

## NEW RECORDS OF SEAWEEDS FROM SOUTH-EASTERN COASTS OF COX'S BAZAR DISTRICT, BANGLADESH

ABDUL AZIZ\* AND MD. ALMUJADDADE ALFASANE

*Department of Botany, University of Dhaka, Dhaka 1000, Bangladesh*

**Keywords:** *Caulerpa chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* Aziz & Alfasane var. nov.; *C. fergusonii* G. Murray; *C. sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov.; *Gracilaria tenuistipitata* var. *liui* Zhang et Xia; *Ulva linza* Linnaeus; St. Martin's Island; Bangladesh.

### Abstract

*Gracilaria tenuistipitata* var. *liui* Zhang et Xia from sand-flat at Nuniachara, Cox's Bazar, *Ulva linza* Linnaeus from west coast of Naf River at Noapara, Teknaf and Fishery Ghat in the River Bakkhali, at Cox's Bazar and *Caulerpa fergusonii* G. Murray from St. Martin's Island (SMI) have been newly recorded and illustrated from Bangladesh. *Caulerpa chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* Aziz & Alfasane var. nov. and *C. sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov. from SMI, Cox's Bazar District, Bangladesh are new to science. Total number of marine algal taxa recorded from Bangladesh coasts till 2020 is 210.

### Introduction

In the last quarter of 20<sup>th</sup> century significant contributions have been made on the seaweed flora of the Indian subcontinent and adjacent regions. In Bangladesh, National Professor AKM Nurul Islam was the pioneer on algal researches and published the monumental work "Contribution to the study of the marine algae of Bangladesh" in 1976 where 69 genera with 140 taxa of seaweeds were reported. Later the first author joined with Prof. Islam and a number of students over the years did M. S. theses on seaweeds under the supervision of the first author and also with Prof. Islam adding 65 seaweed taxa including sub-littoral seaweeds collected with the help of Bangladesh Navy in 2013 till 2015 making the total number of taxa 205 along Bangladesh coasts mainly SMI (Aziz, 2015). Billah *et al.* (2018) investigated relative abundance of 11 greens, 14 browns and 12 red sub-littoral seaweeds collected from January to June in 2007 (but five seaweeds reported as new records were all reported earlier by Islam (1976) and Aziz *et al.* (2015). Recently, seaweed cultivation researches in Bangladesh extended to the evaluation of nutrients and extraction of phycocolloids from a few of them for use as food and in industries (Hassan, 2018; Roy, 2018). In view of the importance mentioned taxonomic studies of the concerned seaweeds and some other related species collected were found to be new records for Bangladesh and created two new varieties of green seaweeds which are described and illustrated.

### Materials and Methods

*Gracilaria tenuistipitata* var. *liui* Zhang et Xia from a sand-flat (300 m East-west × 2000 m North-south) at Nuniachara (21° 28' 07" N 91° 56' 58" E to 21° 28' 37" N 91° 58' 02" E) south-east of Moheshkhali Channel and east of Sonadia, *Ulva linza* Linnaeus from West coast of Naf river estuary, Noapara, Teknaf (21° 06' 48" to 21° 06' 58" N and 92° 12' 07" to 92° 12' 17"E) and Bakkhali river, at Fishery Ghat, about 3 km north-east of Nuniachara, Cox's Bazar, *Caulerpa*

\*Corresponding author, E-mail: dr.aziz.botany@gmail.com

*fergusonii* G. Murray, *C. chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* var. nov. and *C. sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov. from west coast of the SMI (20° 34' 26" to 20° 39' 10" N and 92° 18' 51" to 92° 18' 51" to 92° 20' 17" E) of Cox's Bazar Districts growing abundantly in winter and spring seasons were collected, pressed onto herbarium sheets, photographed alive and also preserved in formaldehyde. Habitat and ecology, geographical distribution and other descriptions are given at the end of each taxon.

## Results and Discussion

A total of five seaweeds such as *G. tenuistipitata* var. *liui* Zhang *et* Xia, *Ulva linza* Linnaeus and *Caulerpa fergusonii* G. Murray have been identified, described and illustrated as new records for Bangladesh. *Caulerpa chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* Aziz & Alfasane var. nov. and *C. sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov. have been identified, described and illustrated as new taxa from the SMI, Bangladesh.

Phylum: Rhodophyta, Class: Rhodophyceae, Order: Gigartinales,  
Family: Gracilariaceae Genus: *Gracilaria*

### 1. *Gracilaria tenuistipitata* var. *liui* Zhang *et* Xia (Figs 1a-k)

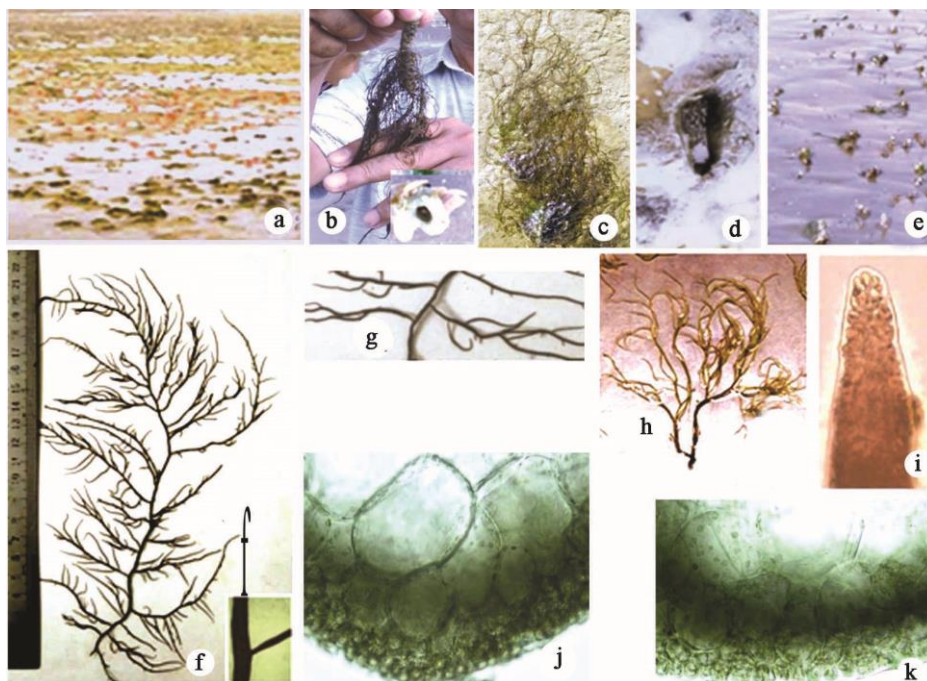
(Zhang *et* Xia 1988, Figs 1, 3-9)

Plants thalloid dark-red, slender, axis with tapered delicate lateral branchlets (terete fronds) short or long present in loose spirals attaining about 50 cm long, 0.25 to 1.0 mm wide in natural habitat (Figs 1a-c, f-g). The seaweed from the base produces lateral branches firmly attached deep inside the semi-solid Tube-worm cases lodged in the intertidal sand-flat (Figs 1a-f) but no disc or any vertical threads are visible like other species for attachment, in other words attachment organ not specifically developed (Fig. 1f) even while culturing in circulating aquarium (Fig. 1h). The bases of branches distinctly narrowed, <0.5mm wide for about 2 mm distance and then gradually widen to 0.50 to about 1.00 mm (Figs 1f-g). Branch tip possesses four to five ellipsoidal apical meristem cells side by side (Fig. 1i) and cross-sections consist of several very large medullary cells (central axial cell absent) derived from the apical cells called multiaxial growth/construction, followed by one, some part with two layers of smaller cortical cells ending with radial rectangular epidermal cells covered by cuticle (Figs 1j-k).

The repeatedly curled flagelliform tapered branches in laboratory cultured seaweeds using circulator (Fig. 1h) are exactly similar to the holotype (Haikou, Hainan Island, Guangdong Province, China, Zhang *et* Xia, AST 85-652, April 1, 1986) with narrowed base of branches as observed by Zhang *et* Xia 1988, Fig. 1). The habit of the present plant variety are close to *G. tenuistipitata* by having enormous morphological variations but constriction at the base of branches are not found (Barufi *et al.* 2010, Fig. 1A; Song *et al.* 2015); type specimen contains urn-shaped cystocarp (Zhang *et* Xia 1988, Fig. 4) but not found in the present natural and laboratory-grown plants. Identification of *Gracilaria* species is difficult due to lack of sexual reproduction in most of the species (Lewmanomont, 1996). In the present study plants collected every month from nature during the growing period did not produce any cystocarp, propagation was vegetative. However, Aziz *et al.*, (2002) reported *Gracilaria dura* (Ag.) J. Ag., *G. spinuligera* Börg. and a related seaweed *Gracilariopsis rhodotricha* Dawson from coasts of SMI during March in mid 1990's.

*Habitat and ecology:* *G. tenuistipitata* var. *liui* grew abundantly attached to tube-worm cases (Figs 1a-c) on an intertidal sand-flat at Nuniachara, north of Cox's Bazar Airport, south-east of Moheshkhali Channel and north-east of Sonadia Is., having 1.5 to 2.0 m high tides (PCR, 2019).

The plant growth is severely affected by silt deposition due to dredging in the Moheshkhali Channel on the sand-flat destroying its habitat when Tube-worms moved on to the shore (Figs 1d-e) severely decreasing the population. Physical and chemical conditions of the seawater were 25 to 33° C temperature, turbidity ranging from 20 to 27 (>40) NTU and 22 to 30‰ salinity. There are reports of occurrence of the seaweed at salinity as low as 7.00‰, temperature 34° C on sandy mud in South China (Lewmanomont, 1996). The base of a plant appears to be immersed into the worm case, not visible from outside. During rainy season (rain water degrades the exterior part of the plant on Tube-worm) bases of the plant persisted deep inside the case and grow by mid September having little or no rain and turbidity, salinity about 26‰ and temperature about 30° C continued up to April next year. Zhang *et* Xia (1988) frequently found the type variety in fish ponds and shallow intertidal areas in muddy substrate of South China from November to April each year.



Figs 1a-k. *Gracilaria tenuistipitata* var. *liui* Zhang *et* Xia: (a) Sand-flat at Nuniachara, Cox's Bazar with dark-brown bunches of the seaweed during lowest tide (red crabs roaming around); (b) About a dozen plants attached to over 6 cm long Tube-worm case (inset shows the shiny head of the worm inside the tube); (c) Plants on the sand-flat attached to a Tube-worm case; (d) Foot-print showing extent of silt deposited on the seaweed; (e) Tube-worms moved on to shore due to silt deposits; (f) Semi-dried plant mildly spread on herbarium sheet without pressing (0.3 ×), inset shows constricted base of a branch (2 ×); (g) A portion of the non-pressed main axis enlarged showing curly branches; (h) A portion of the cultured seaweeds showing branching pattern (0.7 ×); (i) A magnified branch tip; (j-k) T. S. (manually) of an axis (Figs 1c-e, h-i, after PCR, 2019).

Phylum: Chlorophyta Class: Chlorophyceae, Order: Ulvales,  
Family: Ulvaceae, Genus: *Ulva*

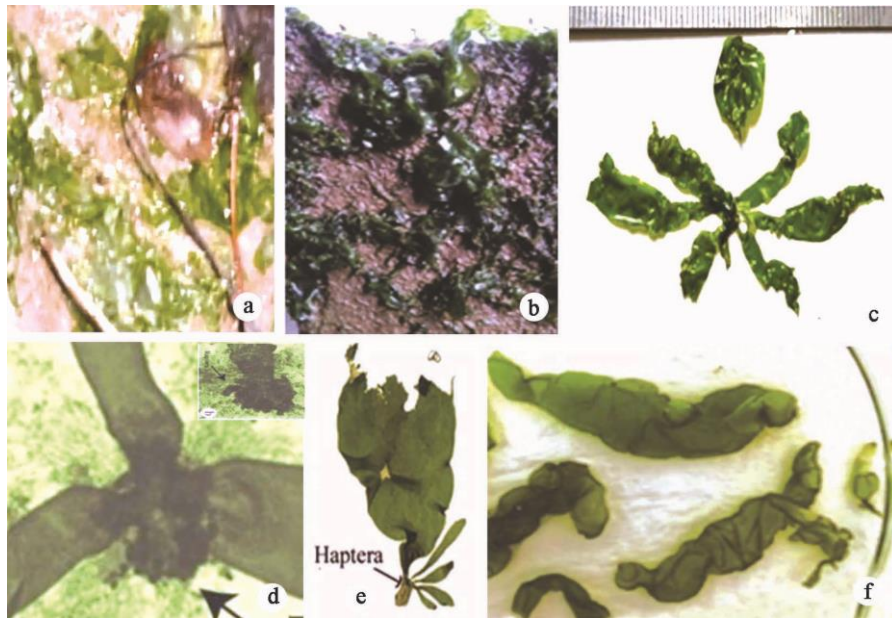
## 2. *Ulva linza* Linnaeus

(Figs 2a-f)

(Van Patten 2006, Guiry and Guiry 2020)

Plants bright “spring” yellow-green colour, unbranched, two layered thick leaf-like and flattened tube at old age with ruffled edges, 3-5 cm long, 1-2 cm wide, several growing

gregariously from a point and attached by haptera consisting of numerous rhizoids (Figs 2a-d). Upper part of mature plants produces spores released by decomposition (Fig. 2e); fully developed slender inflated fronds with ruffled edge developed in old laboratory cultures (Fig. 2f).



Figs 2a-f. *Ulva linza* Lin.: (a) Leafy plants on upper littoral clayey sandy soil, Noapara, during lowest tide; (b) Plants of different ages on a brick surface, 0.4× Bakkhali R.; (c) A bunch of 8 thalli from the brick surface spread on herbarium sheet (scale in mm); (d) Three plants aggregated and attached by haptera (arrow) in culture; inset showing numerous haptera at the base; (e) Herbarium of a mature plant with decomposed upper part producing spores, four young plants developed at the base, 1.5×; (f) Fully developed slender fronds inflated with ruffled edges from old laboratory cultures spread on a Petri dish immersed in culture medium, 1.5× (Figs 2d-f, after PCR, 2019).

Islam (1976) reported *Ulva lactuca* from SMI, while Aziz *et al.* (2008) described and illustrated *Ulva lactuca* L. var. *rigida* (C. Ag.) Le Jolis from Inani beach, Cox's Bazar, including which the total number of taxa under *Ulva* is now three. Van Patten (2006) recorded dimension of *Ulva linza* 40 cm by 5 cm from Long Island Sound, USA. Many species of *Ulva* are difficult to identify because of their simple morphologies and high plasticity, thus ecological properties like salinity preference and phenology have been reported for a limited number of species (Ogawa *et al.*, 2013).

*U. linza* is called “Mini Sea Lettuce” by Americans, in English “Slender Sea Lettuce”, Japanese “Usaba Aonori” (Guiry and Guiry, 2020), and used as Garnish on “Seaweed salad” in fancy restaurants (Van Patten 2006).

**Habitat and ecology:** The seaweed was first found on clayey sandy soil west coast of Naf River estuary, upper intertidal zone (Figs 2a, e) beside salt producing ponds from January to June, Noapara, Teknaf (PCR, 2019), salinity 24-31 ‰, pH 7.5-7.8, turbidity 20-31 NTU (>40). Later it was found growing abundantly on bricks at Fishary Ghat, along intertidal zone of Bakkhali River, Cox's Bazar (Figs 2b, c), from September to April and rotten during June-August, salinity ranging from 17-30‰, pH <8.00.

*Geographic distribution:* Kang *et al.* (2016) described *U. linza*, brackish water green seaweed dissociates from substrata facilitating the initiation of blooms, and the subsequent movement of fronds from estuaries to the inshore, then to offshore environment. Ogawa *et al.* (2013) found it among four marine *Ulva* species by analyzing the internal transcribed spacer regions of 125 marine specimens and 1169 from seven brackish sites, and phenologically some species appeared only for a few months, and others were found at all times of the year.

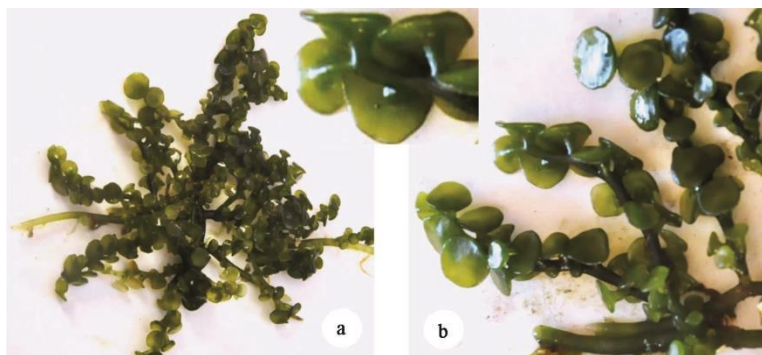
Phylum: Chlorophyta, Class: Ulvophyceae, Order: Bryopsidales;

Family: Caulerpaceae, Genus: *Caulerpa*

3. *Caulerpa chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* Aziz & Alfasane var. nov.

(Figs 3a-b)

Plants bottle-green and bushy; rhizomatous part and branches or fronds are relatively tough or hard, fronds 5.0 to 7.0 cm tall, about 1.7 cm wide at the apex and gradually narrowed (0.5 cm) basally. Pinnae of the frond apex are saucer-shaped large up to 8 mm wide and <1.0 mm thick margin, each attached by a solid stalk of about 1.0 mm broad at the base which gradually broadened upwardly into funnel-shaped structure supporting each pinna. Pinnae are arranged in irregular raceme on the solid axis. Rhizoids developed from lower side attaching with calcareous materials, such as dead fronds of *Halimeda discoidea*. Aziz *et al.* (2015) considered the specimen as *Caulerpa chemnitzia* (Esper) J.V. Lamouroux a syn. of *C. racemosa* (Forssk.) C. Ag. var. *peltata* (Lamx.) Eubank. The present material is based on collections made on 08 March 2013 from south of Cheradia, SMI and from west of Bangladesh Coast Guard Office on 06 March 2016. The size or width of pinnae gradually reduced towards base and arrangement of pinnae was highly irregular raceme compared to other varieties and has been considered as a new variety.



Figs 3a-b. *Caulerpa chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* Aziz & Alfasane var. nov.: a) A whole plant 0.8x, collection on 06 March 2013; (b) A portion of another plant enlarged 2x, collected in 06 March 2016, inset: terminal part showing asymmetric stalked saucer-like pinnae 4x.

*Etymology:* Axis and branches irregular and tough with distal pinnae up to 8 mm wide, smaller basally, saucer-shaped top with <1.0 mm thick margin, stalk short, solid 3 mm long, 1.0 mm wide at the base gradually broad acentrically to about 3 mm wide attached to saucer shaped pinna which are also arranged in irregular raceme on the solid frond.

*Specimens examined:* Aziz & Alfasane, 1382(PLHL), 08.03.2013; 1472(PLHL). 06.03.2016.



*Holotype*: Bangladesh, Aziz & Alfasane, 1382(PLHL), 08.03.2013; Herbarium of National Prof. AKM Nurul Islam Phycology, Limnology and Hydrobiology Laboratory, Department of Botany, University of Dhaka.

*Distribution in Bangladesh*: St. Martin's Island (SMI), abundant on rocky sub-littoral zone and widely distributed (Islam 1976, as *C. peltata*, Figs 50-52) and Aziz and Alfasane collected the seaweed from two locations: south of Cheradia, roughest rocky coast at depths of 1.5 to 7.0 m on 08 March 2013, Fig. 3b, facing the Bay of Bengal, and west of Bangladesh Coast Guard Office, moderately rough area at 3.0 m depth on 06 March 2016, Fig. 3a, both at SMI.

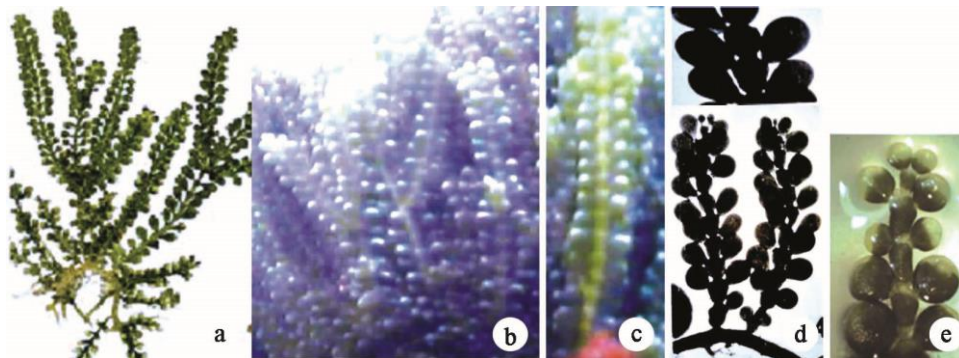
*Geographical distribution*: South-west coast of Mexico, Coast of Salvador, South coast of Nicaragua, Costarica and Panama, South-west coast of Columbia and West coast of Western Australia.

#### 4. *Caulerpa fergusonii* G. Murray

(Figs 4a-e)

(Bold systems: Taxonomybrowser, v3.boldsystems.org; [https://en.wikipedia.org/wiki/Caulerpa\\_fergusonii](https://en.wikipedia.org/wiki/Caulerpa_fergusonii); [https://www.algaebase.org/search/species/detail/?species\\_id=3753](https://www.algaebase.org/search/species/detail/?species_id=3753); as *C. cactoides* in Islam 1976, 18, Pl. 12, figs 94-95; Pl. 14, fig. 103)

Plants thaloid, coenocytic, colourless stolon producing rhizoids from below and erect olive green branches or fronds from above, 4.0 to 9.0 cm tall, 1.0 to 1.5 cm wide; fronds may produce single to several lateral branches from an axis spreading about 18 cm tall in February collections, pinna consists of an axis of series of pyriform or ob-pyriform (balloon-like) 10 up to 30 segments each producing a pair of relatively larger pyriform or balloons called pinnae up to the tip, no internodal cells found (Figs 4a-d); pinnae 5 to 6 mm long and 3 to 4 mm wide; during reproductive phase, pinnae of the upper part become spherical when the whole olive-green cell content of lower half of fronds moves on to the upper half filling lower half of each pinna and axial segments (Fig. 4e). Islam (1976, Pl. 12, figs 94-95; Pl. 14, fig. 103) published the coenocytic



Figs 4a-e. *Caulerpa fergusonii* G. Murray: (a) Herbarium of a plant with repeatedly branched fronds, 0.3 $\times$ ; (b) Videography of submerged vegetation, south of Cheradia, SMI using underwater communication system. (c) A frond from the video enlarged showing axial segments each producing a pair of pinnules distally; (d) A plant with two fronds and an enlarged portion on the top (after Islam 1976, Fig. 94) 1 $\times$ ; (e) Upper half of a frond in reproductive stage where all segments possess gamete producing cytoplasm occupying about 50% space 1 $\times$  (Figs 3a, e, after PCR 2019).

seaweed with similar body structure to the above description without internodal cells but identified as *C. cactoides* (Turner) C. Ag. Literature review revealed that *C. cactoides* is characterized by short inter-nodal segments occurring all along the frond's axis alternating with nodal segment each

producing oppositely placed paired pinnae (Guiry MD, 2013). These features are lacking in the illustrations by Islam (1976, p. 18, fig. 94-95, 103). Therefore, the present material (Figs 3a-b, e) and the illustrations by Islam (1976, Figs 94-95) in Fig. 3d are the same and identified as *C. fergusonii* G. Murray (Guiry MD, 2013) in this report. Dominic *et al.* (2007) remarked that there are two known extra-Australian records of *C. cactoides*, from Bangladesh (Islam, 1976) and Sumba Island in Indonesia (Coppejans and van Reine, 1992), which is a wrong identification for Bangladesh part.

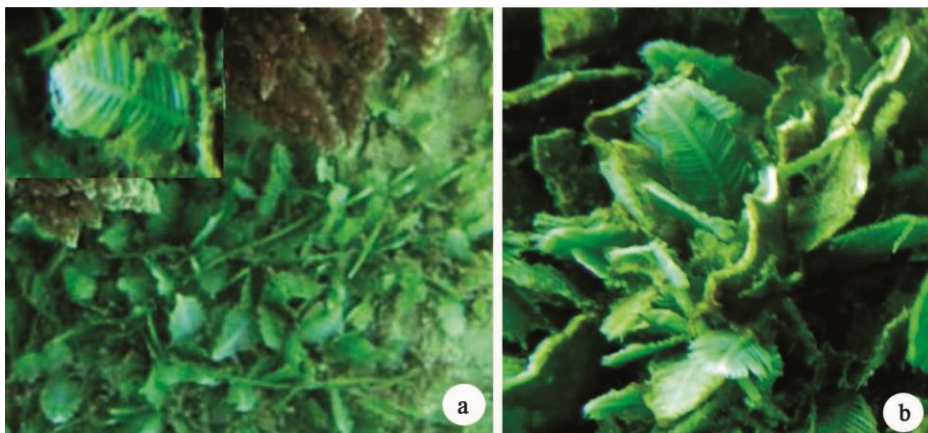
**Habitat:** Rocky littoral or upper littoral zones of west coast of SMI. Islam (1976) recorded it as *C. cactoides* also from rocky littoral zone of the Island. The alga was also recorded in the sub-littoral zone of extreme South of Cheradia forming submerged meadow at a depth of over 2.0 m (Fig. 3b).

**Geographic distribution:** Point Lonsdale, Rock pool, Victoria, Australia environment (Guiry MD 2013). The seaweed is found around finch of Asia (India, Srilanka, Indonesia, Philippines, etc.) and the Pacific islands as well as New Zealand.

##### 5. *Caulerpa sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov.

(Figs 5a-b)

The plant is dark-green, fronds stout, short feather-like and upright, 2.0-3.0 cm high, about 2.0 cm wide consisting of nearly straight 3 to 11 mm long, 1 to 1.5 mm wide needle-like pinnae oppositely developed from robust midrib, closely associated without spaces in between attached by narrow short stalk, slightly upwardly directed giving broadly (Fig. 5a) to narrowly (Fig. 5b) conical apex with extended pointed midrib; stolons stout, more or less straight cylindrical 2 to 2.5 mm diameter and creeping up to about 2 metres; branched rhizoids from below penetrate the sandy substrate.



Figs 5a-b. *Caulerpa sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov.: (a) Submerged creeping plants beside *Asparogopsis taxiformis* bush (1.0 ×), inset showing an enlarged frond attached to stolon, 1.0 ×; (b) fronds growing upright with *Halimeda discoidea* bush (1.0 ×).

**Etymology:** Plants dark-green, short stalked stout feather-like fronds attached to straight and stout straight stolon which creeps up to about 2 metres; pinnae wide needle-like and stout, but slightly upwardly directed giving broadly (Fig. 5a) to narrowly (Fig. 5b) conical apex with extended pointed midrib unlike the species itself and has been considered as a new variety.

*Holotype*: Bangladesh, Aziz & Alfasane, 1383 (PLHL), 08.03.2013; Herbarium of National Prof. AKM Nurul Islam Phycology, Limnology and Hydrobiology Laboratory, Department of Botany, University of Dhaka.

*Habitat*: It grows on sandy floor at a depth of 2 to 3 meters, sub-littoral along with *Asparagopsis taxiformis* and *Halimeda discoidea* bushes, west coast of SMI in March 2013.

*Geographic distribution*: North Carolina to Florida, also found throughout the Caribbean around Bermuda, Bahamas, Greater and Lesser Antilles and in the Gulf of Mexico and in the southern Atlantic Ocean to Brazil; the Pacific Ocean along the in Australia, Western Australia, Papua New Guinea, Philippines and Palau.

Islam (1976) described and illustrated 11 species/taxa of *Caulerpa* from SMI and Aziz and Rahman (2011) later added *C. sertularioides* fa *corymbosa* to the list. Including the present three species, total *Caulerpa* species till 2020 is 15 of which *Caulerpa chemnitzia* (Esper) J.V. Lamouroux var. *irregulare* Aziz & Alfasane var. nov. and *Caulerpa sertularioides* (S.G. Gmelin) M. Howe var. *robusta* Aziz & Alfasane var. nov. are new to science. Total seaweed taxa occurred along Bangladesh coast till 2020 stand at 210, the absolute majority are from the SMI.

### Acknowledgements

In the herbaria of seaweeds collected over several decades National Prof. AKM Nurul Islam identified red seaweed as *Hypnea musciformis* and also published *Caulerpa cactoides* (Islam, 1976). During visit of seaweed specialist Dr. Lawrence Liao, Hiroshima University, Japan in February 2018 the first author presented a seminar of seaweed flora of Bangladesh. Dr. Liao identified the two organisms as *G. tenuistipitata* var. *liui* and *Caulerpa fergusonii*, respectively for which the author is grateful to him. Authors are grateful to Bangladesh Navy authority specially Commander M Zahid Hossain (TAS) PSC Co BNS SAIKAT for providing Scuba Divers with underwater photographic and Communication Systems.

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