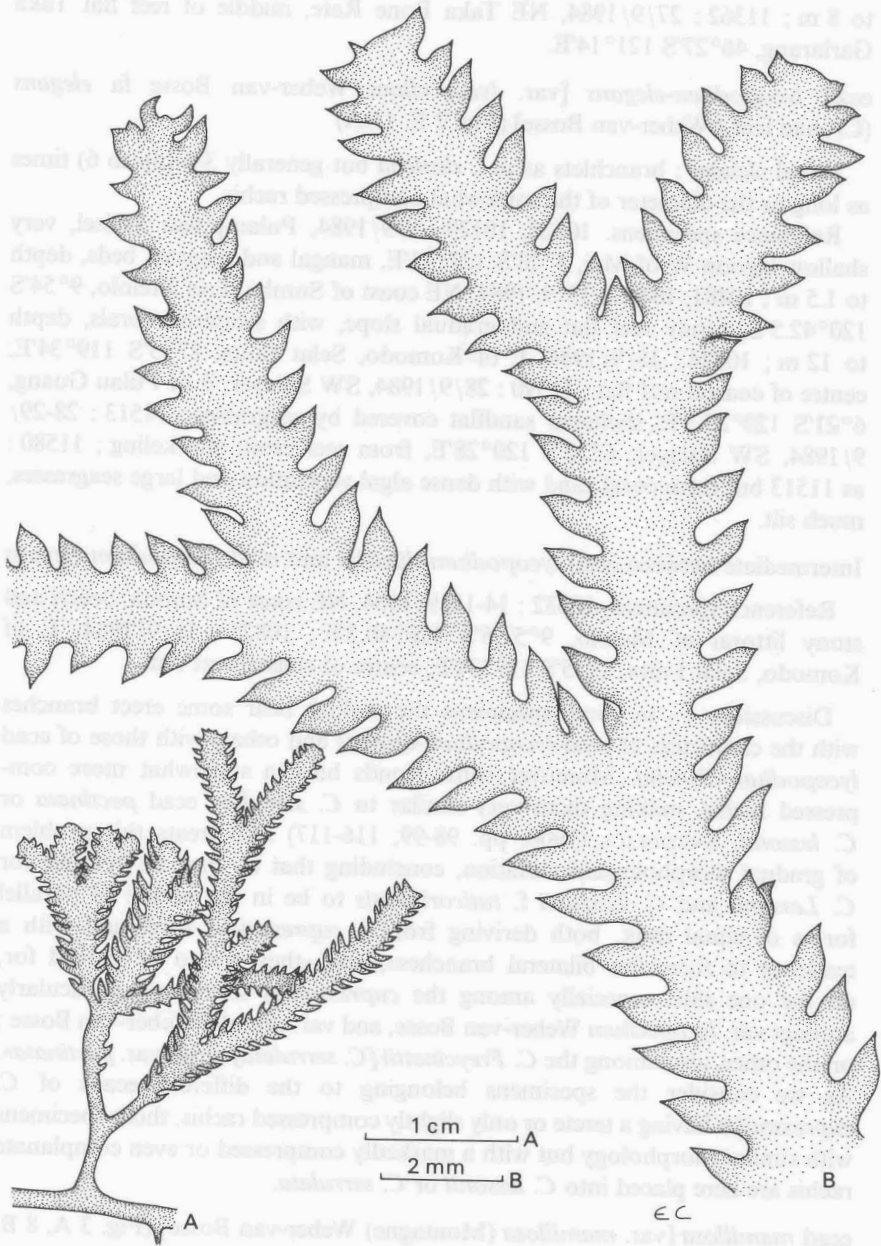


Fig. 5. — *Caulerpa lessonii* Bory  
A. Habit of an erect branch (11120A);  
B. Detail of the same.

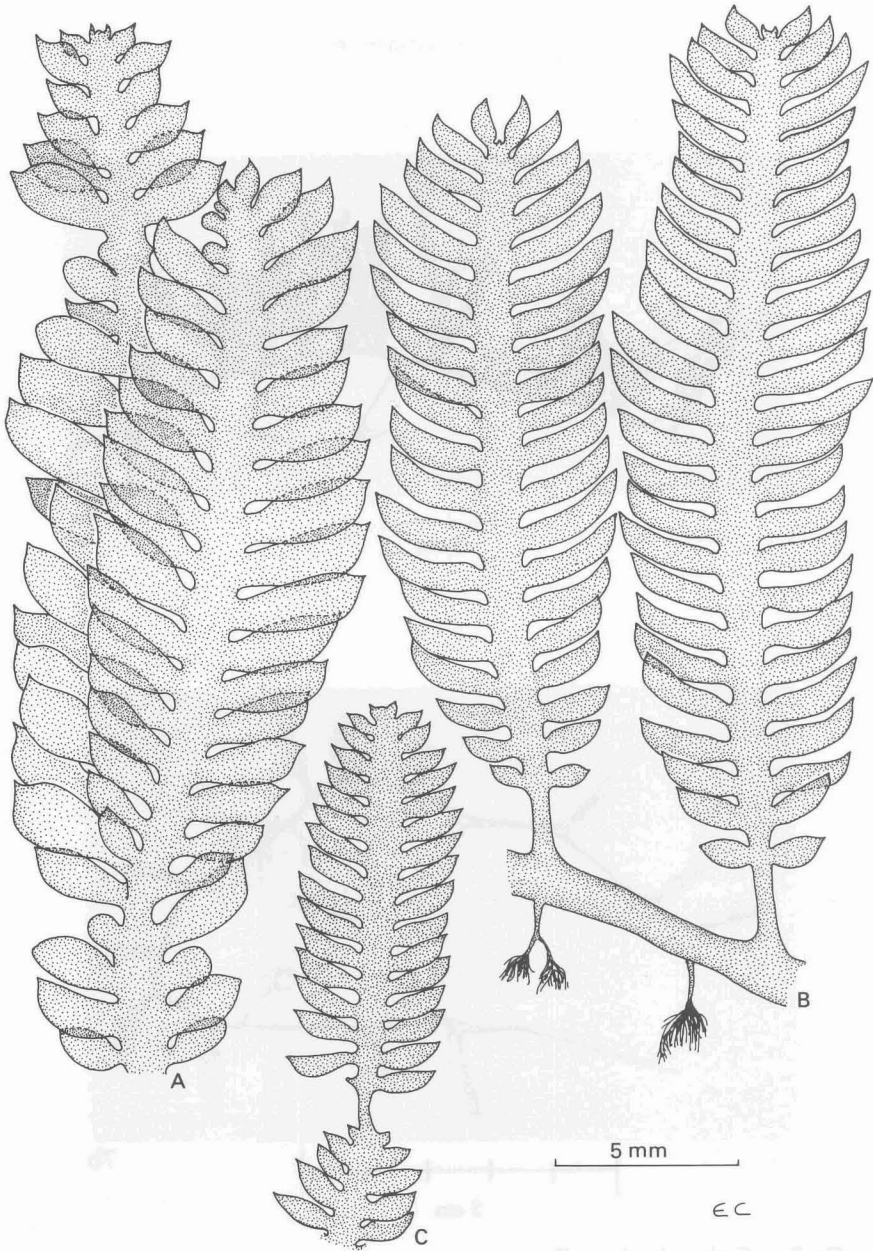
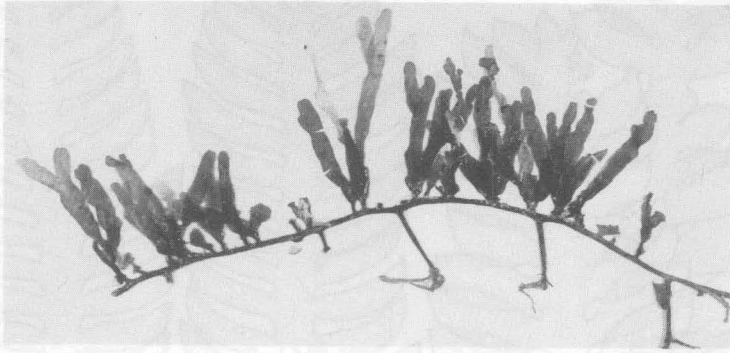
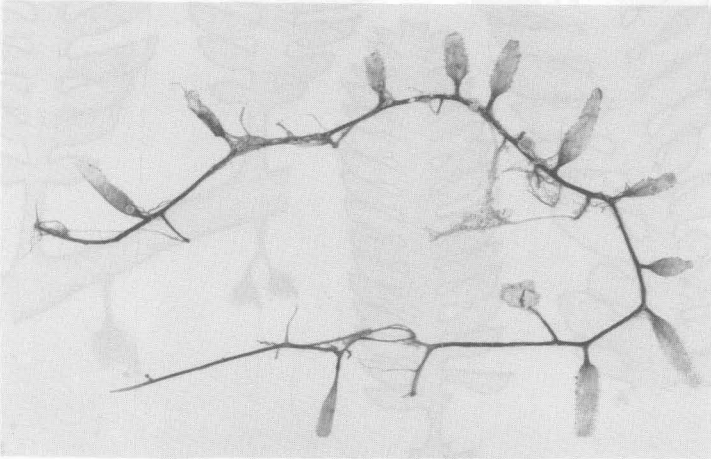


Fig. 6. — *Caulerpa taxifolia* (Vahl) C. Agardh  
 A. ecad *mexicana* : branchlets overlapping (10619E) ;  
 B. ecad *taxifolia* : branchlets not overlapping (11325E) ;  
 C. Smallish intermediate between ecad *mexicana* and ecad *taxifolia* : some branchlets overlapping (11231E).



7a



7b

Fig. 7. — *Caulerpa brachypus* Harvey  
A. Habit of ecad *brachypus* (10826 A);  
B. Habit of ecad *parvifolia* (11358 E).



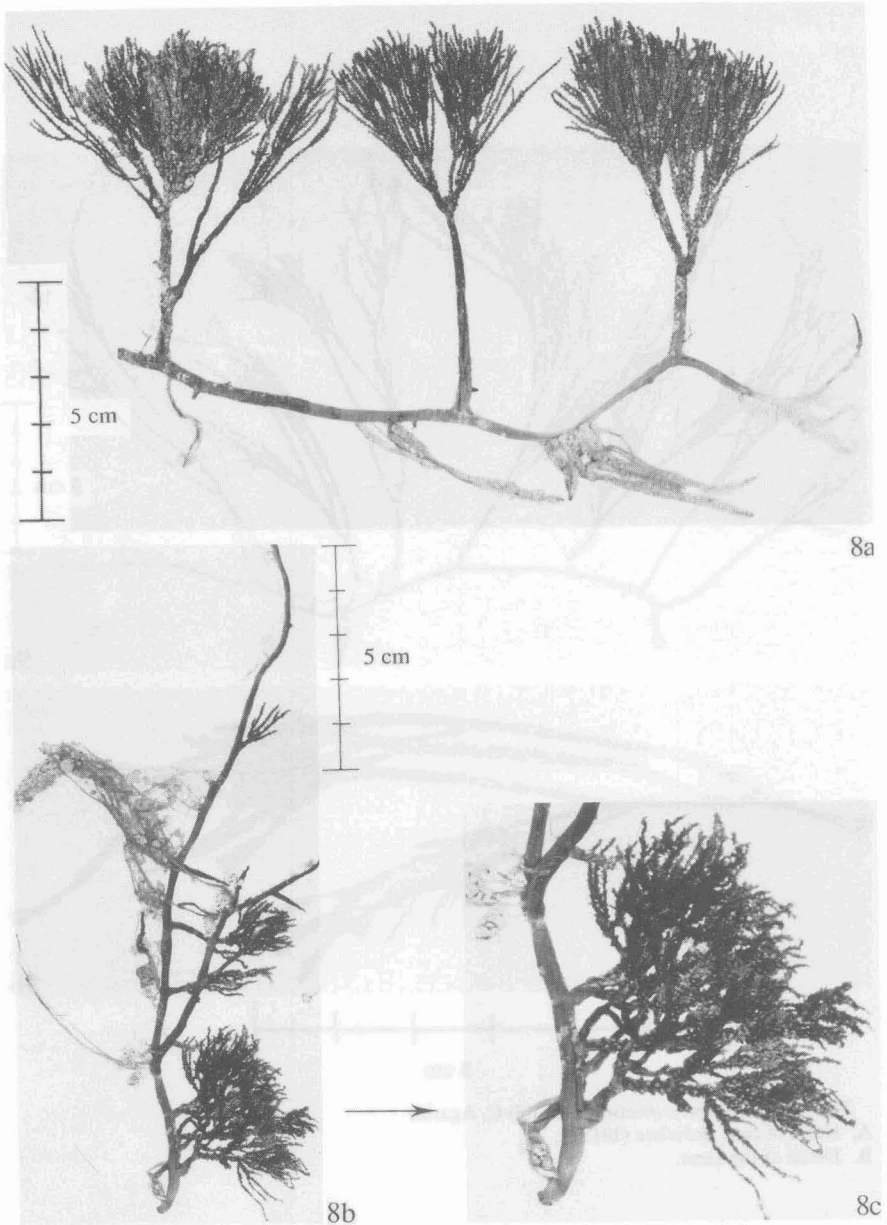


Fig. 8. — *Caulerpa cupressoides* (Vahl) C. Agardh  
A. Habit of *ecad cupressoides* (11211 A);  
B. Habit of *ecad mamillosa* (10396 A).



Fig. 9. — *Caulerpa cupressoides* (Vahl) C. Agardh  
A. Habit of ecad *flabellata* (10130);  
B. Detail of the same.

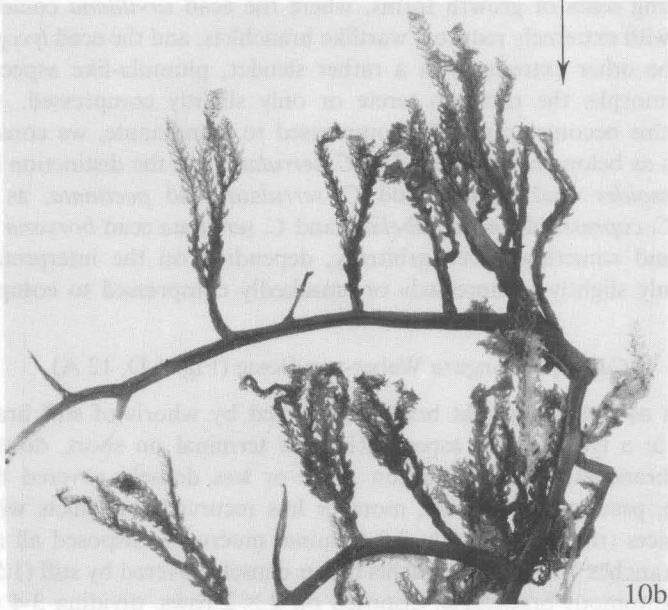
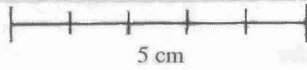
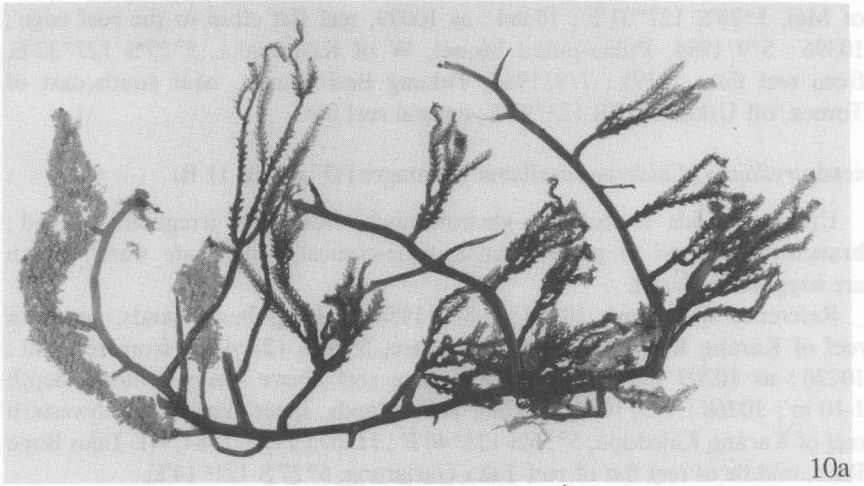


Fig. 10. — *Caulerpa cupressoides* (Vahl) C. Agardh  
A. Habit of ecad *lycopodium-disticha* (10417 A);  
B. Detail of the same.

Reference specimens. 10099 : 4-7/9/1984, Pulau-pulau Maisel, reef flat N of Mai, 5°28'S 127°31'E ; 10384 : as 10099, reef flat close to the reef edge ; 10396 : 5/9/1984, Pulau-pulau Maisel, W of Kaurangka, 5°29'S 127°32'E, from reef flat ; 11191 : 7/9/1984, Tukang Besi Islands, near southcoast of Tomea, off Usku, 5°48'S 123°97'E, coastal reef flat.

ecad *urvilliana* [*Caulerpa urvilliana* Montagne] (Fig. 3 B, 11 B)

Upright fronds terete, (sub-)dichotomous, frequently irregularly curled ; branchlets reduced to perpendicular, wide-conical, mucronate warts, which are irregularly placed.

Reference specimens. 10209 : 6-8/9/1984, Tukang Besi Islands, southern reef of Karang Kaledupa, east of entrance, 5°56'S 123°48'E, from reef flat ; 10226 : as 10209 but from gently sloping reef above sandy bottom, depth 1-10 m ; 10268 : 9/9/1984, Tukang Besi Islands, inner part of southwestern reef of Karang Kaledupa, 5°56'S 123°46'E ; 11357 : 27/9/1984, NE Taka Bone Rate, middle of reef flat of reef Taka Garlarang, 6°27'S 121°14'E.

Discussion on *C. cupressoides*

As already stated in the Nomenclatural remark, *C. cupressoides* occurs in an unending scala of growth forms, where the ecad *urvilliana* could be one extreme, with extremely reduced, wartlike branchlets, and the ecad *lycopodium-elegans* the other extreme with a rather slender, plumula-like aspect. In all these ecomorphs the rachis is terete or only slightly compressed. As soon as the rachis becomes markedly compressed to complanate, we consider the specimens as belonging to an ecad of *C. serrulata*. But the distinction between *C. cupressoides* ecad *disticha* and *C. serrulata* ecad *pectinata*, as well as between *C. cupressoides* ecad *flabellata* and *C. serrulata* ecad *boryana* remains difficult and sometimes even arbitrary, depending on the interpretation of «rachis only slightly compressed» or «markedly compressed to complanate».

*Caulerpa elongata* Weber-van Bosse (Fig. 4 D, 12 A)

Stolons as well as upright branches covered by whorls of stiff branchlets, resulting in a lycopod-like aspect. Rhizoids terminal on short, downwardly growing branches. Ramified stolon more or less densely covered by short (c. 1 mm), pseudodichotomous, more or less recurved branchlets with mucronate apices (rather frequently 2-3 terminal mucrons), disposed all around ; upright branches 1-2 cm high ; rachis rather densely covered by stiff (1.5-2 mm) long, dichotomous branchlets, disposed on 2 × 2 rows, dividing 3-4 times in alternate planes, c. 150 μm at the base, with singly mucronate apices.

Reference specimens. 10827 : 18/9/1984, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat.

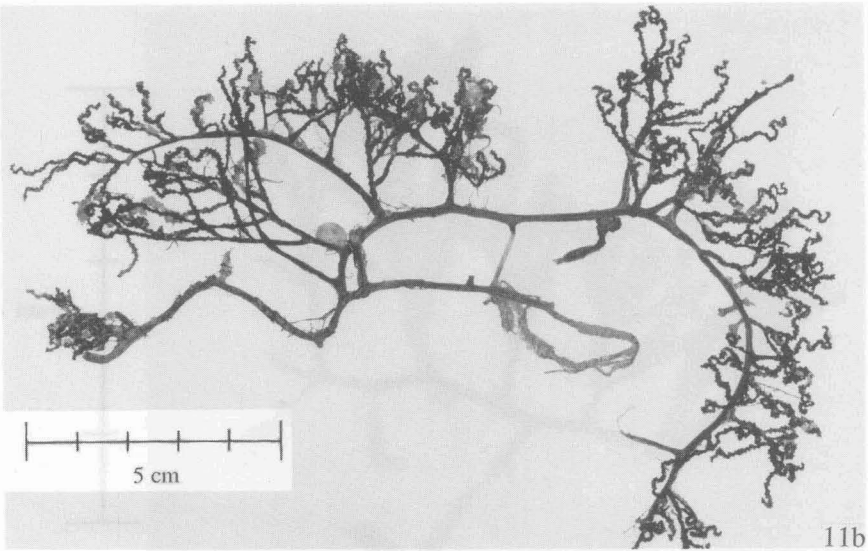
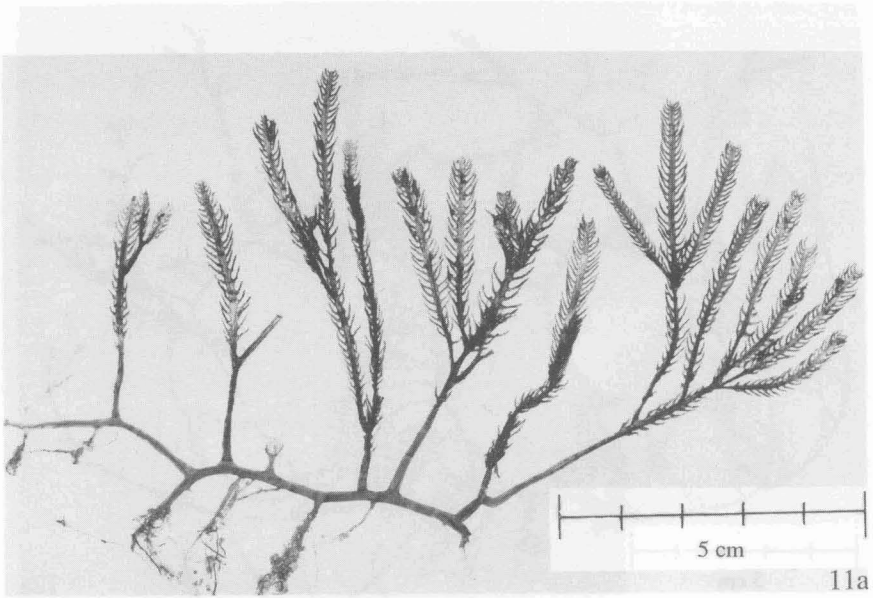


Fig. 11. — *Caulerpa cupressoides* (Vahl) C. Agardh  
A. Habit of ecad *lycopodium-elegans* (10481 A);  
B. Habit of ecad *urvilliana* (11357 A).

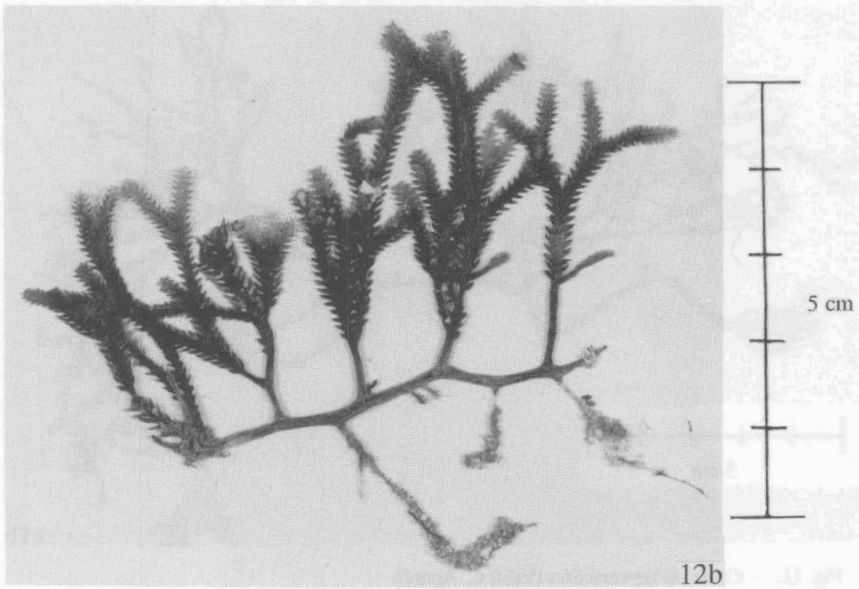
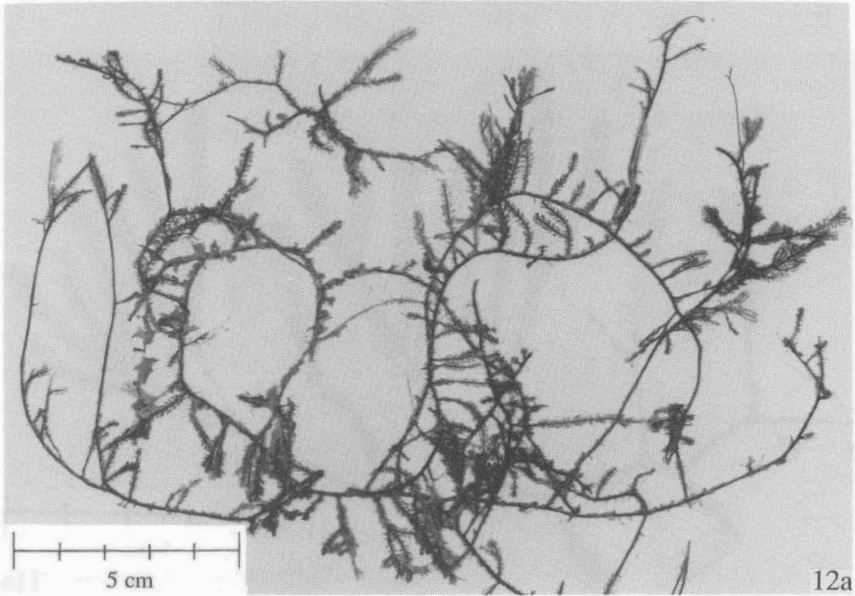


Fig. 12.  
A. *Caulerpa elongata* Weber-van Bosse : habit (10827 A) ;  
B. *Caulerpa lessonii* Bory : habit (11120 A).



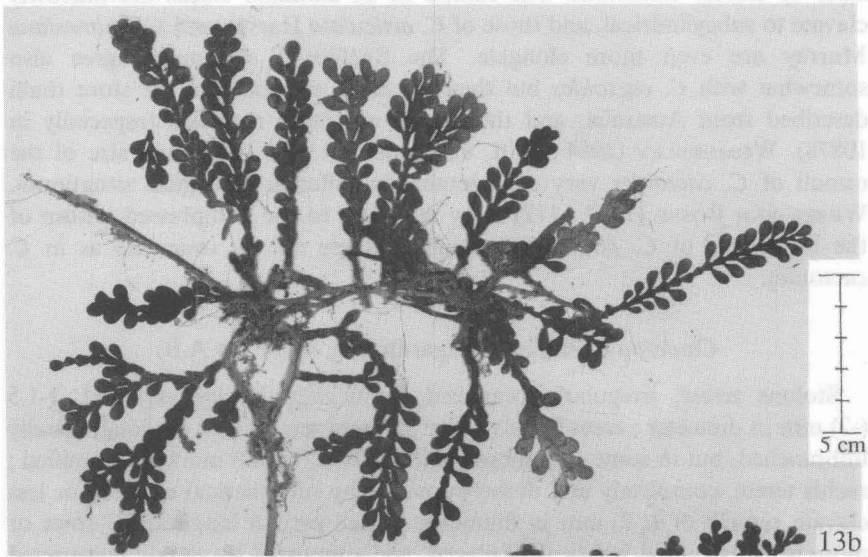
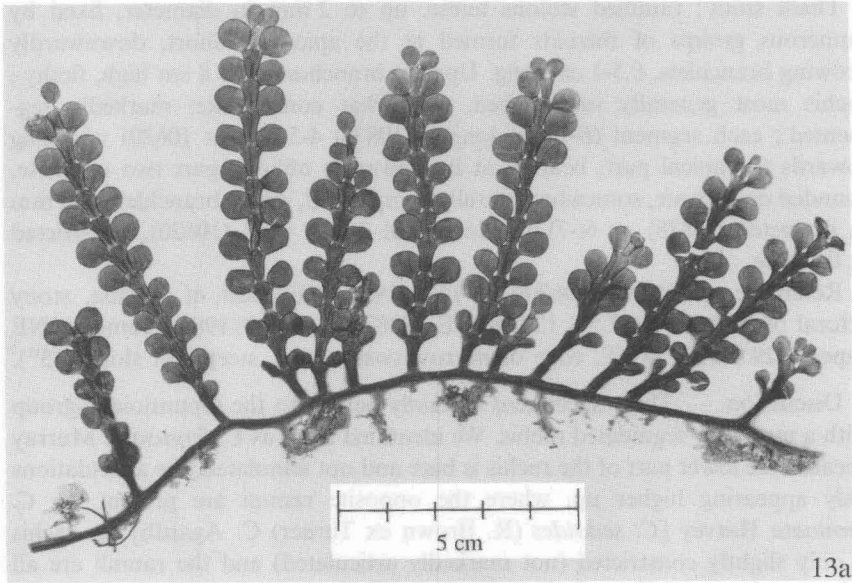


Fig. 13. — *Caulerpa fergusonii* Murray  
A. Habit with more roundish ramuli (10878 A);  
B. Habit with more clavate ramuli (10620 A).

*Caulerpa fergusonii* Murray (Fig. 1 D-E, 13 A,B)

Thalli stout; ramified stolons terete, up to 2 mm in diameter, fixed by numerous groups of rhizoids formed at the apices of short, downwardly growing branchlets, 0.5-1 cm long. Upright branches up to 8 cm high, fleshy; rachis most generally unbranched, somewhat complanate, markedly segmented; each segment (6-7 mm long in 10878, 4-5 mm in 10620) widening towards the apical part, bearing at its upwardly oblique part two opposite, rounded or obovate, somewhat laterally compressed, sessile branchlets, 4-6 mm in diameter (10878) or 6(-7) mm long and 3 mm wide (10620), constricted at the base.

Reference specimens. 10620: 14-15/9/1984, NE coast of Sumba, stony littoral of Melolo, 9°52.5'S 120°40.3 E; 10878: 19-20/9/1984, Komodo, NE cape, 8°29'S 119°34.1'E, edge of narrow coastal reef, steep reef slope (45°).

Discussion. — These specimens certainly belong to the Opuntioideae-group with a markedly segmented rachis. We identified them as *C. fergusonii* Murray because the lower part of the rachis is bare and not annulated, the articulations only appearing higher up, where the opposite ramuli are present. In *C. geminata* Harvey [*C. sedoides* (R. Brown ex Turner) C. Agardh] the rachis is only slightly constricted (not markedly articulated) and the ramuli are all sides or almost distichous. The ramuli of *C. annulata* Lucas are narrowly clavate to subcylindrical, and those of *C. articulata* Harvey and *C. holmesiana* Murray are even more elongate. The Snellius-II specimens agree also somewhat with *C. cactoides* but they are more elegant than the stout thalli described from Australia, and the ramuli are more roundish (especially in 10878). WOMERSLEY (1984: 270), mentions that «the shape and size of the ramuli of *C. cactoides* vary considerably in different ecological situations». WEBER-VAN BOSSE (1913: 112) drew attention to the compressed nature of the branchlets of *C. fergusonii*, which thus are not as vesiculate as in *C. cactoides*.

*Caulerpa lentillifera* J. Agardh (Fig. 4 E-F, 14 A,B)

Stolons terete, irregularly branched (branching density variable), 1-1,5 (-2) mm in diameter; erect fronds rather densely set, up to 8 cm long, usually unbranched, but in some specimens (10486, 10871, 11382) markedly ramified; rachis terete, completely and densely covered by subspherical or more or less clavate ramelli of 1(-2) mm in diameter, placed on 5-8 longitudinal rows or more irregularly and imbricately placed, and supported by clearly constricted pedicels.

Reference specimens. 10125: 7/9/1984, Pulau-pulau Maisel, very shallow lagoon W of Mai, 5°28'S 127°31'E, seagrass beds in front of mangal, down to 1.5 m; 10465: 13-14/9/1984, NE coast of Sumba, E of Melolo, 9°55'S

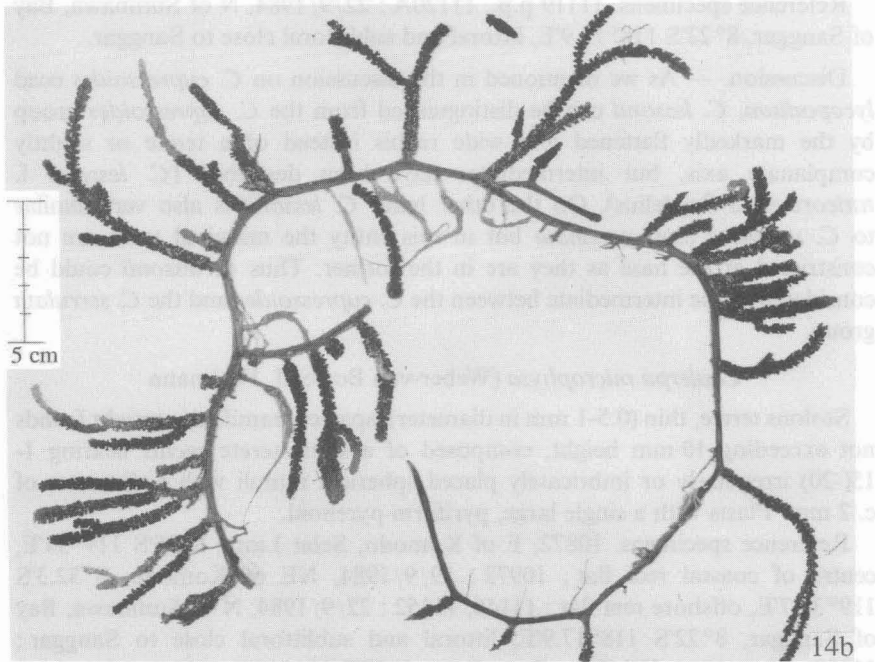
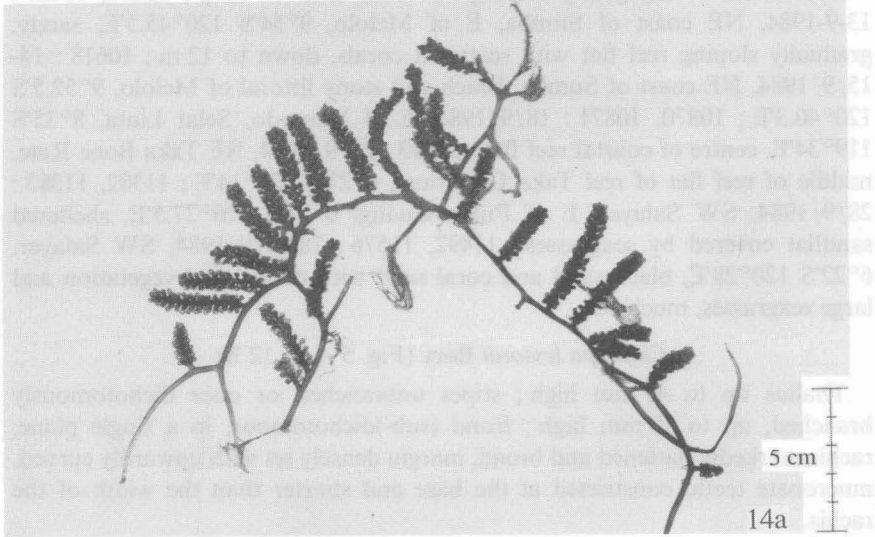


Fig. 14. — *Caulerpa lentillifera* J. Agardh  
A. Habit with spherical ramuli (11576 A);  
B. Habit with clavate ramuli (10871 A).

120°45'E, on a very gently sloping reef flat, 10-15 m deep ; 10486, 10487 : 13-9-1984, NE coast of Sumba, E of Melolo, 9°54'S 120°45.5'E, sandy, gradually sloping reef flat with scattered corals, down to 12 m ; 10618 : 14-15/9/1984, NE coast of Sumba, beach and stony littoral of Melolo, 9°52.5'S 120°40.3'E ; 10870, 10871 : 18/9/1984, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat ; 11363 : 27/9/1984, NE Taka Bone Rate, middle of reef flat of reef Taka Garlarang, 6°27'S 121°14'E ; 11382, 11383 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses ; 11492, 11576 : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, black sand and coral sand with dense algal vegetation and large seagrasses, much silt.

*Caulerpa lessonii* Bory (Fig. 5 A-B, 12 B)

Thallus up to 45 mm high ; stipes unbranched or once dichotomously branched, up to 10 mm high ; frond (sub-)dichotomous, in a single plane, rachis markedly flattened and broad, margin densely set with upwardly curved, mucronate teeth, constricted at the base and shorter than the width of the rachis.

Reference specimens. 11119 p.p., 11120A : 22/9/1984, N of Sumbawa, Bay of Sanggar, 8°22'S 118°17.9'E, littoral and sublittoral close to Sanggar.

Discussion. — As we mentioned in the discussion on *C. cupressoides* ead *lycopodium*, *C. lessonii* can be distinguished from the *C. cupressoides* group by the markedly flattened and wide rachis instead of a terete or slightly complanate axis, but intermediates have been described (*C. lessonii* f. *tuticorinensis* Svedelius). On the other hand *C. lessonii* is also very similar to *C. serrulata* ead *pectinata* but in this entity the marginal teeth are not constricted at the base as they are in the former. Thus *C. lessonii* could be considered as the intermediate between the *C. cupressoides* and the *C. serrulata* group.

*Caulerpa microphysa* (Weber-van Bosse) J. Feldmann

Stolons terete, thin (0.5-1 mm in diameter), sparsely ramified ; upright fronds not exceeding 10 mm height, composed of a short terete rachis bearing 1-15(-20) irregularly or imbricately placed spherical ramuli with a diameter of c. 2 mm. Plasts with a single large, pyriform pyrenoid.

Reference specimens. 10872, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat ; 10972 : 19/9/1984, NE of Komodo, 8°32.3'S 119°35.7'E, offshore reef flat ; 11146, 11152 : 22/9/1984, N of Sumbawa, Bay of Sanggar, 8°22'S 118°17.9'E, littoral and sublittoral close to Sanggar ; 11377 : 27/9/1984, NE Taka Bone Rate, 6°27'S 121°14'E, middle of reef flat of Taka Garlarang reef ; 11620 : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, bare black sand and coral sand with dense algal vegetation and large seagrasses, much silt.

Discussion. — *C. microphysa* could be confused with small specimens of *C. lentillifera* but the pedicels of the vesicular branchlets of the last one are markedly constricted, and the plasts are devoid of pyrenoids. Tiny growth forms of *C. racemosa* can also be distinguished from *C. microphysa* by this last character.

*Caulerpa racemosa* (Forsskål) J. Agardh

This species includes a wide variety of growth forms, the length of the erect fronds as well as the morphology of the branchlets being extremely variable [from (sub-)spherical, over clavate and turbinate to peltate]. It therefore is very difficult to give an overall species description, but most of the specimens are markedly fleshy with differently inflated branchlets. The plasts are always devoid of pyrenoids.

ecad *corynephora* [var. *corynephora* (Montagne) Weber-van Bosse] (Fig. 15 A)

Thallus slender, stolons only rarely branched, erect fronds up to 14 cm high, rachis terete or slightly compressed, unbranched or only rarely so, with a naked basal part (0.5-1 cm) and a series of more or less distant (sub-) opposite branchlets; these ramelli gradually enlarge from base to apex (clavate), with regularly rounded apices.

Reference specimens. 11370 : 27/9/1984, NE Taka Bone Rate, middle of reef flat of Taka Garlarang reef, 6°27'S 121°14'E; 11491, 11578c : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, bare black sand and coral sand with dense algal vegetation and large seagrasses, much silt.

ecad *laetevirens* [var. *laetevirens* (Montagne) Weber-van Bosse] (Fig. 16 A,B,C)

Thallus with a very dense aspect : stolons frequently branched, attached with very well developed rhizoidal branchlets; erect fronds crowded, up to 2-3(-4) cm high, rachis terete, bearing crowded, radially arranged branchlets; these ramelli, in the most typical growth form, all similar, narrowly clavate with regularly rounded apices.

Reference specimens. 10788, 10868, 10869 : 18/9/1984, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat; 11386 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses.

Discussion. — In some growth forms the upper branches have a flattened or even hollowed apex (tending to ecad *turbinata*) or become peltate (tending to ecad *peltata*).

ecad *lamourouxii* [var. *lamourouxii* (Turner) Weber-van Bosse] (Fig. 15 B)

Thallus with a fleshy aspect; erect fronds with very variable morphology : some branches completely naked, terete, slightly compressed or markedly

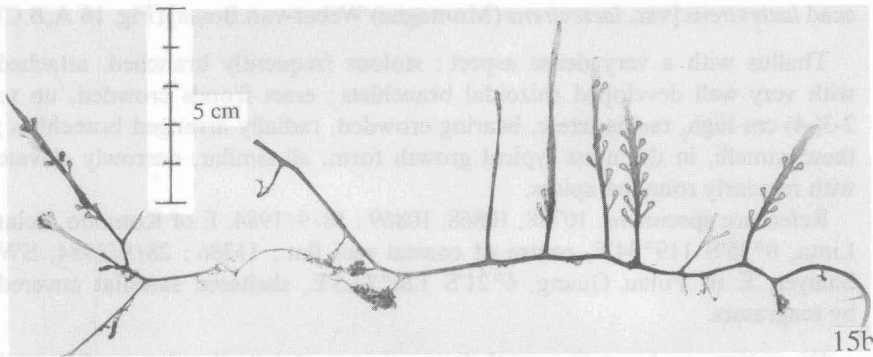
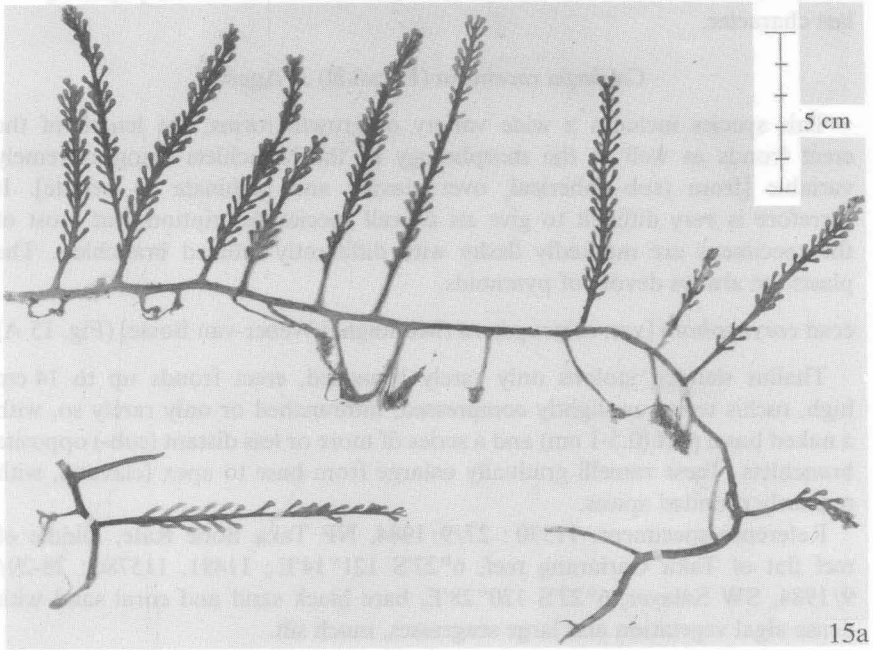


Fig. 15. — *Caulerpa racemosa* (Forsskål) J. Agardh  
A. ecad *corynephora* (11491 E);  
B. ecad *lamourouxii* (11578 A [b]).



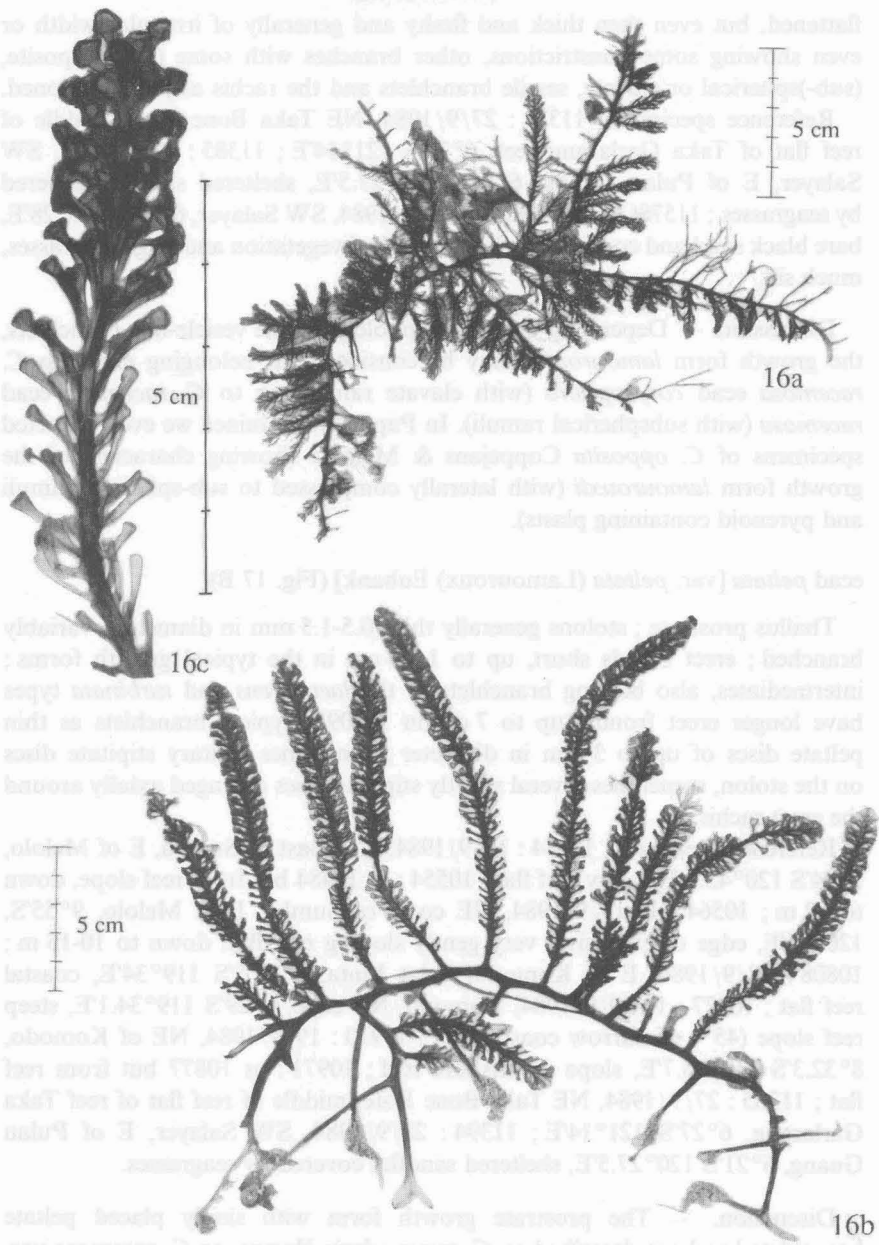


Fig. 16. — *Caulerpa racemosa* (Forsskål) J. Agardh ecad *laetevirens*  
A. Habit of a dense specimen (10869 A);  
B. Habit of a large specimen (10868 A);  
C. Detail of an erect branch (10788 A).

flattened, but even then thick and fleshy and generally of irregular width or even showing some constrictions, other branches with some (sub-)opposite, (sub-)spherical or clavate, sessile branchlets and the rachis as just mentioned.

Reference specimens. 11371 : 27/9/1984, NE Taka Bone Rate, middle of reef flat of Taka Garlarang reef, 6°27'S 121°14'E ; 11385 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses ; 11578(A,b), 11582 : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, bare black sand and coral sand with dense algal vegetation and large seagrasses, much silt.

Discussion. — Depending on the morphology of the vesicle-like branchlets, the growth form *lamourouxii* may be considered as belonging either to *C. racemosa* ecad *corynephora* (with clavate ramuli) or to *C. racemosa* ecad *racemosa* (with subspherical ramuli). In Papua New Guinea we even collected specimens of *C. opposita* Coppejans & Meinesz showing characters of the growth form *lamourouxii* (with laterally compressed to sub-spherical ramuli and pyrenoid containing plastids).

ecad *peltata* [var. *peltata* (Lamouroux) Eubank] (Fig. 17 B)

Thallus prostrate ; stolons generally thin (0.5-1.5 mm in diameter), variably branched ; erect fronds short, up to 1-1.5 cm in the typical growth forms ; intermediates, also bearing branchlets of the *laetevirens* and *turbinata* types have longer erect fronds (up to 7 cm in 10909) ; typical branchlets as thin peltate discs of up to 3 mm in diameter ; sometimes solitary stipitate discs on the stolon, sometimes several shortly stipitate discs arranged axially around the erect rachis.

Reference specimens. 10484 : 13/9/1984, NE coast of Sumba, E of Melolo, 9°54'S 120°42.5'E, sandy reef flat ; 10554 : as 10484 but from reef slope, down to 12 m ; 10564 : 13-14/9/1984, NE coast of Sumba, E of Melolo, 9°55'S, 120°45'E, edge of extensive, very gently sloping reef flat, down to 10-15 m ; 10808 : 18/9/1984, E of Komodo, Selat Linta, 8°32.5'S 119°34'E, coastal reef flat ; 10877 : 19-20/9/1984, Komodo, NE cape, 8°29'S 119°34.1'E, steep reef slope (45°) of narrow coastal reef ; 10910 : 19/9/1984, NE of Komodo, 8°32.3'S 119°35.7'E, slope of offshore reef ; 10971 : as 10877 but from reef flat ; 11365 : 27/9/1984, NE Taka Bone Rate, middle of reef flat of reef Taka Garlarang, 6°27'S 121°14'E ; 11394 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses.

Discussion. — The prostrate growth form with singly placed peltate branchlets has been described as *C. nummularia* Harvey or *C. racemosa* var. *peltata* fa *nummularia* (Harvey ex J. Agardh) Weber-van Bosse. Because some stolons bear singly placed as well as grouped peltate ramelli we do not consider this growth form as a distinct entity.

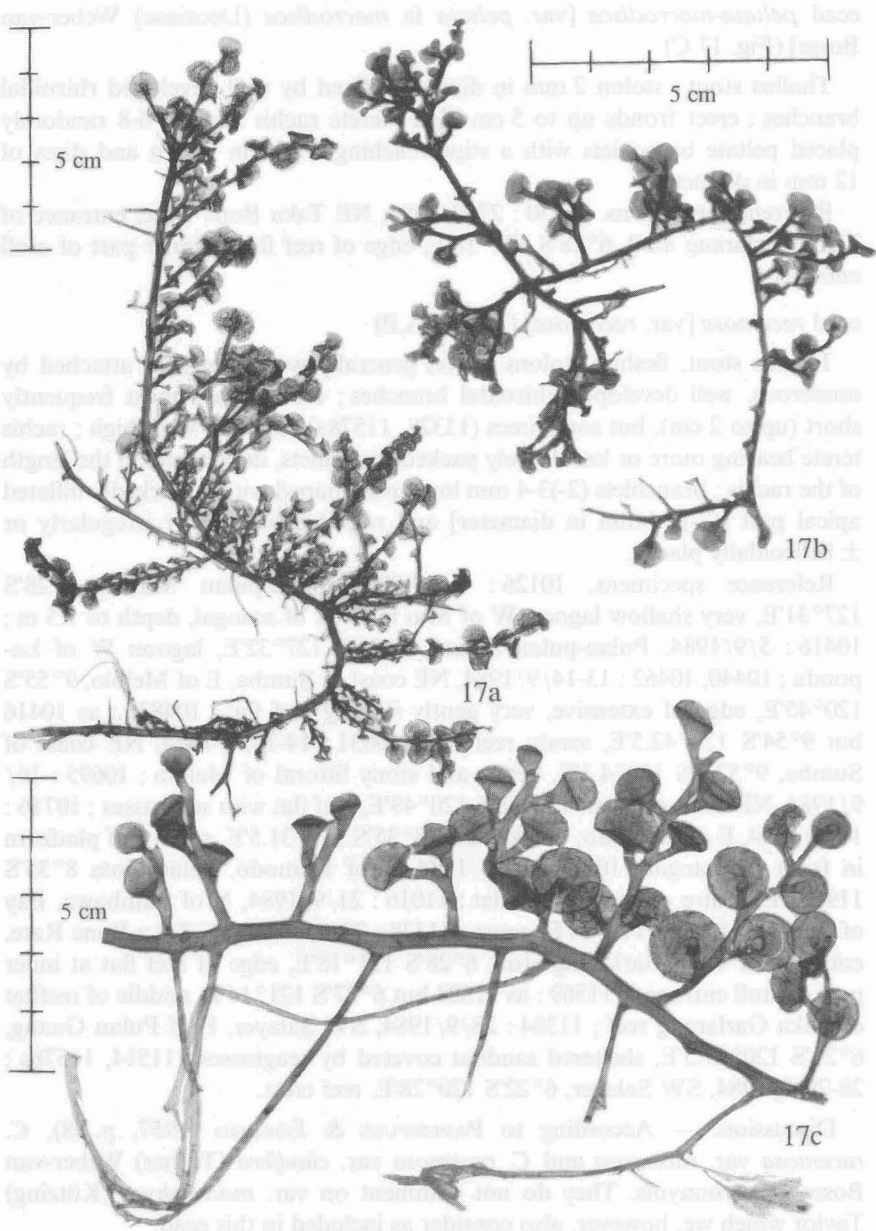


Fig. 17. — *Caulerpa racemosa* (Forsskål) J. Agardh ecad *peltata*  
A. Habit of intermediate between ecad *turbinata* and ecad *peltata* (10909 A);  
B. Habit of ecad *peltata* (11365 A);  
C. Habit of ecad *peltata-macrodisca* (11330 A).

ecad *peltata-macrodisca* [var. *peltata* fa *macrodisca* (Decaisne) Weber-van Bosse] (Fig. 17 C)

Thallus stout ; stolon 2 mm in diameter, fixed by well developed rhizoidal branches ; erect fronds up to 5 cm high ; terete rachis bearing 6-8 randomly placed peltate branchlets with a stipe reaching 5 mm in length and discs of 12 mm in diameter.

Reference specimens. 11330 : 27/9/1984, NE Taka Bone Rate, entrance of Taka Garlarang atoll, 6°28'S 121°18'E, edge of reef flat at inner part of atoll entrance.

ecad *racemosa* [var. *racemosa*] (Fig. 18 A,B)

Thallus stout, fleshy ; stolons terete, generally well branched, attached by numerous, well developed rhizoidal branches ; erect fronds most frequently short (up to 2 cm), but sometimes (11328, 11578a) reaching 4 cm high ; rachis terete bearing more or less densely packed branchlets, depending on the length of the rachis ; branchlets (2-)3-4 mm long, pearshaped with a markedly inflated apical part [(2-)3-4 mm in diameter] and rounded top, either irregularly or  $\pm$  helicoidally placed.

Reference specimens. 10126 : 7/9/1984, Pulau-pulau Maisel, 5°28'S 127°31'E, very shallow lagoon W of Mai in front of mangal, depth to 1.5 m ; 10416 : 5/9/1984, Pulau-pulau Maisel, 5°29'S 127°32'E, lagoon W of Laponda ; 10440, 10462 : 13-14/9/1984, NE coast of Sumba, E of Melolo, 9°55'S 120°45'E, edge of extensive, very gently sloping reef flat ; 10483a : as 10416 but 9°54'S 120°42.5'E, sandy reef flat ; 10631 : 14-15/9/1984, NE coast of Sumba, 9°52.5'S 120°4.3'E, beach and stony littoral of Melolo ; 10695 : 16/9/1984, NE coast of Sumba, 9°58'S 120°49'E, reef flat with seagrasses ; 10716 : 17/9/1984, E of Komodo, Teluk Slawi, 8°35'S 119°31.5'E, small reef platform in front of mangal ; 10867 : 18/9/1984, E of Komodo, Selat Linta 8°35'S 119°34'E, centre of coastal reef flat ; 11016 : 21/9/1984, N of Sumbawa, Bay of Sanggar, 8°20'S 118°14'E, coast ; 11328 : 27/9/1984, NE Taka Bone Rate, entrance of Taka Garlarang atoll, 6°28'S 121°18'E, edge of reef flat at inner part of atoll entrance ; 11369 : as 11328 but 6°27'S 121°14'E, middle of reef flat of Taka Garlarang reef ; 11384 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses ; 11514, 11578a : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, reef crest.

Discussion. — According to PAPENFUSS & EGEROD (1957, p. 88), *C. racemosa* var. *racemosa* and *C. racemosa* var. *clavifera* (Turner) Weber-van Bosse are synonyms. They do not comment on var. *macrophysa* (Kützing) Taylor which we, however, also consider as included in this ecad.

ecad *turbinata* [var. *turbinata* (J. Agardh) Eubank] (Fig. 19 A,B)

Thallus stout, fleshy ; stolons terete, thick (up to 3(-5) mm in diameter), branched, fixed by numerous well developed rhizoid-bearing branches ; erect

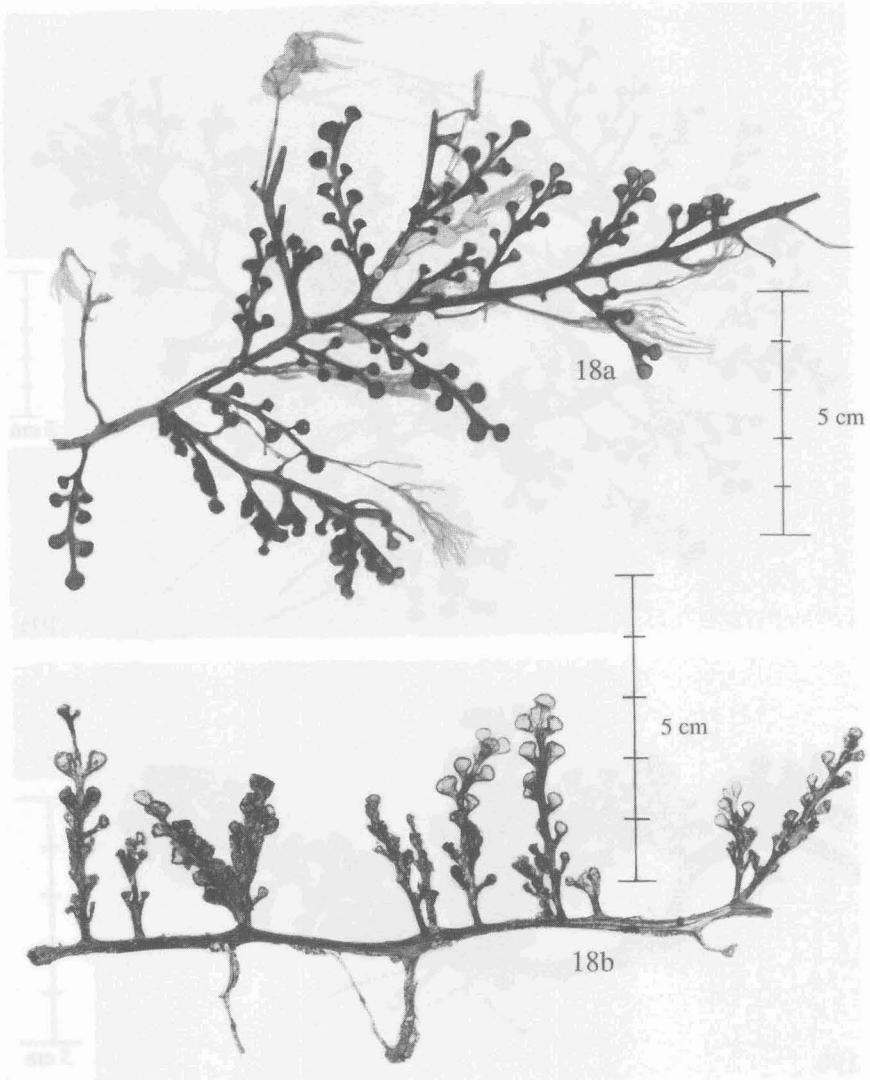


Fig. 18. — *Caulerpa racemosa* (Forsskål) J. Agardh ecad *racemosa*  
A. Habit of a slender form (11328 A);  
B. Habit of a dense form (11578 A).

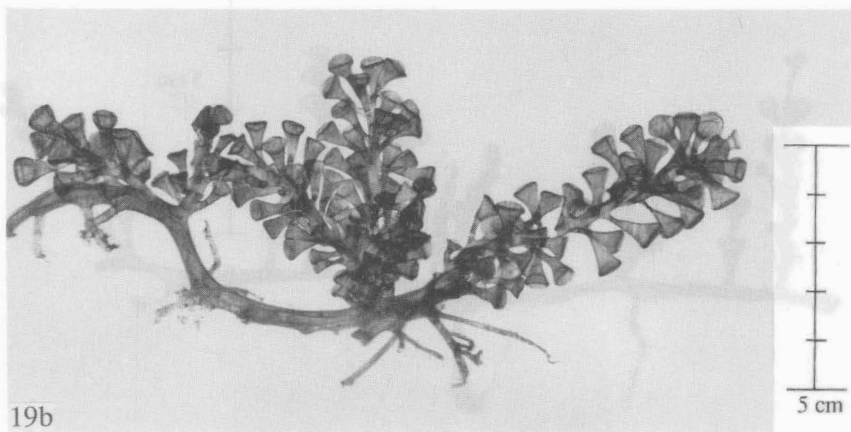
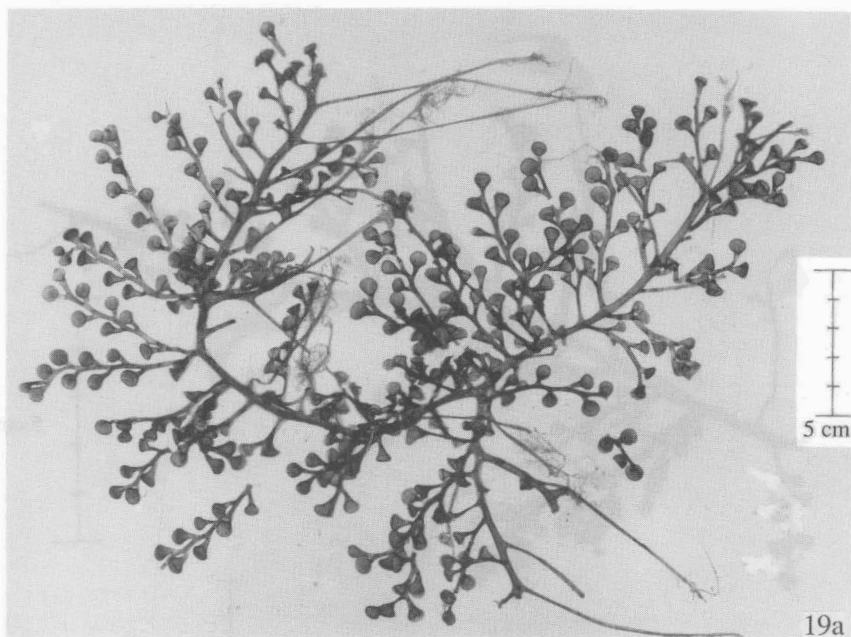


Fig. 19. — *Caulerpa racemosa* (Forsskål) J. Agardh ecad *turbinata*  
A. Habit (11329 A);  
B. Habit (10807 A).



fronds well developed, frequently 6 cm high (in 10897 even up to 17 cm); rachis terete, generally unbranched (branched in 10897), bearing radially (or helicoidally) arranged branchlets; these ramelli gradually expanding towards the apex (broadly clavate), with blunt, flat or even convex top, more or less resulting in a trumpet-shape.

Intermediate ecomorphs between ecad *laetevirens* and ecad *peltata* with turbinate branchlets agree with this description but have smaller sizes.

Reference specimens. 10807: 18/9/1984, E of Komodo, Selat Linta, 8°32.5'S 119°34'E, coastal reef flat; 10868: 18/9/1984, as 10807 but 8°35'S 119°34'E, centre of coastal reef flat; 10893, 10922: 19-20/9/1984, Komodo, NE cape, 8°29'S 119°34.1'E, steep reef slope (45°) along the edge of a narrow coastal reef; 10897: 19/9/1984, NE of Komodo, 8°29.3' S 119°35.3'E, reef slope near small Bugies Island; 11329, 11331: 27/9/1984, NE Taka Bone Rate, entrance of Taka Garlarang atoll, 6°28'S 121°18'E, edge of reef flat at inner part of atoll entrance; 11622: 30/9-1/10/1984, SW Salayer, reef N of Pulau Bahuluang, 6°27'S 120°25.8'E, edge of offshore reef.

Intermediate growth forms of *C. racemosa*

ecad *laetevirens*/*turbinata*/*peltata* (Fig. 17 A)

Branchlets with the characteristics of each of these ecads occur either on the same erect frond, either on different fronds on the same stolon.

Reference specimens. 10251: 9/9/1984, Tukang Besi Islands, inner part of SW reef of Karang Kaledupa, 5°56'S 123°46'E; 10418: 5/9/1984, Pulau-pulau Maisel, lagoon W of Laponda, 5°29'S 127°32'E; 10909: 19/9/1984, NE of Komodo, 8°32.3'S 119°35.7'E, offshore reef slope; 11642: 1/10/1984, SW Salayer, N of Pulau Bahuluang, 6°27.5'S 120°26'E, reef flat.

Discussion on *Caulerpa racemosa*

As already mentioned in the nomenclatural remark and in COPPEJANS & BEECKMAN (1989, p. 390), *C. racemosa* is an extremely variable entity with some recognizable growth forms but with at least as many intermediate ecomorphs.

Within the group of *Caulerpa*'s with vesicular branchlets from the Snellius-II expedition *C. racemosa* differs from *C. microphysa* by the absence of pyrenoids in the plastids, from *C. lentillifera* by the absence of a marked constriction in the branchlet pedicel and from *C. fergusonii* by the absence of a segmented rachis.

*Caulerpa serrulata* (Forsskål) J. Agardh emend. Børgesen

Thallus stiff to very stiff; upright fronds complanate to flat but still more or less fleshy, (pseudo-)dichotomous, in one plane or more or less strongly spirally twisted, margin dentate.

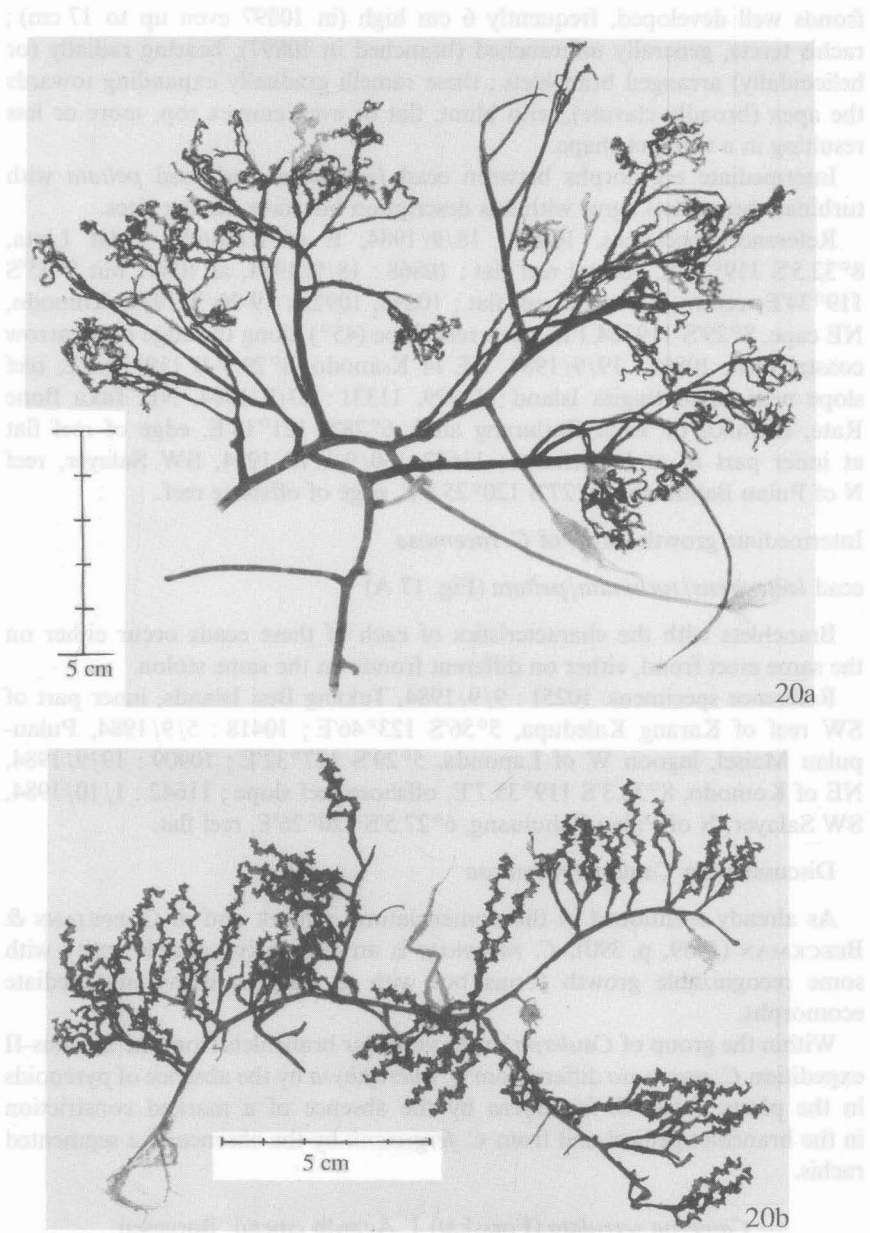


Fig. 20. — *Caulerpa serrulata* (Forsskål) J. Agardh emend. Børgesen  
A. Habit of ecad *boryana* (10407 E);  
B. Habit of ecad *serrulata* (10270 A).

ecad *boryana* [var. *boryana* (J. Agardh) Gilbert] (Fig. 20 A)

Fronds longly stipitate (up to 80 mm) ; stipe terete and scarcely ramified ; frond spirally twisted or torulose, with coarsely dentate margin ; teeth broadly attached, as high as (or even higher than) wide, mucronate.

Reference specimens. 10407 : 5/9/1984, Pulau-pulau Maisel, lagoon W of Laponda, 5°29'S 127°32'E.

Discussion. — See discussion on *C. cupressoides* ecad *flabellata*.

ecad *serrulata* [var. *serrulata*] (Fig. 20 B)

Fronds stiff, shortly stipitate, (sub-)dichotomous, varying from almost plane (only undulated) (11118, 11577) to extremely strongly spirally twisted ; height of the thallus also very variable, from 1 cm (11359) up to 7 cm (10862) ; width of the frond variable, but  $\pm 2$  mm ; frond margin coarsely serrate ; teeth broadly attached, contiguous, as high as wide, mucronate.

Reference specimens. 10097 : 7/9/1984, Pulau-pulau Maisel, reef flat N of Mai, 5°28'S 127°31'E ; 10127 : as 10097 but in very shallow lagoon W of Mai, seagrass beds in front of mangal ; 10187, 10201 : 6-7/9/1984, Tukang Besi Islands, southern reef of Karang Kaledupa, east of entrance, 5°56'S 123°48'E, seagrass meadow in lagoon ; 10208, 10224 : as 10187, but from reef flat ; 10270 : 10/9/1984, Tukang Besi Islands, coastal reef westcoast Binongko, 5°55'S 123°59'E from steep reef slope, down to -20 m ; 10294 : as 10270 but from gently sloping reef at 3-6 m depth ; 10387 : 4 & 7/9/1984, Pulau-pulau Maisel, reef edge N of Mai, 5°28'S 127°31'E, reef flat ; 10441 : 13-14/9/1984, NE coast of Sumba, E of Melolo, 9°55'S 120°45'E, on extensive, very gently sloping reef flat ; 10463 : 13-14/9/1984, NE coast of Sumba, E of Melolo, 9°55'S 120°45'E, extensive, very gently sloping reef flat, 10-15 m depth ; 10485 : NE coast of Sumba, E of Melolo, 9°54'S 120°42.5'E, sandy reef flat, gradually sloping to 12 m depth ; 10630 : 14-15/9/1984, NE coast of Sumba, stony littoral of Melolo, 9°52.5'S 120°40.3'E ; 10694 : 16/9/1984, NE coast of Sumba, 9°58'S 120°49'E, reef flat with seagrasses ; 107717 : 17/9/1984, E of Komodo, Teluk Slawi, small reef platform in front of mangal ; 10862 : 18/9/1984, E of Komodo, Selat Linta, 8°35'S 119°34'E, centre of coastal reef flat ; 11017, 11050 : 21/9/1984, N of Sumbawa, Bay of Sanggar, 8°20'S 118°14'E ; 11118 : 22/9/1984, N of Sumbawa, Bay of Sanggar, 8°22'S 118°17.9'E ; 11190 : 7/9/1984, Tukang Besi Islands, near S coast of Tomea, off Usku, 5°48'S 123°97'E, coastal reef flat ; 11210 : 25-26/9/1984, NE Taka Bone Rate, S of Tarupa Kecil, 6°30'S 121°8'E, sandy areas of reef flat ; 11232 : 25-26/9/1984, NE Taka Bone Rate, S of Tarupa Kecil, edge of reef flat, 6°30'S 121°8'E ; 11284 : 24-26/9/1984, NE Taka Bone Rate, E coast of Tarupa Kecil, 6°29'S 124°8'E, seagrass beds in front of the village ; 11359 : 27/9/1984, NE Taka Bone Rate, middle of reef flat of Taka Garlarang reef, 6°27'S 121°14'E ; 11326 : 27/9/1984, NE

Taka Bone Rate, Taka Garlarang atoll, 6°28'S 121°18'E, edge of reef flat at inner part of atoll entrance ; 11387 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses ; 11429 : 28-29/9/1984, SW Salayer, near Cape Batu Kerapo, 6°23'S 120°27'E, intertidal of bay, surrounded by cliffs, coral sand with dense seagrass beds, strong surf ; 11475 : 28/29-9-1984, SW Salayer, NW coast of Pulau Guang, 6°21'S 120°27'E, reef flat ; 11577 : as 11475 but 6°22'S 120°28'E, bare black sand and coral sand with dense algal vegetation and large seagrasses, much silt.

Discussion. — WEBER-VAN BOSSE (1898 : 313, 314) distinguishes a series of forms within *C. serrulata* var. *serrulata* [as *C. Freycinetii* Agardh var. *typica*] : fa *angusta*, fa *lata*, fa *longi-dentata*, fa *serrulata*, fa *spiralis*, fa *torulosa*. It would be possible to assign some of the Snellius-II specimens to different of these forms, but here again intermediates are so numerous that this seems useless to us.

*Caulerpa sertularioides* (Gmelin) Howe (Fig. 21 A)

Naked, terete, generally well branched stolons bearing pinnate erect branches, varying from 1 cm (11018) to 8 cm (10629) height, 5-15 mm width ; rachis terete, only rarely branched, naked at the base (2-10 mm) ; branchlets on 2 opposite rows in a single plane, terete, upwardly curved, with uniform diameter of 0.5 mm, not constricted at the base, mucronate at the apex.

Reference specimens. 10464 : 13-14/9/1984, NE coast of Sumba, E of Melolo, 9°55'S 120°45'E, extensive, very gently sloping reef flat, down to 10-15 m ; 10480 : 13/9/1984, as 10464 but 9°54'S 120°42.5'E, sandy reef flat and gradual slope, with scattered corals ; 10629 : 14-15/9/1984, NE coast of Sumba, 9°52.5'S 120°40.3'E, stony littoral of Melolo ; 10715 : 17/9/1984, E of Komodo, Teluk Slawi, 8°35'S 119°31.5'E, small reef platform in front of mangal ; 10806 : 18/9/1984, E of Komodo, Selat Linta, 8°32.5'S 119°34'E, coastal reef flat ; 10828 : 18/9/1984, as 10806 but 8°35'S 119°34'E, centre of coastal reef flat ; 11018 : 21/9/1984, N of Sumbawa, Bay of Sanggar, 8°20'S 118°14'E, coast ; 11051 : as 11018 but 8°20.3'S 118°16.4'E, coastal reef down to -8 m ; 11104 : as 11018 but 8°19.2'S 118°14.4'E, lagoon side of barrier reef ; 11117 : 22/9/1984, N of Sumbawa, Bay of Sanggar, 8°22'S 118°17.9' E, sublittoral close to Sanggar ; 11388 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses ; 11581 : 28-29/9/1984, SW Salayer, 6°22'S 120°28'E, bare black sand and coral sand with dense algal vegetation and large seagrasses, much silt.

Discussion. — All specimens seem to belong to fa *brevipes* (Weber-van Bosse) Børgesen.

*Caulerpa taxifolia* (Vahl) C. Agardh  
General appearance as in *caud taxifolia* but only the basal part of the

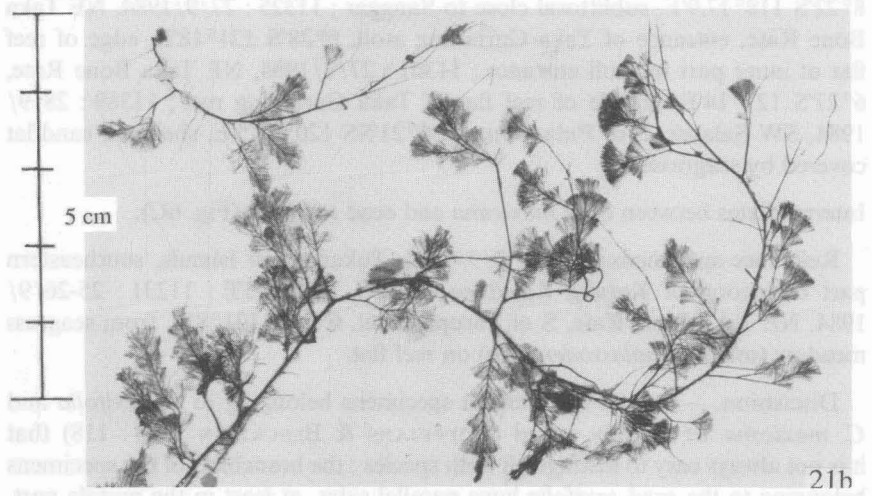
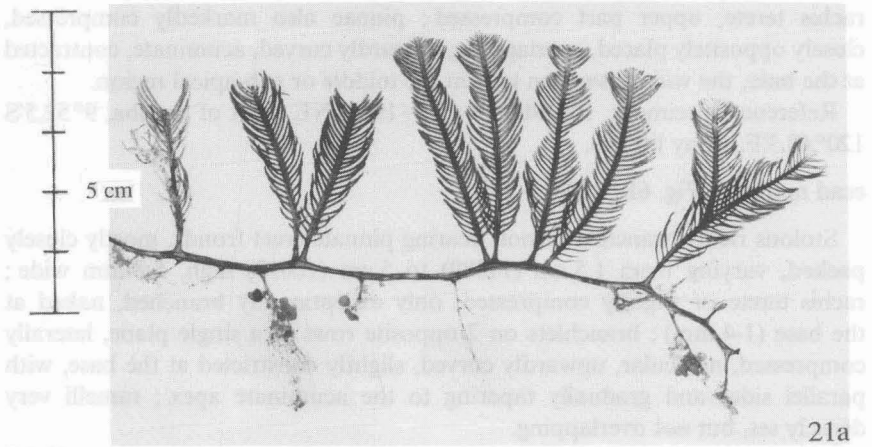


Fig. 21.  
A. Habit of *Caulerpa sertularioides* (Gmelin) Howe (10629 A);  
B. Habit of *Caulerpa verticillata* J. Agardh (11641 A).

... *C. taxifolia* are readily distinguished. (...) This is not so in the Pacific  
... *C. taxifolia* are not infrequent ... The plants for now reducing both entities  
... into synonymy as *PARVENSIS* (1956) does.

*Caulerpa taxifolia* (Vahl) C. Agardh

ecad *mexicana* [*Caulerpa mexicana*] (Sonder) J. Agardh] (Fig. 6 A, 22 A)

General appearance as in ecad *taxifolia* but only the naked part of the rachis terete, upper part compressed; pinnae also markedly compressed, closely oppositely placed, overlapping, upwardly curved, acuminate, contracted at the base, the widest, swollen part in the middle or sub-apical region.

Reference specimens. 10619b : 14-15/9/1984, NE coast of Sumba, 9°52.5'S 120°40.3'E, stony littoral.

ecad *taxifolia* (Fig. 6B, 22B)

Stolons richly branched or not, bearing pinnate erect fronds, mostly closely packed, varying from 1.5 cm (11389) to 5 cm (10619) high, 5-8 mm wide; rachis terete or slightly compressed, only exceptionally branched, naked at the base (1-4 mm); branchlets on 2 opposite rows in a single plane, laterally compressed, navicular, upwardly curved, slightly constricted at the base, with parallel sides and gradually tapering to the acuminate apex; ramelli very densely set, but not overlapping.

Reference specimens. 10619a : 14-15/9/1984, NE coast of Sumba, 9°52.5'S 120°40.3'E, stony littoral; 11121 : 22/9/1984, N of Sumbawa, Bay of Sanggar, 8°22'S 118°17.9'E, sublittoral close to Sanggar; 11325 : 27/9/1984, NE Taka Bone Rate, entrance of Taka Garlarang atoll, 6°28'S 121°18'E, edge of reef flat at inner part of atoll entrance; 11361 : 27/9/1984, NE Taka Bone Rate, 6°27'S 121°14'E, middle of reef flat of Taka Garlarang reef; 11389 : 28/9/1984, SW Salayer, E of Pulau Guang, 6°21'S 120°27.5'E, sheltered sandflat covered by seagrasses.

Intermediates between ecad *mexicana* and ecad *taxifolia* (Fig. 6C).

Reference specimens. 10305 : 9/9/1984, Tukang Besi Islands, southeastern part of lagoon of Karang Kaledupa, 5°56'S 123°47.5'E; 11231 : 25-26/9/1984, NE Taka Bone Rate, S of Tarupa Kecil, 6°30'S 121°8'E, from seagrass meadow (mainly *Thalassodendron*) on reef flat.

Discussion. — About the Kenyan specimens belonging to *C. taxifolia* and *C. mexicana* we already stated (COPPEJANS & BEECKMAN 1990 : 118) that it is not always easy to distinguish both species: the branchlets of the specimens belonging to the ecad *taxifolia* have parallel sides, at least in the middle part, whereas those of the ecad *mexicana* have a marked swollen part in the middle or subapical part, resulting in overlapping ramelli, but intermediates do exist. TAYLOR (1977 : 7) also mentions that «in western Atlantic waters *C. mexicana* and *C. taxifolia* are readily distinguished. (...) This is not so in the Pacific. Intermediates are not infrequent ...». He pleads for not reducing both entities into synonymy as PAPENFUSS (1956) does.



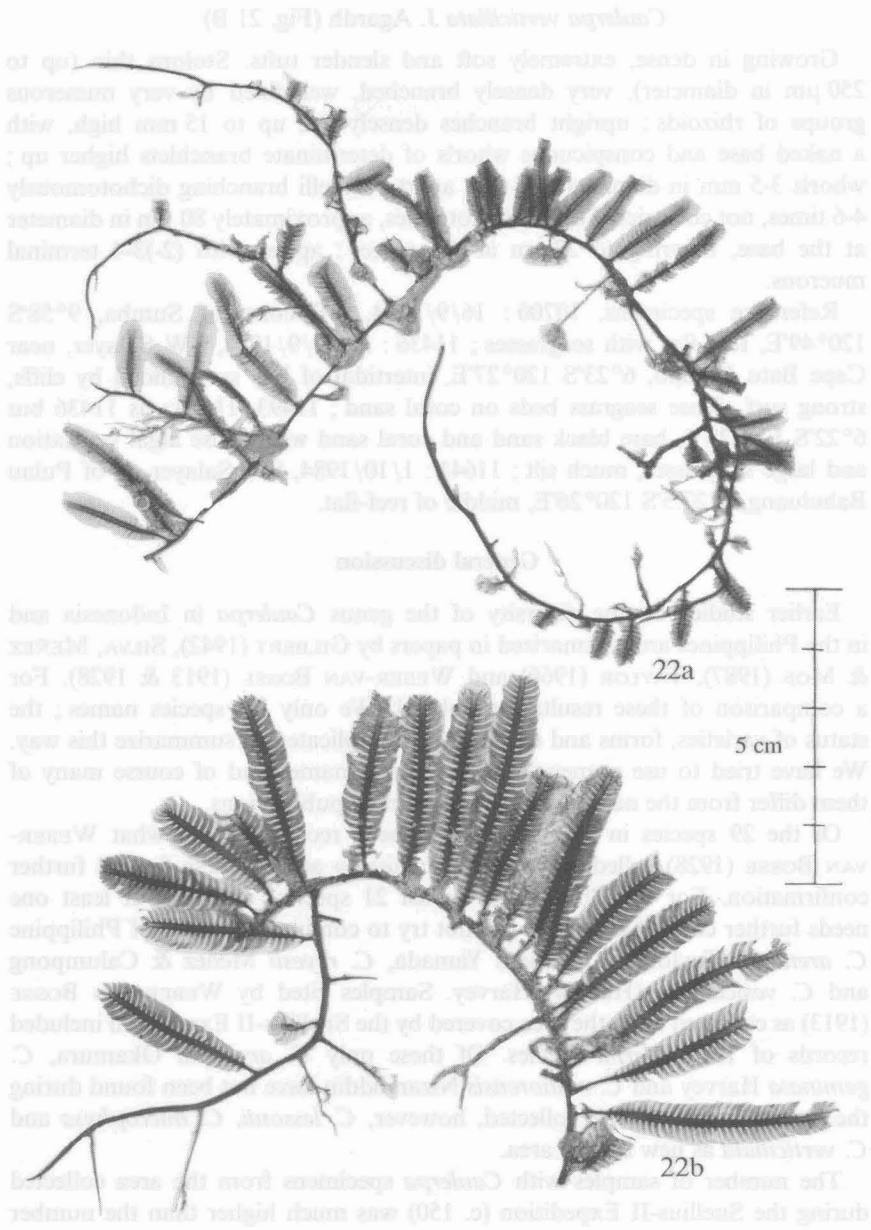


Fig. 22. — *Caulerpa taxifolia* (Vahl) C. Agardh  
A. Habit of ecad *mexicana* (11231 A);  
B. Habit of ecad *taxifolia* (11325 A).

*Caulerpa verticillata* J. Agardh (Fig. 21 B)

Growing in dense, extremely soft and slender tufts. Stolons thin (up to 250  $\mu\text{m}$  in diameter), very densely branched, well fixed by very numerous groups of rhizoids; upright branches densely set, up to 15 mm high, with a naked base and conspicuous whorls of determinate branchlets higher up; whorls 3-5 mm in diameter, 3-5 mm apart; ramelli branching dichotomously 4-6 times, not constricted at the dichotomies, approximately 80  $\mu\text{m}$  in diameter at the base, tapering to 27  $\mu\text{m}$  at the apices; apices with (2-)3-4 terminal mucrons.

Reference specimens. 10700: 16/9/1984, NE coast of Sumba, 9°58'S 120°49'E, reef flat with seagrasses; 11436: 28-29/9/1984, SW Salayer, near Cape Batu Kerapo, 6°23'S 120°27'E, intertidal of bay surrounded by cliffs, strong surf, dense seagrass beds on coral sand; 11493, 11569: as 11436 but 6°22'S 120°28'E, bare black sand and coral sand with dense algal vegetation and large seagrasses, much silt; 11641: 1/10/1984, SW Salayer, N of Pulau Bahuluang, 6°27.5'S 120°26'E, middle of reef-flat.

#### General discussion

Earlier studies on the diversity of the genus *Caulerpa* in Indonesia and in the Philippines are summarized in papers by GILBERT (1942), SILVA, MEÑEZ & MOE (1987), TAYLOR (1966) and WEBER-VAN BOSSE (1913 & 1928). For a comparison of these results see Table I. We only list species names; the status of varieties, forms and ecads is too complicated to summarize this way. We have tried to use nomenclaturally correct names and of course many of them differ from the names used in the original publications.

Of the 29 species in the list 24 have been recorded from what WEBER-VAN BOSSE (1928) called «l'Archipel Malaisien» and of these 8 need further confirmation. For the Philippines we list 21 species, of which at least one needs further confirmation. We did not try to confirm the status of Philippine *C. arenicola* Taylor, *C. filicoides* Yamada, *C. reyesii* Meñez & Calumpang and *C. vesiculifera* (Harvey) Harvey. Samples cited by WEBER-VAN BOSSE (1913) as collected from the area covered by the Snellius-II Expedition included records of 12 *Caulerpa* species. Of these only *C. ambigua* Okamura, *C. geminata* Harvey and *C. manorensis* Nizamuddin have not been found during the latter expedition. We collected, however, *C. lessonii*, *C. microphysa* and *C. verticillata* as new for the area.

The number of samples with *Caulerpa* specimens from the area collected during the Snellius-II Expedition (c. 150) was much higher than the number of samples from the area collected during the Siboga Expedition (c. 50). We are not sure, however, if WEBER-VAN BOSSE could preserve all material she collected during that expedition, visiting more than 300 stations within one year.

**Table 1**  
Records of *Caulerpa*-species from Indonesia and from the Philippines

Name	In general	Indonesia		Philippines	Notes
		Area covered by the Snellius-II Expedition in Weber-van Bosse 1913	Present paper		
<i>C. ambigua</i>	×	×	—	×	1
<i>C. arenicola</i>	—	—	—	×	—
<i>C. brachypus</i>	×	×	×	×	2
<i>C. cupressoides</i>	×	×	×	×	3
<i>C. elongata</i>	×	×	×	×	—
<i>C. fastigiata</i>	×	—	—	×	—
<i>C. fergusonii</i>	×	×	×	×	—
<i>C. filicoides</i>	—	—	—	×	—
<i>C. filiformis</i>	×	—	—	—	4
<i>C. geminata</i>	×	×	—	—	5,7
<i>C. lessonii</i>	×	—	×	×	—
<i>C. lentillifera</i>	×	×	×	×	6
<i>C. lycopodium</i>	×	—	—	—	7
<i>C. manorensis</i>	×	×	—	—	8
<i>C. microphysa</i>	×	—	×	×	—
<i>C. papillosa</i>	×	—	—	—	4
<i>C. parvula</i>	×	—	—	—	7
<i>C. racemosa</i>	×	×	×	×	9
<i>C. reyesii</i>	—	—	×	×	—
<i>C. scalpelliformis</i>	×	—	—	—	4
<i>C. selago</i>	×	—	—	×	7
<i>C. serrulata</i>	×	×	×	×	—
<i>C. sertularioides</i>	×	×	×	×	10
<i>C. simpliciuscula</i>	×	—	—	—	4
<i>C. subserrata</i>	×	—	—	×	—
<i>C. taxifolia</i>	×	×	×	×	11
<i>C. verticillata</i>	×	—	×	×	—
<i>C. vesiculifera</i>	—	—	—	×	—
<i>C. webbiana</i>	—	—	—	×	12

- (1) Is *Caulerpella ambigua* (Okamura) Prud'homme van Reine et Lokhorst (1992).
- (2) Including *C. parvifolia* Harvey and specimens recorded as *C. prolifera* (Forsskål) Lamouroux.
- (3) Including *C. lessonii* Bory, *C. pennata* C. Agardh = *C. plumulifera* Zanardini and *C. urviliana* Montagne.
- (4) Needs confirmation : we have searched in vain for specimens or for figures of specimens originating from the region.
- (5) [= *C. sedoides* (R. Brown) J. Agardh].
- (6) Including *C. kilneri* J. Agardh.
- (7) Needs confirmation, we have not tried to study this species in detail.
- (8) Recorded as *C. crassifolia* (C. Agardh) J. Agardh forma *rotundiloba* Weber-van Bosse.
- (9) Including *C. peltata* (Lamouroux) Weber-van Bosse.
- (10) Probably including the specimens of *C. selago* recorded for the region.
- (11) Including *C. crassifolia* (C. Agardh) J. Agardh, *C. falcifolia* Harvey et Bailey and *C. mexicana* Sonder ex Kützing.
- (12) Including *C. pickeringii* Harvey et Bailey.

During the Snellius-II Expedition, five phycologists collected and preserved samples from 200 stations within one month. Collecting methods during both expeditions differ a great deal and of course at many of the stations no algal material at all was present. In spite of all these differences the results of both expeditions for *Caulerpa* samples do not differ very much. Thus we can suppose that we have been able to produce a reasonable survey of the rather large diversity in *Caulerpa* in the studied area of Eastern Indonesia.

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