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MARINE ALGAE OF PAPUA NEW GUINEA (MADANG PROV.) 2. A REVISED AND COMPLETED LIST OF CAULERPA (CHLOROPHYTA-CAULERPALES)[1]

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SUMMARY

The study of marine macroalgae collected in N Papua New Guinea in 1980, 1986, 1988 and 1990 resulted in 14 species (29 entities) of *Caulerpa*: *C. biserrulata*, *C. cupressoides* (5 ecads), *C. elongata* (2 ecads), *C. filicoides* var. *andamanensis*, *C. lentillifera*, *C. manorensis*, *C. microphysa*, *C. opposita*, *C. racemosa* (8 ecads), *C. serrulata* (3 ecads), *C. sertularioides*, *C. taxifolia* (2 ecads), *C. verticillata*, and *C. webbiana* ecad *disticha*. An identification key is added.

INTRODUCTION

In a previous paper (Coppejans & Meinesz, 1988) descriptions and illustrations are given of the *Caulerpa*s collected in 1980 and 1986 in the Hansa Bay (Bogia) area mainly. Thirteen taxa (11 species and 2 varieties) were then treated.

Since then we had the opportunity to study *Caulerpa* material from Kenya (Coppejans & Beeckman, 1989, 1990) and from Indonesia (Coppejans & Prud'homme van Reine, 1992) resulting in a change of our varietal concept, especially in the extremely variable species *C. cupressoides*, *C. racemosa*, and *C. serrulata*. We therefore prefer to use the designation ecad rather than var. (Coppejans & Prud'homme van Reine, l.c.).

MATERIAL AND METHODS

After 1986 supplementary seaweed collections have been made from June to August 1988 between Ulingan Bay and Hansa Bay as well as in the Madang area (map: C) and in Astrolabe Bay (Saidor area) (map: B): herbarium specimens numbers HEC 7444–8102. In July and August 1990 collecting was mainly done in the Madang area: herbarium specimens numbers 13000–13866. In 1986 research was carried out at the Laing Island Biological Station (Bogia), in 1991 in the Christensen Research Station (Madang). The position of the collecting sites, according to the Papua New Guinea 1 : 100,000 Topographic Survey Maps is given in the following alphabetically arranged list. They are indicated approximately on map B and C. From W to E the following maps were used: Watam (7890), Nubia (7889), Manam (7989), Adelbert (7988), Karkar (8088), Madang (8087), Bagabag (8188), Saidor (8186).

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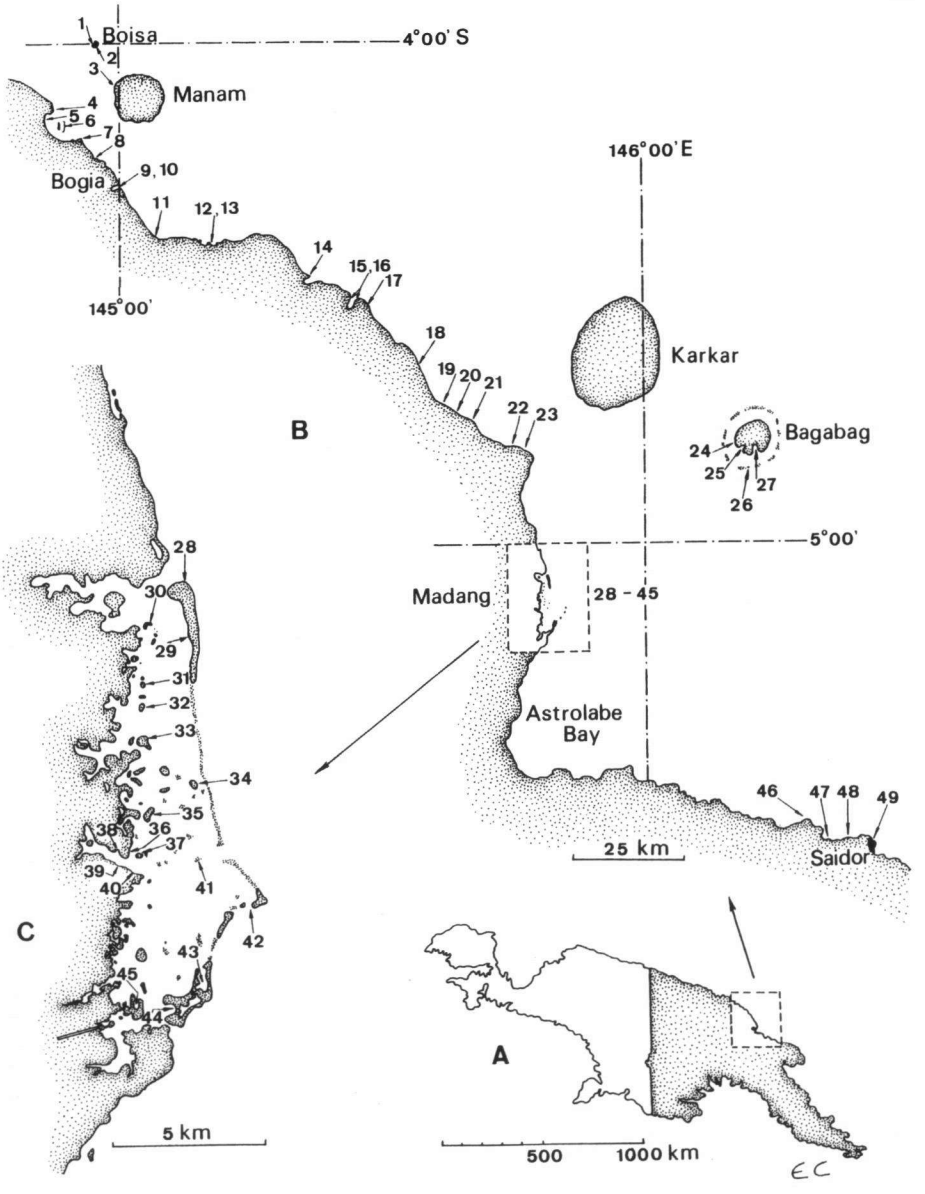

Maps. — A: Position of Madang Prov. in Papua New Guinea (boundaries approximate). — B: Coast of Madang Prov. with sampling stations; 1: Boisa N; 2: same S; 3: Manam (Baliau); 4: Awar Point; 5: Awar; 6: Laing I. area; 7: Hansa Point; 8: Malagere I.; 9: Bogia Bay; 10: Kolakola & Reamuna Is.; 11: Suaru; 12: Chirimosh I.; 13: Hatzfeldthafen; 14: Malala village; 15: Ulingan Bay W; 16: same, E; 17: Neptune Point; 18: Murukinam; 19: Sarang Harbour; 20: Walog; 21: Megiar Harbour; 22: Mugil Harbour; 23: Hole in the Wall; 24: Badilu village; 25: Christmas Bay; 26: New Year's Bay; 27: The Pinacle; 46: Cape Iris/Biliau; 47: Suit; 48: Gumbi Bay; 49: Saidor. — C: Detail of the Madang lagoon area with sampling stations; 28: Sek I., N; 29: same W; 30: Megas I.; 31: D'Lole I.; 32: Tausch I.; 33: Malamal I.; 34: Wongat I.; 35: Demasa I.; 36: Jais Aben Resort; 37: Gosem I.; 38: Christensen Research Institute; 39: in front of same; 40: in front of Gosem I.; 41: Padoz Tinan; 42: Tab I.; 43: Kranket I., enclosed bay; 44: same, SW bay; 45: Beliau I.

Location		Map	Coordinates	coord. S	coord. E	Nr. on map
Awar		Nubia	BR 607 413	5° 17	147° 38	5
Awar Point		Nubia	BR 633 425	4° 08	144° 52	4
Bagabag	Badilu village	Bagabag	DQ 109 703	4° 48	146° 12	24
	Christmas Bay		DQ 118 678	4° 49	146° 12	25
	New Year's Bay		DQ 148 673	4° 49	146° 14	26
	The Pinacle		DQ 150 641			27
Beliau Island		Madang	CQ 675 252	5° 12	145° 49	45
Bogia Bay		Nubia	BR 746 250	4° 18	144° 58	9
Boisa	N	Watam	BR 733 583	4° 00	144° 58	1
	S	Nubia	BR 743 572			2
Cape Iris/Biliau		Saidor	DP 270 838	5° 35	146° 20	46
Chirimosh Island		Manam	CR 003 138	4° 23	145° 14	12
Demasa Island		Madang	CQ 677 313			35
D'Lole Island		Madang	CQ 676 355	5° 11	145° 49	31
Gosem Island		Madang	CQ 675 298	5° 09	145° 50	37
Gumbi Bay		Saidor	DP 368 795	5° 37	146° 26	48
Hansa Point		Nubia	BR 685 363	4° 11	144° 54	7
Hatzfeldthafen		Manam	CR 013 140	4° 24	145° 13	13
Hole in the Wall		Karkar	CR 660 650			23
Jais Aben Resort		Madang	CQ 673 299			36
Kolakola & Reamuna Islets		Nubia	BR 754 258 & BR 754 261	4° 17	144° 59	10
Kranket Island enclosed bay		Madang	CQ 697 257	5° 12	145° 49	43
	SW bay	Madang	CQ 685 248			44
Laing Island		Nubia	BR 637 385	4° 11	144° 52	6
Malagere Island		Nubia	BR 715 322	4° 14	144° 57	8
Malala Village		Manam	CR 182 094	4° 27	145° 22	14
Malamal Island		Madang	CQ 675 336	5° 07	145° 48	33
Manam		Nubia	BR 770 528	4° 05	145° 02	3
Megas Island (Alexishafen)		Madang	CQ 679 375	5° 05	145° 50	30
Megiar Harbour		Karkar	CR 632 678	4° 49	145° 46	21
Mugil Harbour		Karkar	CR 641 659	4° 50	145° 47	22
Murukinam		Karkar	CR 415 873	4° 38	145° 34	18
Nagada Harbour CRI area		Madang	CQ 668 299	5° 10	145° 49	38
in front of CRI		Madang	CQ 668 296			39
in front of Gosem Island		Madang	CQ 675 293			40
Neptune Point		Manam	CR 284 030	4° 29	145° 49	17
Padoz Tinan (submerged patch reef)		Madang	CQ 688 300			41
Pig Island (see Tab Island)						
Saidor		Saidor	DP 417 770	5° 38	146° 28	49
Sarang Harbour		Karkar	CR 722 565	4° 46	145° 42	19
Sek Island	W	Madang	CQ 690 370	5° 06	145° 49	29
	N		CQ 688 388			28
Suaru		Manam	BR 881 161	4° 23	145° 05	11
Suit		Saidor	DP 327 792	5° 37	146° 24	47
Tab Island (= Pig Island)		Madang	CQ 713 285	5° 08	145° 49	42
Tausch Island		Madang	CQ 675 348	5° 07	145° 49	32
Ulingan Bay	W	Manam	CR 247 032	4° 29	145° 25	16
	E		CR 251 026			17
Walog		Karkar	CR 572 712	4° 48	145° 43	20
Wongat Island (Wonad Island)		Madang	CQ 692 322	5° 08	145° 49	34

Collecting and preparation of the specimens was done as mentioned in Coppejans & Meinesz (1988). The 1988 specimens are deposited in the Herbarium of the State University Gent (GENT); in 1990 duplicates have been made; the A collection is in Leiden, B in Gent, C in the Christensen Research Institute, D in the University of Papua New Guinea (Port Moresby), E in the Herbarium of Lae (the C, D, E collections are incomplete).

All the drawings were made by the author from collected material, details have been drawn by camera lucida.

IDENTIFICATION KEY OF CAULERPA FROM MADANG PROVINCE

1a. Erect parts entire, blade-like, unbranched (rarely proliferating from the middle part), lanceolate, provided with small marginal teeth which are generally grouped in two's ..... **C. biserrulata**
b. Erect part variously branched, divided or incised. 2
2a. Branchlets either peltate or vesicle-like (spherical, clavate or turbinate) 3
b. Branchlets filiform or spiny or strap-like and with dentate margin or strongly compressed and with pinnate aspect 16
3a. Branchlets peltate (stalk-like lower portion abruptly expanded into a horizontally spread structure) 4
b. Branchlets not peltate but vesicle-like 5
4a. Horizontally spread structure disciform with entire margin
C. racemosa ecad **peltata**
b. Horizontally spread structure like a snow crystal
C. filicoides var. **andamanensis**
5a. Branchlets gradually enlarged from base to apex (clavate), with rounded or flattened apex 6
b. Branchlets (sub)spherical and sessile on the erect shoots or abruptly expanded into a (sub)spherical top from the terete or constricted stalk-like lower portion 11
6a. Ends of branchlets flattened ..... **C. racemosa** ecad **turbinata**
b. Ends of branchlets rounded 7
7a. Branchlets on longitudinal rows (or sometimes rare to absent, but then the rachis markedly compressed) 8
b. Branchlets radially arranged 10
8a. Rachis at least partly compressed to complanate (sometimes even foliose), with some (rare) opposite vesicle-like branchlets (sometimes even completely naked)
C. racemosa ecad **corynephora-lamourouxii**
b. Rachis completely terete, vesicle-like branchlets numerous 9
9a. Thallus stout, stolon thick, rhizoidal branches well developed, upright branches 15–20 mm wide; branchlets ± wide-angled, on 2, 3 or 4 rows
C. racemosa ecad **macra**
b. Thallus more slender, upright branches up to 10 mm wide; branchlets narrow-angled, always on 2 opposite rows ..... **C. racemosa** ecad **corynephora**
10a. Branchlets crowded, gradually clavate .... **C. racemosa** ecad **laetevirens**
b. Branchlets not crowded with a slender pedicel which is at least as long as the diameter of the markedly inflated part .... **C. racemosa** ecad **occidentalis**

11a. 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 12
b. Vesicle-like branchlets larger; neither a constricted pedicel nor plasts with pyrenoids 13
12a. Stalk-like portion markedly constricted; numerous vesicle-like branchlets very densely packed, ± in longitudinal rows along the erect branches; plasts without pyrenoids . . . . . **C. lentillifera**
b. Stalk-like portion not constricted; vesicle-like branchlets less numerous, more irregularly grouped; plasts with pyrenoids . . . . . **C. microphysa**
13a. Rachis compressed, (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 **C. racemosa** ecad **racemosa-lamourouxii**
b. Rachis terete, branchlets numerous, densely set (without naked portions on the upright branches, except for the basal part) 14
14a. Branchlets on 2 opposite longitudinal rows, dorsoventrally compressed (blunt apices), blackish green; plasts with pyrenoids . . . . . **C. opposita**
b. Branchlets not on longitudinal rows 15
15a. Branchlets with a slender pedicel which is at least as long as the diameter of the markedly inflated part, resulting in a slender habit **C. racemosa** ecad **occidentalis**
b. Pedicels shorter, resulting in a more stout habit; erect shoots either short (1–2 cm), bearing only a few branchlets, resulting in a prostrate thallus or longer, bearing numerous branchlets; spherical part of the branchlets 1–2 mm wide (or more), shortly stipitate . . . . . **C. racemosa** ecad **racemosa**
16a. Branchlets in whorls 17
b. Branchlets not in whorls but dichotomous or opposite 18
17a. Verticils conspicuous, well separated; branchlets rather long and elegant, souple, 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** ecad **elongata**
18a. Upright branches markedly compressed 19
b. Upright branches terete or only slightly compressed; the branchlets also terete, reduced to mucrons or compressed 22
19a. Frond strap-like, generally unbranched, thin, with deeply lobed, smooth margins . . . . . **C. manorensis**
b. Frond (pseudo)dichotomous with teethed margin; teeth varying from long and terete (short branchlets) to short and broadly attached 20
20a. Frond with long (several cm) unbranched terete stipe and long, narrow, (sub)-dichotomous, compressed, straight, vertical fronds; marginal teeth very small, distant . . . . . **C. serrulata** ecad **boryana-occidentalis**
b. Frond shortly stipitate (< 1 cm) 21
21a. Frond generally spirally twisted and ± horizontally spread, marginal teeth well marked and serial . . . . . **C. serrulata** ecad **serrulata**
b. Rachis generally not twisted, vertical; margin set by upwardly curved, mucronate branchlets . . . . . **C. serrulata** ecad **pectinata**

22a. Branchlets terete, spiny or reduced to mucrons. 23
b. Branchlets complanate (at least slightly compressed dorsoventrally). 31
23a. Branchlets (sub)dichotomous, mucronate 24
b. Branchlets not ramified. 25
24a. Stolonoids also (partly) covered by branchlets . . **C. elongata** ecad **disticha**
b. Stolonoids without branchlets but with numerous rhizoids
C. webbiana ecad **disticha**
25a. Branchlets short (1–3 mm), spiniform, on 2 opposite or 3 longitudinal rows, or reduced to irregularly placed mucrons. 26
b. Branchlets longer (4–5 mm), on 2 opposite rows 30
26a. Upright branches terete, subdichotomous, often 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. 27
27a. At least the basal branchlets markedly inflated, generally not longer than the diameter of the rachis, densely packed . . **C. cupressoides** ecad **mamillosa**
b. Branchlets not markedly inflated but terete. 28
28a. 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 three longitudinal rows . . . **C. cupressoides** ecad **cupressoides**
b. Frond rather slender, the branchlets not constricted at the base, on 2 opposite rows. 29
29a. 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 rachis . . . . . **C. cupressoides** ecad **lycopodium-elegans**
30a. Total width of the frond not exceeding 4 mm
C. cupressoides ecad **lycopodium-elegans**
b. Total width of the frond generally 10–15 cm (rarely down to 7 mm)
C. sertularioides
31a. 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**

DESCRIPTIONS

Caulerpa biserrulata Sonder

The specimens described and illustrated in Coppejans & Meinesz (1988: 184, 194, fig. 35–38) do not belong to *C. brachypus* Harvey as stated in that article, but to *C. biserrulata* as most of the teeth are composed of 2 or 3 double spines; some teeth of the same fronds are simple. *Caulerpa brachypus* s.s. has not been collected in PNG yet.

Reference material – HEC 8015: 1-8-1988, Ulingan Bay (W-side), vertical coral wall, -6 m; HEC 8081: 15-6-1988, Murukinam, vertical coral wall just under low water mark; 13686 (A, B, C): 18-8-1990, Mugil Harbour, as undergrowth of larger algae, horizontal coral surface, -8 m.

Discussion – Several authors have been discussing synonymies within the *C. brachypus* group (Gilbert, 1942: 2; Papenfuss & Egerod, 1957: 86; Taylor, 1967: 46), putting *C. parvifolia* Harvey, *C. anceps* Harvey ex J. Agardh, *C. mauritiana* Børgesen, *C. simplex* Levring, and *C. stahlii* Weber-van Bosse in *C. brachypus* Harvey. Papenfuss & Egerod (l.c.) suggest that *C. subserrulata* Okamura and *C. biserrulata* may also be synonyms of *C. brachypus*. For *C. subserrulata* they follow suggestions by Weber-van Bosse (1913: 98; 1928: 89), but for *C. biserrulata* they only suggest the possibility. This is later supported by Taylor (1967). Study of herbarium specimens (in L) of *C. subserrulata* and *C. biserrulata* from Papua New Guinea do not endorse these statements (Prud'homme van Reine, pers. comm.).

Caulerpa cupressoides (Vahl) C. Agardh

As described in Coppejans & Prud'homme van Reine (1992), but the stolons rather scarcely ramified.

Remark – Just as in other regions *C. cupressoides* grows here in an almost unending series of ecomorphs in which some 'characteristic' ones can be recognized. They have formerly been described as many varieties or formas, but because of the presence of so many intermediates we consider them as ecads.

ecad **cupressoides** [var. *cupressoides*] – Fig. 1C.

As in Coppejans & Prud'homme van Reine (l.c.).

Reference material – HEC 6489: 17-8-1986, Suaru, sandy bottom between seagrasses and coral boulders, sheltered area, -1 m; HEC 6544: 20-8-1986, Ulingan Bay (W-side), sunny, sandy patches in a rockpool on fossil coral platform, midlittoral; 13718 (A, B): 18-8-1990, in front of Malala village, close to the beach, on sand, just below low water mark, down to -0.5 m.

ecad **lycopodium-disticha** (var. *lycopodium* Weber-van Bosse forma *disticha* Weber-van Bosse) – Fig. 1B.

As in Coppejans & Prud'homme van Reine (l.c.).

Reference material – HEC 6531: 18-8-1986, Megiar Harbour, silty sand, sheltered habitat, -0.5/-1 m, between seagrasses, small specimens; 13039 (A, B): 9-7-1990, Nagada Harbour, in front of CRI on silty sand, -4 m at low tide; 13326 (B): 21-7-1990, Ulingan Bay (W-side), sand covered pool on fossil reef platform, low midlittoral; 13800 (A, B): 22-8-1990: lagoon between Sarang Harbour and Walog, sandy bottom between coral boulders, -0.5 m, close to the beach.

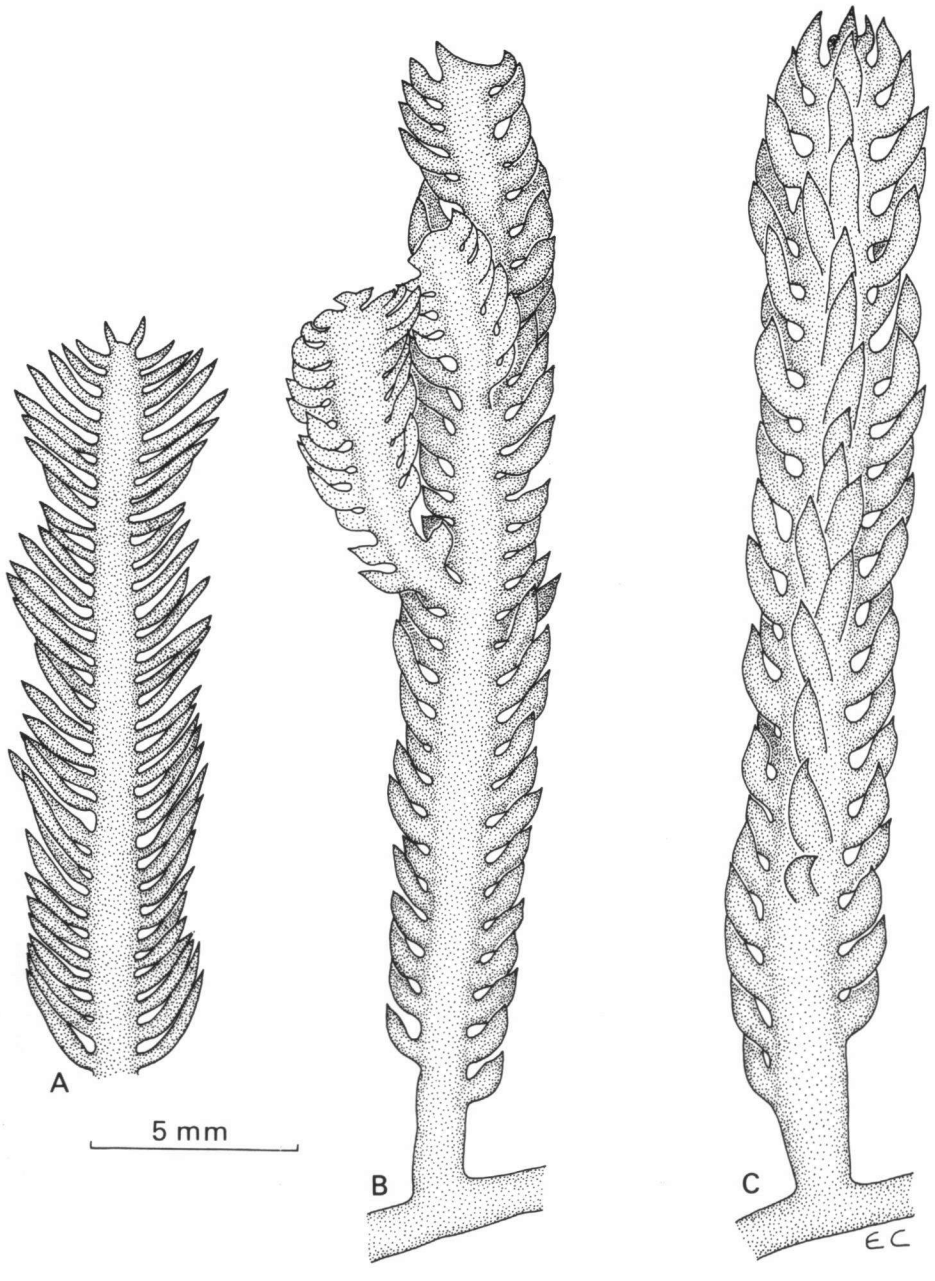

Fig. 1. *Caulerpa cupressoides* (Vahl) C. Agardh: A. ecad *lycopodium-elegans* (13601B); B. ecad *lycopodium-disticha* (13600B p.p.); C. ecad *cupressoides* (13600B p.p.).

ecad **lycopodium-elegans** [var. *lycopodium* Weber-van Bosse forma *elegans* (Crouan frat.) Weber-van Bosse] – Fig. 1A.

As in Coppejans & Prud'homme van Reine (l.c.).

Reference material – 13601 (B): 7-8-1990, Nagada harbour, in front of Gossem Isld, on horizontal surface of dead coral boulders.

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

Some fronds with shorter ramuli (ecad *lycopodium-disticha*), others on the same stolon with longer ramuli (ecad *lycopodium-elegans*).

Reference material – HEC 7504a: 20-6-1986, Nagada Harbour, in front of CRI, silty sand, -4 m at low tide.

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

Some fronds with at least some ramuli on 3 rows (ecad *cupressoides*); other fronds on the same stolon with all ramuli on 2 opposite rows (ecad *lycopodium-disticha*).

Reference material – HEC 7464: 17-6-1988, Kolakola Islet and Reamuna Islet (Bogia Bay), sand with small coral rubble, close to the water surface at low tide, sheltered side of the islands; HEC 7880: 21-7-1988, Chirimosh Isld (Hatzfeldt-hafen), shallow, sheltered channel between reef platform and the island, coarse sand, -0.5 m; 13600 (A, B): 7-8-1990, Nagada Harbour, in front of Gossem Isld, on horizontal surface of dead coral boulders in beach lagoon, very shallow water, close to the beach; 13637 (A, B, C): 8-8-1990, Bagabag, SE Point of Christmas Bay, on horizontal, sand-covered coral substrate between coral boulders, -0.5/-1 m.

ecad **mamillosa** [var. *mamillosa* (Montagne) Weber-van Bosse]

As in Coppejans & Prud'homme van Reine (1992), but only a few lowermost branchlets are markedly inflated and closely packed.

Reference material – 13718 (A, B) p.p.: 18-8-1990, in front of Malala village, on sand, just below low water mark, down to -0.5 m, close to the beach.

ecad **urvilliana** [*Caulerpa urvilliana* Montagne] – Fig. 2.

Frond with long (1–1.5 cm), unbranched, terete stipe and densely pseudodichotomously ramified branches; these irregularly curled, terete, and covered by numerous perpendicularly placed, mucronate, warty branchlets.

Reference material – 13720 (A, B): 18-8-1990, in front of Malala village, on sand, just under low water mark, down to -0.5 m, close to the beach.

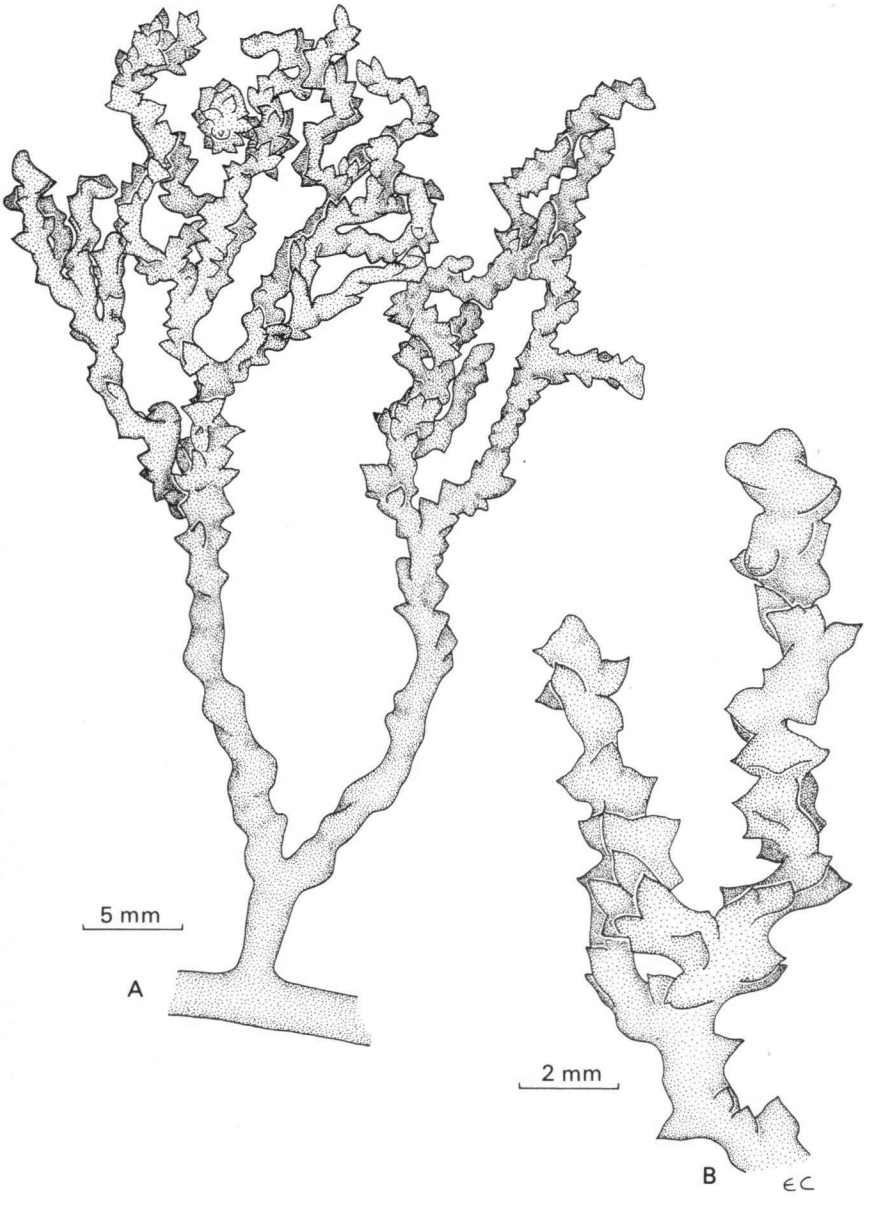

Fig. 2. *Caulerpa cupressoides* (Vahl) C. Agardh ecad *urvilliana*: A. Morphology of a pseudodichotomous, torulose, upright branch; B. detail of a subapical part of A: irregularly placed, warty, mucronate branchlets.

Caulerpa elongata Weber-van Bosse – Fig. 3.

ecad **elongata** – Fig. 3B–F.

As in Coppejans & Prud'homme van Reine (1992).

Reference material – HEC 6467: 15-8-1986, Laing Island, vertical and overhanging walls of coral boulders in the lagoon, -1.5 m; HEC 6513: 17-8-1986, Suaru, ecology as 6467, -0.5/-1 m; HEC 6663: 10-7-1986, Laing Island, ecology as 6467; HEC 7449: 17-6-1988, Kolakola and Reamuna Islets., hanging down from a vertical coral wall, -3 m, very large specimen (erect branches up to 8 cm high!); HEC 7522: 21-6-1988, Wongat Isld, inner side of fringing reef, on coral rubble, -20 m; HEC 7850: 19-7-1988, Suaru, ecology as 6467; HEC 7953: 25-7-1988, Suit (Saidor area), ecology as 6467; HEC 8001: 28-7-1988, seaward side of Wongat Isld, vertical coral wall, -2 m; HEC 8098: 16-6-1988, Laing Island lagoon, ecology as 6467; 13528 (A, B): 2-8-1990, Bagabag, NW point of Christmas Bay, reef flat, ecology as 6467; 13660 (A, B): 15-8-1990, N of Tab Isld, inner slope of reef, on coral rubble, -8 m.

ecad **disticha** [forma *disticha* W.R. Taylor] – Fig. 3A.

Branchlets on the erect axes not in verticils but on 2 opposite rows, resulting in a more slender, pinnate aspect.

Reference material – HEC 6469: 15-8-1986, Laing Island, vertical and overhanging walls of coral boulders in the lagoon, -1.5 m; 13486 (A, B): 2-8-1990, Bagabag, NW point of Christmas Bay, on and between *Halimeda copiosa*, steep reef slope, -10 m.

Intermediate between ecad *elongata* and ecad *disticha*

Some fronds with verticillate branchlets, others on the same stolon with opposite ramuli.

Reference material – HEC 7522: 21-6-1988, Wongat Isld, inner slope of the fringing reef, on coral rubble, -20 m; 13572 (A, B, C): 5-8-1990, N of Tab Isld, ecology as 7522, -25 m.

Caulerpa filicoides Yamada var. **andamanensis** Taylor

As in Coppejans & Meinesz (1988: 184, 187 figs. 12–14).

Reference material – HEC 8033: 1-8-1988, W-side of Ulingan Bay, horizontal, silt covered coral surface, -3/-10 m, turbid water, extensive populations; 13556 (A, B, C): 2-8-1990, Bagabag, The Pinacle, S of New Year's Bay, on coral and sand-covered coral on small platforms of the vertical reef wall, -30 m; 13768 (A, B): 20-8-1990, N coast of Boisa, on horizontal coral surface under overhanging walls, -35 m.

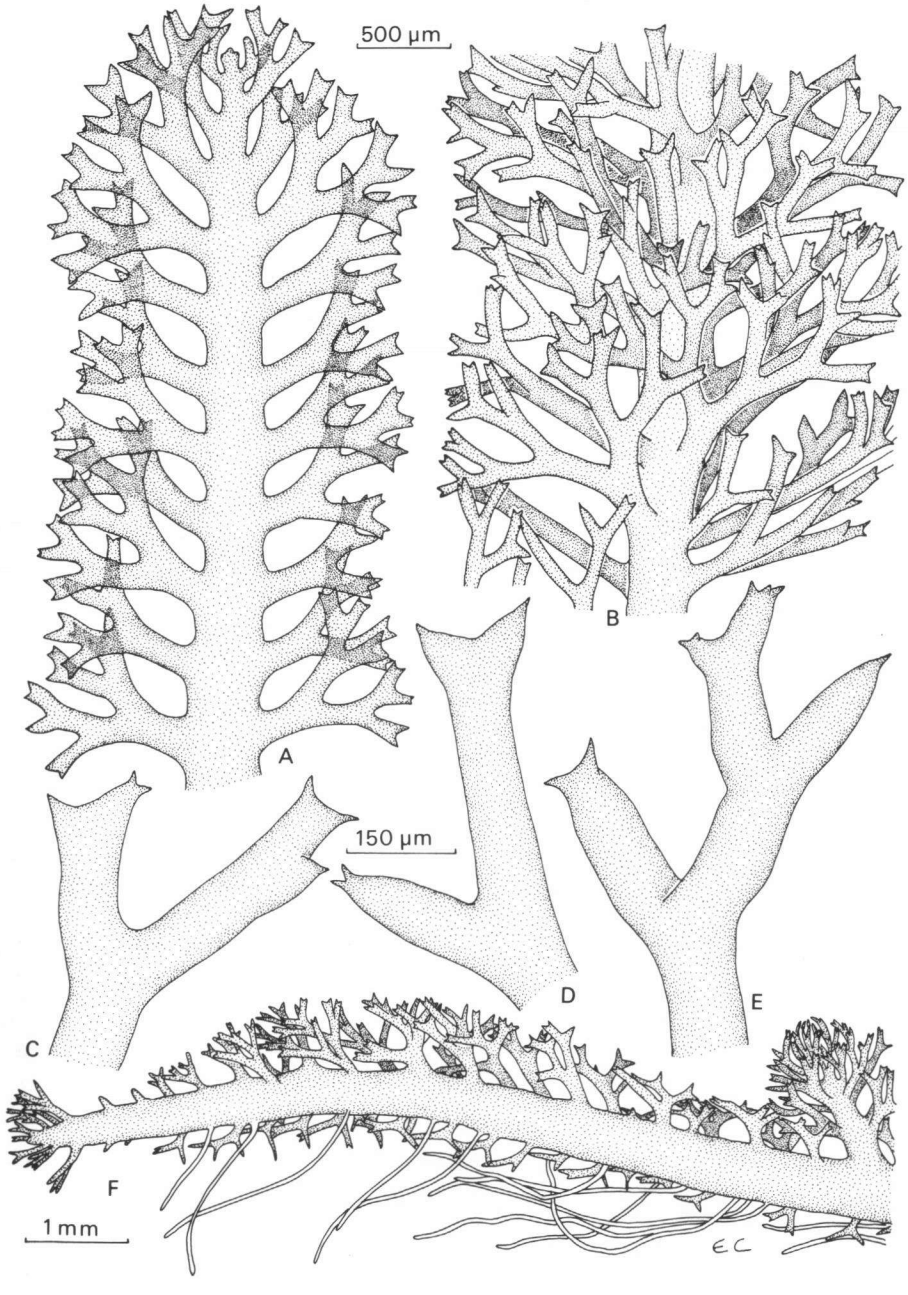

Fig. 3. *Caulerpa elongata* Weber-van Bosse. A. ecad *disticha*: upright branch with distichously placed branchlets (13486B); B. ecad *elongata*: intermediate part of an upright branch with branchlets in verticils; C, D, E. details of the pseudodichotomous mucronate branchlets; F. apical part of stolon, covered with short branchlets (13660B) (>< *C. webbiana*).

Caulerpa lentillifera J. Agardh

As in Coppejans & Meinesz (1988: 184).

Reference material – HEC 7506: 20-6-1988, patch reef in front of Jais Aben Resort, on coarse sand, sheltered between coral boulders, -4 m; HEC 7563: 23-6-1988, enclosed bay of Kranket Isld, on silty sand, -1 m, under a mangrove tree; HEC 7938: 25-7-1988, Gumbi Bay, sandy bay at inner slope of the reef, moderately coarse sand, -2 m; HEC 7958: 25-7-1988, Suit, coarse sand between pebbles, -0.5 m; HEC 8039: 2-8-1988, Nagada harbour (CRI area), sandy bottom, -6 m; 13071 (A, B): 10-7-1990, Beliau Isld, on vertical wall of a spunge covered coral boulder, -2 m; 13132 (A, B): 13-7-1990, enclosed bay of Kranket Isld, on coarse coral sand, -1 m; 13164 (A, B): 15-7-1990, island N of Demasa Isld, growing in a large tuft of *Dictyota* and on coarse coral sand, -3 m; 13550 (A, B): 2-8-1990, Bagabag, New Year's Bay, reef flat, vertical wall of coral boulder, -0.5 m.

Caulerpa manorensis Nizamuddin

As in Coppejans & Meinesz (1988: 186).

Reference material – HEC 7627: 29-6-1988, Laing Isld, coarse sand, subhorizontal substrate, -35 m; HEC 7779: 14-7-1988, Malagere Isld, silty sand, -22 m; HEC 7890: 21-7-1988, Bogia Bay, silty bottom, -22 m; 13743 (A, B): 19-8-1990, Awar, extremely silty, subhorizontal substrate, -10 m; 13799 (A, B): 22-8-1990, lagoon between Sarang Harbour and Walog, on sandy-silty, subhorizontal lagoon bottom, subjected to strong tidal current, -15 m.

Caulerpa microphysa Feldmann

As in Coppejans & Meinesz (1988: 190).

Reference material – HEC 4273: 1-6-1980, Laing Isld, inner reef slope, vertical walls of dead coral boulder, -12 m; HEC 6468: 15-8-1986, Laing Isld, vertical and overhanging walls of coral boulders in the lagoon, -1.5 m; HEC 7757: 13-7-1988, Laing Isld, on silty sand, -22 m; HEC 7970: 26-7-1988, Cape Iris-Biliau, silty-sandy bottom of the lagoon, -18 m; 13197 (A, B, C): 17-7-1990, S of Wongat Isld, inner slope (45°) of fringing reef, *Halimeda*-sand, -20/-30 m; 13646 (B): 8-8-1990, Bagabag, in front of Badilu village, reef slope, coarse coral sand, -25 m; 13663 (B): 15-8-1990, Tab Isld, basal part of inner reef slope, coral sand, -27 m.

Caulerpa opposita Coppejans & Meinesz

As in Coppejans & Meinesz (1988: 190).

Reference material – HEC 6461: 15-8-1986, Laing Isld, on coarse sand, under overhanging wall of coral boulder, lagoon, -1 m (!); HEC 6492: 17-8-1986, in sand between seagrasses, under overhanging coral wall, -1 m (!); HEC 7533: 21-6-1988, Wongat Isld, inner and outer side of the fringing reef, on coral and coral rubble, -20/

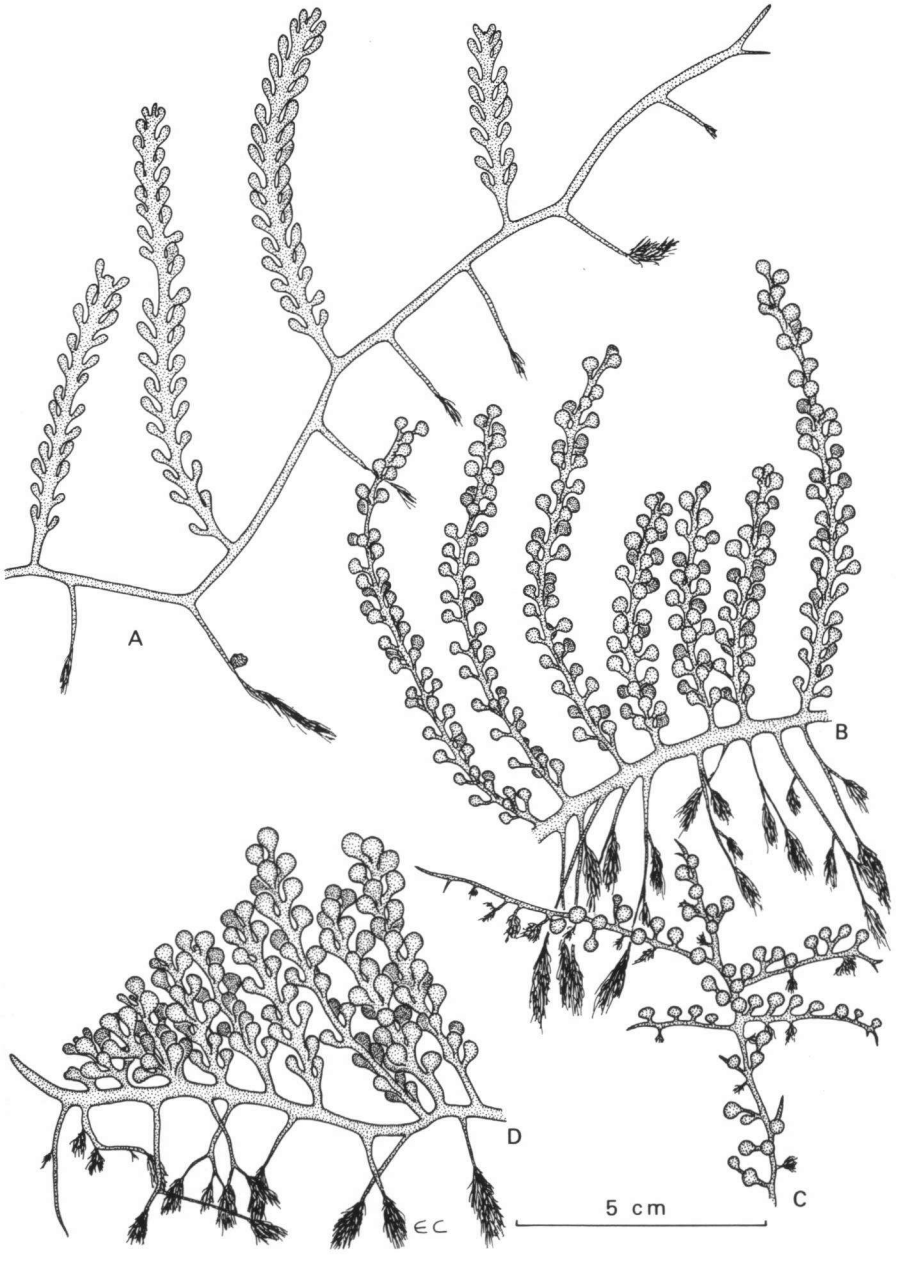

Fig. 4. *Caulerpa racemosa* (Forsskål) J. Agardh. All the drawings of figs. 4, 5 & 6 are at the same scale. A. ecad *corynephora* (13198B); B. ecad *occidentalis* (HEC 7480); C. ecad *racemosa* (var. *clavifera* auct.) (HEC 8020); D. ecad *racemosa* (var. *uvifera* auct.) (13842).

-25 m; HEC 7582: 25-6-1988, Padoz Tinan (seaward side), silty sand, -30 m; HEC 7686: 5-7-1988, Laing Isld, inner slope of the reef, sand, -14 m; HEC 7803: 16-7-1988, Manam, outer slope of reef platform, coral rubble and sand, -20/-35 m; HEC 7885: 21-7-1988, Kolakola Isld, silty-sandy coastal slope, -15 m (stolons > 2 m long!); HEC 7971: 26-7-1988, Cape Iris-Biliau, outer reef slope, coral rubble, -15 m; HEC 8021: 1-8-1988, W-side of Ulingan Bay, horizontal sand-covered coral wall, -10 m; HEC 8051: 3-8-1988, SW bay of Kranket Isld, sand + coral rubble, -10 m; 13149 (A–E): 14-7-1990, patch reef SW of Wongat Isld; reef slope, on coral rubble and between branches of an Acroporoid coral, -10 m; 13276 (A, B, C): 20-7-1990, patch reef between Tausch and Sek Isld, on silty sand and coral rubble, -20 m; 13615 (A, B): 8-8-1990, Bagabag, SE point of Christmas Bay, hanging down from coral boulders, reef slope, -15/-30 m; 13648 (A, B): 8-8-1990, Bagabag, in front of Badilu village (W-coast), on coral rubble and coarse sand, small platforms of the (sub)vertical reef wall, -20/-25 m; 13676 (A, B): 29-7-1990, Megas Isld, on a dead infundibuliform Acroporoid coral, -8 m; 13700 (A, B): 18-8-1990, Mugil Harbour, on horizontal coral surface, -10/-15 m.

Caulerpa racemosa (Forsskål) J. Agardh

In Coppejans & Meinesz (1988: 191) we stated that this species "is rather rare in the Hansa Bay region." In the Nagada area (Madang) on the contrary it is widely distributed; in sheltered biotopes it frequently has a huge biomass. The morphology of *C. racemosa* is extremely variable, as in *C. cupressoides*, depending on the habitat. Here too some 'characteristic' ecomorphs can be recognized; they have been described as varieties (or even different species) in the past, but we consider them as ecads. Numerous intermediates exist between these entities (the same stolon can even bear branches belonging to several of these ecads), especially between ecad *laetevirens*, *turbinata* and *peltata*, but also between ecad *clavifera* and ecad *racemosa* [see also the discussion in Coppejans & Beeckman (1989: 390) and Coppejans & Prud'homme van Reine (1992)].

ecad **corynephora** [var. *corynephora* (Montagne) Weber-van Bosse] – Fig. 4A.

As in Coppejans & Prud'homme van Reine (1992).

Reference material – HEC 7543: 22-6-1988, close to Wongat Isld, inner side of the fringing reef, on coarse sand + coral rubble, -35 m; 13198 (A, B, C): 17-7-1990, locality and ecology as 7543, slope 45°, -20/-30 m (large specimens: upright branches up to 12 cm high!).

ecad **laetevirens** [var. *laetevirens* (Montagne) Weber-van Bosse]

As in Coppejans & Prud'homme van Reine (1992).

Reference material – 13297 (A, B): 21-7-1990, Neptunus Point, sand-covered coral pools, high midlittoral.

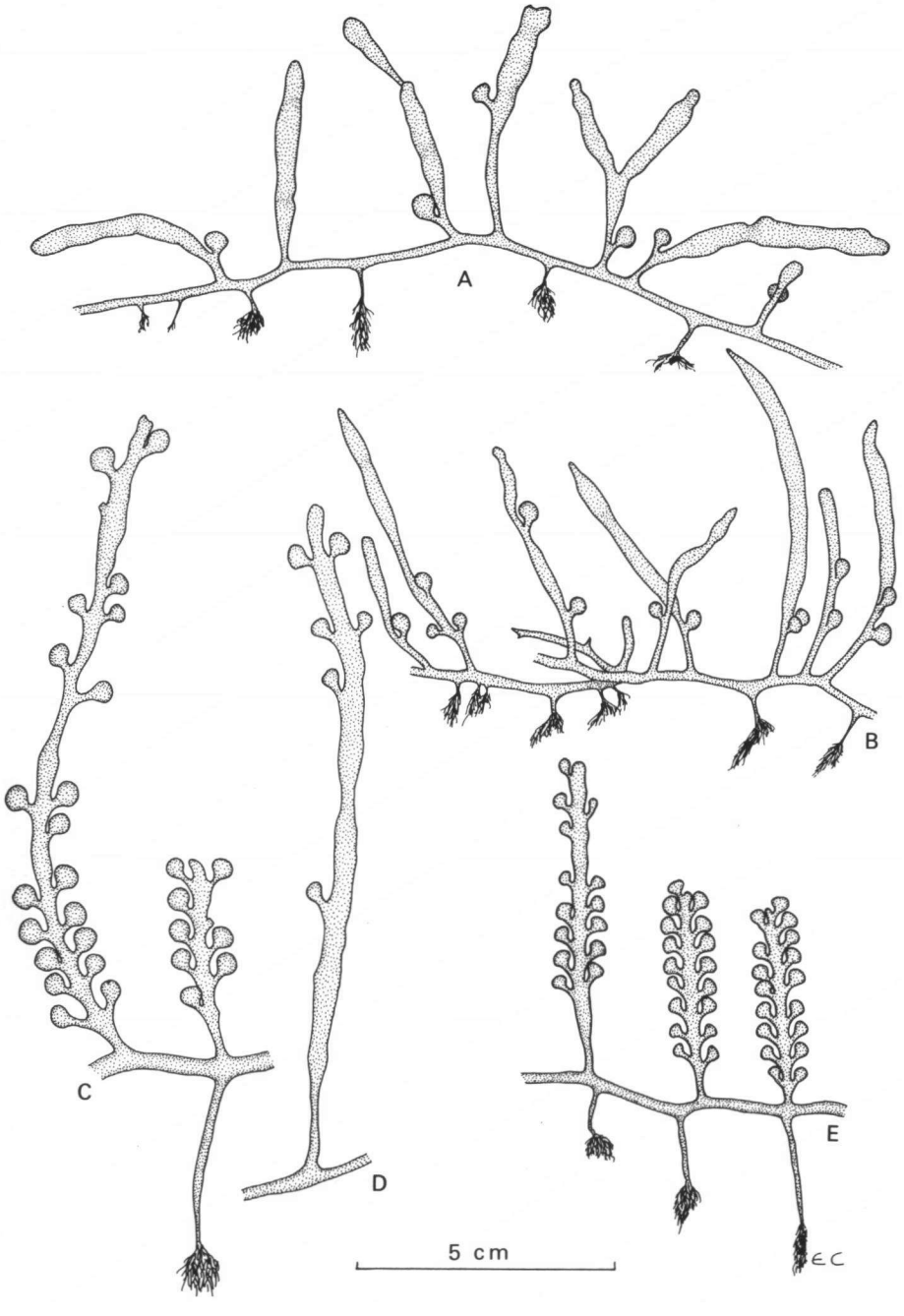

Fig. 5. *Caulerpa racemosa* (Forsskål) J. Agardh ecad *lamourouxii*. All the drawings of figs. 4, 5 & 6 are at the same scale. A, B. Specimens with foliose rachis and rare subspherical branchlets (HEC 8019); C. very large specimens with markedly complanate rachis and numerous (sub)opposite branchlets (13401B'); D. complanate rachis and very numerous (sub)opposite branchlets (13847B).

Intermediate between ecad *laetevirens* and ecad *turbinata*

Thallus stout, fleshy; stolons terete, not much branched, attached by numerous well developed rhizoidal branches, erect fronds densely placed, up to 6 cm high; terete rachis unbranched, bearing closely packed, radially arranged branchlets from the basis onwards; basal ramuli smaller and narrowly clavate (ecad *laetevirens*), the upper ones pear-shaped with a markedly inflated part with a flattened apex (ecad *turbinata*).

Reference material – 13617 (A, B, C): 8-8-1990, Bagabag, SE point of Christmas Bay, reef slope, on upper surface of huge coral boulder, -8 m.

ecad **lamourouxii** [var. *lamourouxii* (Turner) Weber-van Bosse] – Fig. 5.

This ecomorph is well characterized by the compressed, though fleshy rachis, being either short (1.5–2 cm, HEC 6551) or long (up to 15 cm: 13401), bearing either numerous, generally (sub)opposite vesicle-like (13847) or rare (to absent) branchlets (HEC 8019). All intermediates can be present on the same stolon.

Reference material – HEC 6540: 20-8-1986, W-side Ulingan Bay, pool on fossil coral platform, midlittoral; HEC 6551: as 6540 but sublittoral, -2 m; HEC 8019: 1-8-1988, locality as 6540, -3/-10 m; HEC 8068: 7-8-1988, W of Malamal Isld, vertical, shaded wall of coral boulder, close to low water mark, -1 m; 13310 (A, B): 21-7-1990, E-side Ulingan Bay, sand-covered coral, -0.5 m at low tide; 13401 (A, B): 26-7-1990: landward side of patch reef between Tausch and Sek Islds, on very silty sand, subhorizontal substrate, -20 m; 13847 (B): 29-8-1990, Bay of Demasa Isld, shaded, horizontal coral bottom, -3 m.

ecad **macra** [var. *macra* Weber-van Bosse] – Fig. 6.

Thalli very large and fleshy, growing in extensive populations in shallow, sheltered bays (frequently surrounded by mangrove) with silty-sandy substrate. Stolons up to 5 mm in diameter; downward growing, rhizoid-bearing branches numerous and well developed (up to 11 cm long); erect branches only rarely branched, up to 18 cm high, bearing 2, 3, or 4 rows of clavate ramuli, reaching 1 cm in length.

Reference material – HEC 7479: 20-6-1988, Nagada Harbour (CRI jetty bay), muddy sand, -1/-4 m, extremely sheltered, huge amounts, cover of 80%; HEC 7566: 23-6-1988, Kranket Isld (enclosed bay), ecology as 7479; HEC 8040, 8041: 2-8-1988, Nagada Harbour (opposite CRI), sandy bottom, -6 m; HEC 8052: 3-8-1988, Kranket Isld (SW-bay), on sand + coral debris, -10 m; 13072 (A, B): 10-7-1990, Beliau Isld, very silty sand, -0.5/-3 m.

Remark – Weber-van Bosse does not mention this variety in her 'Monographie des Caulerpes' (1898), but in her 'Liste des Algues du Siboga I' (1913).

ecad **occidentalis** [var. *occidentalis* (J. Agardh) Børgesen] – Fig. 4B.

As in Coppejans & Beeckman (1989: 384) but branchlets radially placed.

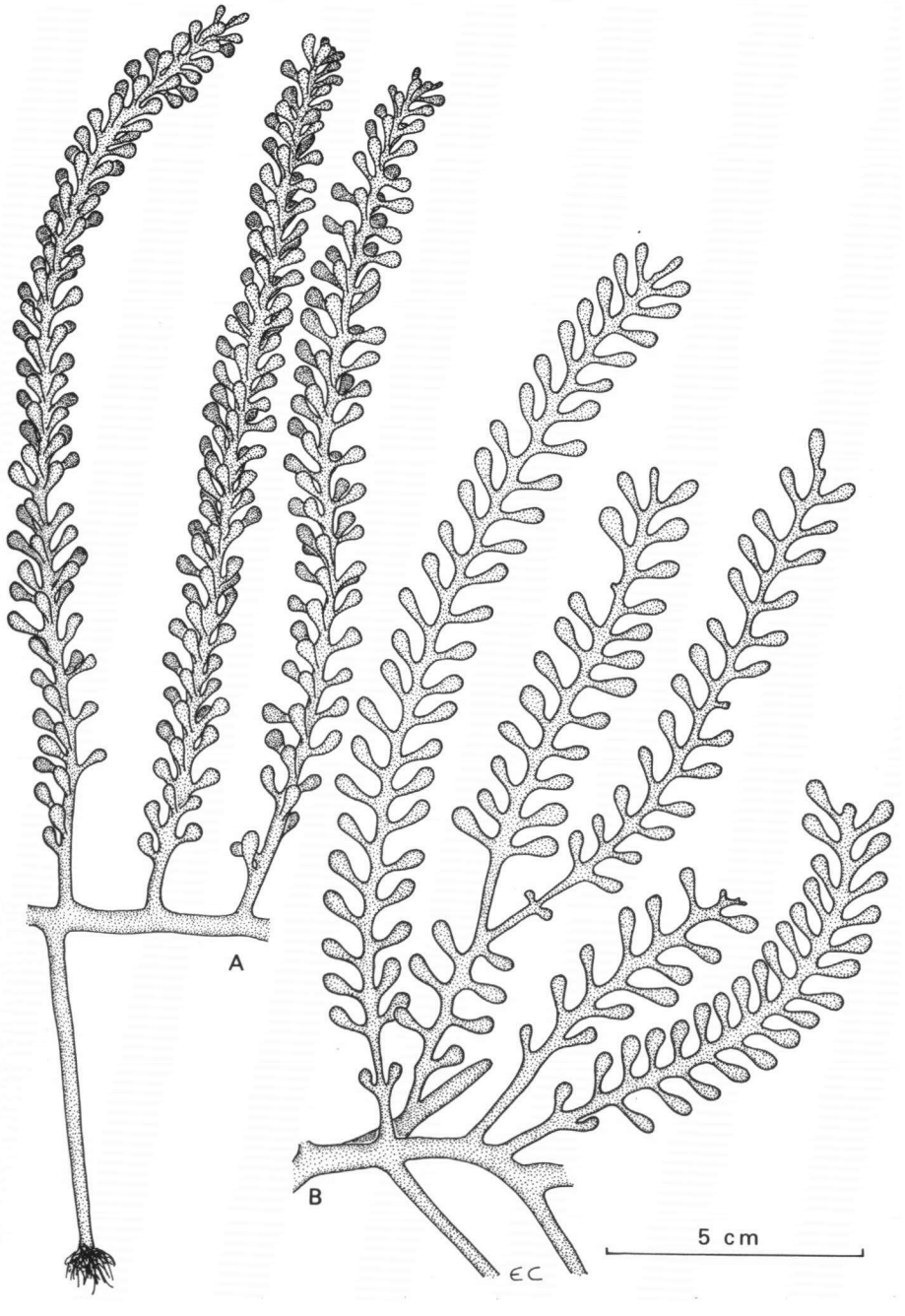

Fig. 6. *Caulerpa racemosa* (Forsskål) J. Agardh ecad *macra*. All the drawings of figs. 4, 5 & 6 are at the same scale. A. Specimen with branchlets on 3 or 4 longitudinal rows (HEC 7566); B. specimen with (sub)opposite branchlets (HEC 8052).

Reference material – HEC 7480: 20-6-1988, Nagada Harbour (bay at CRI jetty), on silty-sandy substrate, -1 m.

ecad **peltata** [var. *peltata* (Lamouroux) Eubank]

As in Coppejans & Meinesz (1988: 191).

Reference material – HEC 6470: 15-8-1986, Laing Isld, overhanging wall of a coral boulder in the lagoon, -1 m; HEC 6530a: 18-8-1986, Megiar Harbour, on vertical coral boulder wall, -2 m; HEC 6672: 10-7-1986, as 6470; HEC 7482: 20-6-1988, Nagada Harbour (CRI jetty bay), vertical coral wall, -1 m; HEC 7914: 25-7-1988, Gumbi Bay, under an overhanging coral boulder, outer rim of reef, -1 m; HEC 8080: 15-6-1988, Murukinam, vertical coral wall, infralittoral fringe; 13336 (B): 22-7-1990, Laing Isld, overhanging coral wall on reef flat; 13542 (B): 2-8-1990, Bagabag, New Years Bay, vertical wall under an overhanging coral boulder, reef flat, -1 m.

ecad **racemosa** [var. *racemosa*] – Fig. 4C, D.

Mentioned as *C. racemosa* var. *clavifera* (Turner) Weber-van Bosse in Coppejans & Meinesz (1988: 191), according to Papenfuss & Egerod (1957: 88) this variety and var. *racemosa* are synonyms.

As in Coppejans & Prud'homme van Reine (1992). Because of the numerous intermediates between prostrate growth forms and specimens with well developed erect branches (up to 6 cm), we consider var. *macrophysa* (Kützing) Taylor as belonging to this ecad.

Reference material – HEC 6552: 20-8-1986, W-side Ulingan Bay, horizontal coral surface, -3 m; HEC 6597: 23-8-1986, Boisa; horizontal, sand-covered coral substrate, -1 m; HEC 6671: 10-7-1986, Laing Isld, sandy substrate between coral boulders, inner part of reef flat, -1 m; HEC 7549: 22-6-1988, Sek Isld, on coarse sand + coral rubble, -5 m; HEC 7578: 24-6-1988, Gosem Isld, on coral rubble, -1 m; HEC 7716: 7-7-1988, Boisa (N coast), horizontal, sand covered coral substrate, -0.5 m; HEC 7766: 14-7-1988, Malagere Isld, coarse sand, -12 m; HEC 7913: 25-7-1988, Gumbi Bay, horizontal coral substrate and on coral rubble, pools of reef platform, close to low water mark; HEC 8020: 1-8-1988, W-side Ulingan Bay, vertical coral wall, -6 m; 13489 (A, B): 2-8-1990, Bagabag (NW point of Christmas Bay), on and between Acroporoid corals, coral platform, -1 m; 13599 (A, B): 7-8-1990, Nagada Harbour (in front of Gosem Isld), beach lagoon, horizontal surface of a dead coral boulder, just under low water mark, close to the beach; 13696 (B): 18-8-1990, Mugil Harbour, horizontal coral surface, -4 m; 13811 (A, B): 22-8-1990, Hole in the Wall, horizontal, sand-covered coral substrate, -0.5 m; 13842 (A, B, C): 28-8-1990, Kranket Isld (enclosed bay), sand, -0.5 m.

ecad **turbinata** [var. *turbinata* (J. Agardh) Eubank].

As in Coppejans & Prud'homme van Reine (1992).

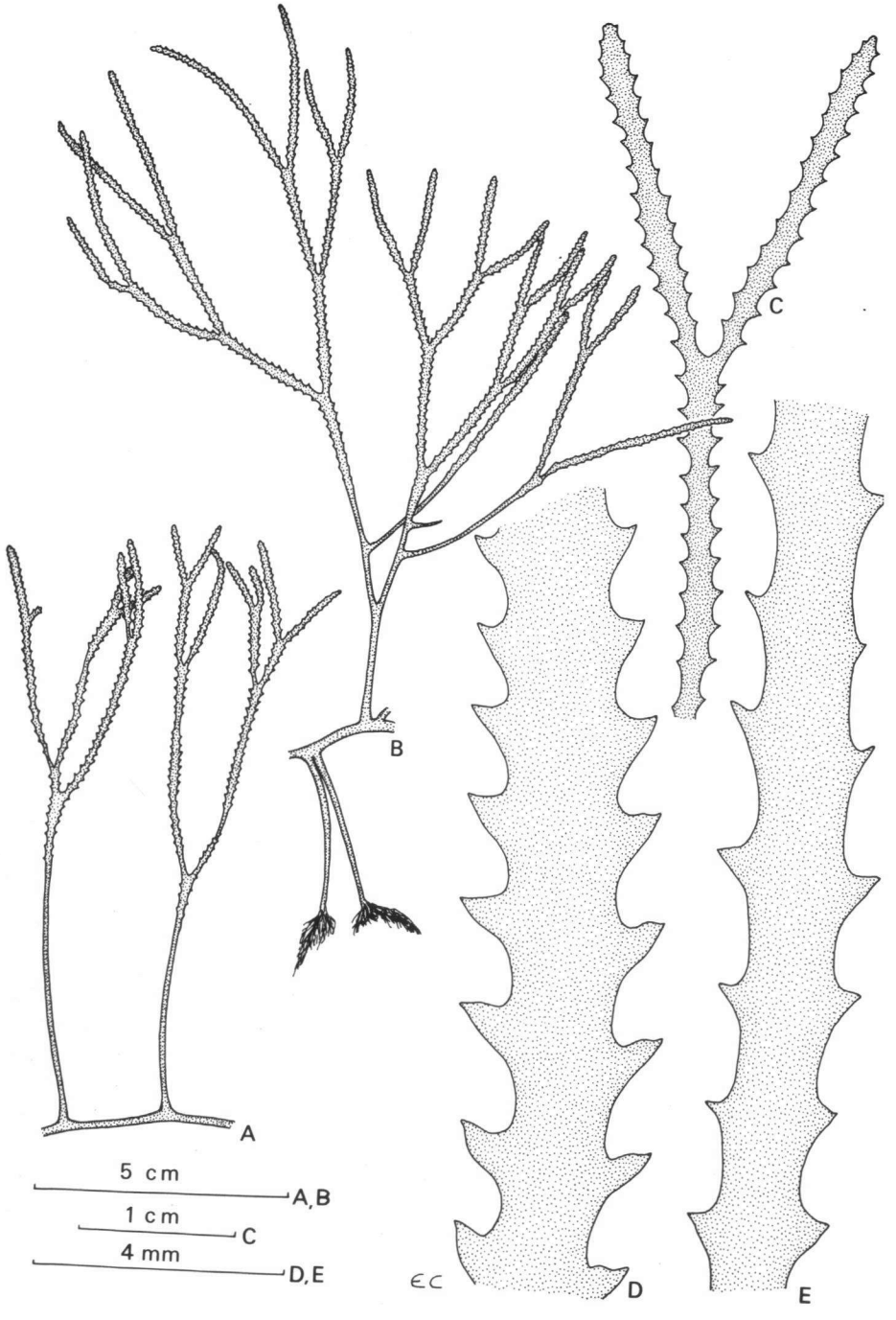

Fig. 7. *Caulerpa serrulata* (Forsskål) J. Agardh ecad *boryana-occidentalis*. A. Specimen with long unbranched stipes (HEC 7501 p.p.); B. specimens with branched stipe (HEC 7501 p.p.); C, D, E. details with markedly serrate margins (D: upper part; E: lower part of the frond) (HEC 7501).

Reference material – HEC 8060: 4-8-1988, landward side of D'Lole Isld, along the mangrove, -1 m (dense form on coral boulders, large, erect form on silty sand); HEC 8071: 7-8-1988, W of Malamal Isld, vertical and overhanging walls of coral boulder, -0.5 m; 13616 (A, B, C): 8-8-1990, Bagabag (SE point of Christmas Bay), reef slope, coral rubble at the base of a large coral boulder, -10 m.

Intermediate between ecad *peltata* and ecad *turbinata*

Some fronds with peltate ramuli, others on the same stolon with turbinate ramuli, or both types of ramuli on the same rachis.

Reference material – HEC 6530b: 17-8-1986, Megiar Harbour, horizontal sand-covered coral boulder, -2 m; HEC 7481: 20-6-1988, Nagada Harbour (bay of CRI jetty), on silty sand, more or less shaded places, -5 m.

Caulerpa serrulata (Forsskål) J. Agardh emend. Børgesen

As in Coppejans & Prud'homme van Reine (1992).

ecad **boryana-occidentalis** [var. *boryana* (J. Agardh) Gilbert forma *occidentalis* (Weber-van Bosse) Yamada & Tanaka] – Fig. 7.

Upright fronds vertically directed, more or less in one plane (not spirally twisted) up to 15 cm high; stipe terete and devoid of teeth, either unbranched over a long distance (up to 6 cm), either repeatedly branched. Upper parts markedly compressed, dichotomous, serially serrate; teeth broadly attached, as high as (or even higher than) wide, mucronate.

Reference material – HEC 7501: 20-6-1988, Nagada Harbour, opposite CRI, silty sand, -5 m; 13051 (B): 9-7-1990, as 7501.

ecad **pectinata** [var. *pectinata* (Weber-van Bosse) Taylor]

As in Coppejans & Meinesz (1988: 192).

Reference material – HEC 6459: 15-8-1986, Laing Isld, coarse sand between coral pebbles, lagoon, -0.5 m; HEC 7687: 5-7-1988, Laing Isld, inner slope of the reef, -14 m.

ecad **serrulata** [var. *serrulata*]

As in Coppejans & Meinesz (1988: 191); in deep water more fragile growth forms occur. HEC 8073 agrees completely with Weber-van Bosse's description and illustration (1898: 314, pl. 25 fig. 9) of *Caulerpa freycinetii* (*serrulata*) var. *typica* forma *torulosa*. Because of the extreme variability of the torulosity and the marginal indentation we consider all these ecomorphs as belonging to the ecad *serrulata*.

Reference material – HEC 4346: 12-6-1980, Hansa Point, seaward side of Purar Reef, slope of 60°, on sandy platform, -30 m; HEC 6491: 17-8-1986, Suaru, on sand between seagrasses and coral boulders, sheltered area, -1 m; HEC 6529: 18-8-1986, Megiar Harbour, silty sand, sheltered habitat, -0.5/1 m, between seagrasses; HEC 6553: 20-8-1986, W-side Ulingan Bay, sand between coral boulders, -2 m (tending to ecad *pectinata*); HEC 7542: 17-6-1988, Kolakola & Reamuna Islds, sheltered side, sand + small coral rubble, close to water surface at low tide; HEC 7484: 20-6-1988, Nagada Harbour (bay of CRI jetty), sandy-silty creek bottom (-4 m), as well as coarse sand closer to the surface; HEC 7505: as 7484, but opposite CRI; HEC 7523: 21-6-1988, Wongat Isld, inner slope of fringing reef, on coral rubble, -20 m; HEC 7717: 7-7-1988, Boisa (N coast), reef platform, coral rubble on coarse sand, between coral boulders, -6 m; HEC 7788: 15-7-1988, Laing Isld, sand covered coral, -3 m; HEC 7925: 25-7-1988, Gumbi Bay, sand-covered pools on reef platform; HEC 8022, 8023: 1-8-1988, W-side of Ulingan Bay, horizontal sand-covered coral, -5 and -8 m; HEC 8073: 7-8-1988, W of Malamal Isld, sandy bottom at -3 m; 13165 (A, B): 15-7-1990, island N of Demasa Isld, sheltered part behind the inlet-reef of the bay, on coral sand + silt, -3 m; 13205 (A, B): 17-7-1990, S of Wongat Isld, reef platform, on coral rubble, -3 m; 13420 (A, B): 27-7-1990, Tab Isld, outer side of the fringing reef, horizontal, sandy platform of the vertical coral wall, -20/-25 m, deep water form; 13481 (A, B): 2-8-1990, Bagabag, NW point of Christmas Bay, sand covered coral, -30 m, deep water form; 13482 (A, B): as 13481 but on sand between coral boulders, -2 m, 'typical' growth form; 13699 (A, B): 18-8-1990, Mugil Harbour, horizontal coral surface, -10 m; 13719 (A, B): 18-8-1990, bay in front of Malala village, sand-covered coral, close to the beach, just below low water mark; 13807 (A, B): 22-8-1990, Hole in the Wall, horizontal sand-covered coral substrate, -1 m.

Caulerpa sertularioides (Gmelin) Howe

As in Coppejans & Prud'homme van Reine (1992).

Reference material – HEC 7450: 17-6-1988, Kolakola & Reamuna Islds, sandy bottom with small coral rubble, just below low water mark, dense tiny specimens; HEC 7502: 20-6-1988, Nagada Harbour, opposite CRI, silty sand, -5 m; HEC 7526: 21-6-1988, Wongat Isld, inner slope of fringing reef, on and between coral rubble, -20 m; HEC 7579: 25-6-1988, Gosem Isld, coarse sand with coral rubble, -5 m; HEC 7685: 5-7-1988, Laing Isld, inner slope of the reef, on sand, -12 m; HEC 7695: as 7685 but sandy slope of the sheltered side (lagoon) of the island, -15 m, large specimens (up to 10 cm high and 2 cm wide); HEC 7952: 25-7-1988, Suit, coarse sand between pebbles, -0.5 m at low tide, small dense specimens; 13048 (A, B): 9-7-1990, Nagada Harbour, opposite CRI, silty sand, -5 m, large specimens (up to 11.5 cm high); 13075 (A, B): 10-7-1990, Beliau Isld, silty sand, -1 m; 13200 (A, B): S of Wongat Isld, inner slope (45°) of fringing reef, *Halimeda*-sand, -25/-30 m; 13403 (A, B): 26-7-1990, landward side of patch reef between Tausch and Sek Isld, sandy slope, -10 m.

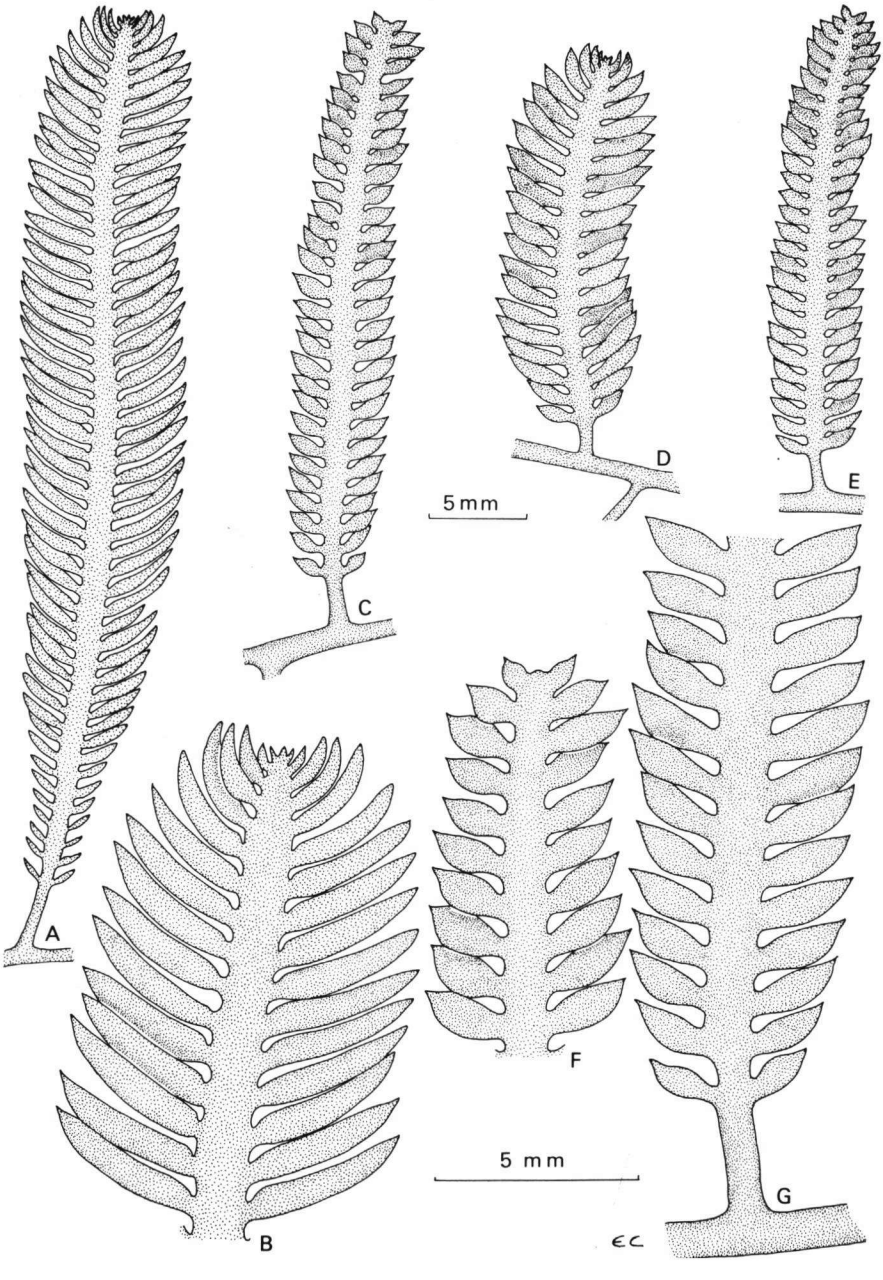

Fig. 8. *Caulerpa taxifolia* (Vahl) C. Agardh ecad *taxifolia*: A. Morphology of an upright branch; B. detail of an apical region, branchlets with parallel sides (13462B). – ecad *mexicana*: C, D, E. Morphology of upright branches (D & E from the same stolon); F. detail of an apical region, branchlets inflated in the middle part and overlapping; G. detail of a basal part (13589B).

Caulerpa taxifolia (Vahl) C. Agardh

ecad **mexicana** [*C. mexicana* (Sonder) J. Agardh] – Fig. 8C–G.

As in Coppejans & Prud'homme van Reine (1992).

Reference material – 13589 (A, B, C): 5-8-1990, N of Tab Isld, upper part of inner slope of the reef, coarse sand mixed to coral rubble, -5/-10 m.

ecad **taxifolia** [var. *taxifolia*] – Fig. 8A–B.

Reference material – HEC 7483: 20-6-1988, Nagada Harbour (bay of CRI jetty), on coral boulder, close to the creek outlet, -1 m; HEC 7503 p.p., as 7483, but opposite CRI, silty sand, -4 m; HEC 7545: 22-6-1988, Wongat Isld, inner slope of fringing reef, coarse sand + coral rubble, -30 m; HEC 7969: 26-7-1988, Cape Iris, Biliau, outer slope of the reef, coral debris, -5 m; HEC 8061: 4-8-1988, back-side of D'Lole Isld, silty sand with dead wood fragments, -0.5 m, dense growth form; 13199 (A, B): 17-7-1990, S of Wongat Isld, inner slope (45°) of fringing reef, on *Halimeda*-sand, -5/-30 m (!); 13462 (A, B): 1-8-1990, N of Wongat Isld, upper part of inner reef slope, coarse sand + coral rubble, -8 m; 13603 (A, B): 7-8-1990, Nagada Harbour, opposite Gosem Isld, coral sand, coastal slope, -5/-10 m; 13844 (B): N of Tab Isld, lower part of inner slope of fringing reef, on sand, -25 m.

Intermediate between ecad *mexicana* and ecad *taxifolia*

Some branchlets of the upright branch with parallel sides and not overlapping, others ± inflated in the middle part and overlapping.

Reference material – HEC 7503 p.p.: see ecad *taxifolia*.

Caulerpa verticillata J. Agardh

As in Coppejans & Meinesz (1988: 194).

Reference material – HEC 7569: 23-6-1988, enclosed bay of Kranket Isld, on coconutshell on silty sand, -0.5 m; HEC 7758: 13-7-1988, Laing Isld, on coconutshell on silty sand, -20 m; HEC 8062: 4-8-1988, back-side of D'Lole Isld, on diverse debris and sand, -0.5 m; 13120 (A, B, C): 13-7-1990, enclosed bay of Kranket Isld, on very fine sediment containing dead *Halimeda*-segments as well as on vertical basal parts of corals, -18 m; 13456 (A, B): 30-7-1990, N of Wongat Isld, inner side of the fringing reef, subhorizontal surface, coarse sand + silt, -27 m; 13618 (A, B, C): 8-8-1990, Bagabag, SE point of Christmas Bay, reef slope, coral rubble and sand, -50 m.

Caulerpa webbiana Montagne ecad **disticha** [forma *disticha* Weber-van Bosse] Fig. 9.

Thallus largely prostrate, intricate; stolons with a naked apical region, followed by a zone exclusively covered by unbranched (more rarely branched) rhizoids; 'up-

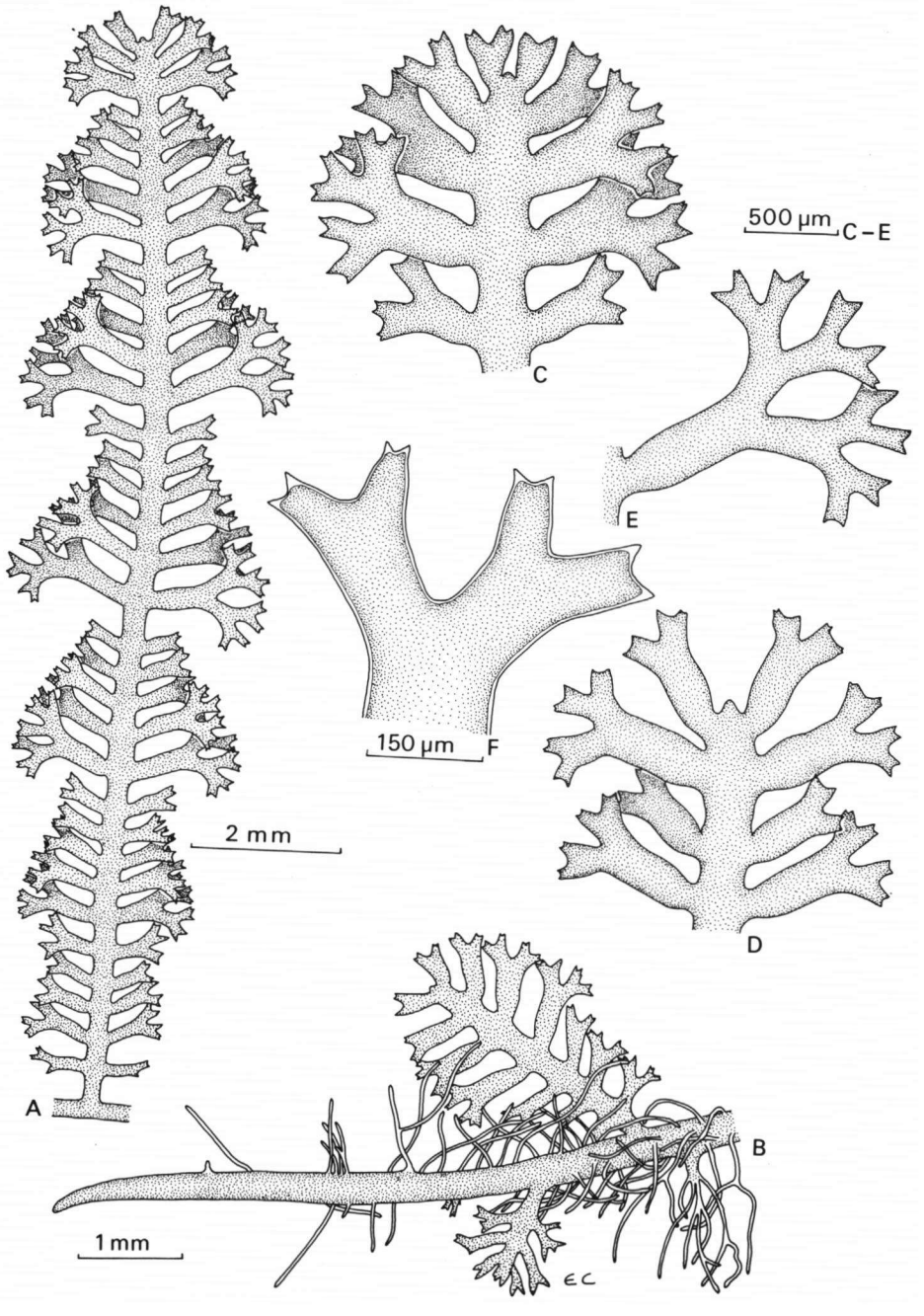

Fig. 9. *Caulerpa webbiana* Montagne ecad *disticha* (13656B). A. Morphology of a branch; B. apical part of the stolon with numerous rhizoids, two young branches but without branchlets (>< *C. elongata*); C, D. details of apical parts of the upright branches; E, F. details of the dichotomous mucronate branchlets.

right' branches also prostrate, up to 1.5 cm long bearing 2 opposite rows of branchlets; these are slightly constricted at the base, 2–4 times regularly dichotomous in one plane (the plane of the rachis) and have mucronate apices; branchlets ± grouped in series of 5(–6) with larger basal ramuli, gradually decreasing towards the distal part of the series, more or less resulting in a pine-tree silhouet aspect.

Reference material – 13656 (A, B, C): 15-8-1990, N of Tab Isld, inner slope of the reef, on a sunken tree trunk, -15 m.

Discussion – This *Caulerpa* could be mistaken for *C. elongata* ecad *disticha* which also occurs in this region but the stolons of that ecad are covered by short branchlets up to the apices, the upright branches are vertically placed, the branchlets are not constricted at the base, and their ramification is pseudodichotomous.

GENERAL DISCUSSION

In a previous paper (Coppejans & Meinesz, 1988) 11 *Caulerpa* species (13 taxa) were mentioned from Madang Province, but collecting was up to then mainly restricted to the Hansa Bay area. The coast just N of Madang is characterized by a submerged (1–3 m deep) fringing reef of over 8 km and 20–50 m wide. The seaward side consists of a (sub)vertical coral wall, dropping down to 400 m within a km of the reef, interrupted at several sites by deep (30 m) channels with swift currents. The inner slope of c. 45° is composed of coral rubble and sand and goes down to 30–35 m depth. The even lagoon bottom is sandy to muddy; scattered larger and smaller patch reefs occur; they are affected by different current regimes and their top is at different depths (1–15 m). Numerous islands and islets are spread over the lagoon; some larger ones are on the fringing reef itself and exposed to strong surf, but most of them are rather close to the inner coastline and more sheltered. The coast is characterized by long meandrous harbours with restricted freshwater input and fringed by mangroves at their landward extremities. This enormous variety in biotopes on a rather restricted area makes the Madang lagoon extremely species-rich and also creates the optimal conditions for the development of different growth forms within some species.

Supplementary seaweed collecting in this region in 1988 and 1990 resulted in a total of 231 *Caulerpa* samples, of which 14 species and 29 entities for the Madang Province. This is a very high number considering the relatively restricted area studied: for the Philippines 20 species (after taxonomic rearrangements according to our species concept) are known, and during the Snellius-II Expedition 12 species (26 entities) were collected in E Indonesia (Coppejans & Prud'homme van Reine, 1992). The following species mentioned from this part of the Indonesian archipelago have not been found in Papua New Guinea (yet): *C. ambigua* Okamura, *C. brachypus* Harvey, *C. fergusonii* Murray, *C. geminata* Harvey, and *C. lessonii* Bory. Inversely, *C. biserrulata, C. filicoides, C. opposita,* and *C. webbiana,* present in Papua New Guinea, have not been mentioned from Indonesia yet.

The absence of *C. fastigiata* Montagne from our collections in Papua New Guinea is remarkable as this species is mentioned from neighbouring regions: the Philippines

(Silva et al., 1987), from Australia (Cribb, 1958), from W Indonesia (Weber-van Bosse, 1928).

Finally, we want to stress again the variability of certain species (*C. cupressoides, C. racemosa, C. serrulata*) depending on the biotope. This has already been mentioned by several authors (Weber-van Bosse, 1898; Taylor, 1960), but the description of new 'varieties' and 'forms' went on (Børgesen, 1907; Durairatnam, 1961; Gilbert, 1942; Joly & Semir, 1973). Based on laboratory experiments on *C. racemosa* Peterson (1972: 84) suggested that at least some of the growth forms of this species should be considered as ecophenes or ecads. We expand this idea to the above mentioned species (Coppejans & Prud'homme van Reine, 1992) hoping that genetic information might give a definitive answer in a near future.

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