

The genus *Codium* (Chlorophyta, Codiales) from Kenya, Tanzania (Zanzibar) and the Seychelles

by

Caroline Van den heede and Eric Coppejans

Vakgroep Morfologie, Systematiek en Ecologie; Laboratorium Plantkunde
Universiteit Gent; Ledeganckstraat 35, 9000 Gent, Belgium

With 32 figures and 3 tables

Van den heede, C. & E. Coppejans (1996): The genus *Codium* (Chlorophyta, Codiales) from Kenya, Tanzania (Zanzibar) and the Seychelles. - Nova Hedwigia 62: 389-417.

Abstract: Descriptions and illustrations are provided of 14 species. *Codium*, collected in Kenya, Zanzibar and the Seychelles Archipelago from 1985 to 1994 of *C. arabicum*, *C. cicatrix*, *C. duthieae*, *C. dwarfkense*, *C. extricatum*, *C. geppiorum*, *C. lucasii*, *C. ovale*, *C. pocockiae*, *C. prostratum*, *C. repens*, *C. taylorii*, *C. vaughanii* and *C. sp.* *Codium cicatrix* and *C. repens* are new records for Kenya; *C. extricatum*, *C. lucasii* and *C. pocockiae* are new for Tanzania; *C. arabicum*, *C. cicatrix*, *C. extricatum*, *C. vaughanii* and probably *C. sp.* are new for the Seychelles.

Keywords: Chlorophyta, Codiales, *Codium*, East Africa, Indian Ocean.

Introduction

In 1988 E. Coppejans started macroalgal research in Kenya in the framework of the "Fonds voor Kollektief en Fundamenteel Onderzoek"-project 2.0043.88 "Floristics, faunistics and ecology of Kenyan coastal biotopes". In 1992 this project was succeeded by F.K.F.O. 2.0009.92 "Systematics, ecology and biogeography of marine organisms in the Indian Ocean". The aim of the present study is the inventory and description of the *Codium* species along the East African coast, resulting in a useful identification key. These data will be incorporated in a flora of the Chlorophyta from the western Indian Ocean, which is in preparation. Such a marine macroalgal flora, comparable to that of Lawson & John (1987) for the West African coast, is still non-existing, although indispensable as a basis for ulterior ecological field work, monitoring and managing coastal ecosystems.

Materials and methods

Material was collected along the Kenyan coast by phycologists of the University of Ghent (Belgium), during 9 field trips over a period of 8 years (Beeckman & Coppejans July 1985, January-February 1986; Coppejans July-August 1987, February-March 1988, January 1989, September 1990; Coppejans, De Pauw & De Schrijver July-August 1989, Coppejans, Provoost & Van Zele September 1991; Coppejans,

0029-5035/96/0062-0389 \$7.25

© 1996 J. Cramer in der Gebrüder Borntraeger
Verlagsbuchhandlung, D-14129 Berlin · D-70176 Stuttgart

Vackier & Verstraete September 1992). The specimens from Zanzibar were gathered in July-August 1993 by Coppejans & Van den heede and in August 1994 by Coppejans & De Clerck. One month (December-January) of collecting around the Seychelles took place during the Netherlands Indian Ocean Expedition 1992-1993 (Coppejans et al. 1994).

Sampling was done by wading in the intertidal zone at low tide and by snorkeling in the subtidal areas. During the Seychelles Expedition, SCUBA-diving (down to -25 m) and dredging from the ship resulted in specimens from deeper waters (Coppejans et al. 1994). Ecological data and vegetation transects or species lists were noted in situ on a plexiglass plate. Fragments of some specimens were preserved in 4% formalin/seawater for further study, but the major part of the collected specimens was dried and pressed as herbarium reference material. The study of the material was carried out in the framework of an MSc-thesis (Van den heede 1994). Macromorphological features (incl. growth pattern: repent, ascending, erect; branching pattern) were examined in both dried and preserved specimens. Anatomical characters were studied in preserved specimens when available, or in resoaked herbarium fragments. The results of soaking or boiling herbarium specimens briefly were not satisfactory: most of the utricles were still folded or dented. Optimal results were obtained by soaking fragments for at least 72 h in a solution of 3,5% formalin (avoiding decaying process) and 5% glycerin in distilled water. The anatomical analysis was carried out on all the collected specimens with a light microscope; drawings were made by camera lucida. Identification was mainly based on the publications of Silva (1952, 1959, 1960), Silva & Womersley (1956) and Schmidt (1923).

Results

Identification key to the species of *Codium* from Kenya, Zanzibar and the Seychelles (western Indian Ocean)

1. a. Thallus unbranched, possibly irregularly lobed..... 2
 b. Thallus branched..... 5
2. a. Thallus crustose; utricles in clusters, hairs (or their scars) present..... 3
 b. Thallus inverted drop-like or club-shaped; utricles individual, hairs absent..... 4
3. a. Inconspicuous primary utricles to 700 μm long, maximum of 5 secondary utricles per primary
 utricle..... *C. lucasii*
 b. Conspicuous primary utricles 700-1270 μm long, up to 10 secondary utricles per primary utricle
 *C. arabicum*
4. a. Thallus inverted drop-like, hollow; utricles broadly clavate or subcylindrical..... *C. ovale*
 b. Thallus narrowly club-shaped, solid; small utricles obtriangular..... *C. sp.*
5. a. Thallus repent..... 6
 b. Thallus erect..... 9
6. a. At least a few utricles obpyriform..... 7
 b. Utricles never obpyriform..... 8
7. a. Utricles elongate obpyriform; gametangia fusiform..... *C. geppiorum*
 b. Utricles inflated obpyriform; gametangia ovate..... *C. repens*
8. a. Thallus surrounded by a halo of hairs, some of these with inflated tips; utricles [(410-)520(-855)
 μm long] with rounded or truncate apices..... *C. vaughanii*
 b. Thallus not surrounded by a halo of hairs; utricles long and slender [(615-)850-1115(-1410) μm]
 with truncate apices..... *C. prostratum*
9. a. Branching (rather) regularly dichotomous; branches completely terete (1-3 mm diameter); utricles
 irregularly capitate..... *C. dwarkense*
 b. Branching cervicorn or dichotomous; branches either completely terete or partly or completely
 compressed; utricles never capitate..... 10

- 10. a. Branching divaricately dichotomous to cervicorn, branches completely terete or completely compressed 11
- b. Branching dichotomous; branches partly compressed 12
- 11. a. Terete branches with a diameter of 3-4 mm; utricles with rounded apices, (525-)630-815(-1030) μm long *C. pocockiae*
- b. Branches completely compressed, 3-8 mm broad; utricles with truncate apices, (790-)980-1350 (-1625) μm long *C. taylorii*
- 12. a. Terete interdichotomies 3-6 mm broad, compressed dichotomies 8-12 mm broad; utricles (455-) 980-1265(-1425) μm long *C. duthieae*
- b. Lower part of the thallus compressed, upper part terete, branches 1-4 mm broad 13
- 13. a. Utricles typically wedge-shaped with slightly depressed apices *C. cicatrix*
- b. Utricles never wedge-shaped, but clavate and subcylindrical with truncate apices *C. extricatum*

Description of the species

Codium arabicum Kützing

Figs 1, 5, 7

Syn.: *Codium coronatum* Setchell

Codium coronatum Setchell var. *insculptum* Setchell

Codium coronatum Setchell var. *aggregatum* Børgesen

Morphology: thallus crustose, with irregular dorsiventral (cortex only on the upper surface) lobes of 1-5 cm width. Thallus up to 10 cm long, tightly adherent to rocky substrate or to the host plant, becoming convoluted with age and developing orbicular foliose isobilateral (with cortex on upper and lower surface) excrescences of 1-3 cm diameter; olive to dark green.

Anatomy: primary utricles formed by enlargement of medullary filaments; secondary utricles arising as buds from the lower part of primary utricles; thallus dissecting out into large clusters of utricles, varying greatly in size from thallus to thallus (Silva 1952: 382). Primary utricles (sub)cylindrical to clavate, (90-)185-230(-385) μm diameter, (700-)990-1115(-1290) μm long. Secondary utricles (sub)cylindrical to capitate, (55)110-140(-175) μm diameter, (230-)400-530(-780) μm long. Utricular wall 2 μm thick, either not thicker at the apices (specimens from the Seychelles) or very slightly (6 μm) to slightly (15 μm) thicker, and so with or without palisade-like structure (Fig. 7d). Apices rounded or truncate. Hairs or hair scars common on older utricles (max. 20 per utricle), borne in the zone 55-155 μm below the apex (between 120-225 μm below the apex for the specimens from the Seychelles). Gametangia fusiform, elliptical to oval, (45-)75-95(115) μm diameter, (200-)230-240(-270) μm long, shortly pedicellate, borne between 230-325 μm below the utricle apex (for both primary and secondary utricles). Medullary filaments 15-30 μm diameter.

Ecology: epilithic, mainly in infralittoral (fringe) reef pools on vertical and overhanging rock walls; epiphytic in low midlittoral or high infralittoral zones of sandy lagoons, on stipes of the seagrass *Thalassodendron ciliatum* (Forssk.) den Hartog.

Geographic distribution: described by Kützing (1856) from the Red Sea (type locality). Indian Ocean: Tanzania (Jaasund 1976), Kenya (Isaac 1967), Mauritius (Børgesen 1940, 1945, 1948), Seychelles (Coppejans et al. 1994), Sri Lanka (Børgesen 1936, Durairatnam 1961), Indonesia (Verheij & Prud'homme van Reine 1993), Thailand

- Andaman Sea Coast (Egerod 1974, 1975). Pacific Ocean: Malaysia (Crane 1981), Philippines (Meñez 1961, Trono & De Lara 1981), Taiwan (Tseng 1984), China (Tseng 1984), Marshall Islands (Dawson 1957), Fiji Islands, Tonga Islands, Samoa Islands, Cook Islands, Hawaii Islands (Silva 1952).

Specimens examined: Kenya: HEC 7434: 22/03/1988 - Malindi; HEC 8249: 05/08/1989 - Diani; HEC 8842: 24/09/1991 - Msambweni; HEC 9433: 13/19/1992 - Tiwi; HEC 9456: 14/09/1992 - Chale Island. Tanzania (Zanzibar): HEC 9846: 03/08/1993 - Mbweni Cliffs; HEC 9878: 04/08/1993 - Matemwe; HEC 10463: 19/08/1994 - Mbweni Cliffs; HEC 10647: 25/08/1994 - Ras Fumba. Seychelles: SEY 14: 10/12/1992 - Mahé, Anse Forbans; SEY 25: 11/12/1992 - Mahé, North East Point; SEY 54: 12/12/1992 - Mahé, Le Corsaire; SEY 373: 10/12/1992 - Mahé, Ile Sourie, Pointe du Sel.

The specimens examined agree best with the descriptions and drawings of Silva (1952), although some primary utricles are longer (1285 μm) and broader (385 μm) than the maximum length (1000 μm) and width (300 μm) given by Silva. The utricle dimensions mentioned by Schmidt (1923: 30) (to 700 μm long and to 300 μm broad) are even smaller. A specimen identified by Tseng (1984: 296) as *C. arabicum* is presumably *C. lucasii*, because of the very long (up to 1170 μm) but also very slender (up to 115 μm diameter) utricles. These dimensions rather correspond with the description of *C. lucasii* by Silva & Womersley (1956: 265).

Codium arabicum shows both morphological and anatomical resemblance with *C. lucasii*. In *C. arabicum* the primary "mother"-utricles are generally much larger (especially broader) and more irregular in shape than the secondary utricles. In *C. lucasii* the primary utricles are about the same size as the secondary ones. The presence of exclusively (sub)cylindrical utricles or utricles with depressed apices also points to *C. lucasii*. The specimens of *C. arabicum* from the Seychelles differ from the other specimens studied, by the absence of apical utricle wall thickenings and the lower insertion of the hairs.

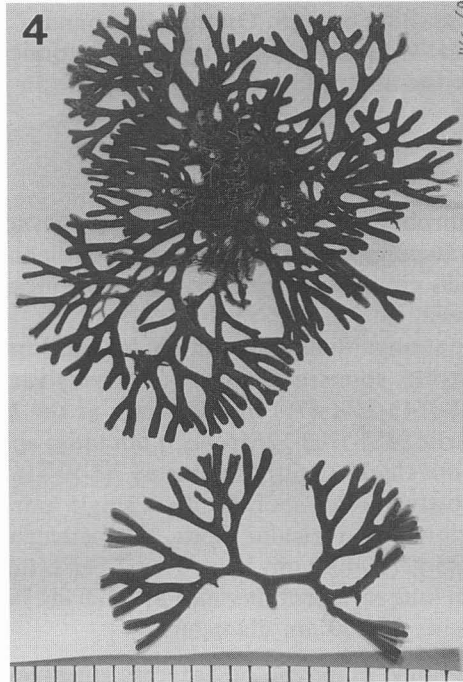
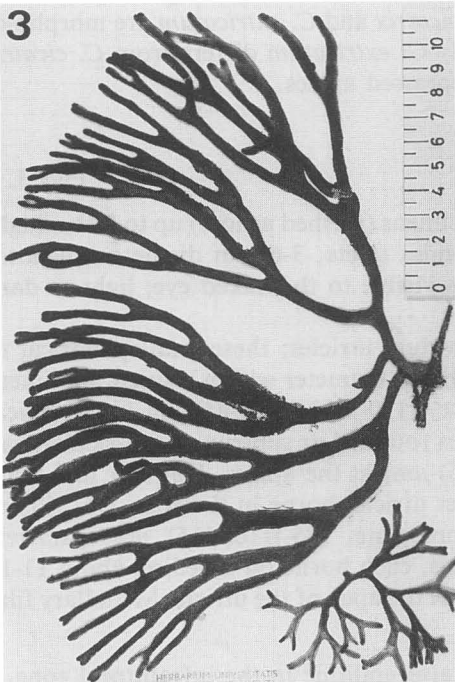
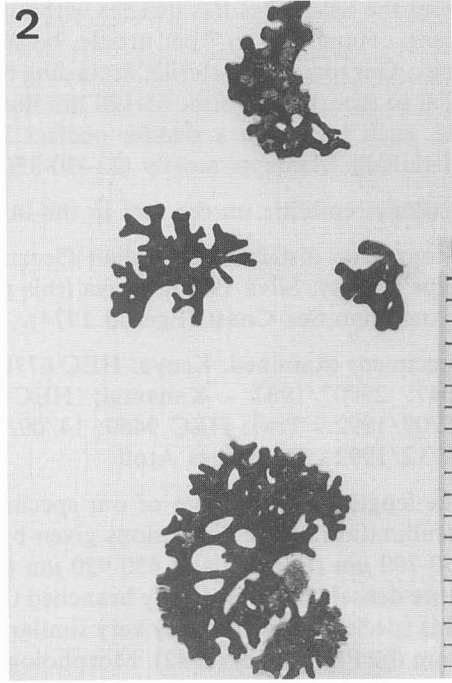
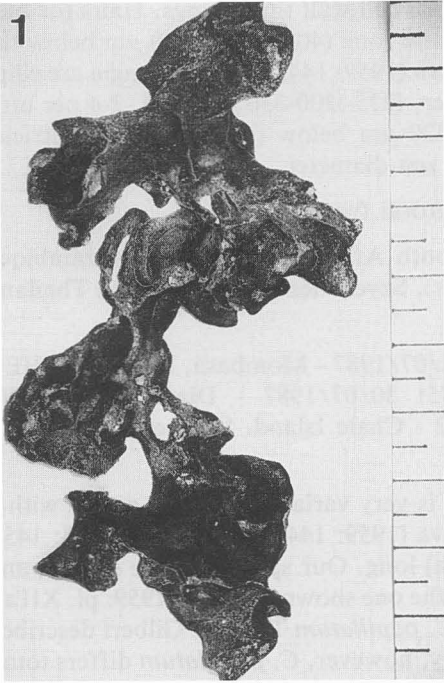
Codium cicatrix Silva

Figs 2, 8

Morphology: thallus erect, up to 3,5 cm high; branching rather dense, divaricately dichotomous (up to 7 orders), branches 3-4 mm diameter at the compressed base, terete (3 mm) in the upper parts, with obtuse apices; grass to dark green with translucent margins.

Anatomy: thallus dissecting out into individual utricles; these typically cuneate, (sub)cylindrical, clavate, or slightly obpyriform, (60-)175-235(-345) μm diameter in apical parts, (25-)60-75(-195) μm diameter in basal parts, (330)480-660(-930) μm long; apices (sub)truncate or even slightly depressed; utricle wall 1,5 μm thick, only very slightly (6 μm) to slightly (15 μm) thickened at the apices. A single specimen

Figs 1-4. General morphology. (One unit = 0,5 cm). Fig. 1. *Codium arabicum* Kützinger: habit of epiphytic thallus (HEC 7434). Fig. 2. *Codium cicatrix* Silva: habit of HEC 6778. Fig. 3. *Codium duthieae* Silva: habit of HEC 5546. Fig. 4. *Codium dwarkense* Silva: habit of HEC 6956.



from the Seychelles has utricles without apical cell wall thickenings. Hairs (or hair scars) common, 0 to 7 per utricle, borne in the zone (40-)55-70(-130) μm below the apex. Our material is sterile; according to Silva (1959: 144), the gametangia are elliptical to stoutly fusiform, 65-120 μm diameter, (235-)300-330 μm long, 2-4 per utricle, each borne on a slender pedicel 300-420 μm below the apex of the utricle. Medullary filaments mostly (23-)30-35(-42) μm diameter.

Ecology: epilithic on the reef in the infralittoral fringe.

Geographic distribution: Indian Ocean: South Africa (Silva 1959), Mozambique (type locality, Silva 1959), Kenya (this paper), Seychelles (this paper) and Thailand - Andaman Sea Coast (Egerod 1974).

Specimens examined: Kenya: HEC 6778: 12/07/1987 - Mombasa, Nyali reef; HEC 7047: 29/07/1987 - Kanamai; HEC 7075: 30/07/1987 - Diani; HEC 9430: 13/09/1992 - Tiwi; HEC 9460: 14/09/1992 - Chale Island. Seychelles: SEY 550: 30/12/1992 - Desroches Atoll.

The length of the utricles of our specimens is very variable, but still agrees with a combination of the dimensions given by Silva (1959: 144) and Egerod (1974: 145): 350-700 μm (Egerod) and 630-920 μm (Silva) long. Our specimens are smaller and more densely dichotomously branched than the one shown by Silva (1959: pl. XIIa). This species is anatomically very similar to *C. papillatum* Tseng & Gilbert described from the Philippines (1942). Morphologically, however, *C. papillatum* differs totally from *C. cicatrix* by the broadly compressed axes and the irregular (cervicorn) branching pattern. On the other hand, *C. cicatrix* and *C. extricatum* are morphologically difficult to distinguish; anatomically *C. extricatum* differs from *C. cicatrix* by the absence of cuneate utricles with depressed apices.

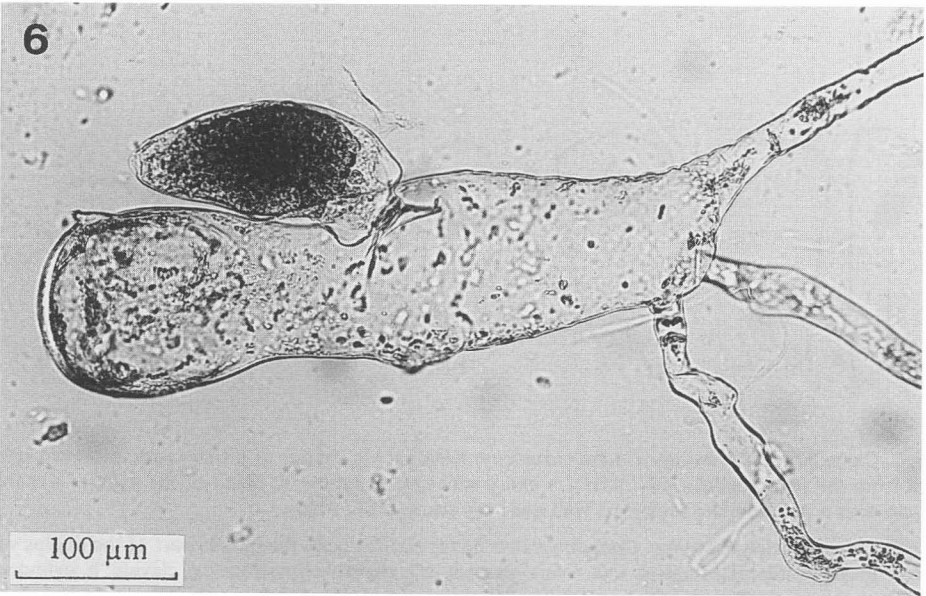
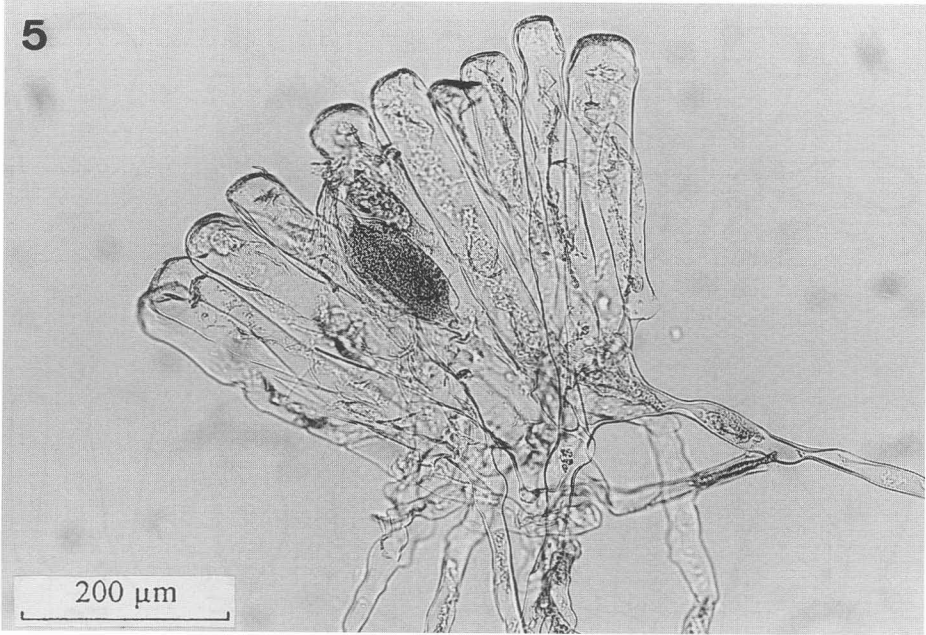
Codium duthieae Silva

Figs 3, 9

Morphology: thallus erect, fully grown specimens (washed ashore) up to 30 cm high; branching (sub)dichotomous; interdichotomies terete, 3-6 mm diameter, dichotomies compressed, 1-2 \times 8-12 mm; utricles visible to the naked eye; light to dark green.

Anatomy: thallus dissecting out into individual utricles; these (sub)cylindrical to clavate, sometimes obpyriform, very variable in diameter within a single specimen: (55-)145-240(-470) μm diameter at the base, (170-)365-430(-745) μm in the apical parts; (455-)980-1265(-1425) μm long; apices rounded or subtruncate; utricular wall 2 μm thick, slightly thickened [(5-)9-11(-15) μm] at the apices. Hairs or hair scars mostly absent; sporadically a single hair per utricle, borne in the zone 195-240 μm below the utricular apex. Gametangia urceolate, (85-)110(-115) μm diameter, (245-)275(-400) μm long, 1 or 2 per utriculus, each borne on a pedicel about 11-15 μm long on a protuberance 310-520 μm below the apex of the utricle. Medullary filaments 38-100 μm diameter.

Ecology: epiphytic on seagrass stipes and also epilithic in the infralittoral zone.



Figs 5-6. LM. Fig. 5. *Codium arabicum* Kützing: a cluster of utricles (HEC 9846). Fig. 6. *Codium dwarfense* Silva: a mature utricle with a gametangium and a scar of a gametangium (HEC 9712).

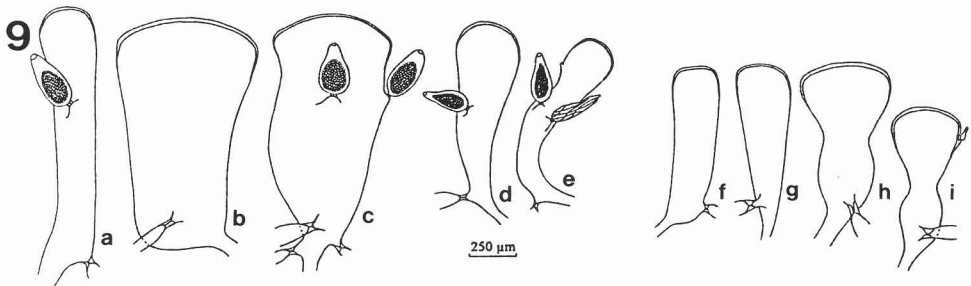
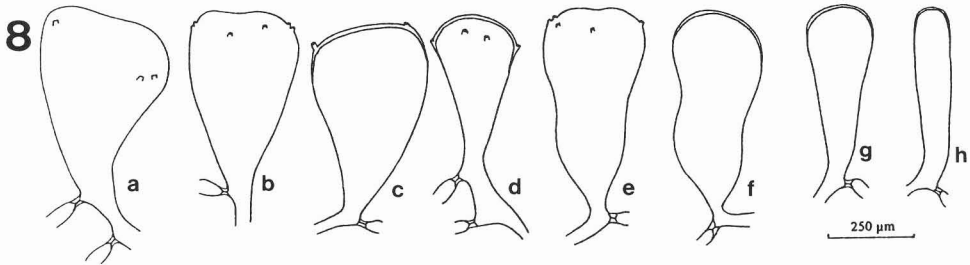
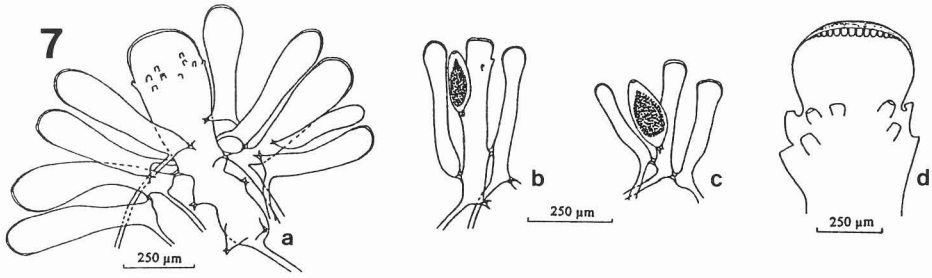


Fig. 7. Camera lucida drawings. *Codium arabicum* Kützing: a-c. cluster of utricles with thickened apical wall from the same thallus (HEC 9456), b and c with gametangium; d. detail of the apex of a mature utricle with a palisade-like thickened wall and hair scars (HEC 9456).

Fig. 8. Camera lucida drawings. *Codium cicatrix* Silva: utricles from the middle part of the thallus with (sub)truncate or depressed apices: a-d. wedge-shaped; e, f. slightly obpyriform; g. clavate; h. cylindrical [a, b, e. without thickened apical wall (SEY 550); c, d, f-h. HEC 6772].

Fig. 9. Camera lucida drawings. *Codium duthieae* Silva: a-e. utricles from the middle part of the thallus (HEC 5866): a. cylindrical; b, c. subcylindrical; d, e. clavate (e. with a mature and an empty gametangium); f-i. utricles from the apical part of the thallus (HEC 5546): f. cylindrical; g. clavate; h, i. obpyriform (i. with a young hair).

Geographic distribution: Indian Ocean: South Africa (type locality, Silva 1959), Mozambique (Silva 1959), Kenya (Gerloff 1960, Isaac 1967) and southern Australia (Silva & Womersley 1956).

Specimens examined: Kenya: HEC 5546: 01/07/1985 - Mombasa, Mc. Kenzie Point; HEC 6924: 21/07/1987 - Mombasa, Mc. Kenzie Point.

The dimensions of the utricles of the specimens examined agree with those given by Silva & Womersley (1956: 275): 450-1800 μm long and 130-750 μm diameter. Their specimens have utricles with more numerous hairs than were observed on the Kenyan specimens, but Silva (1959: 150) emphasizes that *C. duthieae* exhibits a wide range of variability in both habit and anatomy. Therefore it is very difficult to distinguish *C. duthieae* from *C. decorticutum* (Woodward) Howe. According to Silva (1960: 518) the utricles of this species are (790-)1100-1750(-2000) μm long and (115-)220-500(-850) μm diameter. Specimens of *C. decorticutum* from the Atlantic Ocean have an irregularly dichotomous branching pattern with elongated compressed dichotomies (Taylor 1960: 715).

Codium dwarkense Børgesen

Figs 4, 6, 14

Morphology: thallus erect, attached by a spongy hapteric base, more or less regularly dichotomously branched; branches completely terete, with a constant diameter within a specimen, but varying from 1 to 3 mm; basal branches sometimes repent (thallus ascendent), anastomosing and repeatedly attached to the substrate; dark green.

Anatomy: thallus dissecting out into individual utricles; these capitate, cylindrical, (pedicellate) clavate or suborbiculate; the capitate utricles show a constriction in the region 80-200 μm below the apex. Utricles from the middle or the basal part of the thallus (60-)135-185(-300) μm diameter at capitulum height, (25-)70-85(-160) μm diameter at the base, (330-)465-550(-770) μm long. Utricles of the apical parts (60-)75-115(-195) μm diameter, (215-)315-355(-470) μm long. Apices rounded or truncate, utricular wall 2 μm thick, (very) slightly thickened [(3-)4-7,7(-11) μm] at the apices. 0-4(-5) hairs or hair scars per utricle in the zone (40-)60-75(-115) μm below the apex. Gametangia fusiform, elliptical, ovate or even pyriform, (40-)65-85(-110) μm diameter, (130)175-210(-270) μm long, 1 or 2 per utricle, each borne on a pedicel about 8 μm long on a protuberance between 190-310 μm below the apex. Medullary filaments mostly (23-)25-30(-40) μm diameter.

Ecology: generally epilithic in reef pools situated in the infralittoral (fringe) zone; also epiphytic on stipes of the seagrass *Thalassodendron ciliatum* and on the brown alga *Hormophysa cuneiformis* (Gmelin) Silva.

Geographic distribution: Indian Ocean: India (type locality, Børgesen 1947), Tanzania (Jaasund 1976, this paper) and Kenya (Gerloff 1960).

Specimens examined: Kenya: HEC 5609: 05/07/1985 - Mombasa, Mc Kenzie Point; HEC 6010: 26/01/1986 - Mombasa, Nyali Beach; HEC 6956: 23/07/1987 - Mombasa, Mc. Kenzie Point; HEC 7064: 30/07/1987 - Diani; HEC 7442: 22/03/1988 -

Malindi; HEC 8252 & 8253: 05/08/1989 - Diani; HEC 9428 & 9429: 13/09/1992 - Tiwi; HEC 9457 & 9459: 14/09/1992 - Chale Island. Tanzania (Zanzibar): HEC 9712: 26/07/1993 - Uroa; HEC 9922: 05/08/1993 - Paje; HEC 10512, 10513 & 10514: 20/08/1994 - Uroa; HEC 10648: 25/08/1994 - Ras Fumba.

According to Silva (in litt.) in *C. capitatum* Silva [mentioned by Silva (1959: 135) from South Africa and Mozambique] the utricles are regularly capitate with apices that usually are externally foveolate or verruculose. Hairs or hair scars are uncommon. In *C. dwarkense* the utricles are often irregularly constricted. The apices are not ornamented. Hairs or hair scars are abundant. The constriction of the utricles is a character that is variable within a population and especially between populations.

Codium extricatum Silva

Figs 10, 15

Morphology: thallus erect, 2-7 cm high, firm, attached by a spongy hapteric base; branching dense, dichotomous, branches slightly compressed in lower part of the thallus, reaching 4 mm width, terete and gradually tapering in the upper parts to 1 mm diameter; dark to brownish green.

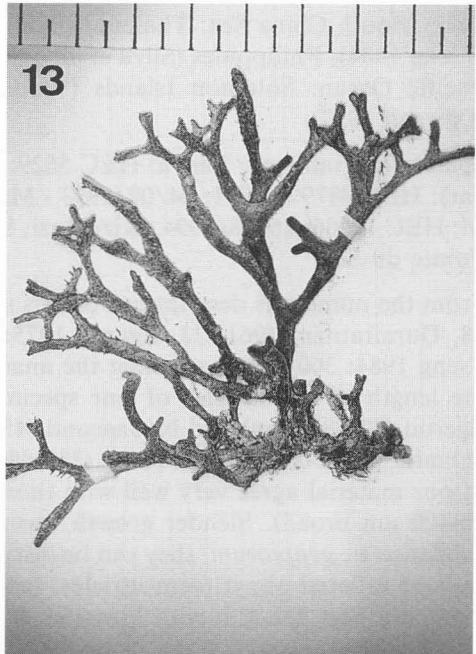
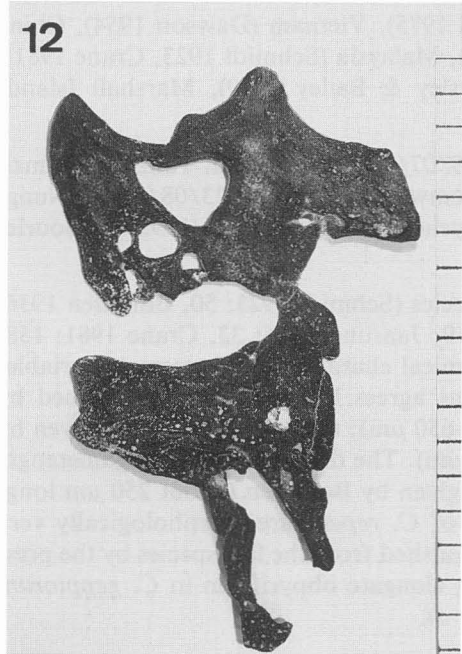
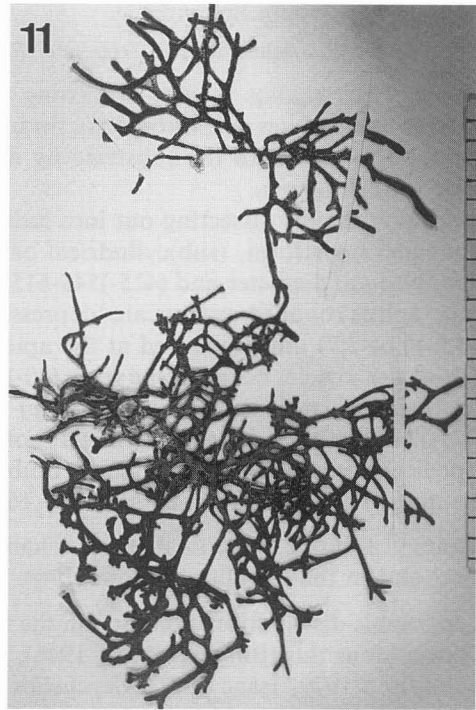
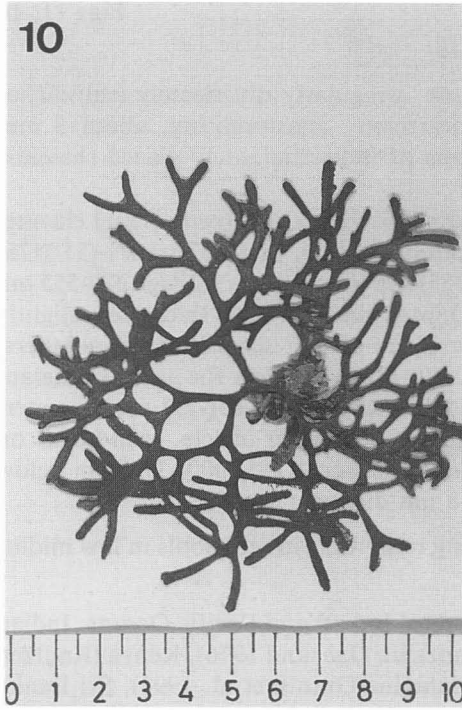
Anatomy: thallus dissecting out into individual utricles; these (pedicellate) clavate or subcylindrical, (60-)145-175(-325) μm diameter, (465-)590-635(-825) μm long, with truncate or rounded, sometimes even depressed apices; utricular wall about 2 μm thick, very slightly (5-7,7 μm) to slightly (15,5 μm) thickened at the apex. Hairs or hair scars generally limited, (0-)2-5 per utricle, borne in the zone (30-)60-75(-115) μm below the apex. One specimen (SEY 4) has more numerous hairs: (1-)6-7(-9) per utricle. Gametangia ellipsoidal or fusiform (45-)55-60(-90) μm diameter, (230-)255-265(-310) μm long, 1-3 per utricle, each borne on a pedicel about 11 μm long on a protuberance 230-370 μm below the apex of the utricle. Medullary filaments 23-38 μm diameter.

Ecology: epilithic, mostly on vertical and overhanging walls in reef pools from the low midlittoral down to the infralittoral zone. Only SEY 33 grew epiphytic on an old *Sargassum* stipe.

Geographic distribution: Indian Ocean: South Africa (type locality, Silva 1959), Tanzania (this paper), Kenya (Isaac 1971), Seychelles (this paper).

Specimens examined: Kenya: HEC 6858: 15/07/1987 - Diani; HEC 6892: 16/07/1987 - Mombasa, Fort Jesus; HEC 9416: 12/09/1992 - Mombasa, Mc. Kenzie Point. Tanzania (Zanzibar): HEC 9880: 04/08/1993 - Matemwe; HEC 9923: 05/08/1993 - Paje; ODC 349: 29/08/1994 - Mangapwani. Seychelles: SEY 4: 10/12/1992 - Anse Forbans; SEY 33: 11/12/1992 - Bay just south of North East Point; SEY 51: 12/12/1992 - Mare Anglaise; SEY 300: 20/12/1992 - Bird Island.

Our specimens anatomically agree very well with Silva's original description (1959: 147); morphologically they are smaller and more densely branched, but Silva already stressed the variability in thallus size, diameter and degree of compression of the branches.



Figs 10-13. General morphology. (One unit = 0,5 cm). Fig. 10. *Codium extricatum* Silva: habit of HEC 9416. Fig. 11. *Codium geppiorum* Schmidt: habit of HEC 9879. Fig. 12. *Codium lucasii* Setchell: habit of HEC 6762. Fig. 13. *Codium pocockiae* Silva: habit of HEC 8497b.

Codium geppiorum Schmidt

Figs 11, 16

Syn.: *Codium divaricatum* Gepp & Gepp, *non aliorum*

Morphology: thallus repent; branching dense, irregularly divaricately (sub)dichotomous (sometimes trichotomous); branches terete, anastomosing, about 3 mm diameter, attached to the substrate by means of indiscriminately placed rhizoids; olive to dark green.

Anatomy: thallus dissecting out into individual utricles; these (pedicellate) clavate, elongate obpyriform, (sub)cylindrical or (sub)orbiculate; mature utricles (55-)175-270(-345) μm diameter and (425-)545-615(-855) μm long, young utricles 270-555 μm long; apices rounded or truncate (depressed); utricular wall 2 μm thick, very slightly [(4,6-)6,6(7,7) μm] thickened at the apices. Hairs or hair scars in small numbers: 0-3(-4) per utricle, borne in the zone (40-)70-80(-115) μm below the apex. Gametangia fusiform (with or without a nozzle) to elliptical, (45-)60-65(-75) μm diameter, (225-)240(-260) μm long, generally 1, sometimes 2 or 3 per utricle, each borne on a pedicel (about 4 μm long) on a protuberance between (255-)300(-375) μm below the apex. Medullary filaments mostly 16-38 μm diameter.

Ecology: epilithic on vertical and overhanging rock walls in reef pools in low midlittoral and in the infralittoral zone.

Geographic distribution: common in the tropical Indian and Pacific Oceans. Indian Ocean: Mauritius (Børgesen 1940, 1946), Tanzania (Jaasund 1976), Kenya (Knutzen & Jaasund 1979, Isaac 1971), Seychelles (Kalugina-Gutnik et al. 1992), Sri Lanka (Børgesen 1936, Durairatnam 1961), Indonesia (Verheij & Prud'homme van Reine 1993). South China Sea: Thailand (Egerod 1975), Vietnam (Dawson 1954), China (Tseng 1984), Philippines (Silva et al. 1987), Malaysia (Schmidt 1923, Crane 1981). Pacific Ocean: Solomon Islands (Womersley & Bailey 1970), Marshall Islands (Dawson 1957).

Specimens examined: Kenya: HEC 5629: 09/07/1985 - Kanamai. Tanzania (Zanzibar): HEC 9879 & 9881: 04/08/1993 - Matemwe; HEC 10560: 23/08/1994 - Nungwi; HEC 10686: 26/08/1994 - Kizinkazi. Seychelles: SEY 8: 10/12/1992 - Ile Sourie, Pointe du Sel.

From the numerous descriptions of this species (Schmidt 1923: 50, Børgesen 1936: 68, Durairatnam 1961: 23, Egerod 1975: 59, Jaasund 1976: 33, Crane 1981: 158, Tseng 1984: 300) it appears that the anatomical characters are extremely variable: the length of the utricles of our specimens agrees best with that mentioned by Egerod (472-800 μm) and by Jaasund (450-650 μm); they are longer than given by Schmidt (300-500 μm) and Tseng (330-480 μm). The dimensions of the gametangia of our material agree very well with those given by Børgesen (about 250 μm long, 50-100 μm broad). Slender growth forms of *C. repens* are morphologically very similar to *C. geppiorum*; they can be distinguished from the last species by the presence of inflated obpyriform utricles, being elongate obpyriform in *C. geppiorum* (compare Figs 25a & b with Figs 16a, b & c).

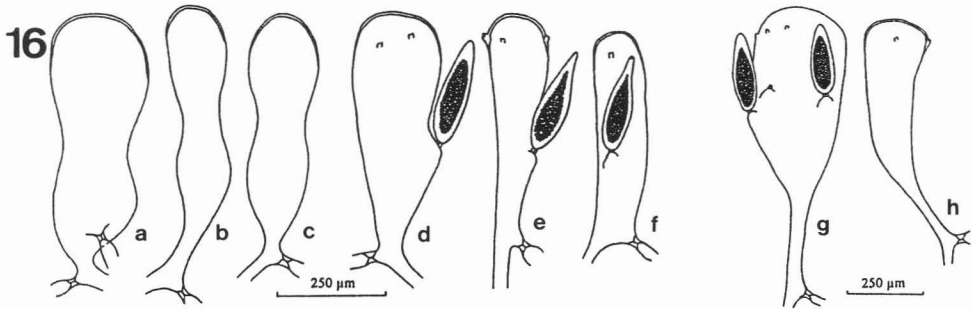
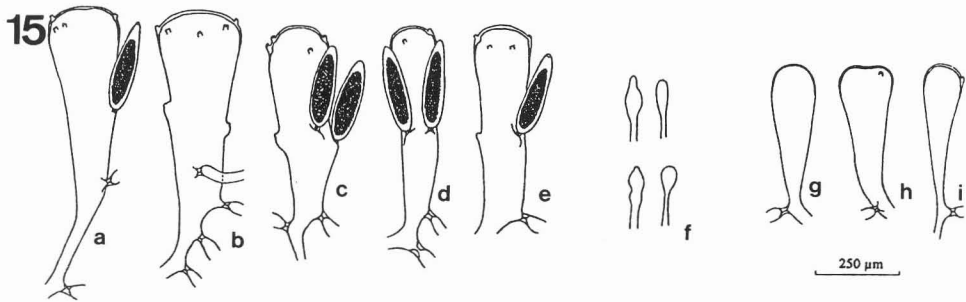
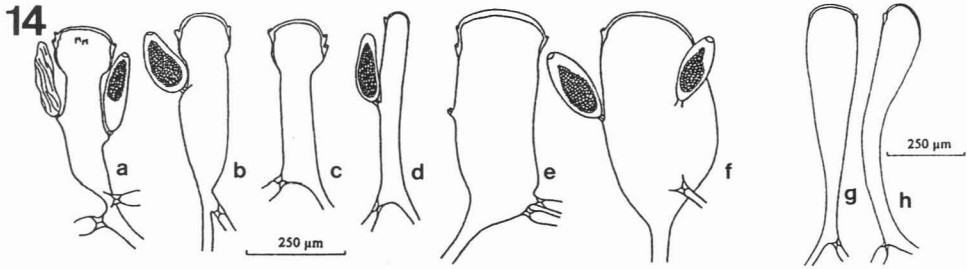


Fig. 14. Camera lucida drawings. *Codium dwarkense* Silva: utricles from the middle part of the thallus with or without gametangia: a-c. capitata (HEC 9712; a. with one mature and one empty gametangium and 5 hair scars); d, e. cylindrical (HEC 9457); f. suborbiculate (HEC 5609); g, h. clavate (g. HEC 8252, h. HEC 9429).

Fig. 15. Camera lucida drawings. *Codium extricatum* Silva: a-e. utricles from the middle part of the thallus (SEY 4) with fusiform to ellipsoidal gametangia, scars of gametangia and scars of hairs: a, b. clavate; c, d. subcylindrical; e. cylindrical; f. variation in swollen hair tips (SEY 4); g-i. clavate utricles of the tip of the thallus (HEC 6858).

Fig. 16. Camera lucida drawings. *Codium geppiorum* Schmidt: utricles from the middle part of the thallus: a-c. elongate obpyriform; d, e. clavate; f. cylindrical; g. pedicellate suborbiculate; h. pedicellate clavate; (a-d, g, h. SEY 8; e, f. HEC 9879).

Morphology: thallus crustose, about 2,5 mm thick, developing small dorsiventral (with cortex only on the top) lobes, tightly adherent to the substrate but with free margins; dark green.

Anatomy: cortex dissecting out into large clusters of utricles without conspicuous large primary utricles, those in the central part of the thallus bearing only 2, those on the margin up to 5 secondary utricles. All utricles cylindrical, slightly to markedly constricted 20-50 μm below the apex, resulting in capitate utricles; apices truncate, rounded or depressed. Smaller utricles from the central part (40-)55-70(-85) μm diameter at capitulum height, (340-)465-545(-670) μm long (measured from apex to point of origin on parent utricle). Broader utricles from the margin (45-)115(-200) μm diameter, (295-)415-470(-580) μm long. Utricular wall about 1,5 μm thick, very slightly (4-7,7 μm) to slightly (13 μm) thickened at the apices, with or without palisade-like structure. Hairs or hair scars absent or when present up to 4-8 per utricle, borne in the zone 33-50 μm below the apex. Gametangia 1 rarely 2 per utricle, fusiform to ovate, (55-)85(-135) μm diameter, (210-)265(-295) μm long, borne on a pedicel between 250-295 μm below the apex of the utricle. Medullary filaments 15-30 μm diameter.

Ecology: epilithic in reef pools and on reef platforms from the low midlittoral and infralittoral zones. Common in areas exposed to surf.

Geographic distribution: first described by Setchell (in Lucas 1935) from Lord Howe Island (Australia), then found along entire southern and western Australian coasts (Silva & Womersley 1956: 265, Womersley 1984: 227). Indian Ocean: South Africa (Silva 1959), Mozambique (Silva 1959), Tanzania (this paper), Kenya (Isaac 1967), Australia (Silva & Womersley 1956).

Specimens examined: Kenya: HEC 6762: 12/07/1987 - Mombasa, Nyali Reef; HEC 6857: 15/07/1987 - Diani; HEC 7062: 30/07/1987 - Diani. Tanzania (Zanzibar): HEC 10547: 22/08/1994 - Matemwe.

Our specimens are thinner and have smaller utricles than those described by Silva & Womersley (1956: 265): thallus 2,5-8 mm thick, utricles 435-800(-1150) μm long; the insertion zone of the hairs is higher than mentioned in literature (70-145 μm below the apex). The gametangium dimensions completely agree with Silva's data from Australia (60-125 μm diameter and 215-360 μm long). The absence of conspicuous primary utricles, the presence of cylindrical utricles with or without capitulum and a limited number of depressed apices, still confirm identification as *C. lucasii*.

In 1959 Silva distinguished *C. lucasii* Setchell subsp. *capense* Silva in South Africa, also found in Mozambique and Kenya. There are minor differences in dimensions between *C. lucasii* Setchell and *C. lucasii* subsp. *capense* Silva (Table I). In our opinion they are too small to separate a subspecies. Therefore we do not agree with Silva's argumentation (1959: 113): "The slightly larger diameter of utricles of *C. lucasii* as represented in South Africa enables a South African specimen to be distinguished from an Australian specimen in a majority of instances. There is an overlap in the range of variation of the two subspecies, however, and certain South African

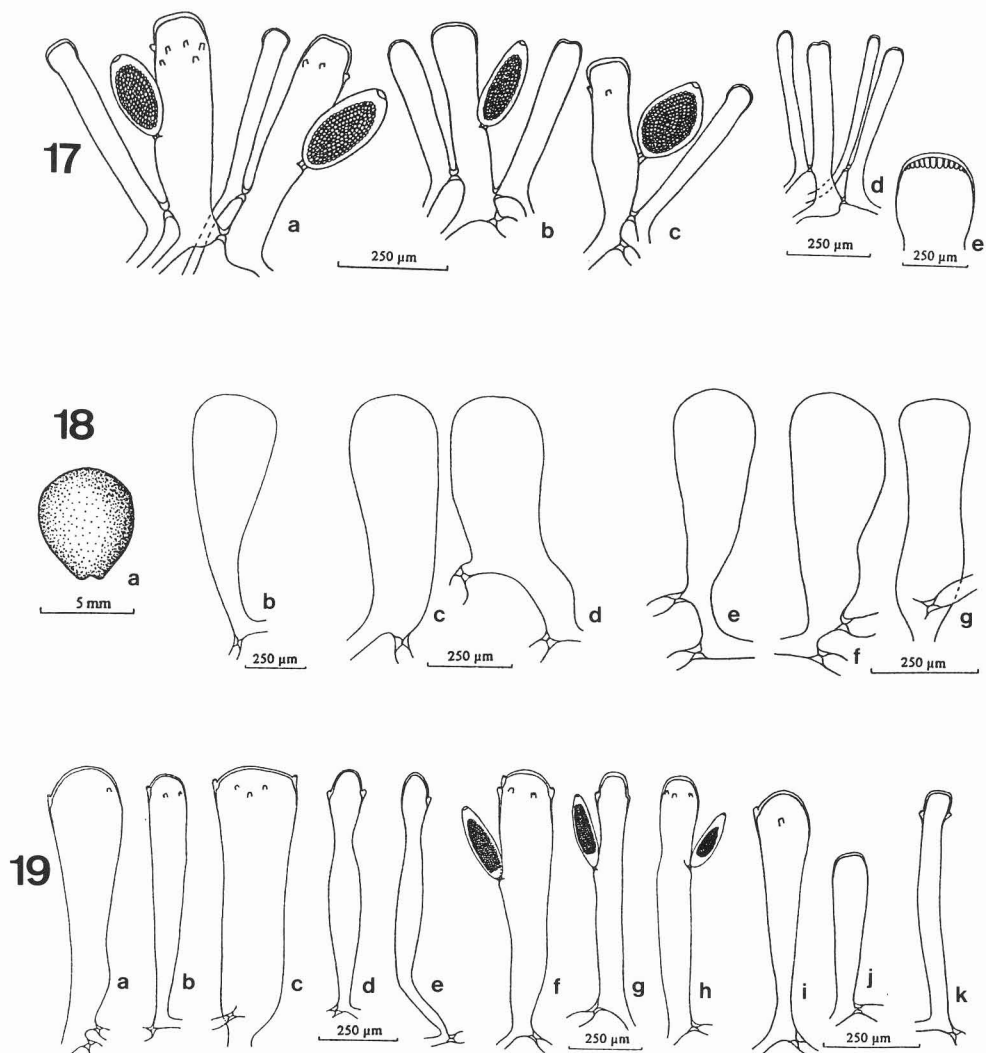


Fig. 17. Camera lucida drawings. *Codium lucasii* Setchell: a-c. cluster of utricles from the central part of the thallus (a. HEC 6857; b, c. HEC 6762) with fusiform to ovate gametangia; d. cluster of utricles from the central part (HEC 7062); e. detail of the apex of a mature utricle with a palisade-like thickened utricular wall (HEC 7062).

Fig. 18. *Codium ovale* Zanardini. General morphology: a. habit of SEY 349. Camera lucida drawings: b-g. utricles (SEY 349); b, e. clavate; c. subcylindrical; d. cylindrical; f, g. clavate or cylindrical with a constriction.

Fig. 19. Camera lucida drawings. *Codium pocockiae* Silva: a-k. utricles from the middle part of the thallus; a, b, i. clavate; c, j. subcylindrical; k. cylindrical; d, e. clavate with a shallow constriction; (a, b, i. HEC 8253; c-e. HEC 7423; k, j. HEC 8497b); f-h. utricles with fusiform gametangia (HEC 10649).

Table I. Anatomical details of *C. lucasii* Setchell and of *C. lucasii* subsp. *capense* Silva.

Features:	<i>C. lucasii</i>	<i>C. lucasii</i> subsp. <i>capense</i>
diameter utricles	(45-) 50-100 (-130) μm	(50-) 60-105 (-125) μm
length utricles	425-800 (-1150) μm	(435-) 500-800 (-1100) μm
constriction below apex	40-70 μm	50-80 μm
insertion of hairs	70-145 μm	70-145 μm
utricular wall	1 μm	1,5 μm
diameter med. filaments	13-33 μm	15-35 μm
diameter gametangia	60-125 μm	(48-) 60-125 μm
length gametangia	215-360 μm	215-370 μm

plants have utricles of an average diameter smaller than certain Australian plants.” The dimensions of the utricles of our specimens from the E. African coast are even smaller, but we still consider them as being within the variability of the species. See also the discussion of *C. arabicum*.

Codium ovale Zanardini

Fig. 18

Morphology: thallus inverted drop-like, hollow, adhering to the substratum with the pointed part. The 3 collected specimens are small and juvenile with a height of 6,5-7 mm and a diameter of 6 mm. The habit is not (yet) compressed; dark green.

Anatomy: thallus dissecting out into individual utricles; these broadly clavate or subcylindrical, sometimes with a slight constriction around the middle of the utricle, (155-)280(-400) μm diameter in their apical part and (470-)635(-985) μm long; apices (sub)truncate or rounded, utricular wall 4 μm thick, not thickened at the apices. Hairs or hair scars absent. The collected specimens are sterile. According to Pramudji (1992: 30), the gametangia are elliptical, 54-116 μm and 246-400 μm long, borne on the middle or upper part of the utricle. Medullary filaments 31-62 μm diameter.

Ecology: a single collection of 3 specimens growing on infralittoral coral rubble, 10-15 m deep. Schmidt (1923), Gepp & Gepp (1911) and Dawson (1957) do not give any ecological data for this species.

Geographic distribution: Indian Ocean: Seychelles (Gepp & Gepp 1908, Schmidt 1923, this paper), Indonesia (Gepp & Gepp 1911, Pramudji 1992). South China Sea: Malaysia (Schmidt 1923), Philippines (Silva et al. 1987). Pacific Ocean: New Guinea (type locality, Zanardini 1878), Marshall Islands (Dawson 1957).

Specimens examined: Seychelles: SEY 349: 23/12/1992 - La Digue Island.

The collected specimens are most probably young, judging from the small dimensions of the plants and of the utricles compared to those given by Schmidt (1923: 37): mature hollow thallus of about 16 mm high, 12 mm broad and utricles of 600-900 μm long. The age of the thalli could also be the explanation for the fact that they are not yet compressed.

Codium pocockiae Silva

Figs 13, 19

Morphology: thallus erect or ascendent; branching irregular, divaricately dichotomous, with both branches of a dichotomy usually not equally developed and the branching thus appearing cervicorn; branches more or less terete, 3-4 mm diameter; light to dark green.

Anatomy: thallus dissecting out into individual utricles, these clavate, (sub)cylindrical or clavate with a shallow constriction above the middle of the utricle, (60-)110-165(-225) μm diameter at apex height, (525-)630-815(-1030) μm long, apices rounded or subtruncate; utricular wall about 2 μm thick, very slightly (5-7 μm) thickened at the apices. Hairs or hair scars common, (0-)3-4(-10) per utricle, borne in the zone 38-92 μm below the apex. Gametangia more or less fusiform, 55-80 μm diameter, 225-285 μm long, mostly 1 (rarely 2) per utricle, borne in the zone 290-335 μm below the apex of the utricle. Medullary filaments 23-31 μm diameter.

Ecology: epilithic on horizontal dead coral or epiphytic on *Thalassodendron* at relatively sheltered places in the low midlittoral zone and the infralittoral fringe.

Geographic distribution: Indian Ocean: South Africa (type locality, Silva 1959), Mozambique (Silva 1959), Tanzania (this paper) and Kenya (Isaac 1967). Pacific Ocean: Easter Island (Etcheverry 1960).

Specimens examined: Kenya HEC 7423: 21/03/1989 - Diani; HEC 8497b: 24/08/1989 - Diani. Tanzania (Zanzibar): HEC 10649 & 10650: 25/08/1994 Ras Fumba.

Our 3 Kenyan specimens show a pronounced variation in branching density: the interdichotomies in HEC 8253 are short (2-11 mm), those in HEC 8497b are medium long (7-20 mm) and in HEC 7423 they are very long (55 mm); the last one, growing epiphytically, is poorly developed and sparsely branched. The dimensions of the utricles agree very well with those given by Silva (1959: 139).

Morphologically, *C. pocockiae* in the Indian Ocean can be distinguished from the other erect *Codium* species with terete branches by its divaricate, dichotomous-cervicorn branching. Anatomically, the species is characterized by its slender clavate utricles with mostly rounded apices. The clavate and subcylindrical utricles of *C. extricatum* have truncate apices, and *C. cicatrix* mainly has wedge-shaped utricles with depressed apices.

Codium prostratum Levring

Figs 20-23, 24

Morphology: thallus repent, very stiff, repeatedly and strongly attached to the substrate by groups of rhizoids; branching (sub)dichotomous or irregular; branches terete or somewhat compressed, 3-7 mm thick, in superposed anastomosing layers, with blunt apices; possible presence of short, erect, dichotomous branches, resulting in dense, hemispherical clumps, up to 13 cm diameter; dark green.

Anatomy: thallus dissecting out into individual utricles; these mostly (pedicellate) clavate or (sub)cylindrical, sometimes markedly tapering towards their base, (55-)125-170(-240) μm diameter at apex height, (615-)850-1115(-1410) μm long;

apices truncate (sometimes rounded); utricular wall about 1,5 μm thick, usually only very slightly (3,5-7,7 μm), rarely slightly (15,4 μm) thickened at the apices. Hairs or hair scars mostly 0-5 (sometimes 6-10) per utricle, borne in the zone (30-)75-115 (-215) μm below the apex. Gametangia fusiform (with or without a nozzle), elliptical to lanceolate-ovate, (45-)60-80(-130) μm diameter, (245-)295-360(-415) μm long, 1 or 2 per utricle, each one borne on a pedicel about 8 μm long on a protuberance 275-425 μm below the apex of the utricle. Medullary filaments 23-31(-38) μm diameter.

Ecology: epilithic on horizontal, vertical or overhanging coral walls of fringing reefs, both in pools as on exposed places at low tide, in the mid and infralittoral zones.

Geographic distribution: Indian Ocean: South Africa (type locality, Levring 1937, Eyre & Stephenson 1938, Silva 1959), Mozambique (Silva 1959) and Kenya (Isaac 1967, this paper).

Specimens examined: Kenya: HEC 5608: 05/07/1985 - Mombasa, Mc. Kenzie Point; HEC 5962a & b: 23/01/1986 - Mombasa, Mc. Kenzie Point; HEC 6821: 13/07/1987 - Tiwi; HEC 6856: 15/07/1987 - Diani; HEC 7046: 29/07/1987 - Kanamai; HEC 7063: 30/07/1987 - Diani; HEC 7298: 10/03/1988 - Shimoni, Wasini Island; HEC 7341: 15/03/1988 - Mombasa, Nyali; HEC 8251: 05/08/1989 - Diani; HEC 8497a: 24/08/1989 - Diani; HEC 8747: 13/09/1991 - Kanamai; HEC 9431 & 9432: 13/09/1992 - Tiwi; HEC 9461, 9462, 9463 & 9464: 14/09/1992 - Chale Island.

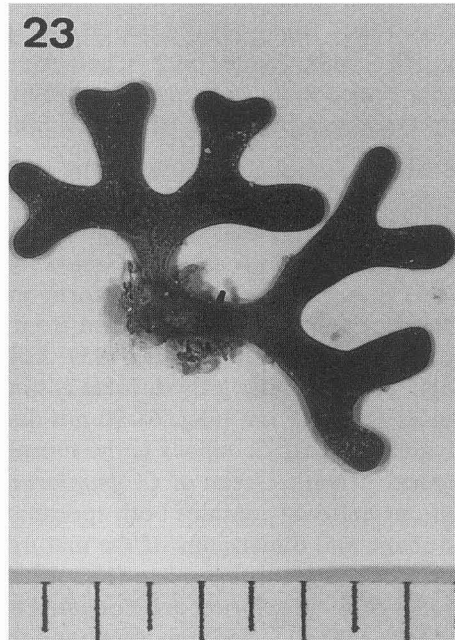
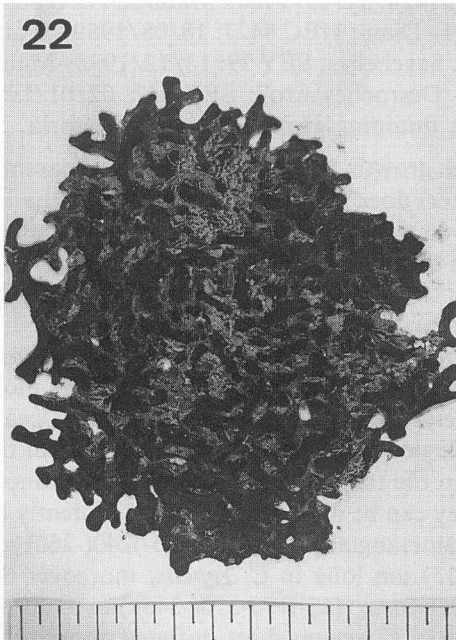
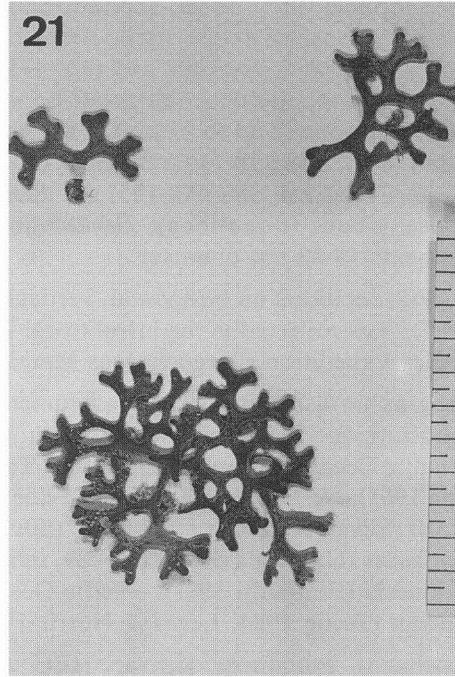
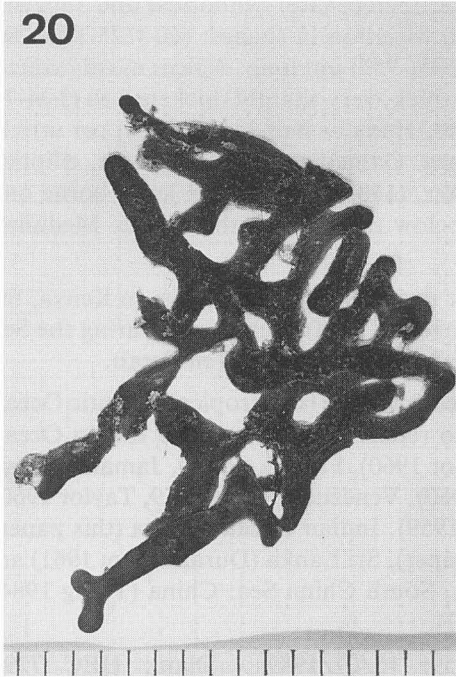
Some juvenile specimens (HEC 5608) of 3 cm length are exclusively erect, not anastomosing yet, but identifiable by their anatomy. The variation of utricle dimensions within a single Kenyan specimen can be extreme: HEC 9431: length (625-)1010 (-1695) μm , HEC 8497a: width (60-)145(-330) μm . This is even more than given by Silva (1959: 134) for South African specimens: length 720-1310 μm , width 65-183 μm . The same applies to the insertion zone of the hairs (80-130 μm in Silva), and the dimensions of the gametangia (33-72 μm wide, 265-635 μm long in Silva). The utricle dimensions given by Levring (1937: 16) are markedly smaller: 500-950 μm . *Codium prostratum* differs from *C. vaughanii* by the absence of the halo of hairs in combination with the longer utricles [(405-)520(-855) μm in *C. vaughanii*]. The other repent *Codium* species have thinner branches and are less stiff; their utricles are also shorter.

Codium repens (Crouan) Vickers

Figs 25, 27-28

Syn.: *Codium tomentosum* Agardh var. *subsimplax* (Crouan) Schramm & Mazé
Codium tomentosum Agardh var. *reptans* (Crouan) Schramm & Mazé
Codium tenue Kützing var. *repens* (Crouan) Schramm & Mazé

Morphology: thallus repent, repeatedly and strongly attached to the substrate by groups of rhizoids, forming extensive, firm mats of up to 11 cm diameter; branching dense, divaricate, more or less dichotomous; branches terete or slightly compressed at the dichotomies, anastomosing, slender (1-2,5 mm diameter); (very) dark green. Anatomy: cortex dissecting out into individual utricles; these morphologically vari-



Figs 20-23. General morphology of *Codium prostratum* Leving. (One unit = 0,5 cm). Fig. 20. Repent thallus with an irregular branching (HEC 7341). Fig. 21. Repent thallus with a dichotomous branching (HEC 8497). Fig. 22. Repent thallus with an extreme dense branching, resulting in a hemispherical clump (HEC 9463). Fig. 23. Juvenile erect thallus (HEC 5608).

able: inflated obpyriform, capitate, clavate, (pedicellate) cylindrical and subcylindrical; dimensions rather stable despite the variation in shapes: (60-)125-170(-295) μm diameter at apex height and (325-)435-545(-755) μm long. Apices mostly rounded or truncate; utricular wall about 1,5 μm thick, very slightly thickened to (3-)4-7,7 μm (exceptionally up to 11 μm) at the apices. Hairs or hair scars 0-3(-6) per utricle, borne in the zone 38-130 μm below the apex. Gametangia, single, ovate, elliptical or short fusiform, (60-)90(-125) μm diameter, (170-)175(-215) μm long, borne on a pedicel (about 10 μm long), 210-285 μm below the apex of the utricle. Medullary filaments 19-38 μm diameter.

Ecology: epilithic on horizontal, vertical or overhanging coral walls. In Kenya, this species was collected in the infralittoral fringe, on the fringing reef. During the Seychelles Expedition *C. repens* was sampled between 10 and 20 m depth.

Geographic distribution: originally described from the (sub)tropical Atlantic Ocean. Durairatnam (1961) was the first author to report *C. repens* in the Indian Ocean. Atlantic Ocean: Bermuda (Silva 1959, Taylor 1960), Florida (idem), Jamaica (Chapman 1961), Netherlands Antilles (Taylor 1960), Venezuela (Silva 1959, Taylor 1960), Brazil (Silva 1959), Canary Islands (Silva 1959). Indian Ocean: Kenya (this paper), Seychelles (Untawala & Jagtap 1989, this paper), Sri Lanka (Durairatnam 1961) and Indonesia (Pramudji 1992). Pacific Ocean, South China Sea: China (Tseng 1984), Taiwan (Tseng 1984, Lewis & Norris 1987).

Specimens examined: Kenya: HEC 6859: 15/07/1987 - Diani; HEC 7299: 10/03/1988 - Shimoni, Wasini Island; HEC 7424: 21/03/1988 - Malindi; HEC 8250: 05/08/1989 - Diani; HEC 8254: 05/08/1989 - Diani; HEC 8427: 18/08/1989 - Wataamu; HEC 9458: 14/09/1992 - Chale Island. Seychelles: SEY 79: 13/12/1992 - Mahé, Petite Police Bay; SEY 551: 30/12/1992 - Desroches Atoll; SEY 647: 02/01/1993 - Ile Desnoeufs; SEY 09/01/1993 - Mahé, dumping-ground north of Victoria.

All of our specimens belong to the slender growth form of *C. repens*, apparently the thick form (branches 2,5-5 mm diameter) does not occur in this part of the Indian Ocean. Our observations agree very well with the descriptions and illustrations of the rare, slender form of *C. repens* from the Atlantic Ocean given by Silva (1959: 514-515): utricles short obpyriform and capitate, 330-550(-700) μm long. The utricles of the frequent thick form from the Atlantic Ocean are clavate or subcylindrical, 700-875 μm long (Silva 1959: 514). Although the general shape of the gametangia of the slender growth form is similar, the Atlantic ones are longer and more slender (205-225 μm long, 68-90 μm diameter) than those from the Indian Ocean. Silva claims that *C. repens* is the morphological and ecological counterpart in the tropical Atlantic Ocean of *C. geppiorum* in the tropical Pacific. We are convinced that our material contains both species: they can be distinguished most evidently by the shape and dimensions of the mature gametangia: fusiform, (225-)240(-260) μm long in *C. geppiorum*, ovate (170-)175(-215) μm long in *C. repens*; moreover the utricles of *C. geppiorum* are elongated obpyriform [(55-)175-270(-345) μm diameter and (425-)545-615(-855) μm long], and those of *C. repens* short, inflated obpyriform [(60-)125-170(-295) μm diameter and (325-)435-545(-755) μm long]. Durairatnam (1961), Tseng (1984) and Pramudji (1992) also mentioned both species from the Indian and Pacific Ocean.

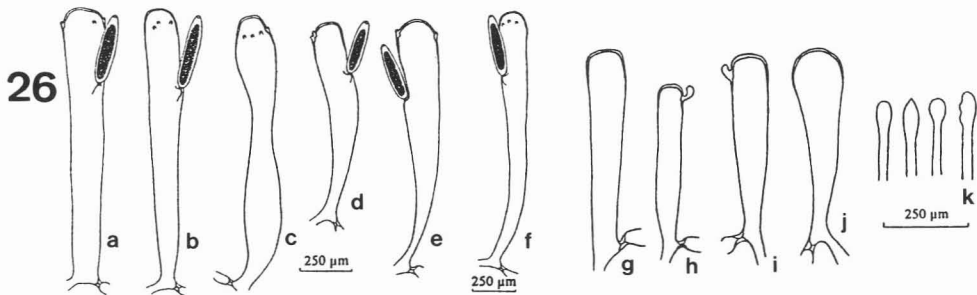
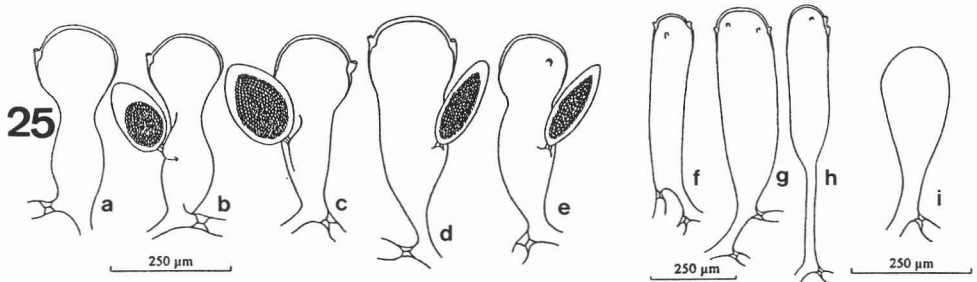
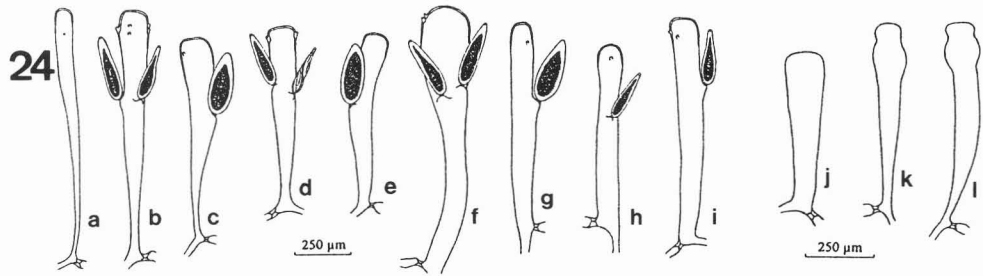


Fig. 24. Camera lucida drawings. *Codium prostratum* Levring: a-i. utricles from the middle part of the thallus with ovate or fusiform gametangia (with or without nozzle); a. (pedicellate) clavate; b-d. clavate; e, f. subclavate; g. subcylindrical; h, i. cylindrical; (a. HEC 5962; b, f, h, i. HEC 7341; c, e, g. HEC 9462; d. HEC 7298); j-l. utricles from the apical part of the thallus (HEC 8497a).

Fig. 25. Camera lucida drawings. *Codium repens* (Crouan) Levring: a-h. utricles from the middle part of the thallus: a-e. utricles from HEC 7424 with ovoid, ellipsoidal or fusiform gametangia (a, b. inflated obpyriform; c-e. capitate); f-h. utricles from HEC 8254 (f. cylindrical; g. subcylindrical; h. pedicellate subcylindrical); i. clavate utricles from the apical part of HEC 9458.

Fig. 26. Camera lucida drawings. *Codium taylorii* Silva: a-f. utricles with fusiform gametangia from the middle part of the thallus SEY 230C (a. cylindrical; b. subcylindrical; c. subcylindrical with a median constriction; d-f. clavate); g-j. immature utricles from the apical parts of the same thallus (g-i. subcylindrical, j. clavate); k. variation in swollen hair tips.

Morphology: thallus erect, up to 7 cm high; branching divaricately dichotomous (up to 6 orders); both branches of a dichotomy frequently not equally developed, resulting in a cervicorn branching pattern; branches compressed throughout, 3-8 mm broad, 3-4 mm thick. A halo (0,5-1,5 mm) of hairs is frequent around the blunt tips; vivid green.

Anatomy: cortex dissecting out into individual utricles; these (sub)cylindrical or (pedicellate) clavate, sometimes with a median constriction, (60-)175-250(-385) μm diameter, (795-)980-1350(-1625) μm long. Young utricles of the apical parts of the thallus smaller: (55-)74-110(-130) μm diameter and (445-)520(-595) μm long. Apices (sub)truncate or slightly rounded; utricular wall 2 μm thick, slightly thickened (up to 10 μm) at the apices. Hairs or hair scars very common, 3-7 per utricle, borne in the zone (30-)55-75(-110) μm below the apex. Mature hairs often with a club-like tip. Gametangia single, slender, fusiform, (55-)65-70(-80) μm diameter, (245-)280-335 (-355) μm long, borne on a short pedicel (about 8 μm long) on a slight protuberance 295-370 μm below the apex of the utricle. Medullary filaments 23-31 (-54) μm diameter.

Ecology: all specimens examined, collected at the same place on Bird Island (Seychelles), epilithic on sublittoral coral rubble near the beach. According to Silva (1959: 512) this species is also found on mangrove roots in the high midlittoral, on rocks and reefs in the low mid and the infralittoral zones (down to 60 m deep) and sometimes as an epiphyte on other seaweeds [e.g. on *Laurencia papillosa* (C. Agardh) Greville].

Geographic distribution: originally described by Silva (1959) from the tropical Atlantic Ocean and the Mediterranean Sea. Egerod (1974) was the first to mention this species for the Indian Ocean. Atlantic Ocean: West coast of Florida (Dawes 1974), Mexico (Silva 1959). Caribbean Sea: Jamaica (Silva 1959, Chapman 1961), Puerto Rico (Silva 1959), Venezuela and Colombia (Silva 1959), (according to Silva 1959): Bermuda, east coast of Florida, Bahamas, Virgin Islands (Taylor 1985), Brazil, Canary Islands, Cape Verde Islands and Ghana. Mediterranean Sea: Israël (Silva 1959). Indian Ocean: Seychelles (Titlyanova & Butorin 1978, this paper), Thailand (Egerod 1974).

Specimens examined: Seychelles: SEY 230 & 231: 20/12/1992 - Bird Island, east coast.

The anatomical dimensions of the specimens from the Seychelles, agree very well with those given by Silva (1959: 511) for the material from the Atlantic Ocean (Table II).

Morphologically, our specimens also agree with the descriptions in literature. Within this species morphological variation is pronounced (Silva 1959: 512): the branches are most generally completely compressed, but sometimes they are only compressed at the dichotomies and rather exceptionally they are even completely terete; they can also be very broad (up to 25 mm); totally unbranched thalli also occur. The specimens described from Thailand by Egerod (1974: 145), have such a habit (compressed "leaves" tapering toward their base, 1 cm broad and up to 17 cm long). *Codium*

Table II. *Codium taylorii* Silva: anatomy of specimens from the Seychelles and from the Atlantic Ocean.

Features	Specimens from the Seychelles (personal observations)	Specimens from Atlantic Ocean (SILVA 1959)
diameter utricles	(62-) 173-251 (-385) μm	(55-) 110-260 (-380) μm
length utricles	(793-) 981-1352 (-1625) μm	(550-) 650-1150 (-1450) μm
insertion of hairs	(31-) 53-77 (-108) μm	50-105 μm
utricular wall	2 μm	2-2,5 μm
diameter med. filaments	23-31 (-54) μm	15-35 μm
diameter gametangia	(54-) 67-72 (-85) μm	45-85 μm
length gametangia	(246-) 279-333 (-354) μm	200-300 (-350) μm
distance gametangia below apex	293-370 μm	275-430 μm

taylorii is closely related to *C. pocockiae* from South Africa, but is distinct from this species by its broader branches (*C. pocockiae*: branches 3-4 mm broad) and its longer utricles with mostly truncate apices [*C. pocockiae*: utricles with rounded apices and (525-)630-815(-1030) μm long]. This is a first record of a “normal growth form” of this Atlantic species in the Indian Ocean. Silva (in litt.) doubts that *Codium taylorii* occurs in the Indian Ocean.

Codium vaughanii Børgesen

Figs 30-31

Morphology: thallus repent, attached by a central disc and by irregularly placed groups of rhizoids; branching dense, (irregularly) subdichotomous; branches terete, 2-4 mm thick; the blunt apices surrounded by a halo (1-2 mm broad) of hairs (only visible on live or formalized material); dark olive green.

Anatomy: cortex dissecting out into individual utricles; these (pedicellate) clavate or subcylindrical, (85-)160(-255) μm diameter, (410-)520(-855) μm long; apices (broadly) rounded or truncate; utricular wall about 1,5 μm thick, very slightly (3-7 μm) thickened at the apices. Hairs or hair scars (1-)2-4(-6) per utricle, borne in the zone 38-62 μm below the apex. The specimen from the Seychelles with swollen hair tips; these thickenings primarily club-like, becoming irregular afterwards. The Kenyan specimen without such swollen hair tips. Gametangia elliptical to fusiform, (38-)60 (-90) μm diameter, (230-)225(-305) μm long, borne on a short pedicel (about 8 μm long) on a protuberance 230-295 μm below the apex of the utricle. Medullary filaments 23-31 μm diameter.

Ecology: both specimens growing on a coral or limestone platform in the infralittoral fringe.

Geographic distribution: Indian Ocean: Mauritius (type locality, Børgesen 1940, 1946), Kenya (Isaac 1968, this paper) and Seychelles (this paper).

Specimens examined: Kenya: HEC 9502: 16/09/1992 - Msambweni. Seychelles: SEY 71: 13/12/1992 - Mahé, Petite Police Bay.

Our specimens agree very well with the descriptions and illustrations of Børgesen (1940, 1946): utricles 400-800(-900) μm long and 44-250 μm broad, gametangia 45 μm diameter and 250 μm long. Two typical features of *C. vaughanii*, the halo of hairs and the swollen hair tips, are also clearly present on the specimen from the Seychelles. Isaac (1968: 2) already mentioned the absence of thickened hair tips in Kenyan specimens. *Codium repens* and *C. geppiorum* can be distinguished from *C. vaughanii* by the presence of obpyriform utricles. See also the discussion of *C. prostratum*.

Codium sp.

Fig. 32

Morphology: thallus erect, unbranched, terete, narrowly clavate, solid, 7,5-9 mm high 0,5-1,2 mm in diameter; light green.

Anatomy: cortex dissecting out into individual utricles; these characteristically obtriangular or more rarely broadly inflated obpyriform, (215-)285(-355) μm diameter at apex height and (45-)70(-90) μm diameter at the basis, (225-)275(-425) μm long; utricular wall 2 μm thick, not thickened at the apices. Hairs or hair scars absent. Both collected specimens sterile. Medullary filaments 23-39 μm diameter.

Ecology: epipsammic at a depth of 2-7 m (infralittoral).

Specimens examined: SEY 491: 29/12/1992 - Poivre Atoll.

According to P.C. Silva (in litt.) this is either an immature specimen or a new species. The characteristic obtriangular utricles are not present in any previously described species. *Codium petaloideum* Gepp & Gepp differs from our *Codium* sp. by the compressed obovate habit and the smaller utricles: 180-240 μm long, 115-180 μm diameter. *Codium* sp. is distinct from *C. ovale* by its club-shaped solid thallus and its obtriangular utricles.

General discussion on the genus *Codium* from our East African collection

The 99 collections studied here belong to 14 different species (Table III).

The 60 collections from Kenya, collected during 9 different field trips, contain 11 species. *Codium prostratum* is markedly the most abundant (18 collections) in this area, followed by *C. dwarkense* (11 collections) and *C. repens* (7 collections). *Codium cicatrix* and *C. repens* are new records for Kenya.

Field work in Zanzibar was restricted to 2 short stays of 2 weeks each in 1993 and 1994, and only resulted in 20 *Codium* collections, including 6 species. The small number could be due to the fact that surf-exposed coasts, where apparently numerous *Codium* spp. have their optimal development, have been undersampled up to

Figs 27-30. General morphology. (One unit = 0,5 cm). Figs 27, 28. *Codium repens* (Crouan) Vickers. Fig. 27. Habit of thallus (HEC 8250) with a "normal" dichotomous branching. Fig. 28. Habit of a thallus (HEC 7299) with a very dense irregular dichotomous branching. Fig. 29. *Codium taylorii* Silva: habit of SEY 230A. Fig. 30. *Codium vaughanii* Børgesen: habit of HEC 9502.

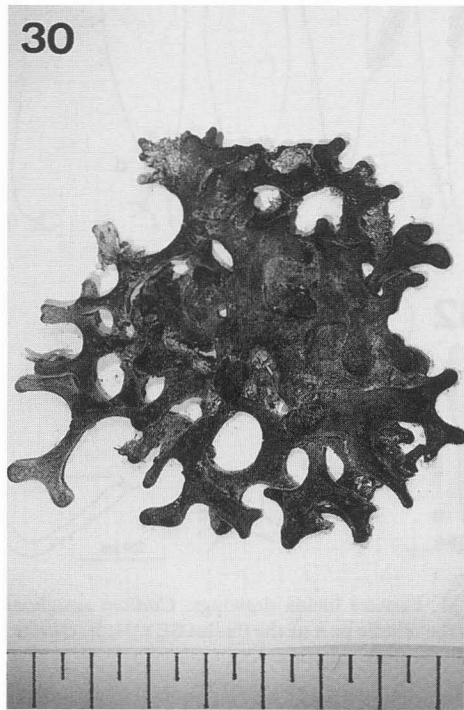
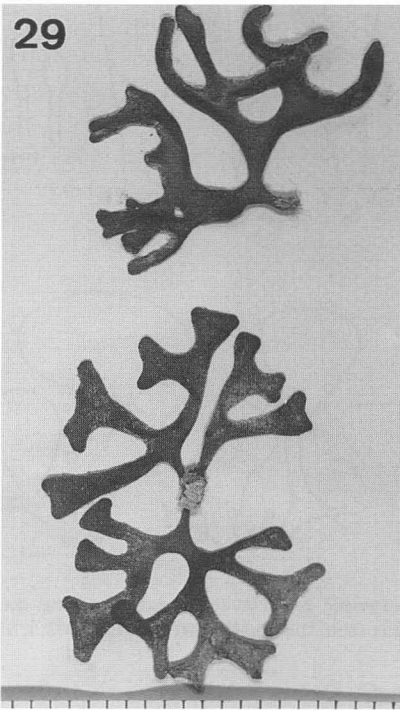
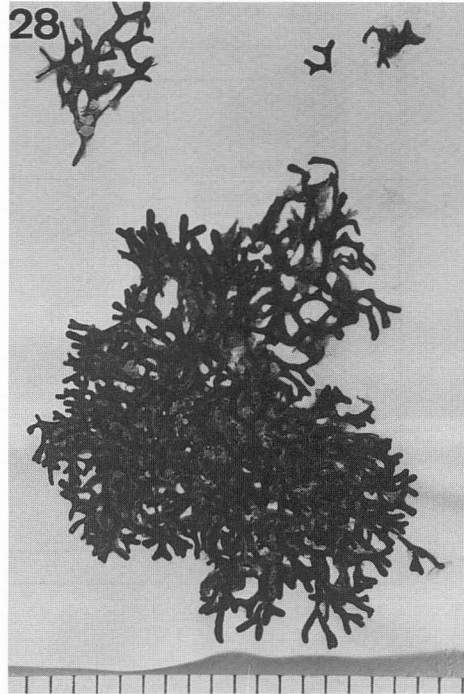
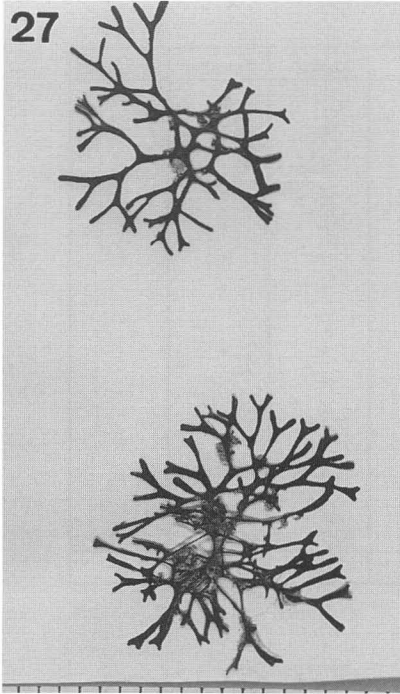


Table III. Survey of the species and their distribution.

Nr	Species	Kenya	Zanzibar	Seychelles
1	<i>C. arabicum</i>	+	+	+
2	<i>C. cicatrix</i>	+		+
3	<i>C. duthieae</i>	+		
4	<i>C. dwarkense</i>	+	+	
5	<i>C. extricatum</i>	+	+	+
6	<i>C. geppiorum</i>	+	+	+
7	<i>C. lucasii</i>	+	+	
8	<i>C. ovale</i>			+
9	<i>C. pocockiae</i>	+	+	
10	<i>C. prostratum</i>	+		
11	<i>C. repens</i>	+		+
12	<i>C. taylorii</i>			+
13	<i>C. vaughanii</i>	+		+
14	<i>C. sp.</i>			+
	number of species	11	6	9

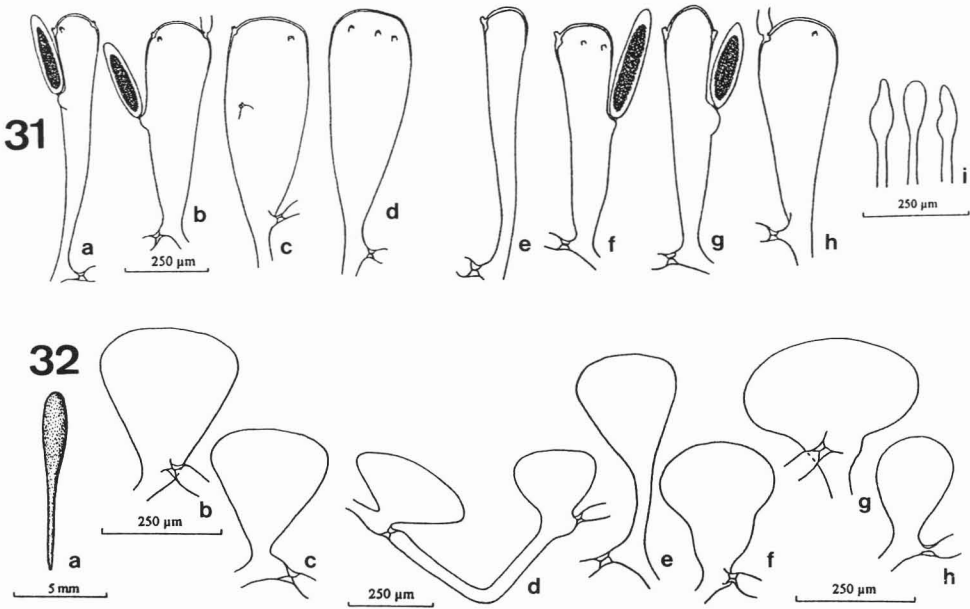


Fig. 31. Camera lucida drawings. *Codium vaughanii* Børgesen: a-g. clavate to subcylindrical utricles from the middle part of the thallus SEY 71; h. clavate utricle from the middle part of HEC 9502; i. variation in swollen hair tips.

Fig. 32. *Codium* sp. (SEY 491). General morphology: a. habit. Camera lucida drawings: b-d. obtriangular utricles; e. stalked obtriangular; f, g. inflated obpyriform; h. immature utricle.

now. Three of the species are mentioned by Jaasund (1976: *C. arabicum*, *C. dwarfkense*, *C. geppiorum*); *C. extricatum*, *C. lucasii* and *C. pocockiae* known from South Africa, are new for the area.

During the Dutch Seychelles Expedition 1992-1993 (1 month), 19 *Codium* collections were gathered, containing 9 different species of which only *C. geppiorum* Schmidt was previously mentioned from the area by Kalugina-Gutnik et al. (1992) in their list of benthic marine algae around the Seychelles collected during the USSR-USA Expedition. They also mention *C. formosanum* Yamada and *C. tomentosum* Stackhouse, species which have not been observed during the Dutch expedition. On Bird Island, characteristic specimens of *C. taylorii* were sampled. The species was described from the Atlantic Ocean and mentioned from the Indian Ocean only once with a deviant form by Egerod (1974).

Although the present species list (14 spp.) is certainly incomplete, it most probably reflects the species richness of the area when compared to other regions such as the tropical West coast of Africa: 3 spp. (Lawson & John 1987), Southeastern United States: 5 spp. (Schneider & Searles 1991), tropical Western Atlantic: 7 spp. (Silva 1959), Hawaii: 6 spp. (Silva 1952). It is similar to species-rich regions such as South Africa: 19 species (Silva 1959), Southern Australia: 16 species (Womersley 1984) and the Philippines: 17 species (Silva et al. 1987).

Collecting in subtidal biotopes along the seaward side of the fringing reef along the African coast has not really been possible yet because of the unavailability of SCUBA-diving gear. Moreover, patchiness seems to be extreme in marine macroalgae; future sampling at more numerous stations certainly will complete this list.

Acknowledgements

We would like to thank the directors of the Kenya Marine and Fisheries Research Institute (Mombasa, Kenya: Mr. Allela and Mr. Okemwa) and of the Institute of Marine Sciences (Zanzibar, Tanzania: Mr. Ngoile) for their help with the accomodation. Our gratitude also goes to E. Martens and Y. Vermeulen for the local organisation of the field work and laboratory research in Kenya and to M. Richmond in Tanzania. The second author acknowledges the Netherlands Marine Research Foundation to join the Seychelles Expedition. We greatly appreciate the prompt reaction and constructive suggestions made by P.C. Silva. Thanks also to W.F. Prud'homme van Reine and E. Verheij for organizing and helping us during our stays at the Rijksherbarium in Leiden. This research was sponsored by the "Nationaal Fonds voor Wetenschappelijk Onderzoek" (Belgium).

References

- BØRGESEN, F. (1936): Some marine algae from Ceylon. - Ceylon J. Sci. **12**: 57-96, 12 fig.
- BØRGESEN, F. (1940): Some marine algae from Mauritius, I. Chlorophyceae. - Det. Kgl. Dansk. Vidensk. Selsk., Biol. Medd. **15**: 1-84, 26 fig., 3 pl.
- BØRGESEN, F. (1946): Some marine algae from Mauritius, an additional list of species to Part I. Chlorophyceae. - Det. Kgl. Dansk. Vidensk. Selsk., Biol. Medd. **20**: 1-64, 27 fig.
- BØRGESEN, F. (1947): Remarks on some Codiums from the Arabian Sea. - J. Indian Bot. Soc., Iyengar Commemoration Vol.: 1-8, 5 figs.
- BØRGESEN, F. (1948): Some marine algae from Mauritius, additional lists to the Chlorophyceae and Phaeophyceae. - Det. Kgl. Dansk. Vidensk. Selsk., Biol. Medd. **10**: 1-55, 24 fig., 3 pl.

- CHAPMAN, V. (1961): The marine algae of Jamaica. Part I. Myxophyceae and Chlorophyceae. - Bull. Inst. Jamaica, Sci. Ser. **12**: 1-159, 178 fig.
- COPPEJANS, E., W. KOOISTRA & P. AUDIFFRED (1994): Preliminary report on the research on macroalgae. - In: VAN DER LAND, J. (ed.): Oceanic reefs of the Seychelles, vol.2: 157-182. National Museum of Natural History, Leiden.
- CRANE, P. (1981): The marine Chlorophyceae and Phaeophyceae of Penang Island. - Malayan Nat. J. **34**: 143-169, 33 fig.
- DAWES, C. (1974): Marine Algae of the West coast of Florida. - University of Miami Press Florida: 201 p., 81 fig.
- DAWSON, Y. (1954): Marine Plants in the Vicinity of the Institut Océanographique de Nha Trang, Viêt Nam. - Pacific. Sci. **8**: 372-481, 63 fig.
- DAWSON, Y. (1957): An annotated list of marine algae from Eniwetok Atoll, Marshall Islands. - Pacific. Sci. **11**: 92-132, 31 fig.
- DURAIRATNAM, M. (1961): Contribution to the Study of the Marine Algae of Ceylon. - Fish. Res. St., Ceylon Bull. **10**: 181 p., 22 pl.
- EGEROD, L. (1974): Report of the Marine Algae Collected on the Fifth Thai-Danish Expedition of 1966, Chlorophyceae and Phaeophyceae. - Botanica Marina **17**: 130-157, 10 fig.
- EGEROD, L. (1975): Marine Algae of the Andaman Sea Coast of Thailand: Chlorophyceae. - Botanica Marina **18**: 41-66, 41 fig.
- ETCHEVERRY, H.D. (1960): Algas marinas de las islas oceanicas Chilenas (Juan Fernandez, San Felix, San Ambrosio y Pascua). - Revista Biol. Mar. **10**: 83-132.
- EYRE, J. & T. STEPHENSON (1938): The South African intertidal zone and its relation to ocean currents V. A subtropical Indian Ocean shore. - Ann. Natal Mus. **9**: 21-46, 3 fig., 2 pl.
- GEPP, A. & E. GEPP (1908): Marine algae (Chlorophyceae and Phaeophyceae) and marine phanerogams of the "Sealark" Expedition, collected by J. Stanley Gardiner, M.A., F.R.S., F.L.S. - Transactions of the Linnean Society of London, Second Series, Botany **7**: 163-188, 2 fig.
- GEPP, A. & E. GEPP (1911): The Codiaceae of the Siboga Expedition including a Monograph of Flabellarieae and Udoteae. - Drukkerij Brill, Leiden: 150 p., 22 pl.
- GERLOFF, J. (1960): Meeresalgen aus Kenya, I. Cyanophyta and Chlorophyta. - Willdenowia **2**: 604-627, 4 fig.
- ISAAC, W. (1967): Marine botany of the Kenya Coast. 1. A first list of Kenya marine algae. - J.E. Africa Nat. Hist. Soc. Natl. Mus. **26**: 75-83.
- ISAAC, W. (1968): Marine botany of the Kenya Coast. 2. A second list of Kenya marine algae. - J.E. Africa Nat. Hist. Soc. Natl. Mus. **27**: 1-28.
- ISAAC, W. (1971): Marine botany of the Kenya Coast. 5. A third list of Kenya marine algae. - J.E. Africa Nat. Hist. Soc. Natl. Mus. **28**: 1-23.
- JAASUND, E. (1976): Intertidal seaweeds in Tanzania, a field guide. - Univ. of Tromsø: 159 p., 291 fig.
- KALUGINA-GUTNIK, A., L. PERESTENKO & T. TITLYANOVA (1992): Species composition, distribution and abundance of algae and seagrasses of the Seychelles Islands. - Atoll Res. Bull. **365**: 1-23.
- KNUTZEN, J. & E. JAASUND (1979): Note on littoral algae from Mombasa, Kenya. - J.E. Africa Nat. Hist. Soc. Natl. Mus. **31**: 1-4, 1 fig., 1 table.
- LAWSON, G. & D. JOHN (1987): The marine algae and coastal environment of tropical West Africa. - Nova Hedwigia **93**: 415 p., 65 pl., 16 fig.
- LEVRING, T. (1937): Verzeichnis einiger Chlorophyceen und Phaeophyceen von Südafrika. - Lunds. Univ. Årsskr. **34**: 1-25, 10 fig., 4 pl.
- LEWIS, J. & J. NORRIS (1987): A history and annotated account of the benthic marine algae of Taiwan. - Smithsonian Institution Press, Washington D.C.: 38 p.

- LUCAS, A. (1935): The marine algae of Lord Howe Island. - Proc. Linn. Soc. New South Wales **60**: 194-232, 7 fig., 4 pl.
- MEÑEZ, E. (1961): The marine Algae of the Hundred Islands, Philippines. - Philipp. J. Sci. **90**: 37-86, 12 pl.
- PRAMUDJI, (1992): Seaweeds of the Snellius-II Expedition (E. Indonesia): the genus *Codium* (Chlorophyta, Codiales). - M. Sc. Thesis, Vrije Univ. Brussel: 60 p., 27 pl.
- SCHMIDT, O. (1923): Beiträge zur Kenntnis der Gattung *Codium* Stackh. - Stuttgart: 67 p., 44 fig.
- SCHNEIDER, C. & R. SEARLES (1991): Seaweeds of the southeastern United States: Cape Hatteras to Cape Canaveral. - Duke Univ. Press, USA: 553 p., fig.
- SILVA, P. (1952): *Codium*. - In EGEROD, L. (ed.): An analysis of the siphonous Chlorophycophyta, with special reference to the Siphonocladales, Siphonales and Dasycladales of Hawaii. - Univ. Calif. Publ. Bot. **25**: 381-395, fig. 11-18.
- SILVA, P. (1959): The Genus *Codium* (Chlorophyta) in South Africa. - S. African Bot. **25**: 103-165, 22 fig., 16 pl.
- SILVA, P. (1960): *Codium* (Chlorophyta) in the tropical Western Atlantic. - Nova Hedwigia **1**: 497-536, pl. 107-123.
- SILVA, P., E. MEÑEZ & R. MOE (1987): Catalog of the Benthic Marine Algae of the Philippines. - Smiths Contr. Mar. Sci. **27**: 179 p.
- SILVA, P. & H. WOMERSLEY (1956): The Genus *Codium* (Chlorophyta) in southern Australia. - Aust. J. Bot. **4**: 261-289, 16 fig., 3 pl.
- TAYLOR, W. (1960): Marine algae of the eastern tropical and subtropical coast of the Americas. - Univ. Michigan Press: 870 p.
- TITLYANOVA, T. & P. BUTORIN (1978): Morskije vodorsli i travy nekotorykh ostrovov Sejshel'skogo i Mal'divskogo arhipelagov. - Acad. Sci. USSR, Far E. Sci. Centr., Inst. Mar. Biol., Trans. **12**: 19-28.
- TRONO, G. & A. DE LARA (1981): Some marine benthic algae from Cabra and Lubang Islands, occidental Mindoro Philippines. - Nat. Appl. Sci. Bull. **33**: 1-49, 12 pl.
- TSENG, C. (1984): Common Seaweeds of China. - Inst. of Oceanology, Academia Sinica, Qingdao, China: 316 p., 149 pl.
- TSENG, C. & W. GILBERT (1942): On new algae of the genus *Codium* from the South China Sea. - J. Washington Acad. Sci. **32**: 291-296.
- UNTAWALA, A. & T. JAGTAP (1989): Observations on marine macrophytes of the Republic of Seychelles. - Botanica Marina **32**: 115-119, 3 fig., 1 table.
- VAN DEN HEEDE, C. (1994): De Codiales (Chlorophyta) van Kenya, Zanzibar en de Seychellen. - M. Sc. Thesis, Faculteit der Wetenschappen, Universiteit Gent: 160 p., 73 pl.
- VERHEIJ, E. & W. PRUD'HOMME VAN REINE (1993): Seaweeds of the Spermonde Archipelago, SW Sulawesi, Indonesia. - Blumea **37**: 385-510, 18 pl.
- WOMERSLEY, H. (1984): The marine benthic flora of southern Australia, Part I. - South Australian government Printing Division, Adelaide: 329 p., 102 fig.
- WOMERSLEY, H. & A. BAILEY (1970): Marine Algae of the Solomon Islands. - Philos. Trans. Roy. Soc. London **259**: 257-352, 10 fig., 24-27 pl.
- ZANARDINI, G. (1878): Phyceae papuanæ novæ vel minus cognitæ. - Nuova Gior. Bot. Ital. **10**: 34-40.