

## SOME NEW RECORDS OF MARINE ALGAE FROM VIETNAM

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Received: 22-6-2014

**ABSTRACT:** In May 2013, a scientific expedition was organized by the Vietnam Academy of Science and Technology and the Far Eastern Branch of the Russian Academy of Sciences (FEBRAS) in the frame of the VAST-FEBRAS International collaboration program. The expedition went along the coast of Vietnam from Quang Ninh to Kien Giang. The objective was to collect natural resources for investigation of the biological and biochemical diversity of the territorial waters of the Socialist Republic of Vietnam. Among the collected algae, six taxa are new records for the Vietnam algal flora. They are the red algae *Titanophora pikeana* (Dickie) Feldmann from Cu Lao Xanh Island, *Laurencia natalensis* Kylin from Tho Chu Island, and *Coelothrix irregularis* (Harvey) Børgesen from Con Dao Island, and the green algae *Caulerpa oligophylla* Montagne, *Caulerpa andamanensis* (Taylor, W. R., 1975) Draisma, Prudhomme et Sauvage from Phu Quy Island and *Caulerpa falcifolia* Harvey & Bailey from Ly Son Island. The seaweed flora of Vietnam now counts 833 marine algal taxa, including 415 Rhodophyta, 147 Phaeophyceae, 183 Chlorophyta and 88 Cyanobacteria.

**Keywords:** *Caulerpa, Coelothrix, Laurencia, marine algae, Titanophora, new records.*

### INTRODUCTION

The first major checklist of the marine algae of Vietnam was published by Nguyen et al., (2013) [1] recording 827 specific and infraspecific taxa. Among these, the Rhodophyta show the highest taxon number (412 taxa), followed by the Chlorophyta (180 taxa), Phaeophyceae (147 taxa) and Cyanobacteria (88 taxa). This species richness is comparable to that of the Philippines (1011 species) and considerably higher than that of Taiwan (288 species), Thailand (182 species) or Malaysia (241 species), which indicates that Vietnam possibly represents a diversity hotspot for macroalgae (Nguyen Van Tu et al.) [1].

In May 2013, a scientific expedition was organized by the Vietnam Academy of Science and Technology and the Russian Academy of Sciences in the frame of the VAST-FEBRAS

International collaboration program on the ship "ACADEMICIAN OPARIN". Samples of about 60 stations along the coast of Vietnam from Quang Ninh to Kien Giang at depths of 1 m to 10 m have been collected. Some of the stations were off islands like Tho Chu, Con Dao, Phu Quy, Cu Lao Xanh and Ly Son. The results demonstrated that the waters surrounding the islands are high biodiversity areas with their coral reefs and the associated flora and fauna. The team collected and identified a total of 118 taxa of marine algae, of which six taxa were newly recorded for Vietnam.

### MATERIALS AND METHODS

The herbarium specimens used for this study were collected from some stations along the coast of Vietnam from Quang Ninh to Kien Giang during the 5<sup>th</sup> Russian - Vietnamese

marine scientific expedition aboard the research vessel "ACADEMICIAN OPARIN", by snorkeling and SCUBA diving around the islands and by scraping off substrata like rocks and dead corals between 1 and 10 meters in depth. All specimens were cleaned and pressed into herbarium vouchers, or preserved in 5% formalin in seawater. The specimens were identified based on morphological and anatomical data, using published keys and taxonomic papers largely following Taylor (1965, 1975) [2, 3], De Clerck et al., (2005) [4], Huisman et al., (2007) [5], Belton et al., (2014) [6] and Draisma et al., (2014) [7]. All specimens were deposited in the Herbarium of the Nha Trang Institute of Technology Research and Application (NITRA). The cross sections were cut by hand and were stained in 1% acidified aniline-blue solution and mounted on glass slides in 20% Karo syrup. Microscopic photographs were made by using an Olympus camera attached to a Nikon microscope and in situ photographs were made by Olympus Stylus Tough-8000 in the USA. All photographs were edited with Photoshop 7.0. The taxonomy and nomenclature of the species largely follows *website www.algaebase.org* (Guiry, M. D., and Guiry, G. M., 2014 [8]).

## RESULTS AND DISCUSSION

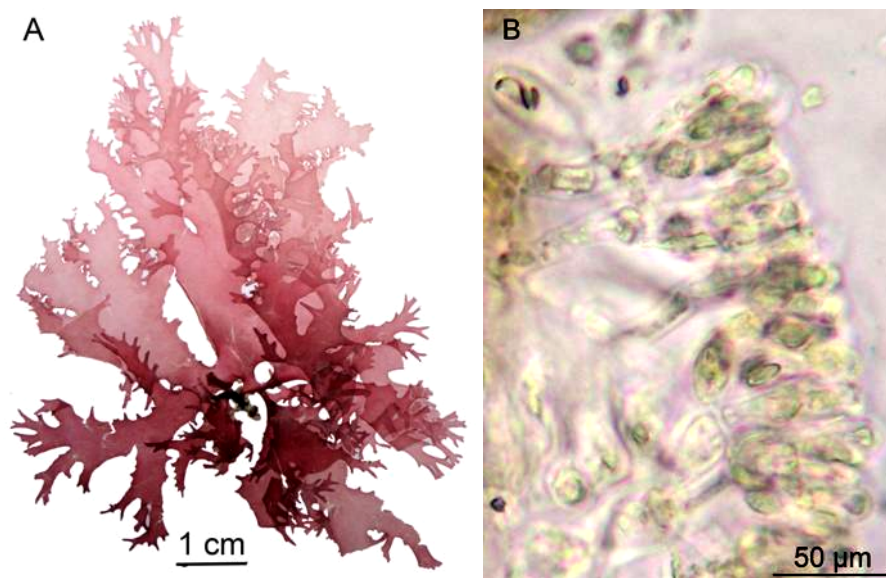
### Order Nemastomatales, Rhodophyta

### *Titanophora pikeana* (Dickie) Feldmann, 1942: 111 [9]

*References:* Schils T. and Coppejans E. (2002: 261, figs. 36-44, [10]). Huisman et al., (2007: 101, [5]).

*Synonym:* *Galaxaura pikeana* Dickie 1874; *Halymenia pickeana* (Dickie) J. Agardh 1885; *Platoma pikeanum* (Dickie) Weber-van Bosse 1921.

*Description:* Thallus attached by a basal disk, forming slick, soft flattened dissected blades, slightly calcified in the central tissues, up to 8 - 11.5 cm high, whitish pink to liver-coloured and chalky rose-white when dried; branches marginally dissected, pinnate to irregular, younger branches somewhat dichotomous. Main axis flat, 7 - 10 mm wide, 0.5 - 1.2 mm thick. Branchlets flattened, apices forked, tapering, bluntly pointed. Medulla of one to several loosely arranged longitudinal filaments (cells 10 - 15  $\mu\text{m}$  diam., 100 - 150  $\mu\text{m}$  long) and many loosely intertwined secondary filaments (cells 5 - 7  $\mu\text{m}$  diam., 20 - 30  $\mu\text{m}$  long) within a mucilaginous gel. Cortex 20 - 30  $\mu\text{m}$  thick, cells spherical to oval, 5 - 7  $\mu\text{m}$  diam., 7 - 10  $\mu\text{m}$  long (fig. 1). Medulla filaments 2 - 3 times di-trichotomously branched, 7 - 10  $\mu\text{m}$  diam., 45 - 60  $\mu\text{m}$  long;



**Fig. 1.** *Titanophora pikeana* (Dickie) Feldmann (A) Habit; (B) Cross section of cortex

*Type locality:* Mauritius.

*Ecology:* Growing on dead coral at 10 m depth.

*Geographical distribution:* South Africa, Madagascar, Mauritius, Réunion, Tanzania, Sri Lanka, Vietnam, Indonesia, Philippines, Papua New Guinea, Western Australia, Fiji, Hawaii.

*Voucher:* NITRA 2101, 2102 and 2103, 28 May 2013, 10 m depth at Cu Lao Xanh Island (13°36'11.09"N, 109°21'48.84"E), Binh Dinh, Vietnam.

*Remark:* The separation into species within the genus *Titanophora* is a heavily debated problem. Mshigeni & Papenfuss (1980) [11] listed eight species worldwide, separated on the basis of their reproductive and vegetative characters. However, for many characters no information is available, resulting in Norris (1992) [12] stating: "It seems likely that there is a single variable species in this genus". It is, however suggested (Masuda & Guiry 1995, p. 66, footnote [13]) that no decisions can be made until pre- and post-fertilization events of all described entities have been studied. The entity *Titanophora pulchra* E. Y. Dawson [14] from Nha Trang, Vietnam has been synonymized to *Titanophora pikeana* [1], but by other researchers to *Titanophora weberae* (N'Yeurt 2001 [15]) Morphologically, *Titanophora pulchra* E. Y. Dawson, (see Tsutsui et al., 2005 [16]) and *T. weberae* Børgesen (De Clerck et al., 2005 [4]) can both be separated from *T. pikeana* by the light degree of calcium carbonate crystals to the medullary layer and the mucronate, freely

projecting papilliform cells and small proliferations along the margins of the thallus. It is, however, possible that calcification with aragonite is not the unifying character it is claimed to be (Masuda & Guiry, 1994 [17]). *T. incrustans* (J. Agardh) Børgesen can be separated from these three taxa because it lacks a cylindrical stalk (Littler & Littler, 2000 [18]).

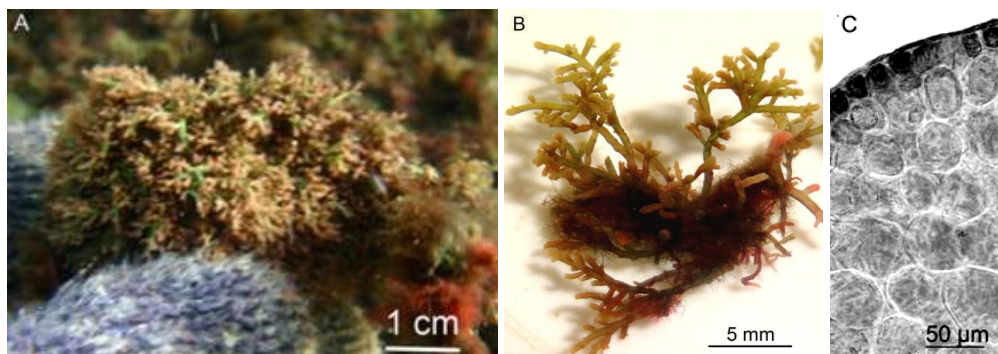
#### Order Ceramiales, Rhodophyta

*Laurencia natalensis* Kylin 1938: 24, pl. 8, fig. 21 [19].

*References:* Coppejans et al. (2009: 218, figs. 11D, 22I, 186E) [20]; De Clerck et al. (2005 : 256, fig. 263) [4].

Synonym: *Laurencia obtusa* var. *natalensis* (Kylin) Børgesen 1945

*Description:* Thallus creeping or sprawling, tough, cartilaginous, up to 2 cm high, to 6 cm in diameter, branching irregular, growing in extensive vegetations with the basal parts being greenish and the apices orangey-red; and black when dried. Branches cylindrical, 0.8 - 1.0 mm in diam. Branchlets generally arranged in spirals, occasionally opposite, 0.3 - 0.5 mm in diam. 0.2 - 1.5 (-3.0) mm long, blunt, wart-like, often swollen; apices tufted with fine deciduous, dichotomously branched filaments, sunken in terminal depression. Surface cells oval, 25 - 30 µm in diam.; medullary cells 80 - 100 µm in diam., colorless, apical cell sunken in a terminal depression. Holdfast inconspicuous, pad-like; secondarily attached by numerous lateral rhizoids arising from branches. Tetrasporangial branchlets slightly enlarged; tetrasporangia tetrahedrally divided, in a single whorl near the branch apex (fig. 2).



**Fig. 2.** *Laurencia natalensis* Kylin. (A) In situ habit; (B) Habit; (C) Cross section showing tetrasporangia

*Type locality:* Isipingo Beach, near Durban, South Africa.

*Ecology:* On hard substrates to wave exposure, intertidal to 1 m depth.

*Distribution:* Kenya, Mozambique, South Africa, Sri Lanka.

*Voucher:* NITRA 2111-2118, 16 May 2013, 1 m depth at Tho Chu Island (9°19'12.14"N, 103°29'53.77"E), Kien Giang, Vietnam.

*Remark:* This is the most abundant *Laurencia* species just above low tide level. This species is distinguished from the other *Laurencia* species by its growing in extensive vegetations with the basal parts being greenish and the apices orangey-red (De Clerck et al., (2005) [4]).

### Order Rhodymeniales, Rhodophyta

***Coelothrix irregularis* (Harvey) Børgesen 1920: 389, figs 373, 374 [21]**

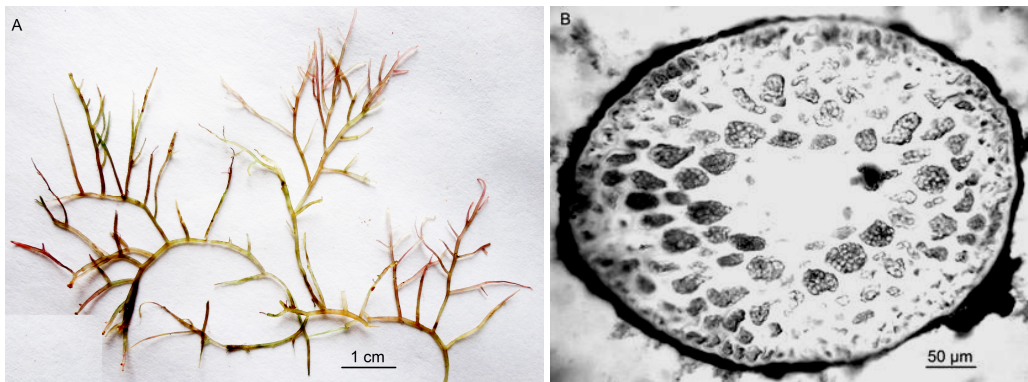
*References:* Taylor (1960: 488, Pl. 45, fig. 3; pl. 46, fig. 4)[22]; Yoshida (1998: 847, figs.

B-E)[23]; Littler & Littler (2000: 137, figs. 1-3) [18].

*Synonym:* *Cordylecladia irregularis* Harvey 1853.

*Type locality:* Key West, Florida, USA.

*Description:* Thallus tuft-like, wiry, entangled, up to 3 cm high, branching irregular; bright iridescent blue and purple-red when dried. Branches cylindrical, 0.3 - 0.8 mm in diam., rigid; apices tapering, bluntly pointed. Central cavity filled with clear mucilaginous gel, 100 - 120 µm in diam.; lined with scarce longitudinal filaments with spherical to club-shaped gland cells, projecting into cavity. Cortex 4 - 6 cells with thick walls; inner cells (near cavity), elongated, 15 - 27 µm in diam., 30 - 50 µm long; surface cells spherical, 15 - 17 µm diam., heavily pigmented. Tetrasporangia irregularly spherical, 20 - 30 µm in diam. Spermatangial sori swollen at branch apices. Cystocarps spherical, 300 - 400 µm diam., solitary or in clusters of 3 - 4 (fig. 3).



**Fig. 3.** *Coelothrix irregularis* (Harvey) Børgesen. (A) Habit of thallus ; (B) Cross section of a branch with tetrasporangia and showed a cavity at the central medulla

*Distribution:* Portugal, Bermuda, Canary Islands, Florida, Belize, Bahamas, Caribbean, Brazil, China, Japan, Philippines, Australia and New Zealand, Hawaiian Islands.

*Voucher:* NITRA 2131, 17 May 2013, 2 m depth at Con Dao Island (8°39'14.05"N, 106°33'34.08"E), Kien Giang, Vietnam.

*Remark:* This species can be distinguished from *Pterocladia* spp., *Gelidiopsis variabilis*

and *Gelidiella* spp. by having a central cavity lined with scarce longitudinal filaments beset with gland cells [24].

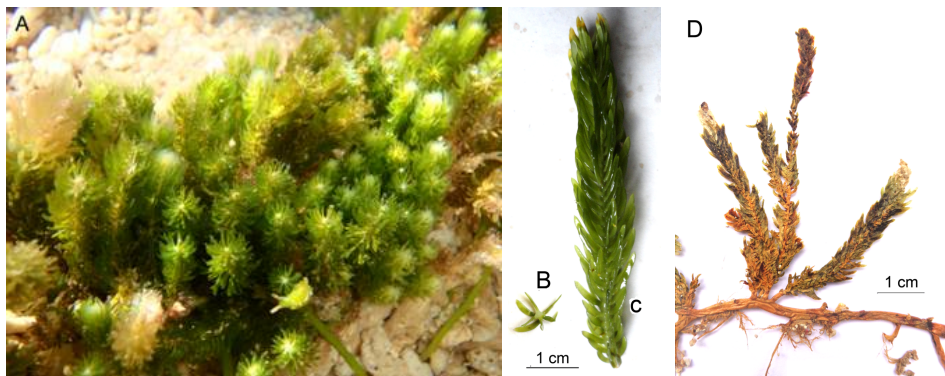
### Order Bryopsidales, Chlorophyta

***Caulerpa falcifolia* Harvey & Bailey 1851: 373 [25]**

*Synonym:* *C. taxifolia* var. *falcifolia* [Harvey & Bailey] W. R. Taylor; *C. taxifolia* f. *tristichophylla* Svedelius

Stolons sparsely branched, 1.0 - 1.5 mm in diam. forming mats on rocks and sand, in the supralittoral zone. Erect branches (assimilators) up to 4 - 8 cm high, 1.2 - 1.5 mm in diam., naked for about 5 mm at the base; simple or occasionally subdichotomous. Branchlets radially arranged into 6 - 8 rows along the main

erect branches, flattened, 3.5 - 4 mm long, 0.7 - 0.9 mm in diam., 0.2 - 0.25 mm thick, but narrower on the more crowded axes, closely placed, up-curved, gradually tapering to the acuminate apex, constricted at the base, not overlapping (fig. 4). Thallus has light green in color but pale yellow-green when dried.



**Fig. 4.** *Caulerpa falcifolia* Harvey & J. W. Bailey. (A) In situ habit of; (B) a cross section of an assimilator showed branchlets radially arranged into 6 rows along the main erect branches; (C) an assimilator; and (D) a branching system from herbarium specimen NITRA 2141

*Type locality:* Tongatapu, Friendly Islands.

*Distribution:* Indonesia, Qld., Tonga, Central Polynesia, North-West Australia, Queensland.

*Vouchers:* NITRA 2141-2146, 29 May 2013, 2 m depth, Ly Son Island (15°22' 44.5206"N, 109°08'59.8290"E), Quang Ngai, Vietnam.

*Remark:* These specimens have the form of *Caulerpa taxifolia* judged from the presence of basal constrictions and elongated branchlets, suggesting relation with infraspecific taxa of *C. taxifolia* like *Caulerpa taxifolia* var. *tristichophylla* with three rows of ramuli at the base of the assimilators (Svedelius 1906 [26]), *Caulerpa taxifolia* f. *falcifolia* (Harvey & Bailey) W. R. Taylor with 3 or more rows in the whole of the assimilators [3]. They do not belong to *C. mexicana* var. *pluriseriata* W.R. Taylor [3] because our plants have shorter branchlets and have only slight or even no constrictions at the base of the branchlets being arranged in more rows and with the presence of long rhizoidal pillars, which are absent in *C. mexicana* (Taylor, W. R., 1975 [3]). It also

does not fit the description of *Caulerpa reyesii* Meñez & Calumpong [27], because that species has overlapping, obovate, clavate branchlets, which can, however, be arranged distichously or tetrastichously [27]. According to comparison with the characters described above, we conclude to have found *Caulerpa taxifolia* var. *falcifolia* (Harv. & J. W. Bailey) W. R. Taylor. However, in a recent paper of Draisma et al, (2014) [7], this taxon was proposed here to reject *Caulerpa taxifolia* var. *falcifolia* (Harv. & J. W. Bailey) W. R. Taylor and to reinstate *C. falcifolia* Harvey & Bailey.

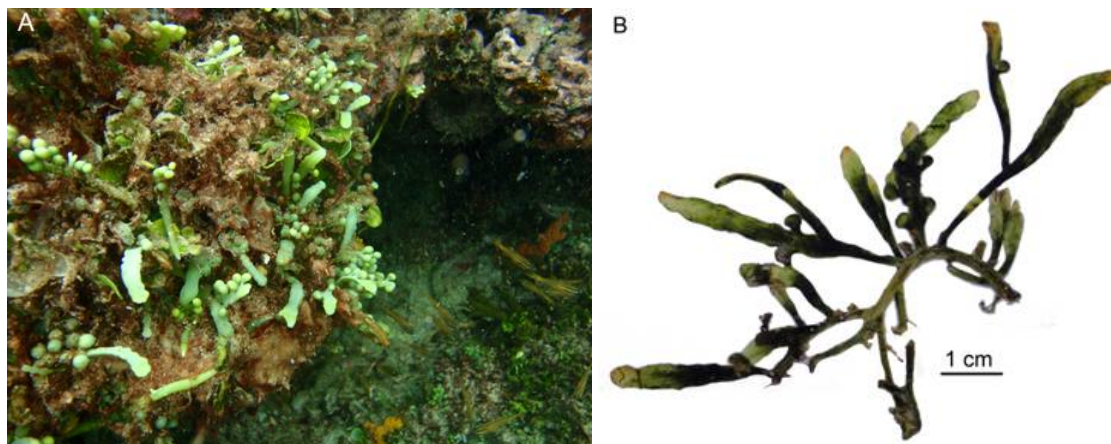
#### ***Caulerpa oligophylla* Montagne 1842: 14 [28]**

*References:* Belton et al. 2014: 46, figs 1B, 5A-F [6]; Weber-van Bosse 1898: 368-370, pl. XXXII, fig. 1-6.[29]; Coppejans and Beeckman (1989: 388-391, plate 2, fig. 7-9, plate 2, fig. 11-20 [30]; Taylor (1960: 153) [22]; Littler and Littler (2000:370-371) [18].

Often identified as *Caulerpa racemosa* var. *lamourouxii* (Turner) Weber-van Bosse 1898: 369, pl. XXXII, figs. 1-4 [29], or as *Caulerpa lamourouxii* (Turner) C. Agardh 1817: XXII [31].

Stolons cylindrical growing on dead coral; erect branches 2 - 6 cm high, cylindrical at the base, 3 - 5 (-10) mm long, 1 - 1.2 mm wide, then slightly compressed and constricted or of irregular width, 2 cm to 4 cm high, 3 - 5 mm wide, with (sub-)opposite (sub-)spherical

branchlets or sometimes partly naked or bearing a single to more spherical branchlets. Branchlets (sub-) spherical, 2 - 3 mm diam., branchlet stalks 1 - 1.2 mm long (fig. 5). Thallus have grass - green in color but dark green when dried.



**Fig. 5.** *Caulerpa oligophylla* Montagne (A) In situ habit; (B) Flattened assimilators with some spherical branchlets at their base in the herbarium specimen NITRA 2151

*Type locality:* Western Australia.

*Ecology:* On hard substrates to wave exposure, intertidal to 2.5 m depth.

*Distribution:* Japan, Indonesia, Philippines, Queensland, Caledonia.

*Vouchers:* NITRA 2151 - 2154, 2158 - 2160, 29 May 2013, 2.5 m depth, Phu Quy Island (10<sup>0</sup>31'19.57"N, 108<sup>0</sup>57'35.59"E), Binh Thuan, Vietnam.

*Remarks:* This species is somewhat similar to *C. racemosa* but its erect branches are very variable and occasionally partly naked, then slightly compressed and constricted or of irregular width, on its spherical branchlets which are either extremely rare, occasionally completely lacking (= *forme requienii*) and irregularly placed or more frequent and then often (sub-)opposite.

*Remark:* In a paper by Belton et al., [6] a new classification has been proposed for the taxa within the *Caulerpa racemosa-peltata* complex and it was demonstrated that the entities within *Caulerpa racemosa* var. *lamourouxii* represent two *Caulerpa* species

viz. *C. oligophylla* Montagne and *C. lamourouxii* (Turner) C. Agardh. Although these taxa are clearly different when studied by molecular methods (sequencing studies), the two species cannot be differentiated by morphological studies. The study by Belton et al., [6] showed different areas of occurrence for *C. lamourouxii* (Indian Ocean and Red Sea) and *C. oligophylla* (Northeastern Australia, New Caledonia, Indonesia, the Philippines and Japan). The latter species is most possibly widespread throughout the western Pacific Ocean and can be supposed to be the species that occurs in Vietnam. The specimens identified as *C. lamourouxii* recorded in Coppejans & Beeckman 1989 [30] do most probably really belong to that species, while those published as *C. racemosa* var. *lamourouxii* in Littler & Littler 2003, p. 228-229 [32] and in Verheij & Prud'homme van Reine 1993, p. 396 [33] most probably belong to *C. oligophylla*. According to Belton et al., (2014, p. 46, [6]) the supposed *C. racemosa* var. *lamourouxii* in Taylor (1960: p. 153, [22]) and in Littler & Littler (2003, p. 370, 371 [32]) do not belong to that taxon but to the *Caulerpa*

*chemnitzia* clade; *C. lamourouxii* does, most likely, not occur in the tropical western Atlantic Ocean.

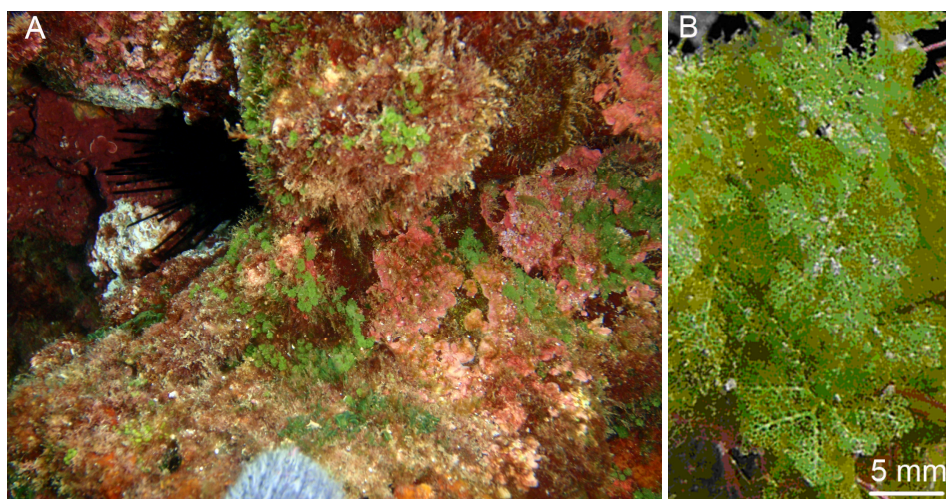
*Caulerpa racemosa* var. *lamourouxii* and *C. oligophylla* are morphologically closely resembling *Caulerpa racemosa* with few or more (sub-)opposite (sub-)spherical branchlets along the assimilators.

***Caulerpa andamanensis* (W. R. Taylor) Draisma, Prudhomme et Sauvage 2014: 1020 [8]**

*References:* Coppejans et al. (2009: 104, figs. 27G, 80) [20].

Basionym: *Caulerpa filicoides* var. *andamanensis* W. R. Taylor 1965: 154-156, fig. 1 [2]

Thallus forming dense, soft and slender, green tufts. Stolons thin, up to 0.2 mm in diam., sparsely branched, well fixed by very numerous groups of rhizoids. Assimilators with a thin, vertically placed stipe 1 - 1,5 mm long, mostly simple, more rarely branched, terminally bearing usually a single, horizontally placed whorl of 6 - 8 branchlets. Each branchlet is branching dichotomously at the base, alternately branched higher up, with acute apices and with the general outlook of a snow crystal (fig. 6). Thallus has green to yellow-green in color but dark green when dried.



**Figure 6.** *Caulerpa andamanensis* (W. R. Taylor) Draisma, Prud'homme & Sauvage (A) In situ habit; (B) In situ close-up of the whorls of 6 - 8 branchlets on the top of the upper parts of the stipes

*Type locality:* Northeast of Ritchie's Archipelago, Andaman Islands.

*Ecology:* On rocks and other hard surfaces, sublittoral to 3 m depth.

*Distribution:* Tanzania, India, Sri Lanka, Andaman Islands, Palau, Micronesia, Papua New Guinea, Australia, Fiji, and also Hawaii.

*Voucher:* NITRA 2155, 2156, 29 May 2013, 3 m depth, Phu Quy Island (10<sup>o</sup>31'15.45"N, 108<sup>o</sup>57'40.92"E), Binh Thuan, Vietnam.

*Remark:* The appearance of this species in the field is in size very similar to *C. verticillata*

but the branchlets are arranged in a single horizontally placed whorl on the top of the upper parts of the stipes. In previous paper, Taylor (1965) [2] has identified it as *Caulerpa filicoides* var. *andamanensis* but in recent paper of Draisma et al., (2014) [7] this taxon was considered to form a separate species, viz. *Caulerpa andamanensis* (W. R. Taylor) Draisma, Prud'homme & Sauvage.

**Acknowledgements:** This study was financially supported by the VAST-FEBRAS International collaboration between the Vietnam Academy of Science and Technology

(VAST) and the Russian Academy of Sciences (RAS), with the code of VAST.HTQT. Nga 06. 13-14. The authors wish to express their thanks to Dr. Dimitrii Pelageev, Victor and Boris for assistance during the survey. Thanks also to Willem Prud'homme van Reine (Naturalis Biodiversity Center, Leiden, The Netherlands) and Stefano Draisma (Institute of Ocean and Earth Sciences, University of Malaya, Kuala Lumpur, Malaysia) for assistance in the comparison of some of specimens and reviewing an earlier draft of the manuscript.

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## MỘT SỐ LOÀI RONG BIỂN BỔ SUNG MỚI CHO KHU HỆ RONG BIỂN VIỆT NAM

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Viện Hàn lâm Khoa học và Công nghệ Việt Nam*

**TÓM TẮT:** Tháng 5 năm 2013, trong khuôn khổ Chương trình hợp tác giữa Viện Hàn lâm Khoa học và Công nghệ Việt Nam (VAST) với Phân Viện Biển Đông Viện Hàn lâm Khoa học Nga (FEBRAS), đã tổ chức một chuyến khảo sát chung Việt Nam - Liên bang Nga lần thứ 5 trên tàu nghiên cứu “Viện Sĩ Oparin” trong vùng biển Việt Nam. Mục đích thu thập mẫu vật cho nghiên cứu đa dạng sinh vật và hóa sinh của vùng nước ven bờ Việt Nam. Sáu loài rong biển được ghi nhận mới cho khu hệ rong biển Việt Nam. Chúng gồm những loài rong đỏ là *Titanophora pikeana* (Dickie) Feldmann ở Cù Lao Xanh, *Laurencia natalensis* Kylin ở đảo Thổ Chu và *Coelothrix irregularis* (Harvey) Børgesen ở Côn Đảo, và những loài rong lục là *Caulerpa oligophylla* Montagne, *Caulerpa andamanensis* (W.R. Taylor) Draisma, Prudhomme et Sauvage ở đảo Phú Quý và *Caulerpa falcifolia* Harvey & Bailey ở đảo Lý Sơn. Do đó, số lượng loài và biển loài rong biển Việt Nam bây giờ là 833, gồm ngành rong Đỏ (415 loài và biển loài), ngành rong Nâu (147 loài và biển loài), ngành rong Lục (183 loài và biển loài) và ngành rong Lam (88 loài và biển loài).

**Từ khóa:** *Caulerpa*, *Coelothrix*, *Laurencia*, loài mới bổ sung, rong biển, *Titanophora*, Tàu “Viện sĩ Oparin”.