

# New records of benthic green algae (Chlorophyta) from Hainan Island (2008 - 2016)

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## Abstract

This study reports on the intertidal and shallow subtidal green algal flora from Hainan Island in the South China Sea, based on a series of extensive sample collection conducted in 2008–2016. An analysis of the data revealed 22 new records of green algae for Hainan Island, including 6 species new to China. 15 of these newly-recorded species are described with photographs.

**Keywords:** Hainan Island, new records, seaweeds, green algae

## Note

This article shares the same information as to “**Introduction**” and “**Materials and Methods**” given in Titlyanova & Titlyanov (2018) and Titlyanova *et al.* (2018). Refer to these publications for details.

## Flora of green algae from Hainan (2008-2016)

A total of 22 taxa of green algae (Table 1) were newly recorded for Hainan Island, of which 7 species belonged to the Order Cladophorales, 5 species to Ulotrichales and Bryopsidales; 3 species belonged to Ulvales and one

species each to Chaetophorales and Dasycladales. Among new findings, epilithic algae amounted to 64%, epiphytic and endophytic algae 36%.

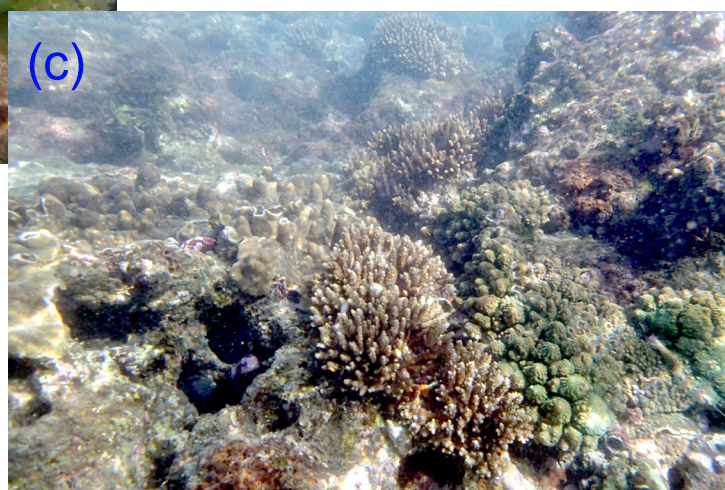
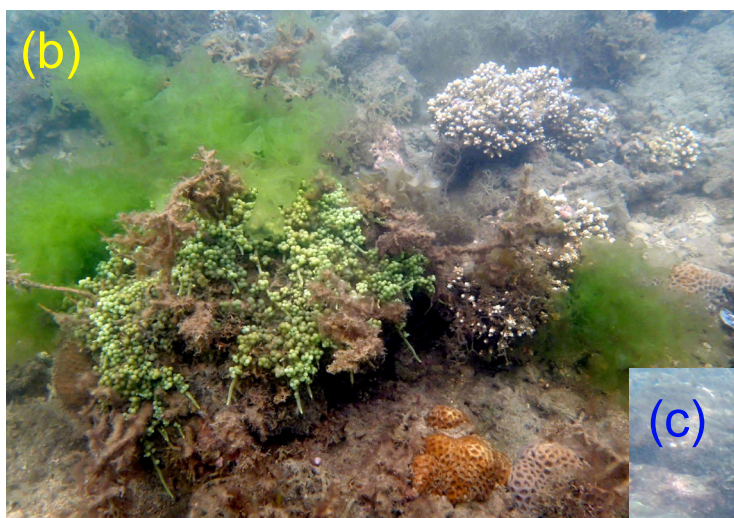
The largest number of new findings was recorded in Luhuitou (12 taxa of 22) and Wenchang locality (6 taxa). In the intertidal zone, 18 species were found in Hainan Island for the first time and in the upper subtidal zone only 10 species. 15 species (64%) were widespread species in tropical and subtropical areas, 7 species (36%) of early collections inhabiting tropics and subtropics of the Indo-Pacific, 8 being widespread species in temperate waters, and 7 in arctic and subantarctic waters. Among these new findings of green algae, invasive (not inhabiting the Indo-Pacific) species were not found in Hainan.

**Table 1.** List of green algae collected from Hainan Island in 2008-2016.

Abundance: rare (+); common (++); abundant (+++). Distribution: T – tropical; S – subtropical; M – temperate; An – Antarctic; T,S,M,An – from tropics to Antarctic; T,S,M – tropics to (cold) temperate zones; T,S – tropical and subtropical Indo-Pacific and Atlantic; T,S,(I-P) – tropical and subtropical Indo-Pacific. Life forms: Ep, epiphyte, HS, algae growing on hard substrate (epilithic), Cr, crust form. ¶ new record for Hainan Island; ¶¶ new record for China. Locality abbreviations (refer to Fig 1): Dadong Hai, Dh; Hong Tang Bay, Ht; Linchang, Lc; Luhuitou, Lh; Nanmai, Nm; Meixia, Mx; Shalao, Sl; Tian Ya Hai Tiao, Ty; Wenchang, Wc; Yalong Wan, Yw; Ying Ge Hai, Yg; Xian Hai, Xn; Xiaodong Hai, Xh; Xincun, Xc; Ximao Zhou, Xz.

Species, varieties and forms	Life form	Distribution	Abundance		Location in Hainan
			intertidal	upper subtidal	
DIVISION CHLOROPHYTA					
CLASS CHLOROPHYCEAE					
<b>Order CHAETOPHORALES</b>					
<b>Family Chaetophoraceae</b>					
<i>Uronema marinum</i> Womersley ¶	Ep	T,S,(I-P)	+		Lh
CLASS ULVOPHYCEAE					
<b>Order ULOTRICHALES</b>					
<b>Family Gomontiaceae</b>					
<i>Gomontia polyrhiza</i> (Lagerheim) Bornet & Flahault ¶	En	T,S,M,Ar	+		Lh
<i>Monostroma latissimum</i> Wittrock ¶	HS	T,S	+		Mx
<b>Family Ulotrichaceae</b>					
<i>Ulothrix flacca</i> (Dillwyn) Thuret ¶	Ep	T,S,M,Ar,An	+		Yw, Lh
<i>Ulothrix implexa</i> (Kützing) Kützing ¶	Ep	T,S,M,Ar,An	+		Lh
<i>Ulothrix subflaccida</i> Wille ¶¶	Ep	T,S,M,Ar	+		Lh
<b>Order ULVALES</b>					
<b>Family Ulvaceae</b>					
<i>Ulva australis</i> Areschoug ¶	HS	T,S,M,Ar,An	+	+	Wc
<i>Ulva reticulata</i> Forsskål ¶	HS	T,S,(I-P)	+		Xn, Wc
<i>Ulva rigida</i> C. Agardh ¶	HS	T,S,M,Ar,An		+	Wc
<b>Order CLADOPHORALES</b>					
<b>Family Boodleaceae</b>					
<i>Cladophoropsis membranacea</i> (Hofman Bang ex C. Agardh) Børgesen ¶	Ep	T,S	+	+	Lh
<b>Family Cladophoraceae</b>					
<i>Chaetomorpha basiretrorsa</i> Setchell ¶	HS	T,S,(I-P)	+		Yg
<i>Chaetomorpha ligustica</i> (Kützing) Kützing ¶¶	Ep	T,S,M	+		Lh
<i>Cladophora rugulosa</i> G. Martens ¶	HS	T,S,(I-P)	+		Yg
<b>Family Siphonocladaceae</b>					
<i>Siphonocladus rigidus</i> M.A. Howe ¶¶	Ep	T,S	+		Wc
<b>Family Valoniaceae</b>					
<i>Valonia fastigiata</i> Harvey ex J. Agardh ¶	HS	T,S	+	+	Wc, Yw
<i>Valonia macrophysa</i> Kützing ¶¶	HS	T,S	+	+	Ht
<b>Order BRYOPSIDALES</b>					
<b>Family Bryopsidaceae</b>					
<i>Bryopsis plumosa</i> (Hudson) C. Agardh ¶	HS	T,S,M,Ar,An	+	+	Wc
<i>Trichosolen mucronatus</i> (Børgesen) W.R. Taylor ¶	HS	T,S,(I-P)	+		Lh
<b>Family Caulerpaceae</b>					
<i>Caulerpa fastigiata</i> Montagne ¶¶	HS	T,S		+	h
<i>Caulerpa mexicana</i> Sonder ex Kützing ¶	HS	T,S		+	Lh
<b>Family Udoteaceae</b>					
<i>Penicillus sibogae</i> A. Gepp and E.S. Gepp ¶¶	HS	T,S,(I-P)		+	Yw, Lh
<b>Order DASYCLADALES</b>					
<b>Family Dasycladaceae</b>					
<i>Bornetella nitida</i> Munier-Chalmas ex Sonder ¶	HS	T,S,(I-P)	+	+	Yw, Lh, Yg, Lh

(a)



**Fig. 1** (a) Collection sites on Hainan Island, China. (Filled circles), collection sites of C.K. Tseng and coworkers in the 1930s–1980s (old spellings of site names); (Stars), collection sites of two German-Chinese expeditions during October–December 1990 and March–April 1992; (Plus), collection sites of T. Titlyanova, E. Titlyanov and Li Xiu Bao in 2008–2016. (b) Luhuitou, upper subtidal, 2 m depth, April 2012. (c) Xiaodong Hai, upper subtidal, 1.5 m depth, December 2016.

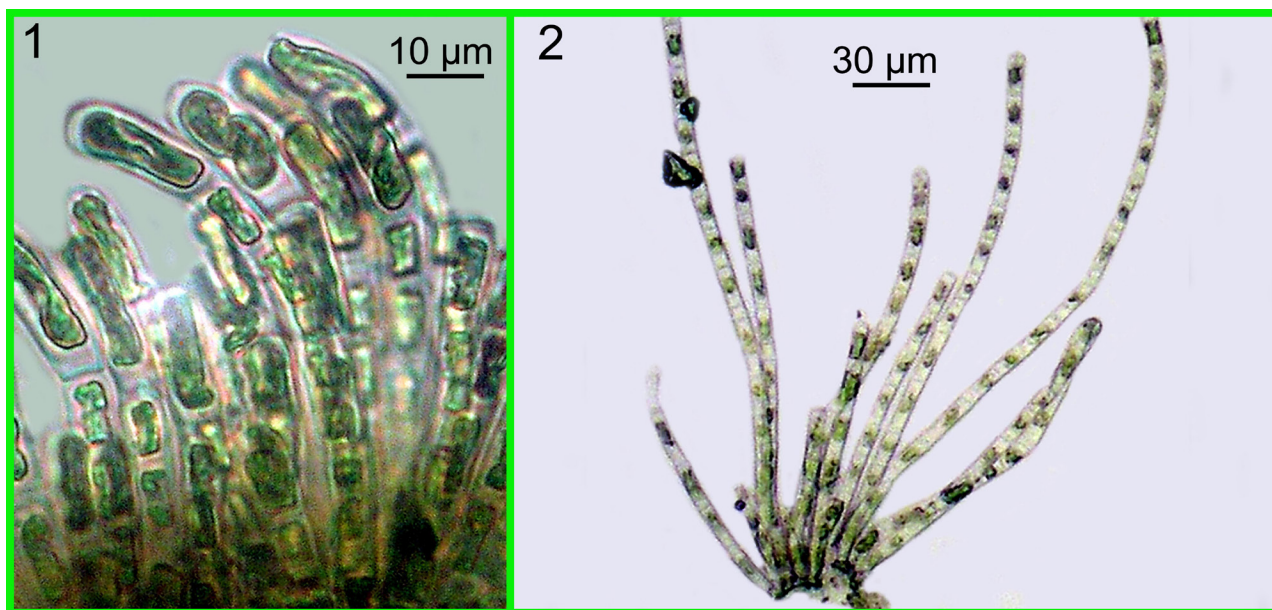


## Description of green algae collected in Hainan Island 2008-2016

## DIVISION CHLOROPHYTA

## Order CHAETOPHORALES

## Family Uronemataceae

*Uronema marinum* Womersley

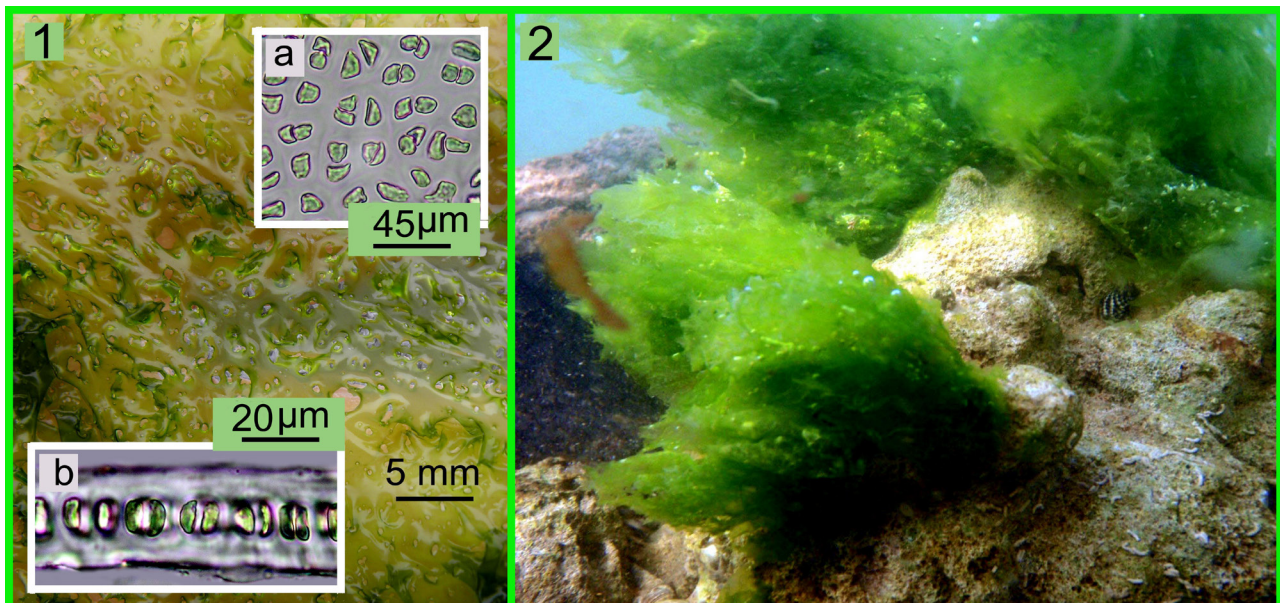
**Fig. 2** *Uronema marinum*. 1. Magnified, near Wenchang, March 2012. 2. Overall morphology. Luhuitou, April 2012.

Characteristics: Thallus composed of erect, straight or slightly curved, uniseriate and unbranched filament, to 400 µm high, originating from conical base, forming tomentose spots of light to dark green color. Filaments are cylindrical increasing in diameter from base upwards, slightly constricted (or not constricted) at cross walls, apical cell with rounded top. Cells 5.0 µm in diam. at base, 7.5 µm at apical cells, 15–25 µm long (2–4 diameters long). Chloroplast single, commonly with one large pyrenoid (rarely two). Cell walls about 1 µm thick. Growing epiphytic on *Anadyomene wrightii*, *Ceramium marshallense*.



## Order ULOTRICHALES

## Family Monostromataceae

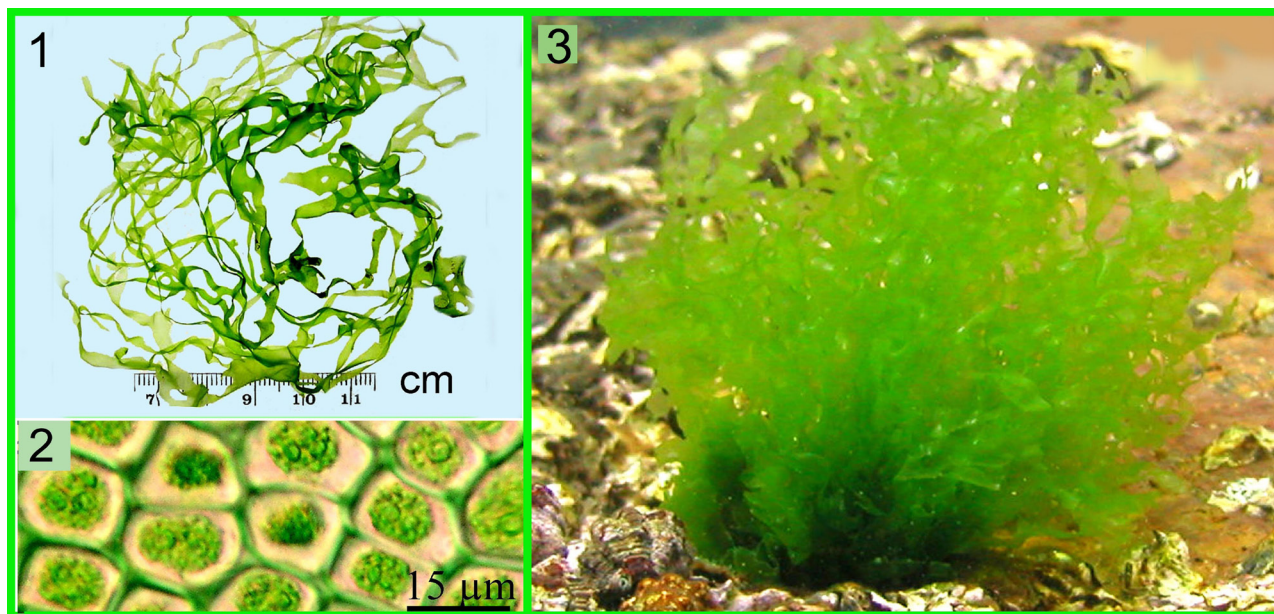
*Monostroma latissimum* Wittrock

**Fig. 3** *Monostroma latissimum*. 1. Part of the thallus showing perforations with raised proliferating margins. Insets: a – surface view of cells; b – transverse section of blade. 2. In habitat at low tide, Meixia locality. April 2012.

Characteristics: Thallus membranous, flaccid, soft, thin, ruffled surface and perforated with many holes of various size, light green, 10–20 cm across. Margins smooth or undulating. Cell from surface view rectangular to polygonal with rounded corners, disordered, often in groups of 2–3(–4), 15–17  $\mu$ m across. In transverse section, blade of one cell thick, 30(–35)  $\mu$ m at the basal portion and 20–25  $\mu$ m above; cells vertically oval 12.5–17.5(–20)  $\mu$ m high. Chloroplast single, central with one pyrenoid. Attachment by small holdfast

## Order ULVALES

## Family Ulvaceae

*Ulva reticulata* Forsskål

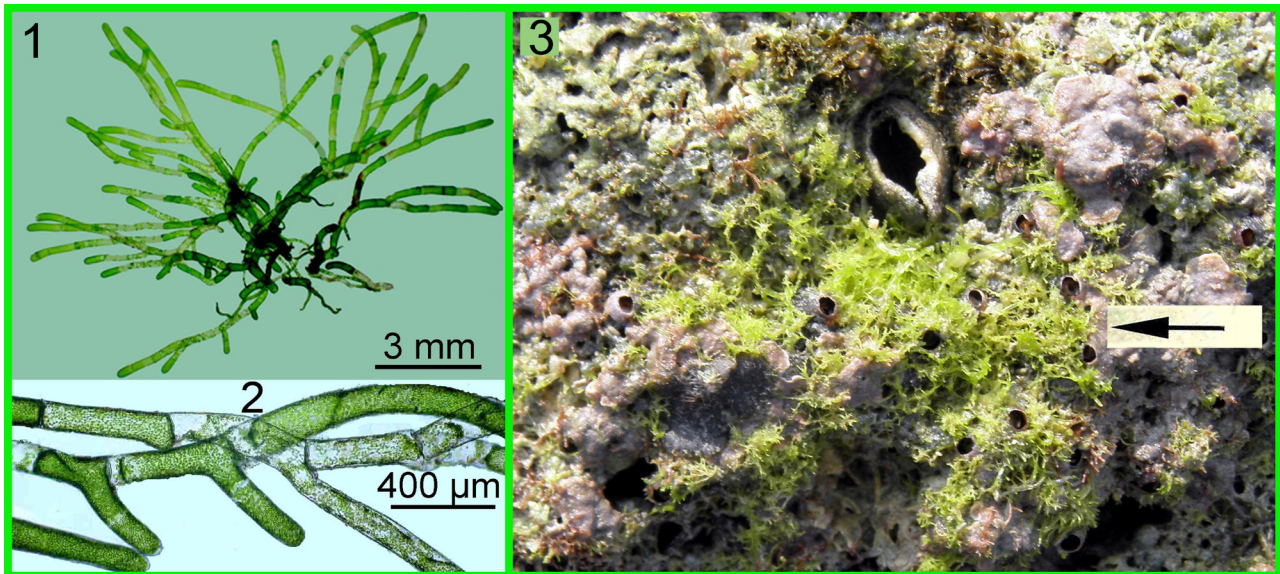
**Fig. 4** *Ulva reticulata*. 1, Overall morphology. 2, Surface view of cells. 3, In habitat.

Characteristics: Thallus rough, ribbon-like, firm in texture, reticulate, netlike (membrane with numerous large and small holes), deeply and irregularly lobed, light to dark green, to 80 cm across. Margins of the thallus and edges around the holes are with microscopic serrations. Cells from surface view rounded polygonal, 20–22×12.5–15 µm. In transverse section, the membrane composed of two cells layers, 45–50(–76) µm thick; cells are oval to roundish, commonly higher than wide, or of more equal sizes, 20–25 µm high, 10–20(–22) µm broad. Growing on hard substrate from upper intertidal to subtidal, common as epiphytes on *Sargassum* spp., seagrasses and other algae. Plants also form masses entangled into larger algae, in moderately wave-exposed shores. Abundant in polluted areas. Plants are often unattached and washed ashore.



## Order CLADOPHORALES

## Family Boodleaceae

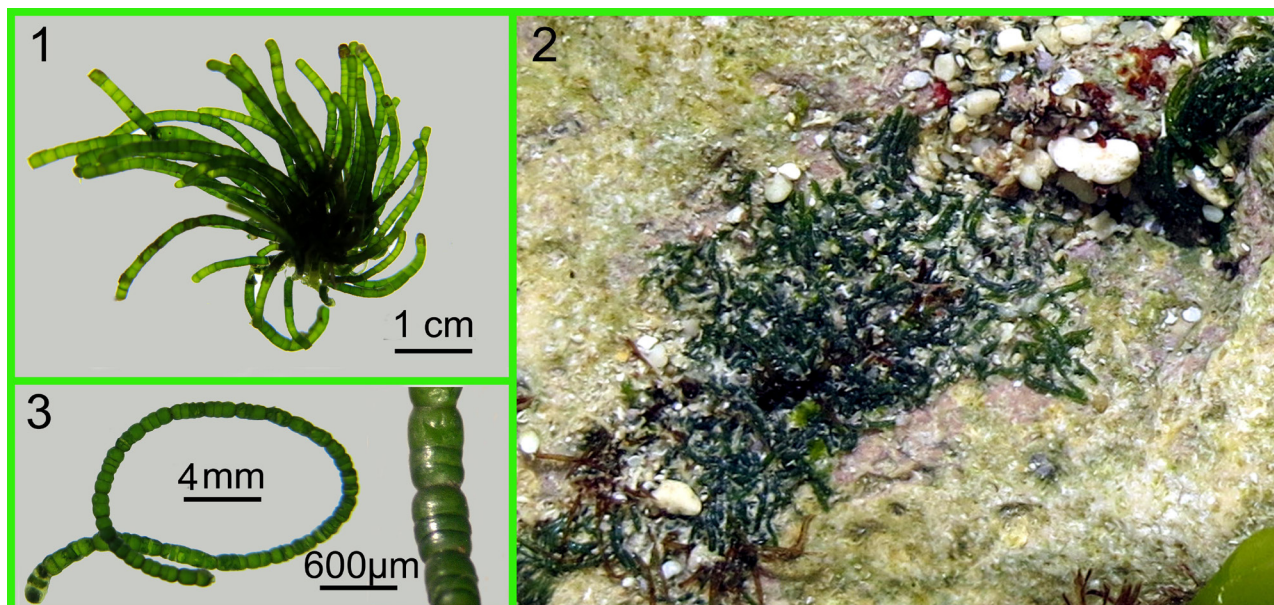
*Cladophoropsis membranacea* (Hofman Bang ex C. Agardh) Børgesen

**Fig. 5** *Cladophoropsis membranacea*. 1, Overall morphology. 2, Branching pattern. 3, In habitat, the low intertidal zone (arrow). Hainan Island, Luhuitou, April 2012.

Characteristics: Thallus filamentous, glossy, forming tufts or dense cushion-like clumps, or mats, bright green color, 2–5 cm high. Branching sparse, mainly irregular, alternate below and unilateral above. Filaments coarse, 170–270(–300) µm in diam., lateral filaments 100–140 µm in diam. No cell wall at the base of lateral branches (in open connection with mother cell). Chloroplasts are ellipsoidal, with one well visible large pyrenoid. Attachment by small, colorless, branched rhizoids ending into pads; secondary attachments (or tenaculae) develop from apices as extension of lateral decumbent filaments.



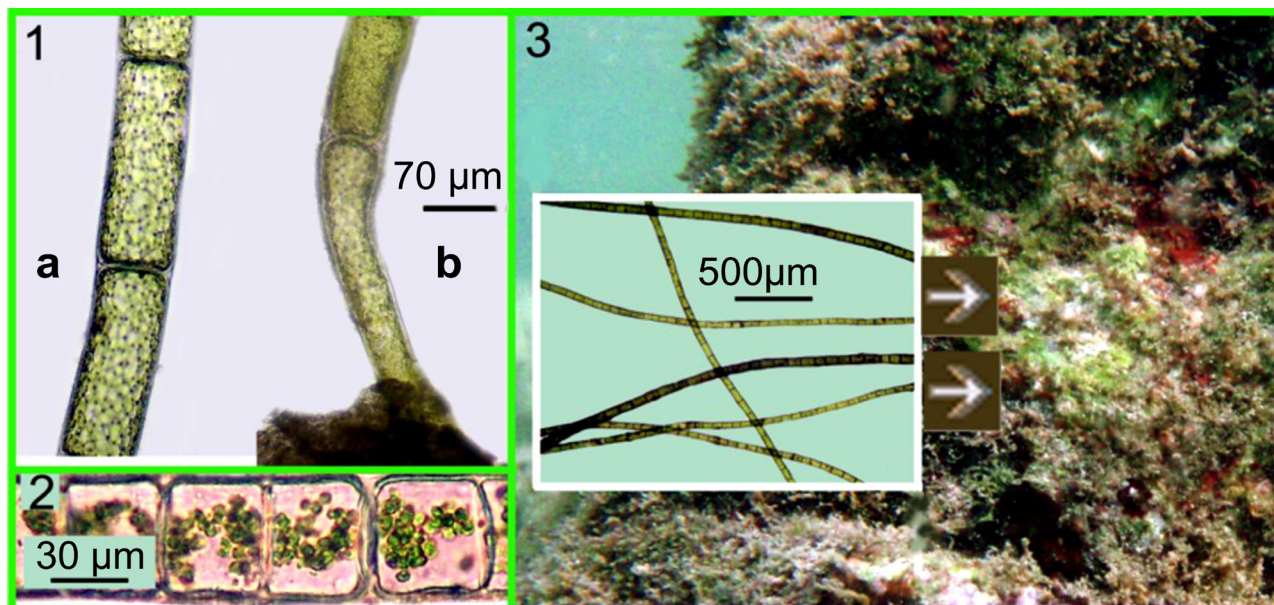
## Family Cladophoraceae

*Chaetomorpha basiretrors* Setchell

**Fig. 6** *Chaetomorpha basiretrors*. 1, Overall morphology. 2. In habitat, Ying Ge Hai, April 2014. 3. Detail showing filament and cells.

Characteristics: Thallus filamentous, rigid, caespitose, gregarious, with curved downward filaments, 2–3(–4.5) cm long, shining, dark-green and iridescent in water. Filaments 500–800(–1000)  $\mu\text{m}$  in diam. gradually decreasing to the base to 200–300  $\mu\text{m}$  in diam. Cells cylindrical, slightly swollen, barrel-shaped, 0.3–4 diameters long, constricted at joints. Cell wall 25–45  $\mu\text{m}$  thick, striated, grayish or light brownish especially in the basal cell. The basal cell to 1.6 mm long ending into long branched rhizoids in open connection with the mother (basal) cell. In most cases, secondary finger-like rhizoids develop laterally on the basal cell. Growing in the middle intertidal zone on hard substrate, forming dense clusters occupying areas to 15 cm in diam.

***Chaetomorpha ligustica* (Kützing) Kützing**



**Fig. 7** *Chaetomorpha ligustica*. 1, Basal portion of filament. Detail showing cells. 2, In habitat, the lower intertidal zone at Xiaodong Hai, among turf algae (arrows). October 2008.

Characteristics: Thallus filamentous, dark-green, 5–10 cm long. Filaments rather coarse, tangled, intertwined (40–)65–80(–100) µm in diam. Cells cylindrical, 1–3(–4) diameters long. Cell walls 2–3(–5) µm thick, not constricted at joints. Basal cell 50 µm in diam., to 200 µm long, ending into fine, slightly lobed attachment. Growing on hard substrates in the lower intertidal zone among turf algae, sometimes on soft grounds, or epiphytic on other algae at sheltered sites and near to estuaries.

***Cladophora rugulosa* G. Martens**

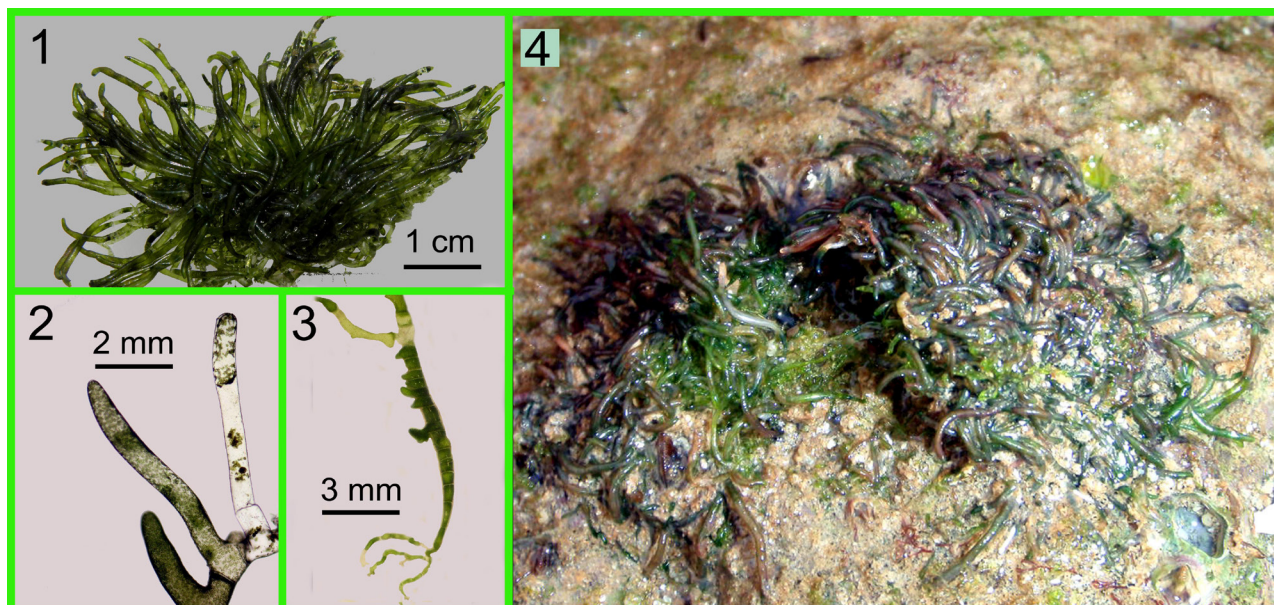
**Fig. 8** *Cladophora rugulosa*. 1, Upper part of branches. 2. Overall morphology. Hainan Island, Ying Ge Hai, April 2014.

Characteristics: Thallus filamentous, caespitose, bushy, densely tufted, (1.4–)3–6 cm high, dark green. Filaments stiff, coarse. Branching is irregular, pseudichotomous, at very narrow angle between axis and branchlets. Cells of the main axes cylindrical, club-shaped, to 250 µm in diam., elongate, gradually tapering downward (6–8 diameters long) in the lower part and 6–12 diameters long in the upper part. Terminal branchlets fasciculate. Maximum number of branches at joints 3–4. Apical cells to 6 diameters long, cylindrical, slightly swollen and tapering toward blunt tips. Attachment by fine branched rhizoids, descending from the lower cells (without cross wall), and forming entangled stipe.



## Family Siphonocladaceae

### *Siphonocladus rigidus* M.A. Howe

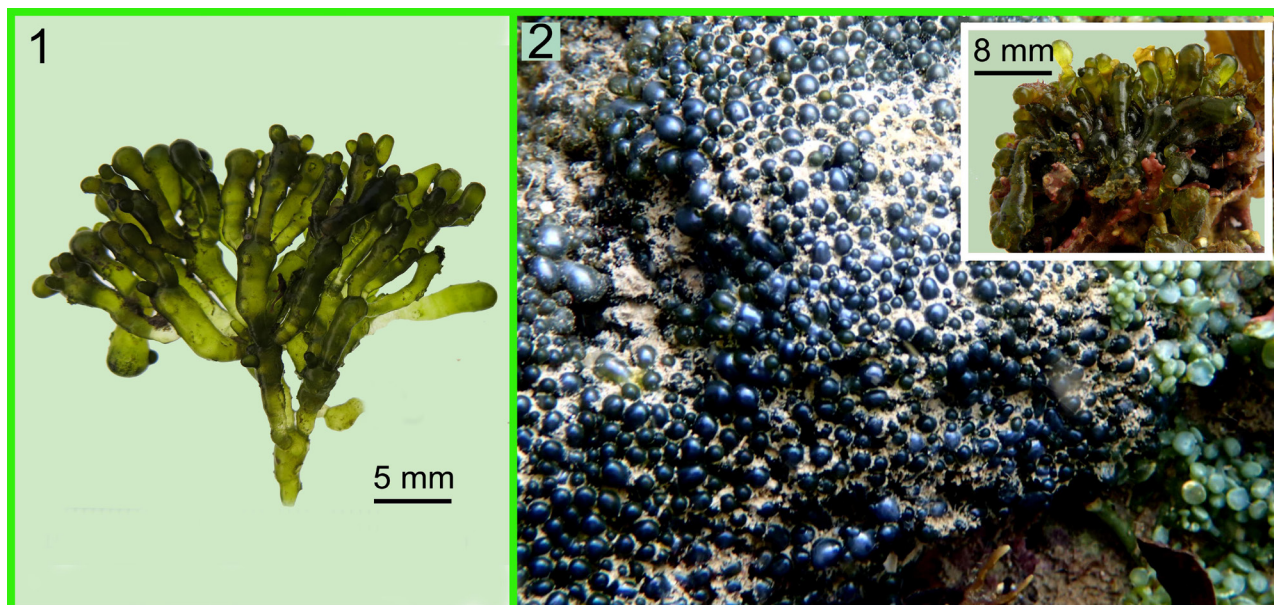


**Fig. 9** *Siphonocladus rigidus*. 1, Overall morphology. 2, Detail showing lateral branches in open connection with bearing (non-septate) cells. 3, Basal portion of isolated filament showing protruding laterals and descending rhizoids. 4, In habitat, on sand covered hard substratum. The vicinity of Wenchang City, March 2012.

Characteristics: Thallus filamentous, rigid, (1-)2.2-4 cm long, forms coarse tufts tightly adhering to the substratum, dark green to pale translucent olive-green color, branching irregular, unilateral. Main axes indistinct, 400  $\mu\text{m}$  in diam. at the basal portion, 550-700(-1100)  $\mu\text{m}$  in diam. in the middle and 550  $\mu\text{m}$  in diam. at apices. Branches are unilateral; branchlets are almost the same size with the branches (350-900  $\mu\text{m}$ ). Apices blunt, curved downward. Cell walls striated, to 20  $\mu\text{m}$  thick. Spores common, spherical, dark green, develop within branch sheath. Rhizoids are branched, finger-like, about 25  $\mu\text{m}$  in diam.

### Family Valoniaceae

#### *Valonia fastigiata* Harvey ex J. Agardh



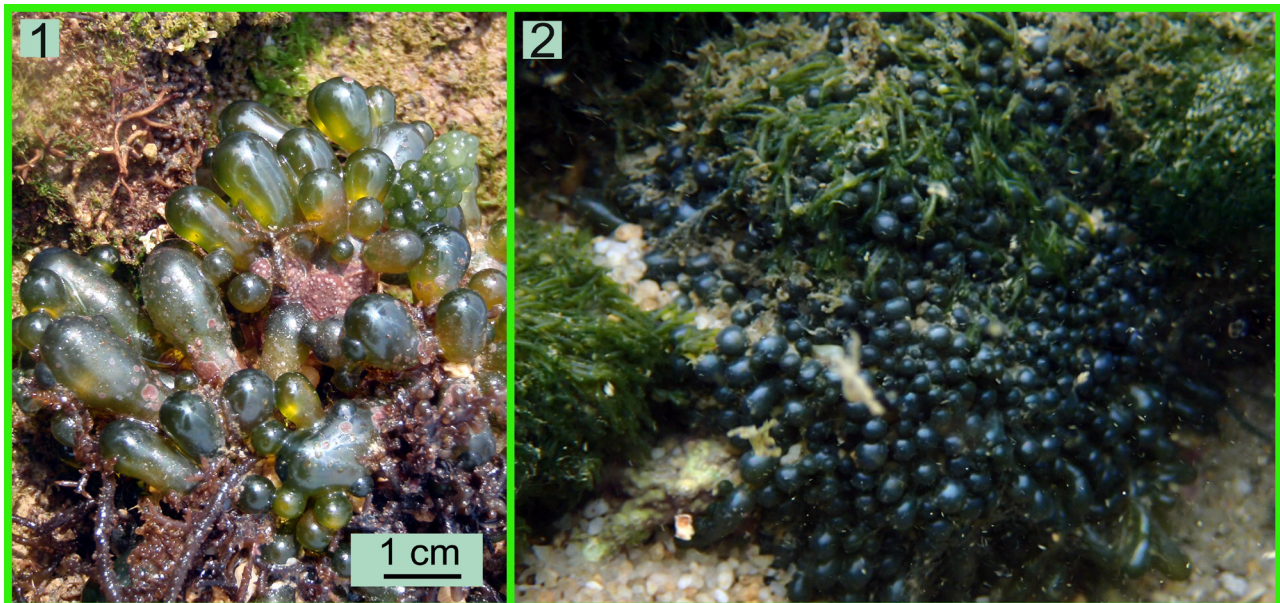
**Fig. 10** *Valonia fastigiata*. 1, Isolated filament showing branching pattern. 2. In habitat, Hainan Island, Yalong Wan, March 2012.

Characteristics: Thallus forming dense hemispherical or flattened cushions, 2–3 cm high, 3–20 cm across, shiny, translucent, bright-green, deep dark-green to bluish-green (in the water), composed of tightly packed branched filaments of macroscopic cells. Cells cylindrical to clavate, straight, 2–3(–4) mm diam., 0.5–1.7 cm long. Branching di-, polychotomous from the apices of bearing cells. Branches almost of the same length. Attachment by minute rhizoidal cells. Growing on hard substrate in sheltered sites and exposed to moderate wave action. Sometimes torn off cushions form congestions in the intertidal pools.



**Family Valoniaceae**

***Valonia macrophysa* Kützing**



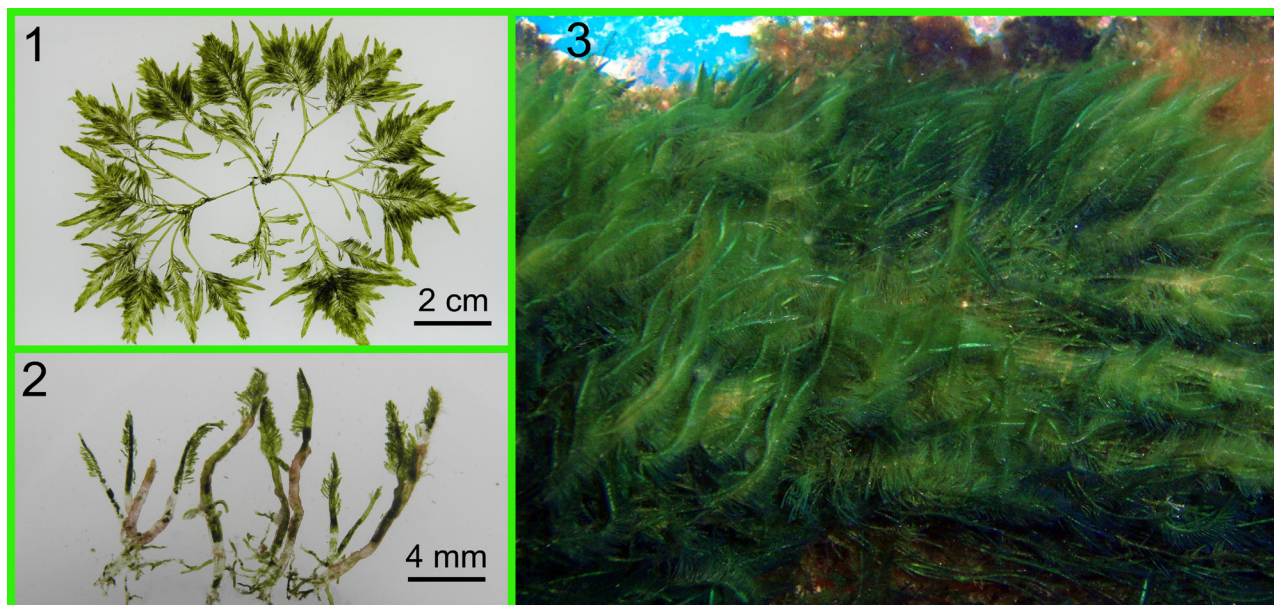
**Fig. 11** *Valonia macrophysa*. 1, Overall morphology. 2, Occuring in association with *Valoniopsis pachynema*, Hong Tang, April 2016.

Characteristics: Thallus aggregate, prostrate, 1-3 cm high, translucent, dark olive-green to deep dark-green, composed of branched filaments of macroscopic cells. Cells firm, not densely packed, saccate (spherical, oblong, elongated, club-shaped) unicellular vesicles, 5-15 mm in diam., 1-4 cm long. Branching irregular. Attachment by minute branched rhizoids issuing from basal cells. Growing tightly adhering to hard substrata, commonly in shaded sites



## Order BRYOPSIDALES

## Family Bryopsidaceae

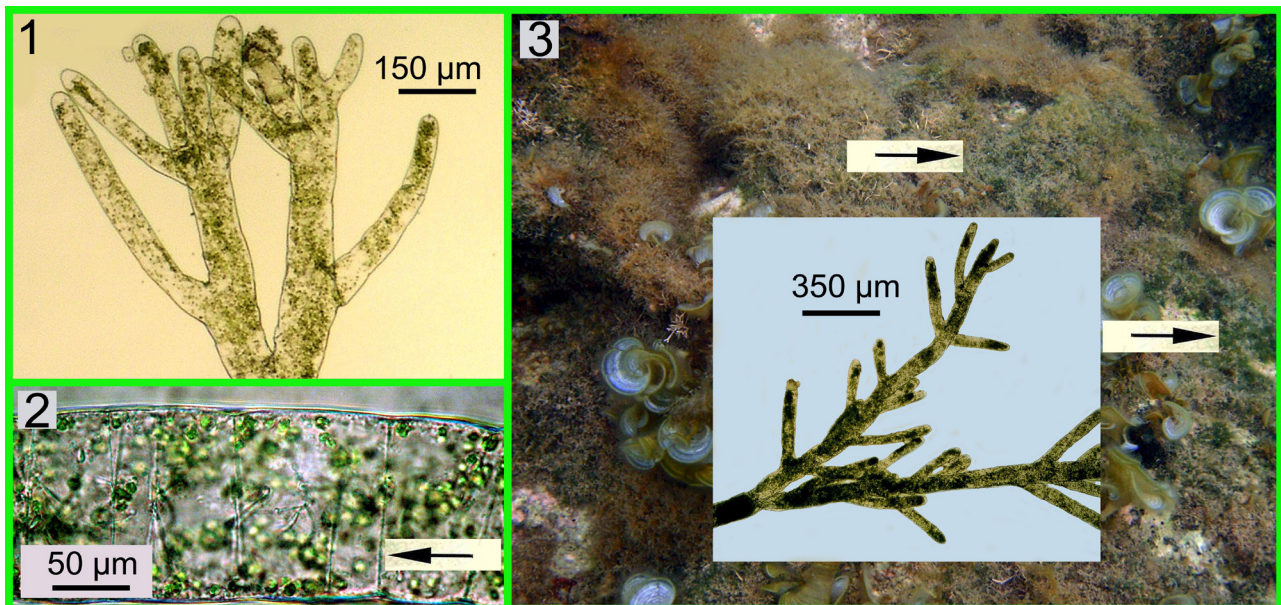
*Bryopsis plumosa* (Hudson) C. Agardh

**Fig. 12** *Bryopsis plumosa*. 1, Overall morphology. 2, Young plants. 3. In habitat, the vicinity of Wenchang City, March 2012.

Characteristics: Thallus fine feather-like, in tufts, soft, 3–6(–15) cm high, translucent light or dark green with bluish iridescent under water. Branching repeatedly pinnate, in one plane. The main axes and branches 0.5–1.5 mm in diam. naked in the basal portion (c. 1/3 from the base) and above covered with primary (alternate) and secondary oppositely arranged branches bearing ultimate branchlets (pinnules) shortening to apices, which give the plant a pyramidal shape. Pinnules are arranged in two opposite rows, constricted at the base, 65–100(–250)  $\mu\text{m}$  in diam. and slightly taper to apices. Attachment by tightly interwoven rhizoids.

## Family Caulerpaceae

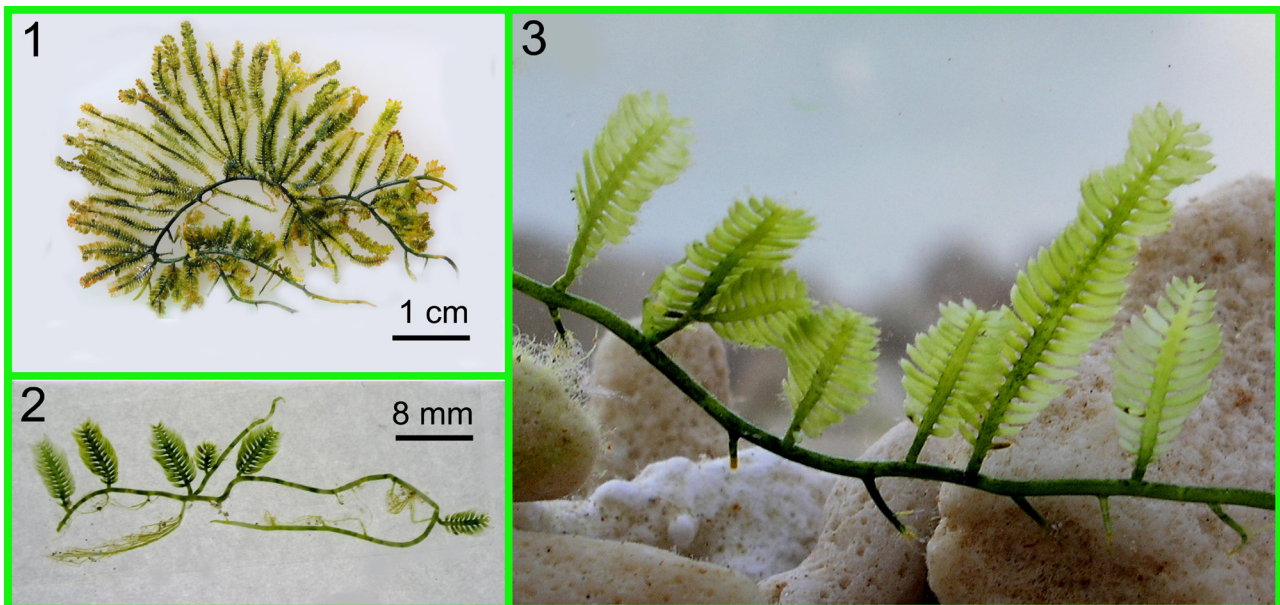
### *Caulerpa fastigiata* Montagne



**Fig. 13** *Caulerpa fastigiata*. 1, Upper part of branch. 2, Detail showing inner trabeculae of a creeping stolon (arrow). 3. In habitat, among turf algae (arrows). Inset: Erect branch. Hainan Island, Luhuitou, April 2012.

Characteristics: Thalli filamentous from light green to dark green color forming mat-like inconspicuous congestions, consisting of creeping stolons and erect slender branches matted and interspersed with sand and shell particles. Creeping stolons 90–130(–150–200) µm in diam., to several centimeters long, bearing dichotomously branched rhizoids. Rhizoids are hyaline, hair-like, 60 µm in diam. at the base and 20 µm in diam. at their ends. Erect filaments fastigiata, 1.5–3 cm high, branching opposite, alternate, dichotomous or irregular. Main axes and branches are of almost equal diameters (to 120 µm).



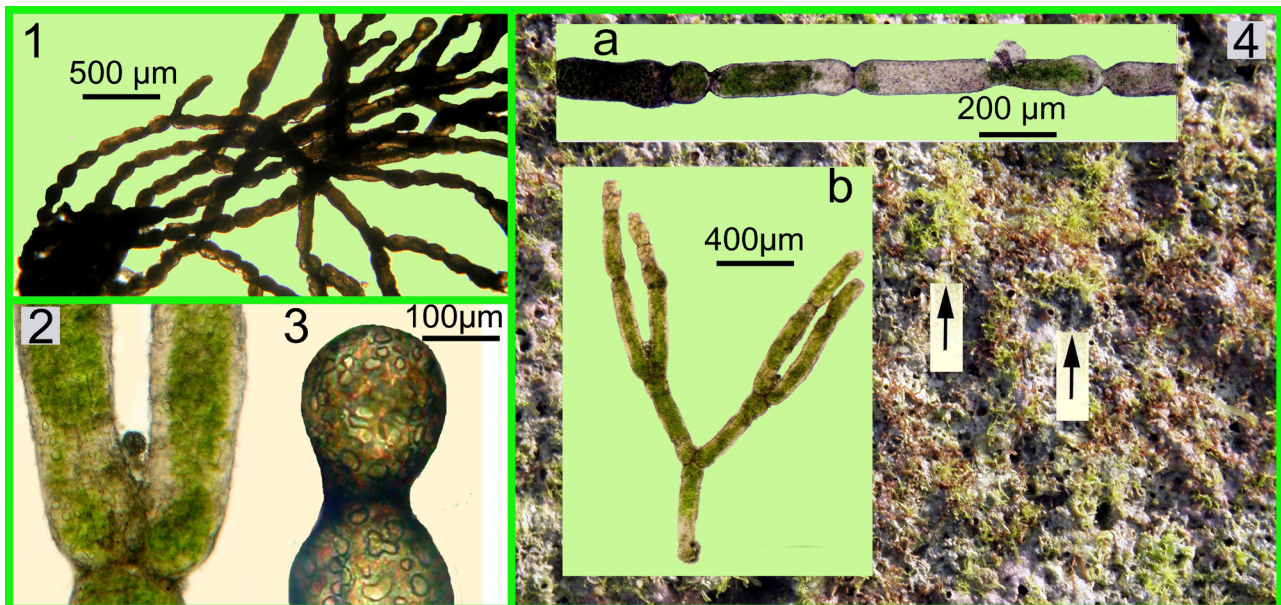
***Caulerpa mexicana* Sonder ex Kützing**

**Fig. 14** *Caulerpa mexicana*. 1, 2. Overall morphology. 3, Plant in aquarium. Luhuitou village. March 2015.

Characteristics: Thallus consist of creeping stolons (0.6–1.25 mm in diam.) bearing numerous descending delicate rhizoids and erect branches at distance 4–8(–13) mm from each other. Branches green, dark green, simple or occasionally branched, ending abruptly in a short apex, shortly stalked, feather-like, oblong or broadly lanceolate, dwarf, 1–3 cm high, 4–8(–10) mm broad, with flat midrib, 1–3 mm broad and with pinnules on both sides of the midrib. The pinnules are flat, oval to oblong, opposite, densely placed, sometimes overlapping each other, upcurved, slightly constricted at base, 0.5 mm broad, to 2.6 mm long, with apiculate tips.



## Family Udoteaceae

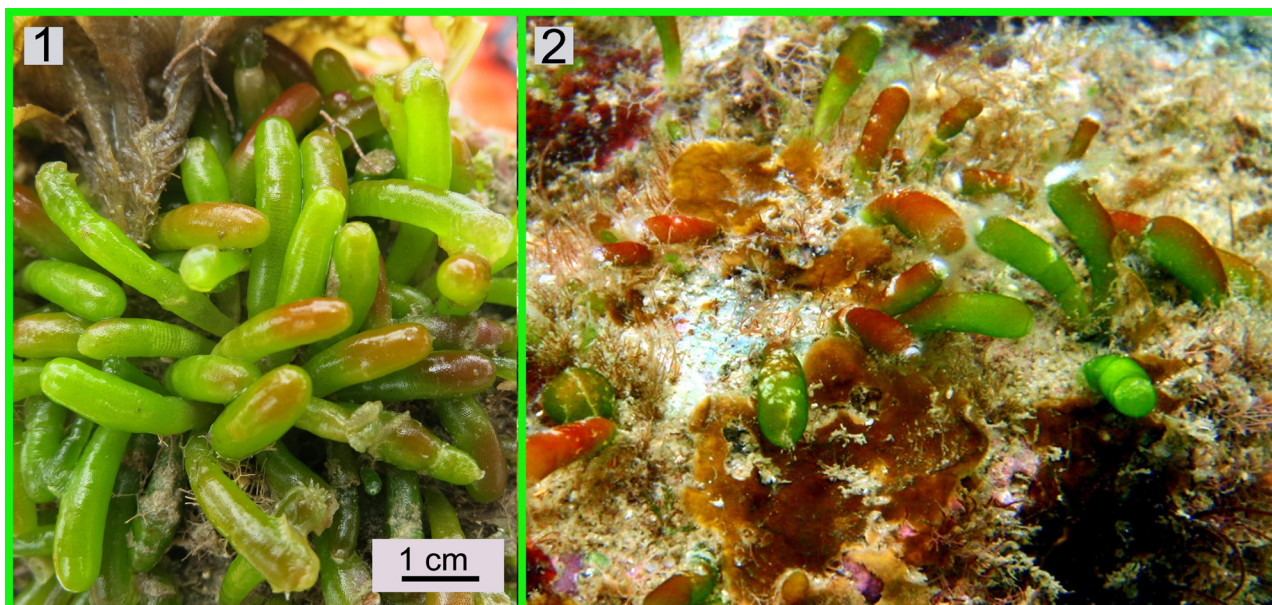
*Penicillus siboga* A. Gepp and E.S. Gepp

**Fig. 15** *Penicillus siboga*. 1, Overall morphology. 2, Detail showing evenly constricted siphons at the dichotomy. 3, Fragment showing cell structure. 4, In habitat (arrow), Hainan Island, Yalong Wan, March 2012. Insets: a – filament with constrictions; b – fragment showing branching pattern.

Characteristics: Thallus filamentous, solitary, inconspicuous, very small, 1.8–2 mm high (rarely higher), greenish or sometimes whitish color. Filaments stiff, lightly calcified. Branching dichotomous. Siphons 100–140 µm in diam., with constrictions in between dichotomies, evenly constricted at the dichotomies. Apices blunt. Holdfast inconspicuous, small, disc-like. Growing on hard substrate covered with sand and mud in the middle, lower intertidal to upper subtidal zones.

## Order DASYCLADALES

## Family Dasycladaceae

*Bornetella nitida* Munier-Chalmas ex Sonder

**Fig. 16** *Bornetella nitida*. 1, 2, In habitat, at the low intertidal zone. Hainan Island, Luhuitou, April 2012.

Characteristics: Thallus solitary, or in groups, subcylindrical, clavate, slightly curved, bright green, brownish-red or brownish-red-green, shining, lightly calcified, (0.7)–1.9–3(–5) cm high, 3.5–4 mm in diam. above, narrowing to the base to 2–2.5 mm. Inner structure: central axis (400–650  $\mu\text{m}$  in diam.) bearing 24–30 primary branches with 4–6(–7) short capitate secondary branches joined together and forming a monostromatic cortex of hexagonal (in surface view) cells, 180–210  $\mu\text{m}$  across. Aplanosporangia (1–2) borne laterally on primary branches; shortly stalked, spherical (130)–180–220  $\mu\text{m}$  in diam., containing 8–24(–26) oval aplanospores. Attachment by small rhizoid-like holdfast to rocks, dead coral blocks.

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## References

- Birrell CL, McCook LJ, Willis BL, Diaz-Pulido GA. 2008. Effects of benthic algae on the replenishment of corals and the implications for the resilience of coral reefs. *Oceanography and Marine Biology, An Annual Review* 46, 25–63.
- Catalogue of Life: 2010 Annual Checklist <http://www.catalogueoflife.org/annual-checklist/2010>
- Charpy-Roubaud CJ, Charpy L. 1994. Nutrients, particulate organic matter, and planktonic and benthic production of the Tikehau Atoll (Tuamotu Archipelago, French Polynesia). *Atoll Research Bulletin* 415–425, 1–30.
- Charpy L, Charpy-Roubaud C, Buat P. 1998. Excess primary production, calcification and nutrient fluxes of patch reefs (Tikehau Atoll, French Polynesia). *Marine Ecology Progress Series* 173, 139–47.
- Diaz-Pulido G, McCook LJ. 2002. The fate of bleached corals: Patterns and dynamics of algal recruitment. *Marine Ecology Progress Series* 232, 115–28.
- Guiry MD, Guiry GM. 2016. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org>; (searched in January 2017).
- Lapointe BE, Littler MM, Littler DS. 1997. Macroalgal overgrowth of fringing coral reefs at Discovery Bay, Jamaica: bottom-up versus top-down control. In: *Proceedings of the Eighth International Coral Reef Symposium*, Smithsonian Tropical Research Institute, Panama, 24–29 June 1996, p 927–32.
- Lapointe BE, Bedford BJ. 2010. Ecology and nutrition of invasive *Caulerpa brachypus* f. *parvifolia* blooms on coral reefs off southeast Florida, USA. *Harmful Algae* 9, 1–12.
- Liu L. 2008. *Checklist of Marine Biota of China Seas*. Beijing: Scientific Book Service Company. 1267 pages.
- Liu PJ, Lin SM, Fan TY, Meng PJ, Shao KT, Lin H. 2009. Rates of overgrowth by macroalgae and attack by sea anemones are greater for live coral than dead coral under conditions of nutrient enrichment. *Limnology and Oceanography* 54: 1167–75.
- Morand P, Merceron M. 2004. Coastal eutrophication and excessive growth of macroalgae. In: Pandai SG, editor. *Recent Research Developments in Environmental Biology*. Vol. 1(2). Research Signpost, Trivandrum, Kerala, India, p 395–449.
- Smith TB, Fong P, Kennison R, Smith J. 2010. Spatial refuges and associational defenses promote harmful blooms of the alga *Caulerpa sertularioides* onto coral reefs. *Oecologia* 164, 1039–1048.
- Titlyanov EA, Titlyanova TV, Xia BM, Bartsch I. 2011a. Checklist of marine benthic green algae (Chlorophyta) on Hainan, a subtropical island off the coast of China: comparisons between the 1930s and 1990–2009 reveal environmental changes. *Botanica Marina* 54: 523–535.
- Titlyanov EA, Kiyashko SI, Titlyanova TV, Yakovleva IM, Li XB, Huang H. 2011b. Nitrogen sources to macroalgal growth in Sanya Bay (Hainan Island, China). *Current Development in Oceanography* 2, 65–84.
- Titlyanov EA, Titlyanova TV, Li XB, Hansen G, Huang H. 2014a. Seasonal changes in the intertidal algal communities of Sanya Bay (Hainan Island, China). *Journal of the Marine Biological Association of the United Kingdom* 94(5), 879–893.
- Titlyanov EA, Titlyanova TV, Huang H., Li XB. 2014b. Seasonal changes in benthic algal communities of the upper subtidal zone in Sanya Bay (Hainan Island, China). *Journal of the Marine Biological Association of the United Kingdom* 94(1), 51–64.
- Titlyanov EA, Titlyanova TV, Li XB, Kalita TL, Huang H. 2015. Recent (2008–2012) seaweed flora of Hainan Island, South China Sea. *Marine Biology Research*. 11(5), 540–550.
- Titlyanov EA, Titlyanova TV, Xia BM, Bartsch I. 2016a. Retrospective analysis of diversity and species composition of marine macroalgae of Hainan Island (China). *Ocean Science Journal* 51(3): <http://dx.doi.org/10.1007/s12601-016-p1SSN 1738-5261eISSN 2005-7172>.
- Titlyanov EA, Titlyanova TV, Li XB, Huang H. 2016b. *Coral Reef Marine Plants of Hainan Island*. Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo: Elsevier Academic Press. 240 pages.
- Titlyanova T, Titlyanov E. 2018. New records of benthic red algae (Rhodophyta) from Hainan Island (1990–2016). (Taxonomic descriptions of species and their varieties). *Coastal Ecosystems*, 5, 22–101.



- Titlyanova T, Titlyanov E, Xia B, Bartsch I. 2012. New records of benthic marine green algae on Hainan Island, China. *Nova Hedwigia* 94, 441–470.
- Titlyanova TV, Titlyanov EA, Kalita TL. 2014. Marine algal flora of Hainan Island: a comprehensive synthesis. *Coastal Ecosystems* 1, 28-53.
- Titlyanova T, Titlyanov E., Xiubao L, Xia B, Bartsch I. 2018. New records of benthic brown algae (Ochrophyta) from Hainan Island (1990-2016). *Coastal Ecosystems*, 5, 102–129.
- Tseng CK. 1935. Economic seaweeds of Kwangtung Province, S. China. *Lingnan Science Journal* 14, 93–102.
- Tseng CK. 1936. Studies on the marine Chlorophyceae from Hainan. I. *Chinese Marine Biology Bulletin* 1, 129–200.
- Tseng CK. 1938. Studies on the marine Chlorophyceae from Hainan. II. *Lingnan Science Journal* 17, 141–149.
- Tseng CK. 1983. *Common seaweeds of China*. Beijing: Science Press. 316 pages.
- Tseng CK, Chang CF. 1962. Studies on Chinese species of Dictyosphaeria. *Acta Botanica Sinica* 10, 120–132.
- Tseng CK, Chang TJ, Chang CF, Xia EZ, Xia BM, Dong ML, Yang ZD. 1962. *Economic Seaweeds of China*. Beijing: Science Press. 198 pages (in Chinese).
- Zhang Q, Shi Q, Chen G, Fong TC, Wong DC, Huang H, et al. 2006. Status monitoring and health assessment of Luhuitou fringing reef of Sanya, Hainan, China. *Chinese Science Bulletin* 51, 81–88.



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