

Lytocarpia and *Cladocarpus* (Cnidaria: Hydrozoa, Aglaopheniidae) from the Bunaken National Marine Park (North Sulawesi, Indonesia)

C. G. Di Camillo · S. Puce · G. Bavestrello

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Abstract The new species *Cladocarpus salix* and three species of *Lytocarpia* (*L. brevirostris*, *L. delicatula* and *L. phyteuma*) were recorded from the Bunaken National Marine Park (North Sulawesi, Indonesia). *Cladocarpus salix* forms large colonies reminiscent of willow trees and differs from the closely similar species *C. keiensis* in the shape and the size of the intrathecal septum, and in the phylactocarp structure. Moreover, the presence of grooves on the external wall of theca is unique feature of this species. The differences of the three *Lytocarpia* species are discussed using microscopic imaging, comparison of measurements, and macroscopic features of living specimens. The bathymetric distribution of these species, studied through vertical transect, showed that *C. salix* and *L. delicatula* are deep species occurring below 20 m and increasing their abundance from 30 to 50 m depth; *L. phyteuma* is more abundant from 5 to 30 m and *L. brevirostris* is more abundant in the shallowest and deepest part of the reef and rarer between 10 and 30 m depth. A series of surveys conducted in the same locality during a year indicated that these species are generally more abundant from November to May (wet season), except for *L. delicatula* which is active in July.

Keywords *Lytocarpia* · *Cladocarpus* · Aglaopheniidae · Celebes sea · Indonesia

Introduction

The aim of this work was to describe some Aglaopheniidae from the coral reef of the Bunaken Marine Park (North Sulawesi, Indonesia). In particular, data on the morphology and ecology of a new species of *Cladocarpus* and three species of *Lytocarpia* (*L. brevirostris*, *L. delicatula* and *L. phyteuma*) are given.

The systematics of the genus *Cladocarpus* is quite complex because of the high morphological variability of the gonosome and the presence of characters shared with other similar genera (e.g. *Streptocaulus* and *Cladocarpoides*). According to Bouillon et al. (2006), the genus *Cladocarpus* includes 65 species and it is characterised by appendages of the hydrocladia which protect the gonothecae, the so-called phylactocarps. Most species show a long, S-shaped hydrotheca and a short, median inferior nematothecae not reaching the thecal margin. One species, erroneously classified as *Macrorhynchia protecta* (Antsulevich 1991), should be attributed to *Cladocarpus* (Di Camillo et al. 2009; Vervoort and Watson 2003).

Ramil and Vervoort (1992) suggested the genus *Cladocarpus* contains two groups of species characterised by a different morphology of the phylactocarps. However, due to the high variability of these structures, Schuchert (2003) and Bouillon et al. (2006) suggested that the genus needs a more comprehensive and deep-going investigation before taxonomic re-arrangements can be made.

Cladocarpus species occur from boreal to tropical seas, although more than 50% of the species are concentrated in temperate and tropical waters of the Atlantic. About 20% of the species have been recorded from the Pacific Ocean and 20% from South Africa, while the species from the Indian Ocean represent less than 8%. Four Atlantic species have

C. G. Di Camillo (✉) · S. Puce · G. Bavestrello
DiSMar, Università Politecnica delle Marche,
Via Breccie Bianche,
60131 Ancona, Italy
e-mail: c.dicamillo@univpm.it

been also found in the Mediterranean, one near Marseille and three in the Alboran Sea.

The genus *Lytocarpia* includes 36 species, occurring in the Pacific Ocean (more than 50%), Atlantic Ocean (16%), Indian Ocean (20%) and South Africa (11%). One species is known from the Antarctic, one from the Arctic, and two from the Mediterranean Sea. This genus differs from the very similar *Aglaophenia* by the presence of a hydrotheca on the corbula ribs in at least one sex. Corbulae of *Lytocarpia* generally have sturdy and fused ribs, even though open ribs can also be observed. Pseudophylactocarpus may occasionally occur in some species as in *Lytocarpia angulosa* and *Lytocarpia perarmata* (Billard 1913); these modified hydrocladia, which are not associated with reproductive structures, present large nematothecae and probably prevent the settlement of potential epibionts (Watson 2000).

Here we describe aspects of living colonies of *Cladocarpus salix* n. sp., *Lytocarpia brevirostris* (Busk, 1852), *Lytocarpia delicatula* (Busk, 1852), and *Lytocarpia phyteuma* (Kirchenpauer 1876). We also provide scanning electronic microscope (SEM) pictures of the main characteristics of these species.

The collection along vertical transects during a year allowed us to summarise the bathymetric and seasonal occurrences of each species.

Materials and methods

Hydroids were collected by SCUBA diving from May 2002 to October 2008 in several sites of the Bunaken Marine

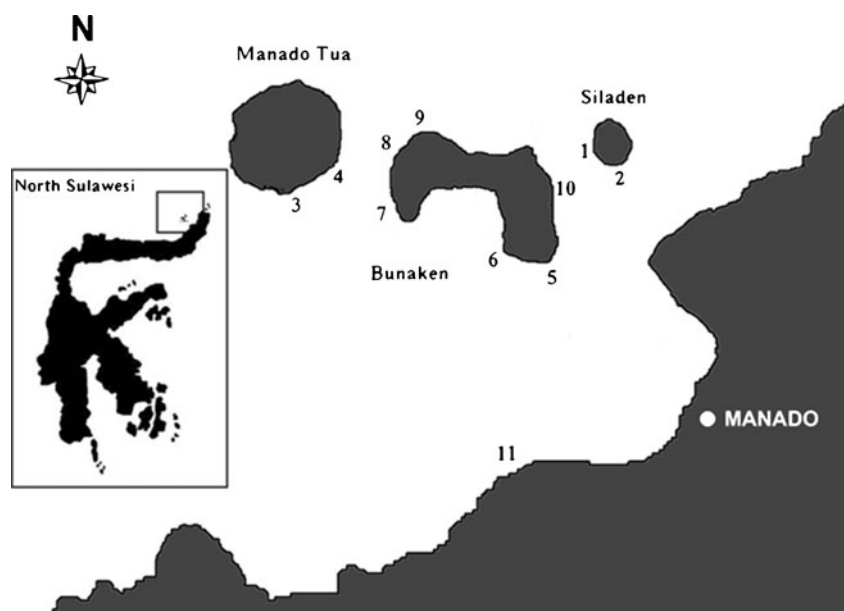
Park (North Sulawesi, Indonesia) from a depth of 2.5–60 m (Fig. 1). The area is characterised by a vertical coral reef with canyons and caves invested by a strong current and densely populated with benthic organisms. In particular, the reef shows an well-lit edge dominated by hardy corals and ends with a gentle slope at a depth of 50–60 m. Hydroids represent one of the richest communities from 10 to 30 m, living both on dead corals and secondary substrates.

Colonies of *Cladocarpus* and *Lytocarpia* were photographed in situ before being removed and placed in plastic bags, then were examined in vivo to observe the morphology and colour of living specimens and fixed using 4% neutralised formaldehyde. The details of the colonies were drawn and photographed using light microscopy; only larger cnidocysts were measured and drawn.

Photographs were also taken under the SEM (Philips XL20). Samples were washed with distilled water, then dehydrated in a graded ethanol series, dried at the Critical Point Dryer and coated with gold-palladium in a Balzer Union evaporator.

In order to study the bathymetric and temporal distribution of *Cladocarpus* and *Lytocarpia* species, samplings were conducted bimonthly from May 2004 to February 2005 in Siladen, a small coralline island surrounded by a fringing reef. As previously described by Di Camillo et al. (2008), three vertical transects, at a distance of about 50 m from each other, were considered. In each transect, samples were collected by diving, at seven depth-ranges: lagoon, 2.5–5 m, 5–10 m, 10–20 m, 20–30 m, 30–40 m and 40–50 m. At each depth all the species found by two divers working together were collected and put in plastic bags.

Fig. 1 Map of sampling sites in the Bunaken Marine Park (North Sulawesi). 1 Siladen, 2 Siladen Timur, 3 Bualo, 4 Negeri, 5 Depan Kampung, 6 Likuan, 7 Mandolin, 8 Raymond's Point, 9 Mike's Point, 10 Bunaken Timur, 11 Mapia



Hydroids were identified and an abundance value varying from 0 (absent) to 3 (very abundant) was assigned to each species.

Voucher samples of the described species were deposited at the Museum of Natural History of Genoa (MSNG).

Results

Taxonomy

Family Aglaopheniidae Agassiz, 1862

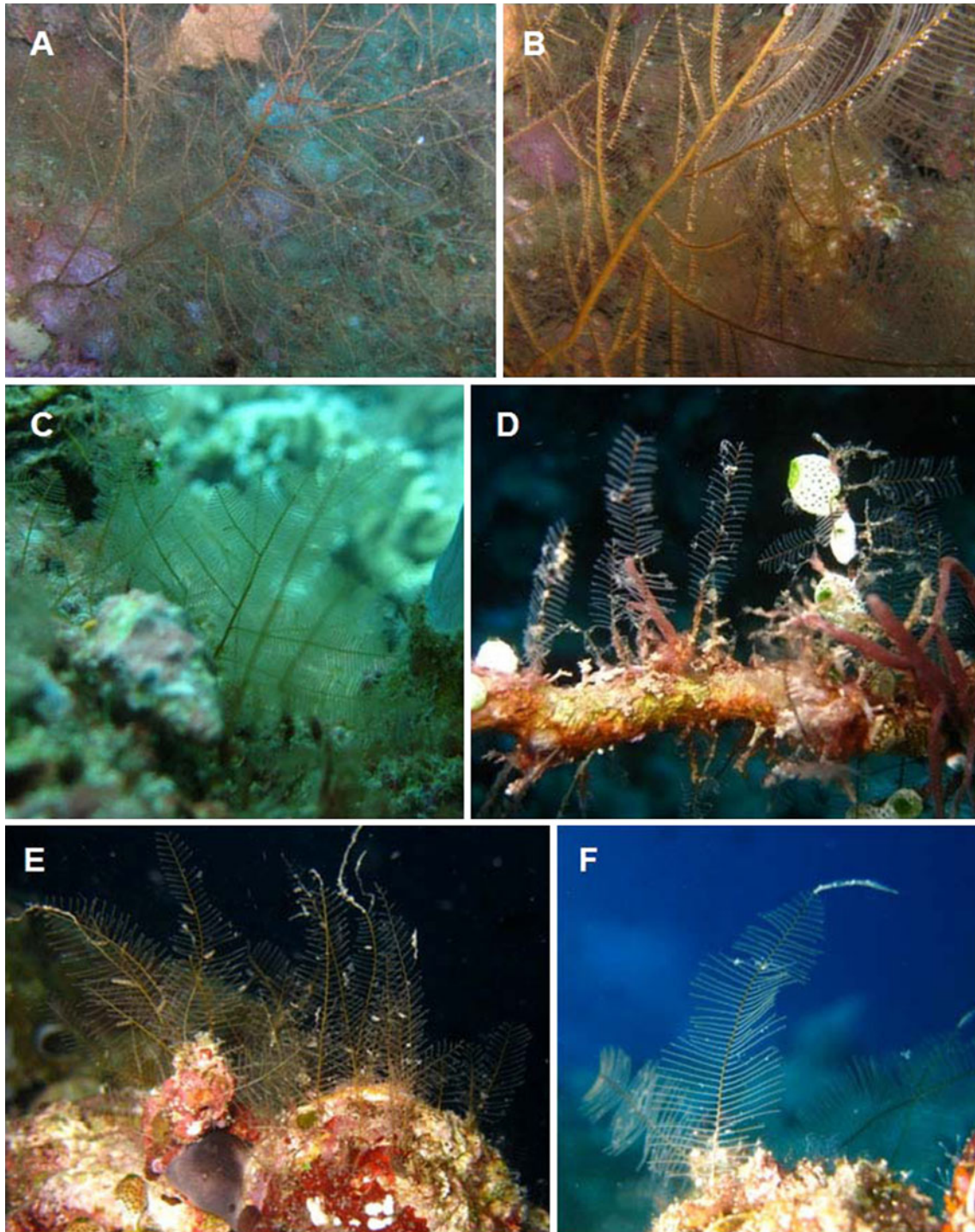


Fig. 2 Comparison of living specimens (underwater pictures). **a** *Cladocarpus salix*, picture of a large colony, Bualo; **b** close view of the same colony showing branches bearing gonophores. **c** *Lytocarpia breviostris*, branched colony, Siladen Timur. **d** *Lytocarpia delicatula*,

notice white hydrocladia, Siladen. **e** *Lytocarpia phyteuma*, several colonies on a coral, Depan Kampung; **f** particular of a colony, Mike's Point

Genus *Cladocarpus* Allman, 1874

Cladocarpus salix n. sp.

Figures 2a, b; 3a; 4a-g; 5a-g; 6a, b.

Material examined

Bunaken National Marine Park, North Sulawesi, (Indonesia): Bualo, 20/30 m (male sample collected in February 2004; female sample collected in November 2006). —Siladen, 20/50 m.

Type material

Holotype MSNG 55844, Bualo (Bunaken Marine Park, Indonesia), 20-30 m, formalin-preserved male colony, coll. C.G. Di Camillo (SCUBA), Feb. 2004.

Paratype MSNG 55845, Bualo (Bunaken Marine Park, Indonesia), 28 m, formalin-preserved female colony, coll. C.G. Di Camillo (SCUBA), Nov. 2006.

Other material examined

MNHG INVE 32487 *Cladocarpus keiensis* from Kei Islands 100 m, schizotype, two slide preparations, Natural History Museum of Geneva, material described in Schuchert (2003)

Diagnosis: large colonies with drooping hydrocladia; elongated hydrothecae with a sharp tooth on the abcauline side and with two characteristic external grooves with converging ends visible in lateral view. A very small intrathecal septum originates from the adcauline side of the theca. Phylactocarps homologous to the hydrocladia; gonothecae observed both on the lower segments of gonocladium and hydrocladial apophyses.

Description

Colonies large branching up to third order in one plane, with downward direct hydrocladia (Figs. 2a,b; 3a; 4a). Height up to 20 cm, stem and proximal parts of first-order branches deprived of hydrocladia. Stem and main branches strongly polysiphonic, composed by a bundle of straight tubes (Fig. 4b), hydrocladia only on the primary tube. Distal part of the stem and main branches with a reduced number of auxiliary tubes, terminal portion of each tube monosiphonic. Primary tubes of first-order branches originating from primary tube of the stem; primary tubes of the branches of second, third and fourth-order arising, respectively, from primary tube of first, second and third-order branches. Auxiliary and primary tubes bear nematothecae throughout their entire length. Primary tubes only occasionally or never segmented, indistinct internodes bearing an apophysis, a mamelon and two to four nematothecae,

one associated to the apophysis and two to three in the lower half of the segment. Hydrocladia on primary tubes alternately arranged on anterior surface of apophyses.

Hydrocladia in one plane in the distal, younger portion of the branches and arranged at variable angles in the proximal oldest part.

Hydrocladia segmented by oblique nodes, each internode with one hydrotheca and three nematothecae: two laterals and one median inferior. Internode divided in six to seven short segments by five to six semicircular ribs (Fig. 4c).

Hydrothecae elongated, adcauline wall completely adnate, abcauline wall slightly sinuous. Margin of theca slightly oblique and with only one tooth on the abcauline side (Figs. 4d; 5a–c). The tooth is triangular and very sharp. A very short intrathecal septum originates from the adcauline side of the theca somewhat proximal of the second rib of the internode (Figs. 4c; 6a, b). Hydrothecae in lateral view show two characteristic external grooves reaching beyond the middle of the hydrotheca (Figs. 4c; 6 b), one groove arising from the adcauline wall and the other from the abcauline side near the median inferior nematotheca. Abcauline groove longer than the adcauline one (Fig. 5c). Grooves sinuous, oblique, distal ends converging in the middle of the hydrothecal wall. From each groove, very thin, short membranes project towards the lumen of the hydrotheca (Fig. 5c inset).

Lateral nematotheca tubular, lower portion slightly oblique and fused to the adcauline side of the theca; an opening is visible on the inner side of the nematotheca; upper portion straight and overtopping the thecal margin; terminal opening circular and with a deep emargination on the inner wall. Median inferior nematotheca present at the base of the hydrotheca, lower half part adnate, upper half part free and gutter-shaped.

Gonothecae borne on apophyses of both hydrocladia and phylactocarps; generally one gonotheca is present on the hydrocladial apophyses and up to three on the phylactocarp. Phylactocarps arise from the first internode of the hydrocladium near to the median inferior nematotheca; they are homologous to the hydrocladia but always shorter and composed by segments of variable length. Shorter segments with one nematotheca only; longer segments with a hydrotheca or with a gonotheca. Segments bearing hydrothecae (one or two) identical to the hydrocladial ones; those with gonothecae present one nematotheca below the gonocladial apophysis and one in the upper part of the segment directed outwards. Gonothecae ovoid in shape, male ones with a clearly distinguishable spadix, female ones with two to four eggs inside (Figs. 4e, f; 5d-g).

Colours: thicker, polysiphonic parts are brown while distal parts are yellow; male gonothecae yellow with an orange spadix, female gonothecae yellow.

Sizes (see Table 1).

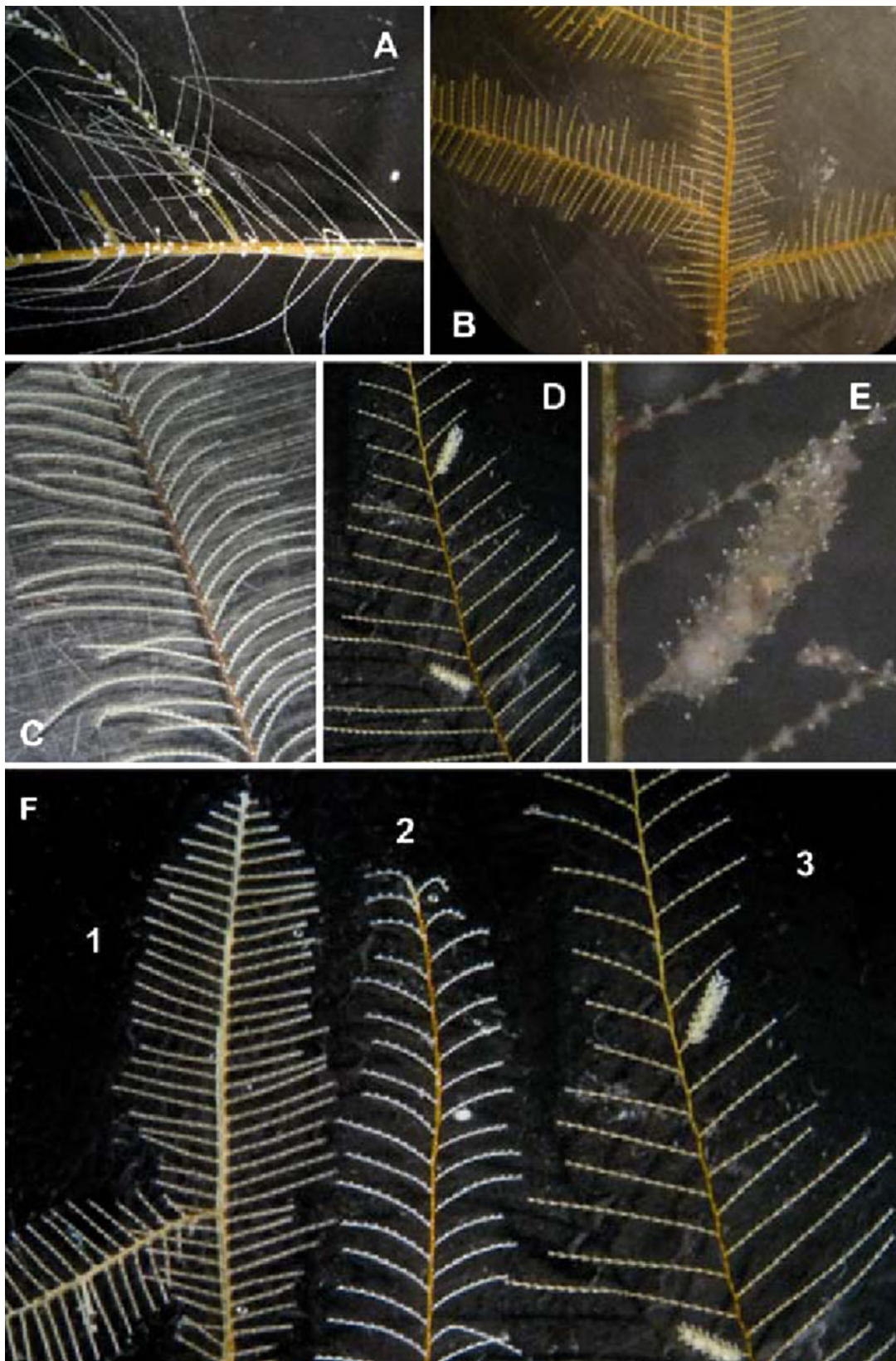
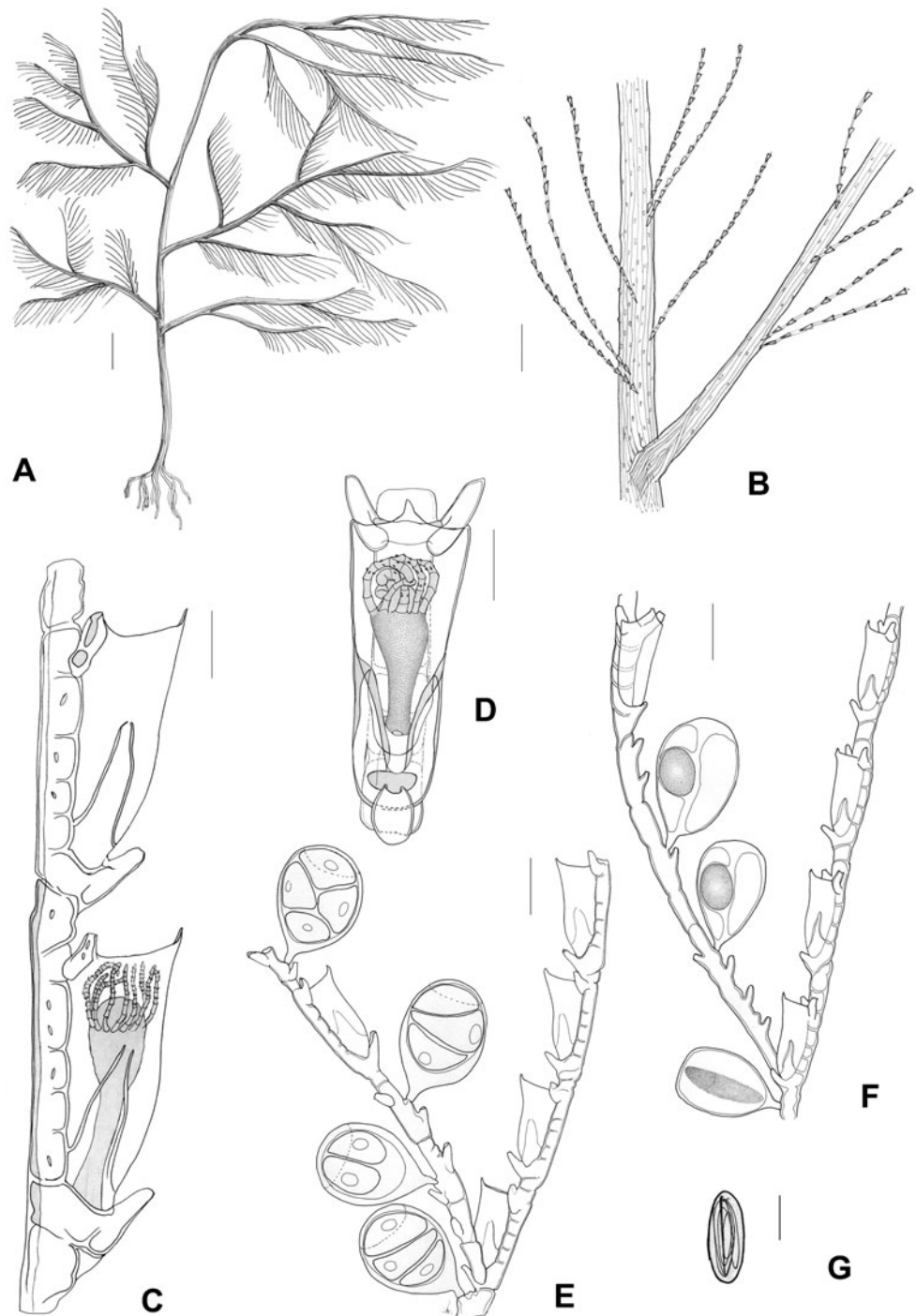


Fig. 3 Comparison of living specimens (stereomicroscope pictures). **a** *Cladocarpus salix*, portion of a colony with the delicate and flexible hydrocladia. **b** *Lytocarpia breviostris*, branched colony. **c** *Lytocarpia delicatula*, note the curved hydrocladia. **d** *Lytocarpia phyteuma*, fertile

colony with widely spaced hydrocladia. **e** *L. phyteuma*, detail of a corbula, note the white, refringent spot in correspondence of nematocytes. **f** Comparison of the three *Lytocarpia* species, note the different hydrocladia: 1 *L. breviostris*; 2 *L. delicatula*; 3 *L. phyteuma*

Fig. 4 *Cladocarpus salix*: colony (a), detail of hydrocaulus and hydrocladia (b) and hydrocladium in lateral view (c); d hydrotheca in frontal view; e female phylactocarp; f male phylactocarp; g microbasic mastigophore. Scale bars a 1 cm; b 1 mm; c, d 100 μ m; e, f 200 μ m; g 10 μ m



Cnidocysts: Ovoidal microbasic mastigophores 17.5–20 \times 6–6.5 μ m present in coenosarcs and nematophores.

Etymology: The specific name refers to the colony shape resembling a willow tree for its drooping hydrocladia.

Remarks: *Cladocarpus salix* strongly differs from the other species belonging to the same genus in theca and phylactocarp shape; the presence of external grooves on the theca—present both on living and preserved specimens, as

well as on samples analysed with electron microscope—is a unique feature of this species. The species resembling *Cladocarpus salix* most closely is *Cladocarpus keiensis* Schuchert, 2003. This author described an adcauline septum inside the hydrotheca of *C. keiensis*, spanning half of the hydrothecal diameter, scoop-shaped, and directed obliquely upward. Besides, the intrathecal septum appears triangular in side view as shown in pictures taken from Kei

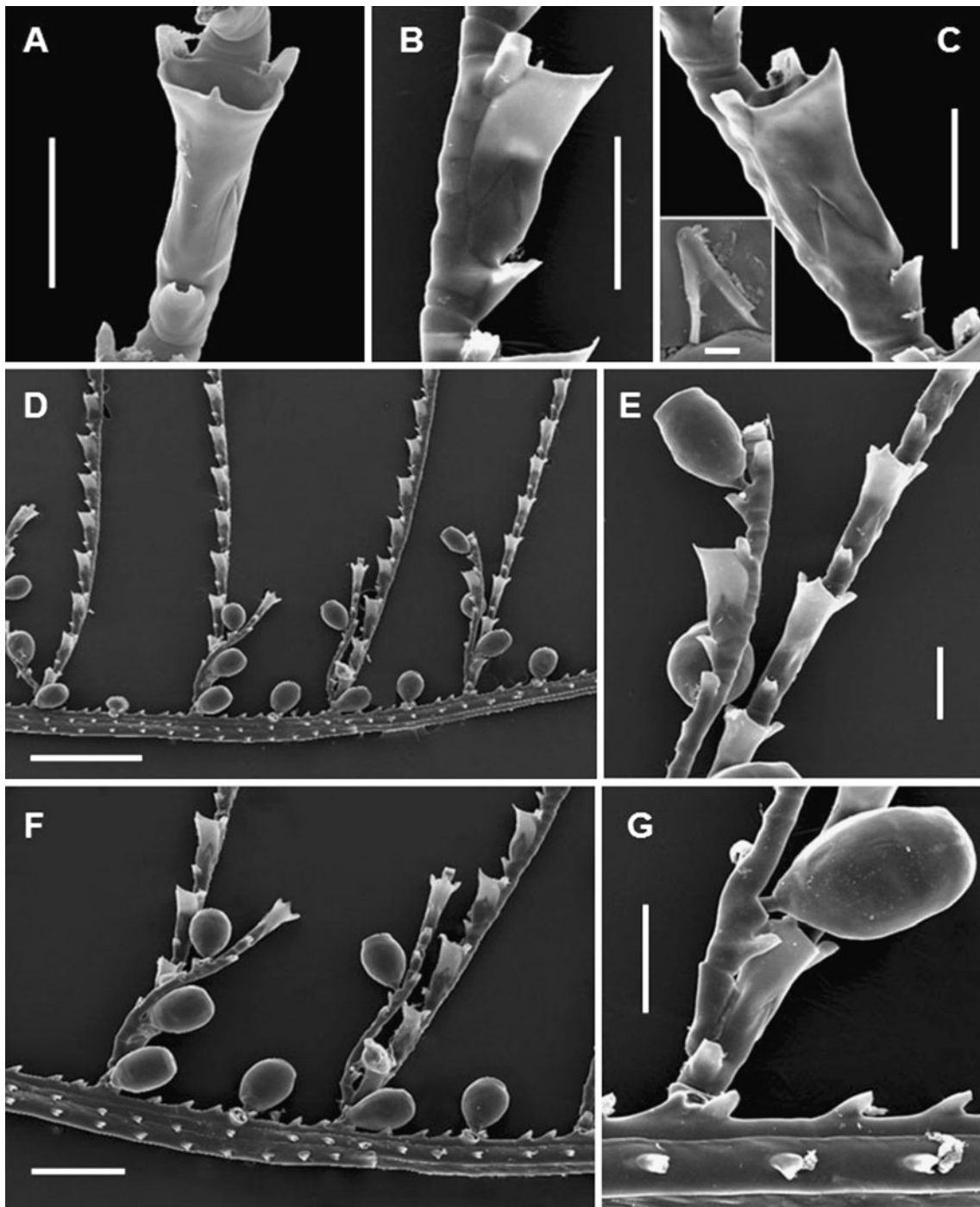


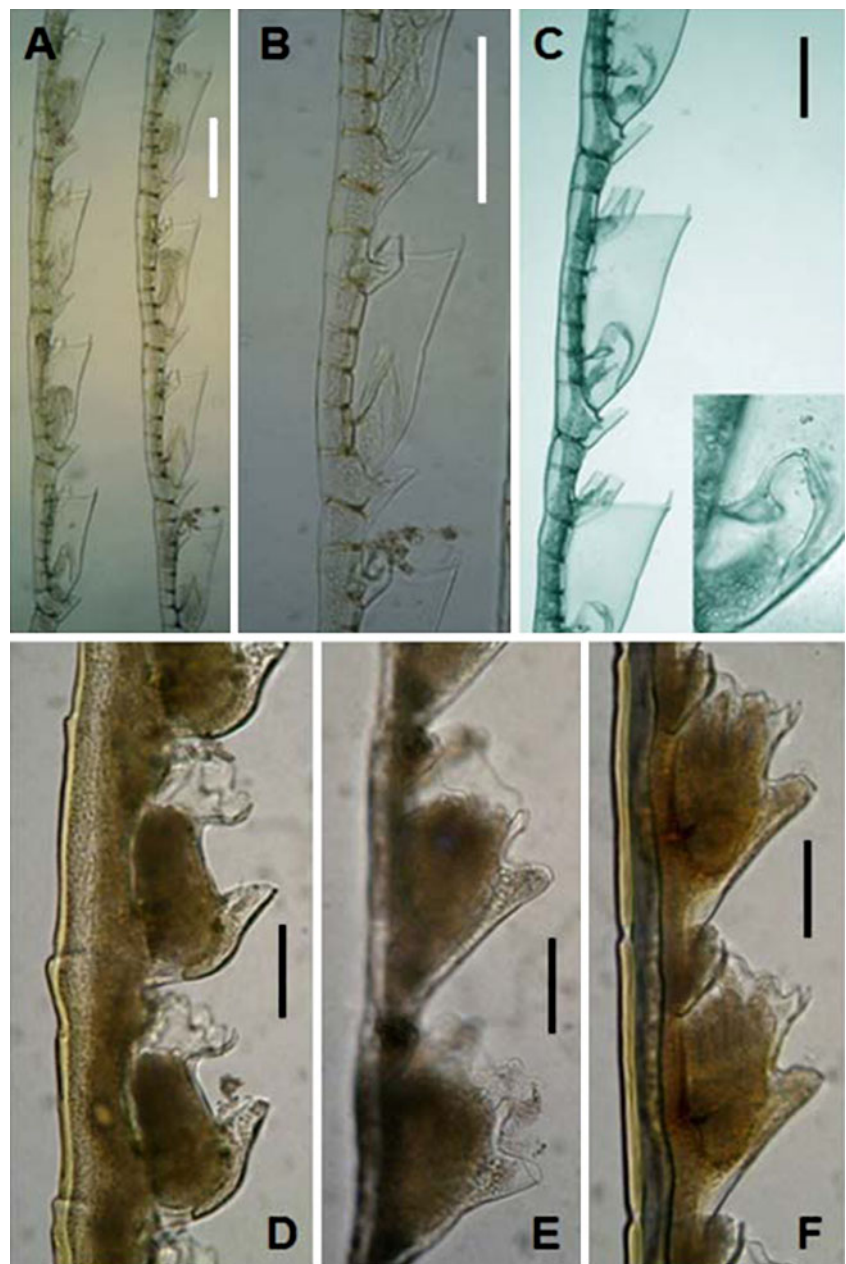
Fig. 5 *Cladocarpus salix* (SEM pictures): hydrotheca in frontal (a) and lateral (b, c) views; note the median tooth on the thecal rim and the characteristic external grooves on the thecal wall (c); the inset shows the inner side of the thecal wall with the protruding membranes of the grooves. d–f Branch bearing hydrocladia and phylactocarps. Some hydrocladial apophyses lacking of hydrocladia (d), detail of a hydrocladium and a phylactocarp bearing one hydrotheca and two

gonothecae (e). Note the nematothecae present throughout the entire length of primary and auxiliary tubes and gonothecae both on phylactocarps and on hydrocladial apophyses (f). g Detail of the first segment of the phylactocarp with the gonotheca inserted on the gonocladial apophysis. Scale bars a–c, e, g, h 200 µm; d 1 mm; f 500 µm, inset 20 µm

Island material (Figure 6c). Hydrothecae of *Cladocarpus salix* present a very small intrathecal septum, which is hardly visible and in lateral view of the hydrotheca as it is usually concealed by the grooves it originates from.

The septum described by Schuchert, continues as a looped ridge to the abcauline wall (Fig. 6c inset), while *C. salix* presents two external grooves with converging ends.

Fig. 6 Optical microscope pictures of the species. **a** *Cladocarpus salix*, hydrocladia with several hydrothecae. **b** Higher magnification with a hydrotheca and the characteristic grooves on the wall. **c** *Cladocarpus keiensis*, (MHNG INVE 32487, schizotype, Indonesia, Kei Island, 100 m), hydrocladium and particular of internal septum and the looped ridge (inset). **d-f** *Lytocarpia brevirostris*, *Lytocarpia delicatula* and *Lytocarpia phyteuma*, hydrothecae in lateral view. Scale bars **a-c** 200 μ m; **d-f** 100 μ m



C. salix differs from *C. keiensis* also by the presence of gonothecae on the hydrocladial apophyses. Moreover, in our material the gonothecae are placed only on the lower segments of gonocladium, while in *C. keiensis* segments with hydrothecae are alternated with two to three segments bearing gonothecae.

Genus *Lytocarpia* Kirchenpauer, 1872 = *Acanthocladium* Allman, 1883 = *Thecocarpus* Nutting, 1900

Key to *Lytocarpia* species from North Sulawesi

- 1 Thecal margin with five teeth, hydrothecae delicate, hydrocaulus brown and hydrocladia white, with prosegment and one or two hinge-joints, corbulae open.....
.....*Lytocarpia delicatula*
- 1 Thecal margin with seven teeth.....2
- 2 Hydrocaulus yellow-brown, hydrocladia yellow; hydrothecae with abcauline wall sinuous, with a deep fold just below marginal teeth; margin inclined towards below, corbulae closed and short.....*Lytocarpia brevirostris*
- 2 Hydrocaulus light brown, hydrocladia yellow, hydrothecae tubular, hydrocladia generally wide spaced, hydrothecal wall with an undulated and oblique intrathecal thickening, corbulae closed and elongated.....*Lytocarpia phyteuma*

Table 1 Measurements of the described species. Sizes in microns, except for colony height (cm)

		<i>Cladocarpus salix</i>	<i>Lytocarpia brevirostris</i>	<i>Lytocarpia delicatula</i>	<i>Lytocarpia phyteuma</i>	<i>Lytocarpia phyteuma</i> variations
Hydrocaulus	Diameter of hydrocaulus	110-3,500	200-600	360-380	180-210	190-270
	Distance between hydrocladia on the same side	550-600	370-420	890-950	1,060-1,400	650-890
	Length of hydrocladial internode	480-500	300-320	350-380	350-360	250-300
	Diameter of hydrocladial internode	70-80	70-130	80-100	70-120	90-130
Hydrothecae	Diameter of hydrothecal margin	155-160	125-115	150-155	190-200	180-190
	Length of theca	350-370	290-300	310-335	300-320	250-265
	Distance between hydrothecae	100-160	15-25	40-45	85-105	50-75
	Number of teeth	1	7	5	7	7
	Adcauline tooth	No	No	No	No	No
	Abcauline tooth	Yes	Yes	Yes	Yes	Yes
Nematocysts	Microbasic mastigophores	17.5-20 × 6-6.5	16.25-17.5 × 2.5	26.25-27.5 × 2.5	21-22.5 × 3.8-5	25-30 × 5
Length of nematothecae	Laterals	100-110	100-105	80-90	65-80	90-97.5
	Median inferior	95-100	115-155	275-310	185-210	110-160
Colony height (cm)		Up to 20	4-4.5	3-10.5	2.5-5.3	2.5-4

Lytocarpia brevirostris (Busk, 1852)

Figures 2c; 3b, f; 6d; 7a-g; 8a-k.

Plumularia brevirostris Busk, 1852: 397.

Aglaophenia brevirostris—Kirchenpauer, 1872: 27; Bale, 1884: 169; Kirkpatrick, 1890: 611; Bale, 1913: 135, pl. 13, figs. 7, 9.

Plumularia vitana Kirchenpauer, 1872: 34, pl. 1 fig. 9, pl. 3 fig. 9.

Aglaophenia maldivensis Borradaile 1905: 843, pl 69, fig. 8; Billard, 1913: 91

Thecocarpus brevirostris—Billard, 1910: 51, fig. 24; 1913: 89, fig. 75; Briggs, 1918: 34, 45; Stechow, 1919: 137, figs. A², B²; Bedot 1921a: 332; Bedot 1922: 157; Jarvis, 1922: 350, pl. 26, fig. 24; Pennycuik, 1959: 187; Rees and Thursfield, 1965: 186; Millard, 1968: 254, 284-285, fig. 6B; Vasseur, 1974: 158; Millard, 1975: 454, fig. 139A-C; 1978: 199; Tang, 1991: 32-33, Fig. 6.

Lytocarpia brevirostris—Ryland and Gibbons, 1991: 545-546, fig. 15.

Material examined

Bunaken National Marine Park, North Sulawesi, (Indonesia): MSNG 55846, Mandolin (Bunaken Marine Park, Indonesia), 5/10 m, formalin-preserved fertile colony, coll. C.G. Di Camillo (SCUBA), Feb. 2005. Mandolin, 25 m (fertile sample collected in February 2005). —Raymond's Point, 16 m (fertile sample collected in January 2006). —Siladen, 2.5/50 m. —Siladen Timur, 20 m.

Description

Colonies pinnate, reaching 5 cm; stem polysiphonic, occasionally branched up to the second order (Figs. 2c; 3b, f; 7a, b); unbranched in young colonies. Polysiphonic parts composed of a superficial primary tube and some auxiliary tubes. Branches arising from primary tubes, alternately arranged and in one plane; basal portion of ramifications generally polysiphonic.

Auxiliary tubes unsegmented, primary tubes segmented in distal parts only. Internodes with a hydrocladial apophysis associated with a mamelon and two nematothecae: one inferior anterior and one axillary anterior; nematothecae large, with double opening, mamelon on the anterior surface of the apophysis (Figs. 7c; 8c).

Hydrocladia alternately arranged on the anterior surface of the hydrocaulus (Fig. 8a, b); hydrocladia of variable length and homomerously segmented by oblique nodes. Hydrothecae on hydrocladium overlapping (Figs. 6d; 7d; 8d, e).

Hydrothecae elongated, (Figs. 7e; 8f, g); adcauline wall almost straight, abcauline wall sinuous, with a deep fold just below marginal teeth; margin inclined towards below, with six lateral teeth, and a prominent abcauline tooth, adcauline tooth absent.

Hydrothecae with a short intrathecal septum in the lower half of the adcauline side.

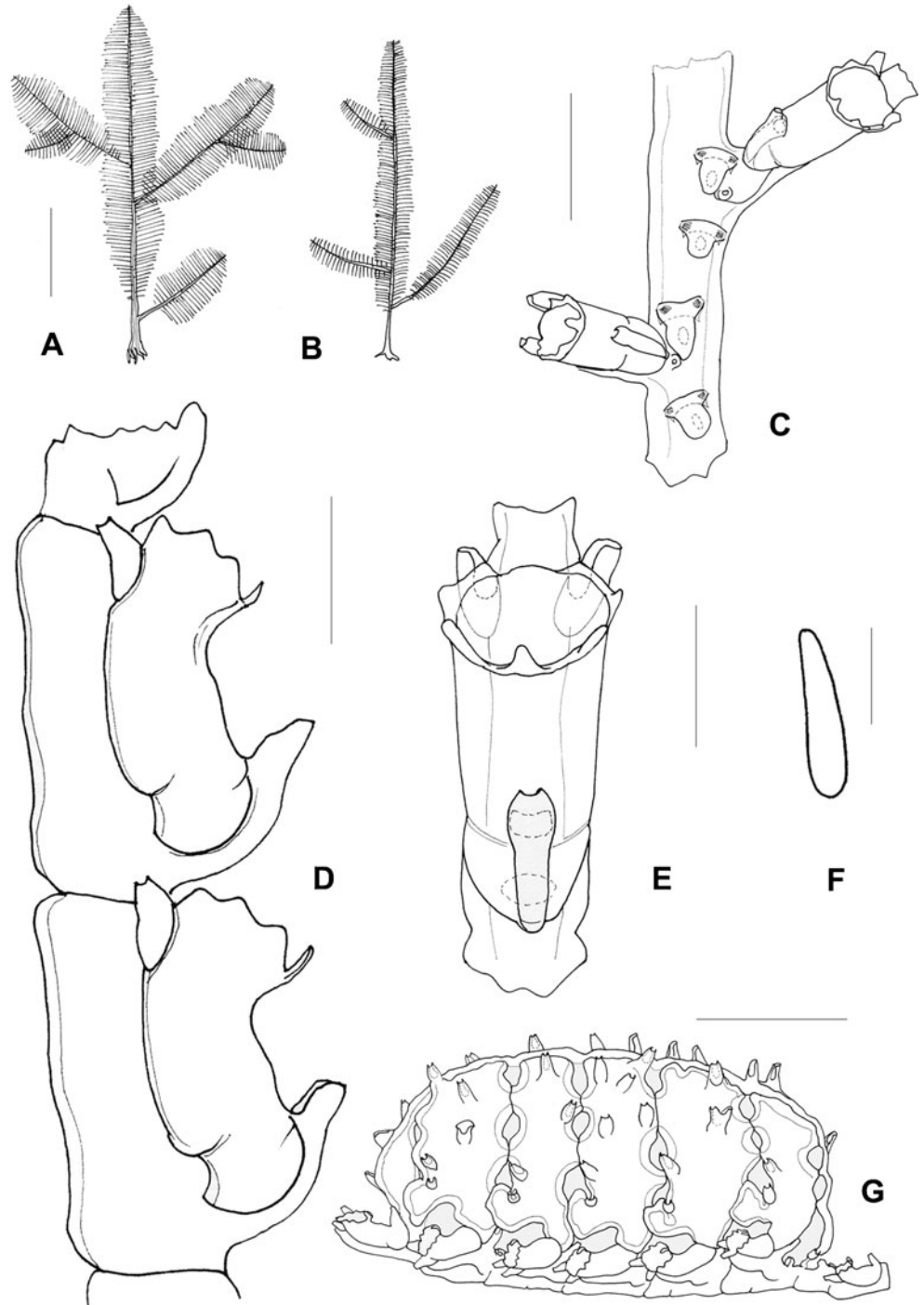
Median inferior nematotheca adnate to the hydrotheca for about half-length and not reaching the hydrothecal

margin; adnate portion tubular, free portion gutter-shaped and bent away from theca, foramen into hydrotheca; lateral nematothecae gutter-shaped and directed upwards.

Corbulae closed, replacing a hydrocladium, bearing six to eight pairs of leaf-like ribs (Figs. 7g; 8h-j); sometimes one or two ribs can be lifted. Corbula axis divided in segments by oblique nodes; first segment as the other hydrocladial internodes, with a hydrotheca and three

nematothecae. Proximal portion of each rib showing a basal crest supporting one hydrotheca with lateral nematothecae and without a median inferior nematotheca; hydrotheca inserted in the space (defined as *fenêtre* by Billard 1913) between the crest and the rib; two nematothecae present just above the crest. Ribs with several nematothecae arranged in rows, all nematothecae gutter-shaped (Fig. 8k). Distal extremity ending with one or two hydrothecate segments.

Fig. 7 *Lytocarpia brevirostris*. Colony with long (a) and short (b) hydrocladia; c detail of an internode with apophyses and associated nematothecae and mamelons; d hydrocladium in lateral view; e hydrotheca in frontal view; f microbasic mastigophores; g corbula. Scale bars a, b 1 cm; c 200 μ m; d, e 100 μ m; f 10 μ m; g 500 μ m



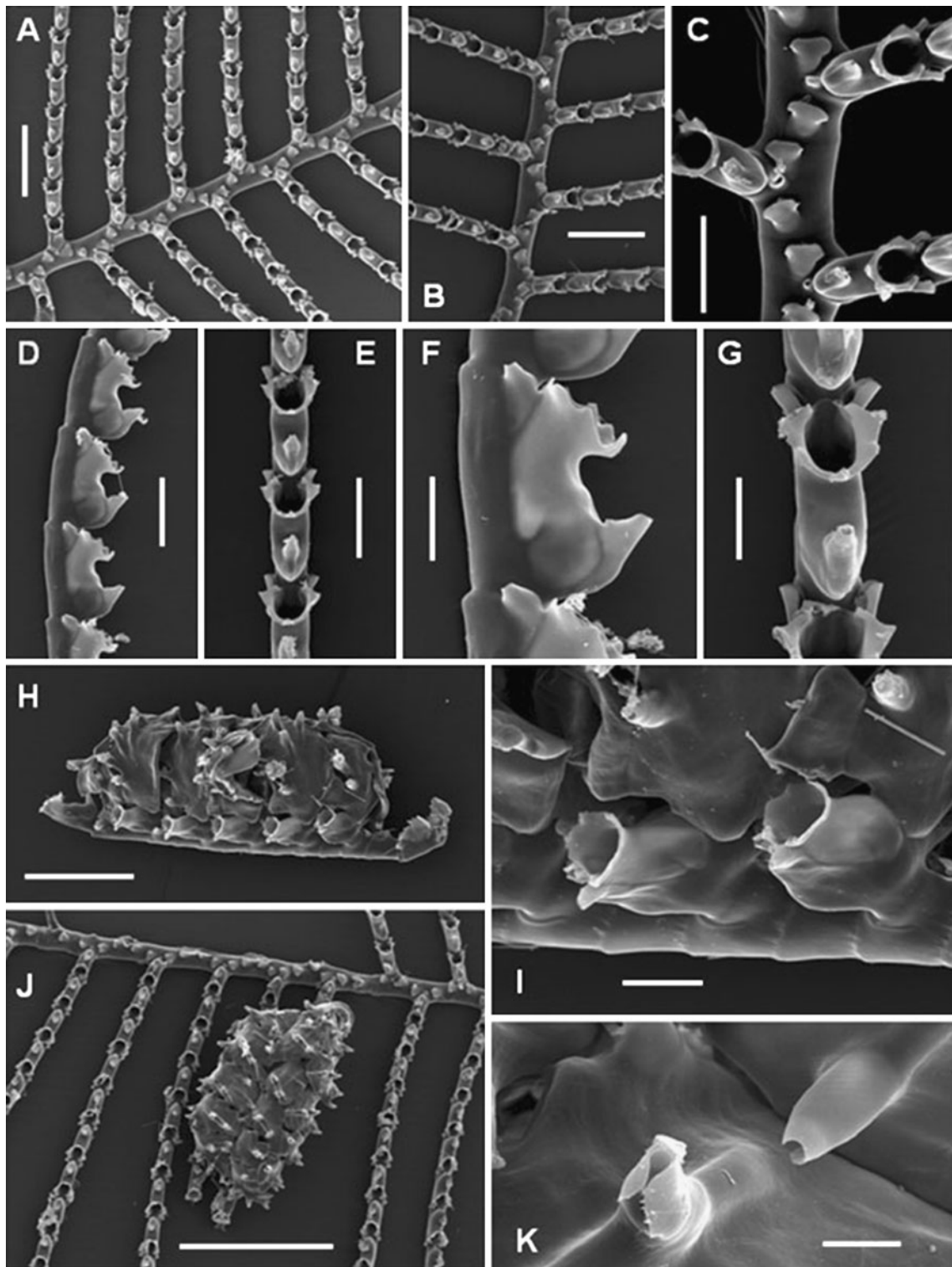


Fig. 8 SEM picture of *Lytocarpia brevirostris*. **a** Hydrocaulus and alternate hydrocladia and details (**b**); **c** higher magnification of the internodes with the hydrocladial apophyses; hydrocladium in lateral (**d**) and frontal (**e**) views; particular of a hydrotheca and associated nematothecae in lateral (**f**) and frontal (**g**) views; **h** corbula; **i** detail of

hydrothecae inserted in the spaced between crests and ribs of a corbula; **j** coalesced corbulae on the same branch; **k** detail of corbula ribs with gutter-shaped nematothecae. *Scale bars a, b, h* 500 μ m; *c–e* 200 μ m; *f, g, i* 100 μ m; *j* 1 mm; *k* 50 μ m

Remarks: *L. brevirostris* from Bunaken occasionally produces fused corbulae on adjacent hydrocladia (Fig. 8j).

Rarely, the ventral sides of the colony in the upper and the lower part of the colony face in opposite directions, an observation also reported by Millard, 1975.

Colour: Hydrocaulus yellow-brown, hydrocladia yellow. Sizes (see Table 1).

Cnidocysts: Elongated microbasic mastigophores 16.25–17.50 × 2.5 μm present in coenosarcs and nematophores.

Distribution

South Pacific Islands, Northern Australia, tropical Indian Ocean from India to Africa. Type locality: off Cumberland Island, Queensland.

Lytocarpia delicatula (Busk, 1852)

Figures 2d; 3c, f; 6e; 9a–g; 10a–i.

Plumularia delicatula Busk, 1852: 396.

Aglaophenia delicatula—Bale, 1884: 167, pl 14 fig. 4, pl 17 fig. 11; Borradaile, 1905: 843, pl. 69: fig. 7; Billard, 1913: 106, fig. 95; Jäderholm 1920: 8, pl. 2 fig. 7; Jarvis, 1922: 350. Pennycuik, 1959: 185; Watson, 2000: 57, fig. 46A–E.

Thecocarpus delicatulus—Millard and Bouillon, 1973: 94, fig. 11J–K; Millard, 1975: 455, 139D–E.

Lytocarpia delicatula—Schuchert, 2003: 235–237, fig. 76.

Material examined

Bunaken National Marine Park, North Sulawesi, (Indonesia): MSNG 55847, Mapia (Bunaken Marine Park, Indonesia), 25 m, formalin-preserved unfertile colony; coll. C.G. Di Camillo (SCUBA), Jan. 2003. —Mandolin, 20/30 m (fertile sample collected in February 2005). —Mapia, 20/60 m. —Mike's Point, 30/40 m. —Siladen, 20/50 m.

Description

Colonies pinnate, reaching 10 cm in height (Figs. 2d; 3c, f; 9a); hydrocaulus unbranched (Figs. 9b; 10a), monosiphonic. With prosegment and one or two hinge-joints in the basal part (Figs. 9c; 10b). Proximal portion of each hinge-joint with a couple of large nematothecae. Part of the stem below the hinge-joints with up to 11 segments bearing couples of nematothecae. Segments above hinge-joints separated by slightly oblique nodes and associated with an apophysis, a mamelon on its anterior surface, and three nematothecae: one inferior anterior and one flanking the apophysis (Fig. 10c).

Hydrocladia alternately arranged on the anterior surface of the hydrocaulus, divided in internodes by slightly oblique nodes and bearing up to 22 hydrothecae

(Fig. 10d, e). Two weakly developed internal ribs visible in each internode. Hydrothecae on hydrocladia little spaced (Fig. 6e), vase-shaped, delicate, narrowing in the basal part; adcauline wall oblique; margin inclined towards below, with five triangular teeth, without adcauline tooth; hydrothecal walls showing an oblique intrathecal thickening spanning through the hydrotheca (Fig. 9d, e).

Median inferior nematotheca adnate to the hydrotheca for about half-length and reaching the hydrothecal margin; adnate portion narrow and tubular, free portion quite enlarged, gutter-shaped, foramen into hydrotheca; lateral nematothecae directed towards outside, gutter-shaped.

Corbulae open, short and replacing a hydrocladium (Figs. 9f; 10f–i), first segment bearing a hydrotheca, following seven to eight segments with seven ribs, six of them alternate along the corbula axis and one originating from the distal segment. First segment of a rib with a nematotheca and a hydrotheca flanked by two lateral nematothecae and lacking of the median inferior nematotheca; ribs not leaf-like, thin as a phylactocarp, replacing the median inferior nematotheca. Distal portion of the rib bearing 10–14 alternately arranged nematothecae (Fig. 10h). Up to six flattened, elongated gonothecae arising from apophyses were observed.

Remarks: colonies often ending with a tendril-like process.

Colour: Hydrocauli brown, hydrocladia white.

Sizes (see Table 1).

Cnidocysts: Elongated microbasic mastigophores 26.25–27.5 × 2.5 μm present in coenosarcs and nematophores.

Distribution

Northern Australia, Great Barrier Reef, Australia, Indonesia, Seychelles, Maldives, Mozambique. Type locality: Torres Strait.

Lytocarpia phyteuma (Kirchenpauer, 1876)

Figures 2e, f; 3d, e, f; 6f; 11a–g; 12a–l.

Aglaophenia phyteuma Kirchenpauer, 1876: 23 no. 3a.

Aglaophenia clavicularia Whitelegge, 1899: 373–374, pl. 23 figs. 4–6.

Aglaophenia elongata var. *sibogae* Billard, 1913: 103.

Thecocarpus phyteuma—Stechow, 1919: 139–143, figs. C², D²; Pennycuik 1959: 187; Millard and Bouillon, 1973: 95–97, fig. 11E–F.

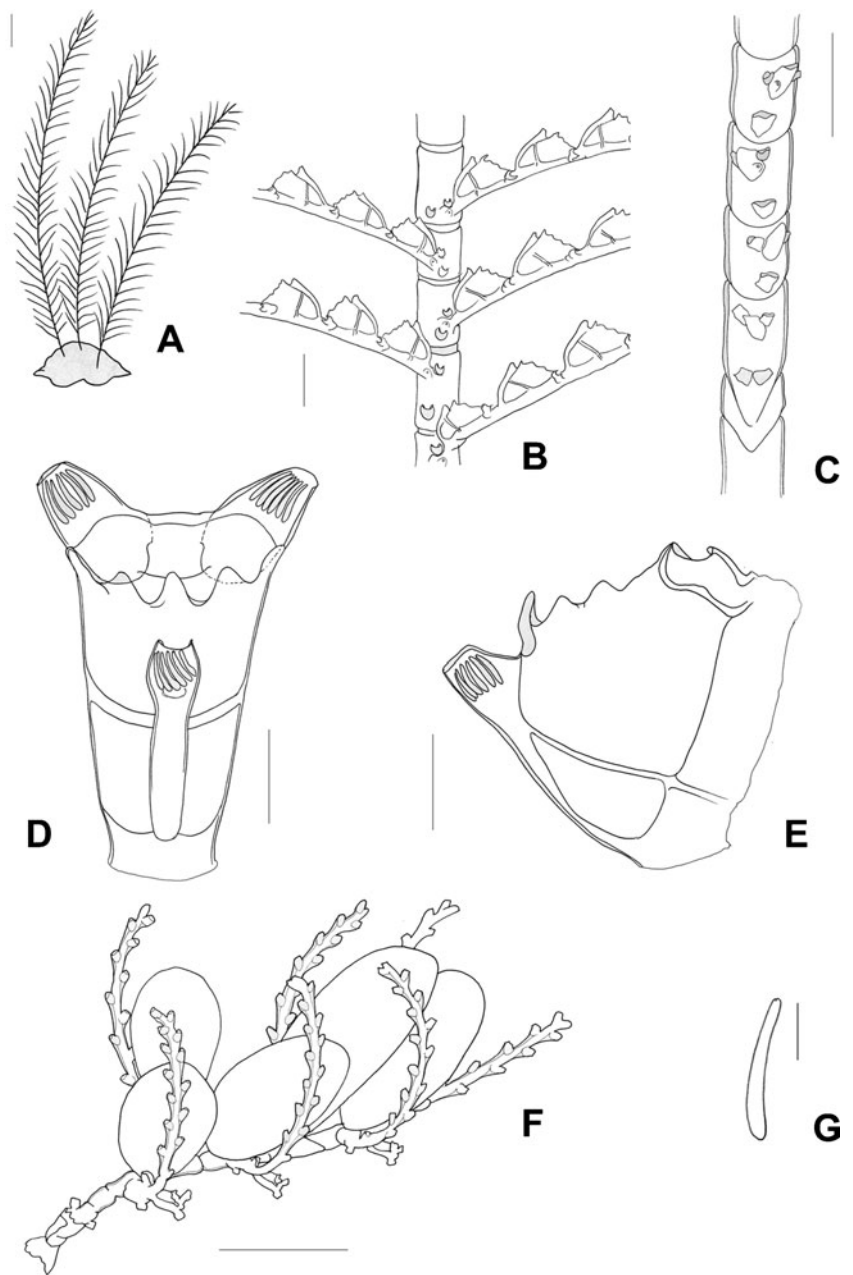
[Not *Thecocarpus phyteuma*—García Corrales et al. 1978: 66–67, fig. 32; Boero and Bouillon, 1993: 263 = *Aglaophenia kirchenpaueri* (Heller, 1868)].

?*Thecocarpus phyteuma*—Vervoort and Vasseur 1977: 86.

Thecocarpus clavicularia—Bedot 1921a: 333.

Thecocarpus leopoldi Leloup, 1930a: 1–3, fig. 1; 1930b: 11–14, figs. 8, 9, pl. 2 figs. 2, 3.

Fig. 9 *Lytocarpia delicatula*. **a** Colony; **b** detail of hydrocaulus and hydrocladia; **c** basal portion of the hydrocaulus; hydrotheca in frontal (**d**) and lateral (**e**) views; **f** corbula; **g** microbasic mastigophores. Scale bars **a** 1 cm; **b, c, f** 500 μ m; **d, e** 100 μ m; **g** 10 μ m



Lytocarpia phyteuma—Ryland and Gibbons, 1991: 548–552, figs. 18–19; Bouillon et al. 1995: 37; Watson, 2000: 65; Vervoort and Watson, 2003: 316; Schuchert, 2003: 237, Fig. 77.

Material examined

Bunaken National Marine Park, North Sulawesi, (Indonesia): MSNG 55848, Negeri (Bunaken Marine Park, Indonesia), 15 m, coll. C.G. Di Camillo (SCUBA), Feb. 2005, formalin-preserved fertile colony. —Bualo, 12 m (fertile sample collected in February 2005). —Bunaken Timur, 10 m (fertile sample collected in October 2008). —

Depan Kampung, 18 m (fertile sample collected in July 2004). —Mandolin, 5/10 m (fertile sample collected in February 2005). —Siladen, 2.5/50 m (fertile sample collected in November 2004).

Description

Colonies pinnate, about 5 cm in height, stem monosiphonic and unbranched (Figs. 2e, f; 3d–f; 11a). Basal part of hydrocaulus without hinge-joints and bearing solitary nematothecae, number variable depending on stem length (Fig. 12b). Stem divided in internodes by slightly oblique nodes (Figs. 11b; 12a). Each segment with an apophysis, a

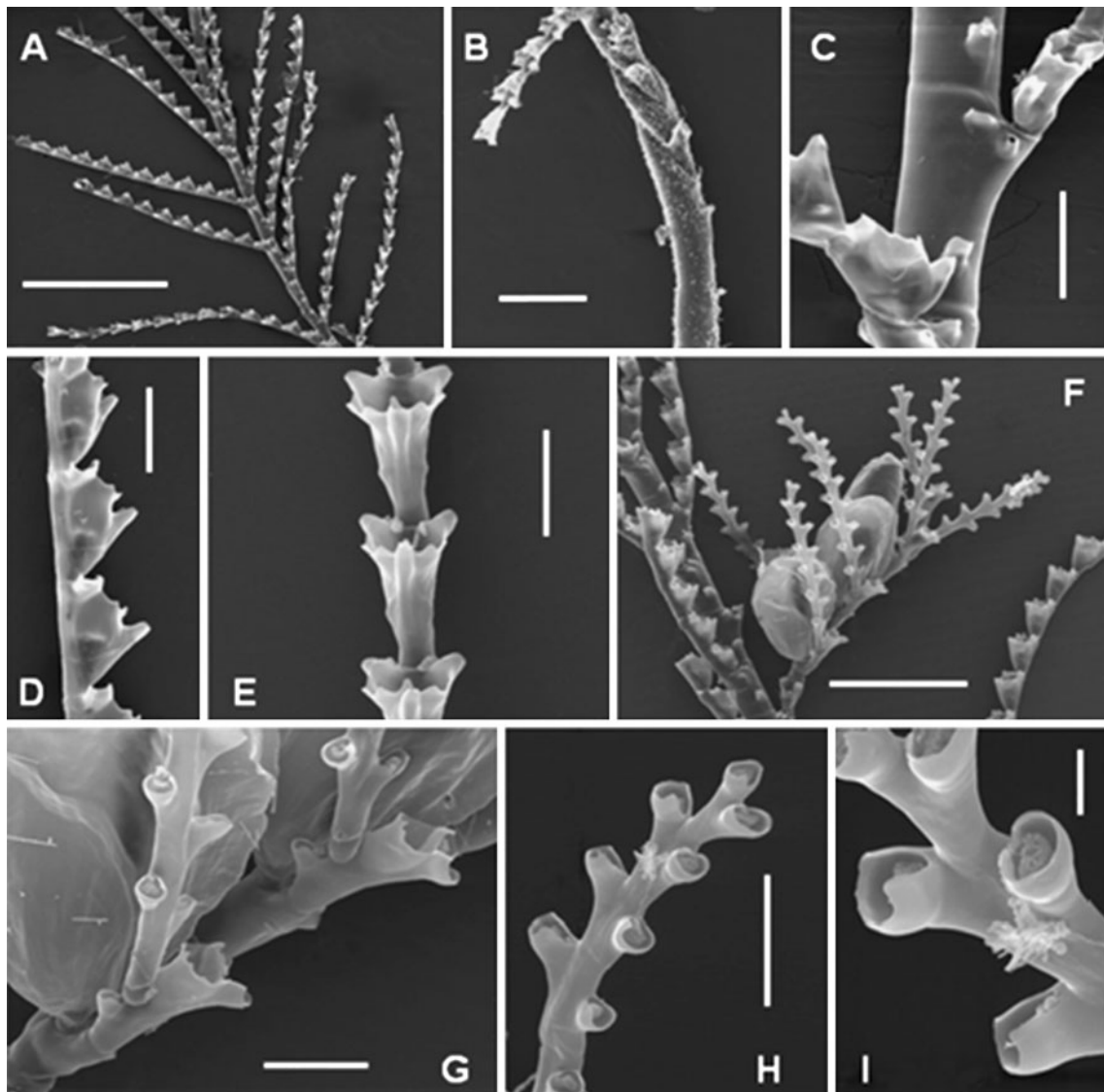


Fig. 10 SEM picture of *Lytocarpia delicatula*. **a** Colony; **b** prosegment and hinge joints on the hydrocaulus proximal portion; **c** internode bearing the hydrocladial apophysis and the associated nematothecae; hydrocladium in lateral (**d**) and in frontal (**e**) views; **f**

open corbula and gonothecae; **g** detail of open ribs and basal hydrothecae; **h** distal portion of a rib bearing alternately arranged nematothecae; **i** detail of nematothecae on a rib. *Scale bars* **a** 2 mm; **c–e**, **g**, **h** 200 μ m; **b** 500 μ m, **f** 1 mm; **i** 50 μ m

mamelon and two nematothecae: one inferior anterior and one flanking the apophysis. Hydrocladia alternately arranged on anterior surface of apophyses.

Hydrocladia generally wide spaced and regularly segmented in internodes by slightly oblique nodes. Each hydrocladial segment with one hydrotheca and three nematothecae: one median inferior and two laterals. Hydrothecae on hydrocladium quite spaced (Figs. 6f; 11c; 12c, d).

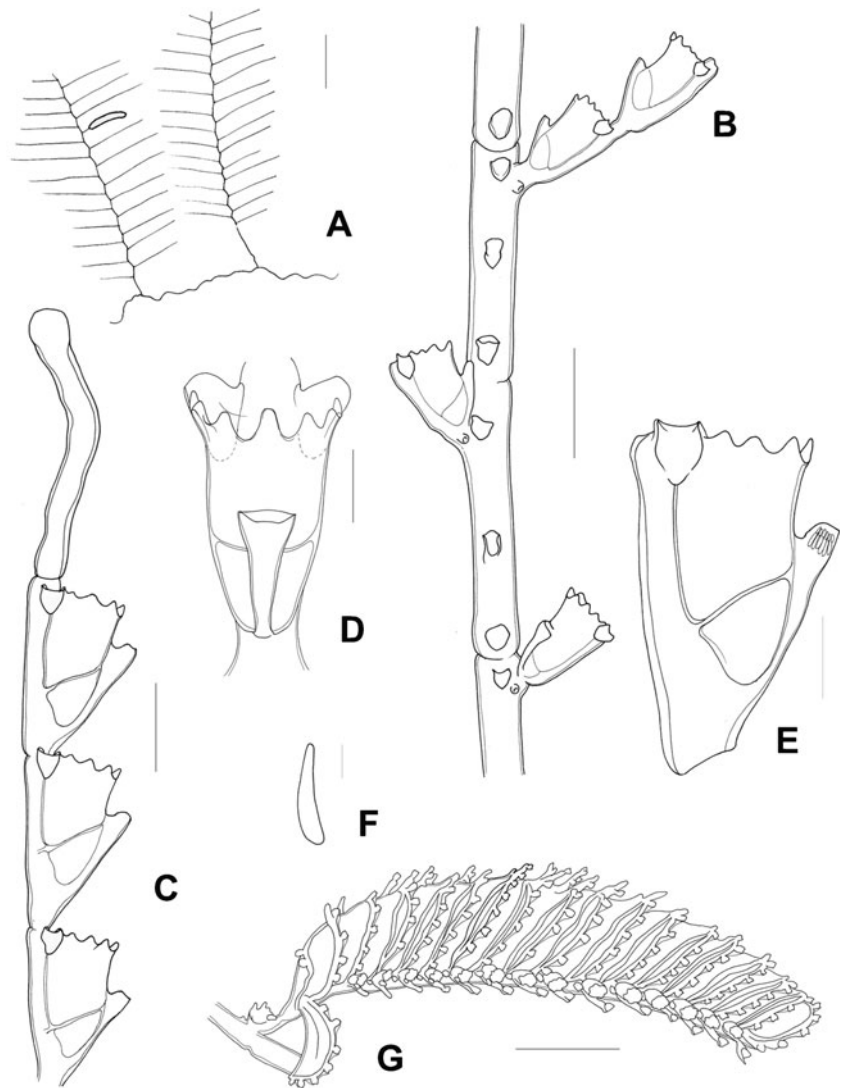
Hydrothecae vase-shaped, elongated, narrowing in the basal part (Figs. 11d, e; 12e, f). Hydrotheca with an intrathecal thickening. This undulated and oblique thickening arises from the adcauline side and reaches the abcauline wall at level where the median inferior nematotheca becomes free. Another short thickening is present in the

hydrocladium in correspondence of the intrathecal one. Adcauline wall completely adnate and straight up to the intrathecal thickening, then becomes slightly oblique; abcauline wall almost straight. Margin perpendicular to the main axis or slightly inclined towards below, with seven triangular teeth, without adcauline tooth.

Median inferior nematotheca not reaching the hydrothecal margin; nematothecae adnate to the hydrotheca for about half-length, adnate portion tubular, free portion quite enlarged, gutter-shaped, foramen into hydrotheca. Lateral nematothecae directed towards outside, gutter-shaped.

Corbulae elongated, closed, sometimes the distal ribs may be open; corbula replacing a hydrocladium, first segment with hydrotheca as other hydrocladial segments;

Fig. 11 *Lytocarpia phyteuma*. **a** Colony; **b** hydrocaulus and internodes; **c** hydrocladium in lateral view ending with a tendril-like process; hydrotheca in frontal (**d**) and lateral (**e**) view; **f** microbasic mastigophores; **g** corbula. Scale bars **a** 1 cm; **b**, **c** 200 μ m; **d**, **e** 100 μ m; **f** 10 μ m; **g** 500 μ m



corbula axis with two alternate rows of leaf-like ribs; margin of ribs with a row of gutter-shaped nematothecae; proximal part of each rib with an elongated processes supporting a hydrotheca; processes of variable length, in general with a nematotheca on the tip; processes shorter in the proximal part of the corbula and occasionally lacking of the nematotheca (Figs. 11g; 12h-l).

Remarks: colonies often ending with a tendril-like process (Fig. 2e, f).

L. phyteuma from Bunaken may form colonies slightly different from the most common type here described. We observed another form characterised by more sturdy perisarc, less-spaced branches, shorter and closer hydrothecae (Table 1). Moreover, SEM pictures of thecae reveal a swelling on the lateral walls resembling protruding cheekbones (Fig. 12g).

Colour: Hydrocaulus light brown, hydrocladia yellow. White and refringent spots visible in correspondence of lateral and median inferior nematothecae of living specimens.

Sizes (see Table 1).

Cnidocysts: Elongated microbasic mastigophores 25–30 \times 5 μ m present in coenosarcs and nematophores.

Distribution

Great Barrier Reef, Northern Australia, Polynesia, Indonesia, Seychelles. Polynesia. Type locality: Tonga Islands.

Ecology

The bathymetric and temporal distributions of the four studied species on the coral reef of Siladen were obtained through vertical transects in the Siladen area, studied during an annual cycle; even if the ecological study was conducted just in Siladen, data about species composition, abundance and distribution reflect those of the entire marine park. The hydroid fauna of the coral reefs of Siladen includes 107 species belonging to 51 genera and 28 families (Di Camillo

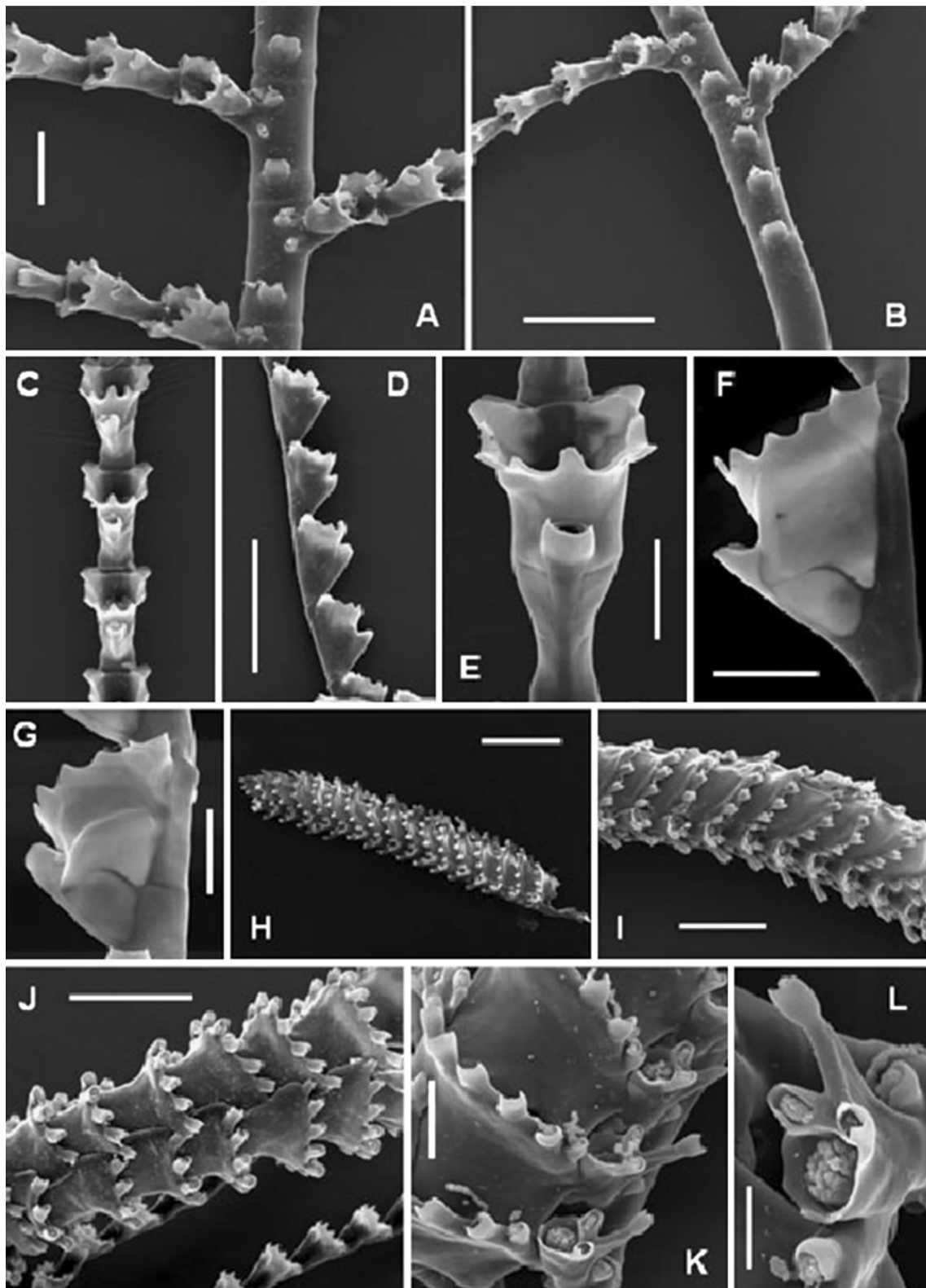


Fig. 12 SEM picture of *Lytocarpia phyteuma*. **a** Detail of hydrocaulus and hydrocladia; **b** basal part of hydrocaulus bearing solitary nematothecae; hydrocladium in frontal (**c**) and lateral (**d**) views; hydrotheca in frontal (**e**) and lateral (**f**) views; **g** hydrotheca of the second type showing the swelling on the lateral wall; corbula (**h**) and

detail of ribs (**i**); frontal view of leaf-like ribs (**j**) and detail of the proximal portion of ribs (**k**); **l** higher magnification showing the hydrothecae on the corbula. *Scale bars* **a, k** 200 μm ; **b, d, i, j** 500 μm ; **e, f, g, l** 100 μm ; **h** 1 mm

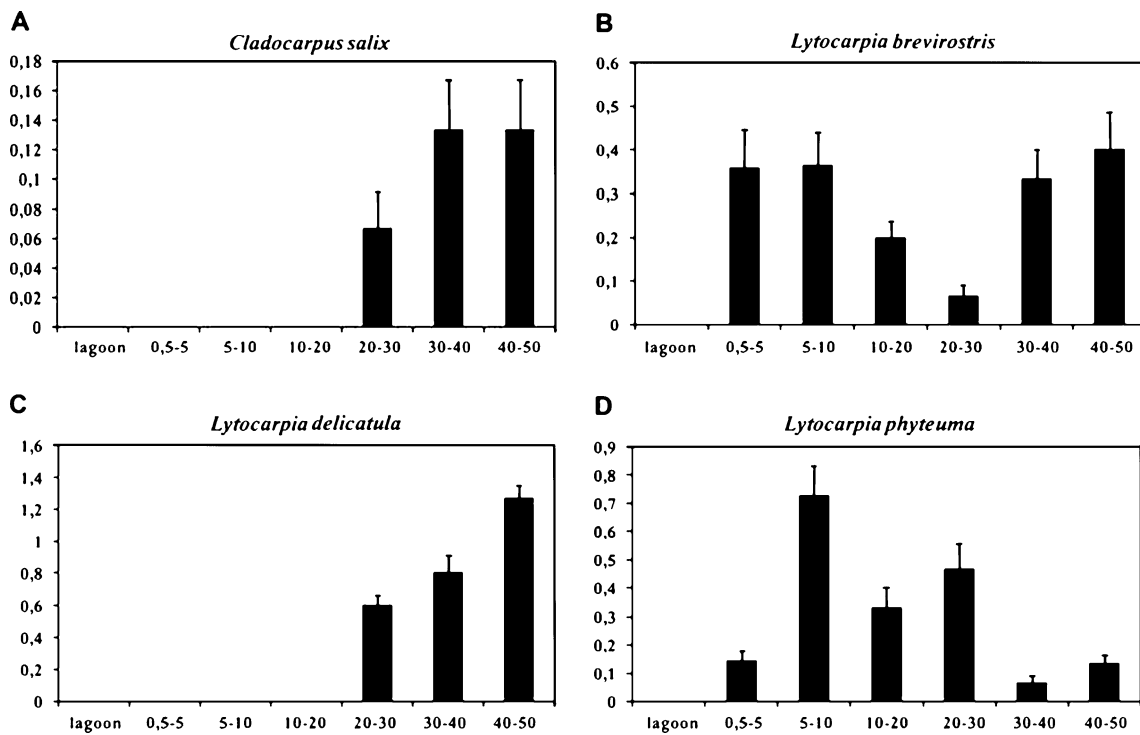


Fig. 13 Bathymetric distribution of *Cladocarpus salix* (a), *Lytocarpia brevisrostris* (b), *Lytocarpia delicatula* (c) and *Lytocarpia phyteuma* (d)

et al. 2008). The family Aglaophenidae is represented by five genera and 14 species, three of which are *Lytocarpia* and one *Cladocarpus*. In this area the number of hydroid species progressively increases from the edge of the reef to 10-20 m depth and slightly decreases until 50 m depth and the highest species diversity, abundance and fertility increased during the wet season due to elevated food availability.

The large colonies of *Cladocarpus salix* settle on corals in shadow habitats. Two species of *Lytocarpia*, *L. brevisrostris* and *L. delicatula*, may settle on corals but were mainly recorded on the membranous tubes of an unidentified polychaete very abundant in the Bunaken area, while *L. phyteuma* was only observed on the coral substratum. In other localities the species were often recorded as epibiont of

Fig. 14 Temporal distribution of the described in Siladen Island. a *Cladocarpus salix*; b *Lytocarpia brevisrostris*; c *Lytocarpia delicatula*; d *Lytocarpia phyteuma*

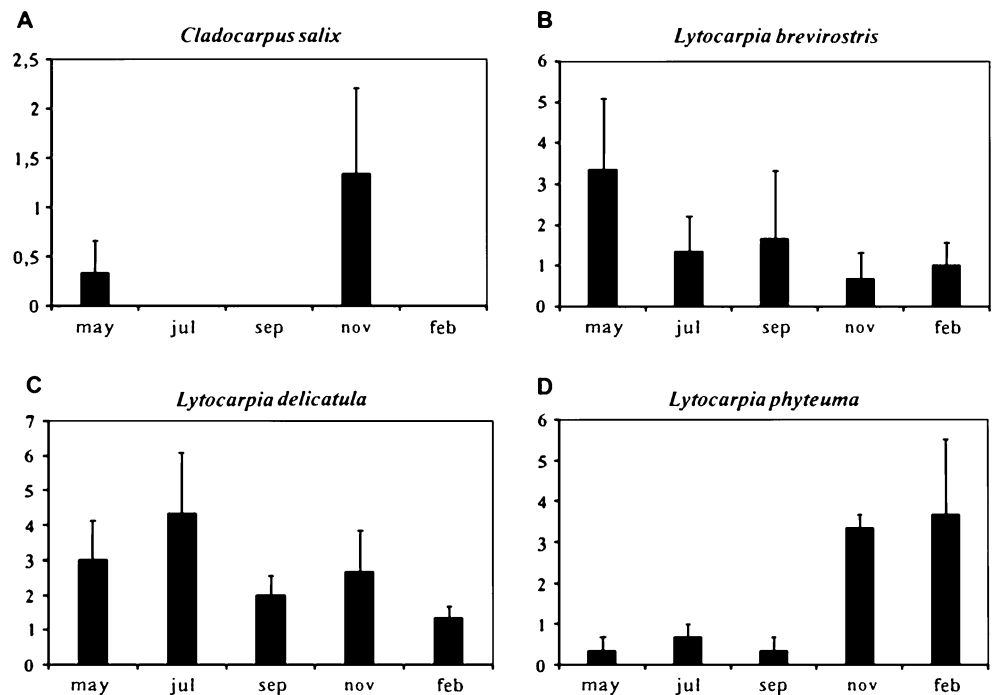


Table 2 Distribution of *L. brevirostris*, *L. delicatula* and *L. phyteuma*

<i>Lytocarpia brevirostris</i> (Busk, 1852) Synonym	Authors	Records
<i>Plumularia brevirostris</i>	Busk, 1852	Off Cumberland Isles, Australia
<i>Aglaophenia brevirostris</i>	Kirchenpauer, 1872	Australia
<i>Aglaophenia brevirostris</i>	Bale, 1884	Off Cumberland Islands, Australia
<i>Aglaophenia brevirostris</i>	Bale, 1913	Fiji, off Cumberland Islands; Torres Strait, Australia
<i>Aglaophenia brevirostris</i>	Kirkpatrick, 1890	Murray Island, Torres Straits, Australia
<i>Aglaophenia maldivensis</i>	Borradaile 1905	Hulule, Male Atoll, Maldive
<i>Aglaophenia maldivensis</i>	Borradaile 1905	Maldives
<i>Plumularia vitana</i>	Kirchenpauer, 1872	Fiji Islands
<i>Thecocarpus brevirostris</i>	Billard, 1913	Borneo
<i>Thecocarpus brevirostris</i>	Stechow, 1919	Tonga Islands
<i>Thecocarpus brevirostris</i>	Briggs, 1918	Lord Howe Island
<i>Thecocarpus brevirostris</i>	Jarvis, 1922	Amirante, Carcados, Farquar, Saya de Malha, Praslin
<i>Thecocarpus brevirostris</i>	Pennycuik, 1959	Heron, North West Reef, Queensland
<i>Thecocarpus brevirostris</i>	Rees and Thursfield, 1965	Murray Island, Torres Straits, Australia
<i>Thecocarpus brevirostris</i>	Millard, 1975	Natal and Mozambique
<i>Thecocarpus brevirostris</i>	Tang, 1991	Nansha Islands, Hainan province, China
<i>Thecocarpus brevirostris</i>	Vasseur, 1974	Tulear, Madagascar
<i>Thecocarpus brevirostris</i>	Ryland and Gibbons, 1991	Fiji Islands
<i>Thecocarpus brevirostris</i>	Irving, 1995	Henderson Island, Ducie and Oeno Atolls (Pitcairn Islands)
<i>Thecocarpus brevirostris</i>	Watson, 2002	Palm Beach, Queensland
<i>Thecocarpus brevirostris</i>	Vervoort and Watson, 2003	Norfolk Island
<i>Thecocarpus brevirostris</i>	Gravier-Bonnet and Bourmaud 2006a	Îles Glorieuses (Southwest Indian Ocean)
<i>Thecocarpus brevirostris</i>	Gravier-Bonnet and Bourmaud 2006b	Nova Island (Southwest Indian Ocean)
<i>Lytocarpia delicatula</i> (Busk, 1852) Synonym	Authors	Records
<i>Plumularia delicatula</i>	Busk, 1852	Torres Strait, Australia.
<i>Aglaophenia delicatula</i>	Bale, 1884	Prince of Wales Channel, Torres Strait; Port Curtis
<i>Aglaophenia delicatula</i>	Billard 1913	Borneo, Kei Islands, Nusa Besi
<i>Aglaophenia delicatula</i>	Kirchenpauer, 1872	Australia
<i>Aglaophenia delicatula</i>	Borradaile, 1905	S. Nilandu Atoll, Maldive
<i>Thecocarpus delicatulus</i>	Millard and Bouillon, 1973	Mahé, Beau Vallon, Glacis (Seychelles)
<i>Aglaophenia delicatula</i>	Jäderholm, 1920	Paumben, East India
<i>Aglaophenia delicatula</i>	Jarvis, 1922	Amirante and Wasin
<i>Aglaophenia delicatula</i>	Pennycuik 1959	Queensland
<i>Aglaophenia delicatula</i>	Watson, 2000	Beagle Gulf and Darwin, Australia
<i>Thecocarpus delicatulus</i>	Millard, 1975	Santa Carolina, Mozambico
<i>Thecocarpus delicatulus</i>	Millard and Bouillon, 1974	Santa Carolina, Mozambico
<i>Lytocarpia delicatula</i>	Schuchert, 2003	Banda Island, Neira Island (Kei Islands)
<i>Lytocarpia phyteuma</i> (Kirchenpauer, 1876) Synonym	Authors	Records
<i>Aglaophenia phyteuma</i>	Kirchenpauer, 1876	Tonga Islands
<i>Thecocarpus phyteuma</i>	Millard and Bouillon 1973	Mahé, Amirante, Praslin (Seychelles)
<i>Aglaophenia clavica</i>	Whitelegge, 1899	Funafuti, Ellice islands, Fiji Islands
<i>Thecocarpus leopoldi</i>	Leloup, 1930	Sorong, Dampier Strait, West Irian
<i>Aglaophenia elongata</i> var. <i>sibogae</i>	Billard, 1913	Borneo, Biaru, Kilsuin, Kei Islands, Cyrus, Pater-Noster Island.
<i>Thecocarpus phyteuma</i>	Stechow, 1919	Tonga Islands
<i>Thecocarpus phyteuma</i>	Pennycuik, 1959	Hardy Reef and Heron Island, Queensland
<i>Thecocarpus phyteuma</i>	Vervoort and Vasseur, 1977	Moorea, French Polynesia

Table 2 (continued)

<i>Lytocarpia brevirostris</i> (Busk, 1852) Synonym	Authors	Records
<i>Thecocarpus leopoldi</i>	Leloup, 1930	Sorong, Dampier Strait, West Irian
<i>Lytocarpia phyteuma</i>	Ryland and Gibbons, 1991	Fiji Islands
<i>Lytocarpia phyteuma</i>	Watson, 2000	Beagle Gulf and Darwin, Australia
<i>Lytocarpia phyteuma</i>	Vervoort and Watson, 2003	Coromandel Peninsula and Rangaunu Bay, New Zealand
<i>Lytocarpia phyteuma</i>	Schuchert, 2003	Banda Island, Neira Island (Kei Islands)
<i>Lytocarpia phyteuma</i>	Schuchert, 2003	Koh Pee, Andaman Sea, Thailand

several organisms, in particular even Watson (2000 and 2002) found *Lytocarpia* on the tube of a worm, this belonging to the genus *Eunice*.

The species described in this paper show wide differences in their bathymetric ranges. *Cladocarpus salix* and *L. delicatula* occur below 20 m and their abundance increases from 30 to 50 m depth. *Lytocarpia phyteuma* and *L. brevirostris* show a contrasting bathymetric distribution. The former was recorded from the edge of the reef to 50 m but it is rare in the shallowest and deepest zones of the reef and more abundant from 5 to 30 m. *Lytocarpia brevirostris* has also a wide vertical distribution, but it is more abundant in the two extremities of its distribution and more rare between 10 and 30 m depth. (Fig. 13).

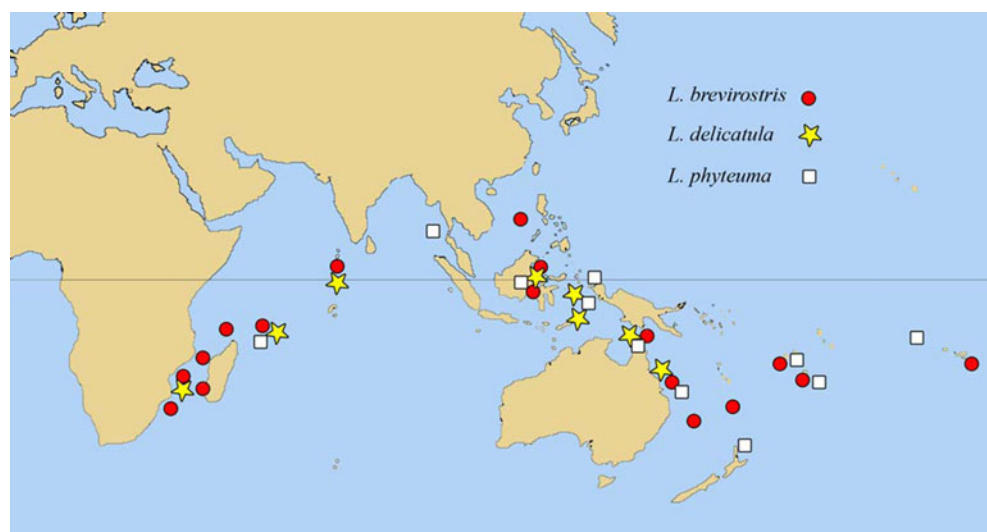
C. salix was abundantly recorded in November and, more rarely in May, the species was never observed in the dry season (from July to September), neither in Siladen nor in other sites, and we tentatively hypothesize it is typical of the wet season. The three species of *Lytocarpia* were observed all around the year but, while *L. brevirostris* and *L. delicatula* spread from May to July,

L. phyteuma is mainly present during the wet season. The gonotheca maturation of *C. salix* and *L. brevirostris* occurs during the wet season. *L. delicatula* and *L. phyteuma* were, on the contrary recorded fertile all year round (Fig. 14).

Few data are available in literature about the bathymetric and temporal distribution and fertility period of the considered *Lytocarpia* species. The species are more common between the reef platform and the outer slope (Gravier-Bonnet and Bourmaud 2006a, b; Vervoort and Vasseur, 1977) and show a wide bathymetric range: *L. brevirostris* was collected from 2 to 70 metres depth in South Africa (Millard, 1975) while *L. delicatula* was reported from shallow waters in Australia (Watson 2000) and up to 500 m during the Siboga expedition (Billard, 1913); even *L. phyteuma* is present from the surface (Fiji Islands, Ryland and Gibbons, 1991) to deeper waters (from 60 to 130 m in New Zealand, Vervoort and Watson, 2003).

The complete list of the records of the three species of *Lytocarpia* (Table 2) indicate for them a typical Indo-Pacific distribution (Fig. 15).

Fig. 15 Distribution of *Lytocarpia brevirostris* (circles), *Lytocarpia delicatula* (stars) and *Lytocarpia phyteuma* (squares)



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